ENCYCLOPEDIA OF science technology AND ethics

volume 4

CARL MITCHAM
EDITOR IN CHIEF

ENCYCLOPEDIA OF science technology AND ethics

EDITORS AND CONSULTANTS

ENCYCLOPEDIA OF science technology AND ethics

EDITED BY
CARL MITCHAM

volume
1
a–c

MACMILLAN REFERENCE USA
An imprint of Thomson Gale, a part of The Thomson Corporation

THOMSON
GALE

Detroit • New York • San Francisco • San Diego • New Haven, Conn. • Waterville, Maine • London • Munich

Encyclopedia of Science, Technology, and Ethics

Carl Mitcham, Editor in Chief

For more information, contact
Macmillan Reference USA
An imprint of Thomson Gale
27500 Drake Rd.
Farmington,
Hills, MI 48331-3535
Or you can visit our Internet site at
http://www.gale.com

LIBRARY OF CONGRESS CATALOGING-IN-PUBLICATION DATA

Encyclopedia of science, technology, and ethics / edited by Carl Mitcham.
p. cm.
Includes bibliographical references and index.
ISBN 0-02-865831-0 (set, hardcover : alk. paper)—ISBN 0-02-865832-9 (v. 1) —
ISBN 0-02-865833-7 (v. 2)—ISBN 0-02-865834-5 (v. 3)—ISBN 0-02-865901-5 (v. 4)
1. Science—Moral and ethical aspects—Encyclopedias.
2. Technology—Moral and ethical aspects–Encyclopedias.
I. Mitcham, Carl. Q175.35.E53 2005
503—dc22 005006968

This title is also available as an e-book.
ISBN 0-02-865991-0
Contact your Thomson Gale representative for ordering information.

Printed in the United States of America
10 9 8 7 6 5 4 3 2 1

CONTENTS

EDITORIAL AND PRODUCTION STAFF

Frank Menchaca
Publisher

Hélène Potter
Director, New Product Development

Monica M. Hubbard
Project Editor

Sara Constantakis, Lynn Koch, Nicole Watkins
Contributing Editors

Joshua Kondek
Editorial Technical Support

Adam Briggle, Elizabeth B. Inserra, Christine Kelley, Eric Lowenkron, David Salamie, Alan Thwaits
Manuscript Editors

John Krol
Proofreader

Laurie Andriot, Susan Kelsch
Indexers

Michelle DiMercurio
Product Dessign

Lezlie Light, Dan Newell, Christine O'Bryan, Robyn Young
Imaging

GGS Information Services, XNR Productions Inc.
Graphic Art

Lori Hines
Rights Acquisition and Management

Cadmus Professional Communications
Typesetter

Evi Seoud
Composition

Wendy Blurton
Manufacturing

PREFACE

The *Encyclopedia of Science, Technology, and Ethics* has had multiple origins. It was when contributing an article on the philosophy of technology to the pioneering first edition of the *Encyclopedia of Bioethics* (1978), that I began to dream of a more general encyclopedic introduction to issues of technology and ethics. Inspired by the perspective of scholars as diverse as Jacques Ellul and Hans Jonas, bioethics appeared only part of a comprehensive need to grapple intellectually with the increasingly technological world in which we live. This idea was pursued in a state-of-the-field chapter on "Philosophy of Technology" in *A Guide to the Culture of Science, Technology, and Medicine* (1980) edited by one of my mentors, Paul T. Durbin. Thus when Stephen G. Post, the editor of the third edition of the *Encyclopedia of Bioethics* (2004), suggested to Macmillan the idea of a more general "Encyclopedia of Technoethics," with me as potential editor, I was primed to be enthusiastic—although I also argued that the field should now be expanded to include ethics in relation to both science and technology.

A high-school attraction to philosophy as critical reflection on how best to live had early morphed into the critical assessment of scientific technology. In contemporary historical circumstances, what has a more pervasive influence on the way we live than modern technology? My initial scholarly publications thus sought to make philosophy and technology studies a respected dimension of the academic world. Over the course of my curriculum vitae this concern further broadened to include science, technology, and society (STS) studies. Given the narrow specializations of professional philosophy, STS seemed better able to function as a home base for philosophy of technology. In fact, in the mid-1980s, George Bugliarello, George Schillinger, and I (all colleagues at Brooklyn Polytechnic University) made a proposal to Macmillan Reference for an Encyclopedia of Science, Technology, and Society." That proposal was declined, but a version eventually found truncated expression in *The Reader's Adviser*, 14th edition, vol. 5, *The Best in Science, Technology, and Medicine* (1994), co-edited with William F. Williams, a colleague at Pennsylvania State University, where I served for a period during the 1990s as director of the Science, Technology, and Society Program. Thus when the opportunity arose to edit an encyclopedia on science, technology, and ethics, I also wanted not to limit such a reference work to ethics in any narrow sense.

Other associations that broadened my perceptions in both philosophy and STS in ways that have found modest reflections here should also be mentioned. One was the collegiality of two professional associations, the Society for the Philosophy of Technology (founded 1980) and the Association for Practical and Professional Ethics (founded 1991), with members from both becoming contributors. Service as a member of the Committee on Scientific Freedom and Responsibility of the American Association for the Advancement of Science, 1994–2000, was one of the most professionally rewarding experiences of my career, and contributed its own perspective. Finally, the critical fellowship of Ivan Illich introduced me to friends and ideas with whom I might not always agree though they seldom failed to inspire.

Developmental Process

When the possibility for the present encyclopedia finally emerged in the Fall of 2002, my initial desire was not only to work with previous colleagues but to seek the collaboration of others who had become leaders in institutionalizing discussions of science, technology, and ethics. Obvious candidates for associate editors were philosopher Deborah Johnson, whose work on computer and engineering ethics during the 1980s and 1990s had helped define both fields, and Stephanie Bird and Raymond Spier, the editors of *Science and Engineering Ethics* (founded 1995), the leading journal in this area of interdisciplinary discourse. It was also desirable to make sure that the project had representation not just from the scientific and technical community (which neuroscientist Bird and biochemical engineer Spier clearly brought to the team) but also from different points on the ethical and political spectrum. Fortunately, political scientist Larry Arnhart, with whom I had recently become acquainted, was willing to bring to the table a conservative philosophical perspective that might otherwise have been inadequately represented, and to go beyond the call of editorial duty in many respects.

The first editorial meeting place in New York City in January 2003, hosted by Hélène Potter of Macmillan Reference USA. This two-day workshop established the general framework for the *Encyclopedia of Science, Technology, and Ethics* and became the basis for collegial productivity over the next two years. During the Spring and Summer 2003 we set up an Editorial Advisory Board which included Durbin, Bugliarello, and Schillinger as well as more than twenty other representatives of important disciplinary and regional perspectives. Commissioned articles began to be submitted in August 2003 and continued over the next eighteen plus months.

For the first year—during a portion of which I served as a Fulbright Scholar at the University of the Basque Country in Spain (where Nicanor Ursua was a supportive host)—the editors worked with authors to refine article definitions, learn from their contributions about new topics that needed to be covered, and thereby deepened and broadened the content of the encyclopedia. Four scholars who played especially important roles in these regards were Robert Frodeman, Valerie Miké, Roger Pielke Jr., and Daniel Sarewitz.

Self Assessment

As the first edition of a reference work, some important topics remain missing from *ESTE*, because of problems with schedule, author availability, or simple oversight. Indeed, because the themes of science, technology, and ethics are so broad, the *Encyclopedia of Science, Technology, and Ethics*, despite its four-volume length, is necessarily selective. Yet in an effort to not let perfection become the enemy of the good, the project has been pursued in a belief that it might advance in its own modest way a contemporary social process in the ethical assessment of science and technology.

This encyclopedia is thus a work in progress. It aims to synthesize, but does not claim to be final or complete. Indeed, all reference works today have to contend with a knowledge production industry that makes it difficult to secure any stable orientation. Despite its efforts, the project cannot hope to please all scientists, engineers, and ethicists—or other scholars and general readers. But the hope is to have pleased sufficient numbers that those who see opportunities for improvement will consider offering to make a second edition better. Critical comments and recommendations are welcome.

Acknowledgments

Beyond those already mentioned, all Associate Editors and members of the Editorial Advisory Board deserve special thanks for their contributions. I should nevertheless single out Stephen H. Cutcliffe, Paul T. Durbin, Helen Nissenbaum, and Nancy Tuana for extra work in identifying authors and reviewing articles. Adam Briggle, as the most qualified and hard-working research assistant I could imagine, functioned during many months of the second year as an editorial assistant. A graduate seminar in STS at the Center for Science and Technology Policy Research during Fall 2004 contributed critical perspectives that measurably improved the project. But primary credit must go to the editors and contributors, many of whom worked well beyond what would have been appropriate for their modest honoraria.

Finally, in the background, my spouse, Marylee, and family cheered on the project whenever they found me available—and when they found me absent, simply suffered a work schedule that for more than two years seldom let me come up for air. Colleagues in the Division of Liberal Arts and International Studies at the Colorado School of Mines similarly tolerated with good nature a tendency to commandeer more work space than was rightly mine; and the Division Director, Laura J. Pang, was generous in directing toward the project modest but not insignificant resources from very limited funds. In the foreground, the daily work of managing the encyclopedia preparation process depended on a production team at Macmillan to efficiently commission articles, maintain contact with authors, coordinate reviews, copyedit manuscripts, secure illustrations,

check revisions and bibliographies, and prepare all materials for publication. In particular, I am fortunate to have had Monica Hubbard, Senior Editor with Macmillan Reference USA, as a guide through the process. This project would not have come to fruition without her good work, good humor, and persistence over the previous two years.

CARL MITCHAM
EDITOR IN CHIEF
MAY 2005

INTRODUCTION

Human beings are in the midst of creating a new world through science and technology. But what kind of world we create will not be decided by science and technology alone. It will depend even more significantly on our views, implicit or explicit, about the nature of the good life—about good and bad, right and wrong, and our abilities to enact ideals in the face of limited knowledge and temptations to ease or arrogance.

Virtually all sciences and technologies today have implications for ethics and politics, and ethics and politics themselves increasingly influence science and technology—not just through law, regulation, and policy initiatives, but through public discussions stimulated by the media, public interest organizations, and religious concerns. According to Alan Leshner, CEO of the American Association for the Advancement of Science, the largest interdisciplinary scientific society in the world, a new science-society relationship has emerged in the public realm and within the scientific community. As he wrote in the lead editorial in *Science* (February 11, 2005):

> We've been used to having science and technology evaluated primarily on the basis of potential risks and benefits. However, our recent experience suggests that a third, values-related dimension will influence the conduct and support of science in the future.

In response, Leshner called on members of the technoscientific community to engage others in discussing the meaning and usefulness of science, engineering, and technology. But such engagement cannot be a one-way street; it must also stimulate scientists and engineers in self-examinations of the social character of their professions and the proper roles of science and technology in society. Additionally, the non-scientific public would do well to eschew any easy criticism or naive enthusiasm in the pursuit of informed consideration. Such multipath assessment is precisely what science, technology, and ethics is all about, and the present encyclopedia aims to contribute in the broadest possible way to this on-going process of promotional and critical reflection.

To this end the *Encyclopedia of Science, Technology, and Ethics* has three objectives:

- To provide a snapshot of emerging bodies of work in the co-construction of an ethical, scientific, and technological world;
- To design and build bridges between these not always collaborative efforts;
- To promote further reflection, bringing ethics to bear on science and technology, and science and technology to bear on ethics.

Background: The Encyclopedic Idea

The term "encyclopedia" comes from the Greek, *enkyklios* (general) + *paideia* (education), and thus alludes to the classical conception of *paideia* as character formation that transmits a level of cultural achievement from one generation to the next among the educated few. In this classical form education came to include the liberal arts of logic, grammar, rhetoric, arithmetic, geometry, astronomy, and music. As achievements in these fields accumulated and became more extensive, explicit efforts were naturally undertaken to summarize them. Early examples of such summaries were the *Antiquitates rerum humanarum et divinarum* and *Disciplinae* of Marcus Terentius Varro (116–27 B.C.E.), neither of which survives. The oldest extant work in this tradition is the *Historia naturalis* of Pliny the Elder (23–

79 C.E.). The *Etymologiarum* of Isadore of Seville (560–636) became a work of standard reference that helped transmit classical learning into the Middle Ages. Medieval and Renaissance encyclopedias continued this tradition in, for example, the *Speculum majus* of the thirteenth century Dominican scholar Vincent of Beauvais and the *Encyclopaedia seu orbis disciplinarum tam sacrarum quam prophanarum epistemon* of the sixteenth century German scholar Paul Scalich, the latter being the first to use the term "encyclopedia" in its title.

The work with which the term is most commonly associated, the Enlightenment *Encyclopédie ou Dictionnaire raisonné des sciences, des arts et des métiers* (1751–1772) marked a three-fold change in the encyclopedia idea. First, the French encyclopedia was written to educate the many as well as the few; the aim was to popularize or democratize knowledge. Second, the knowledge summarized in the French encyclopedia included technical craft traditions as well as learned or intellectual knowledge, thus building a bridge between intellectual and workshop traditions of knowing and making. Third, the French encyclopedia proposed not simply to summarize existing cultural achievements but to produce new ones. In the project of the *philosophes* Denis Diderot, Jean d'Alembert, and others, the modern idea of education as going beyond the transmission of previous cultural achievements to produce new cultural formations found one of its paradigmatic cultural expressions.

As the modern project of knowledge production took hold it proceeded by means of disciplinary specialization. In this context the encyclopedic idea also became a kind of counter movement to the creation of more and more specialized knowledge in the physical sciences, the social sciences, the humanities, and the arts. Projects that exemplified efforts at synthesis range from G. W. F. Hegel's *Encyclopedia of the Philosophical Sciences* (1817) to Otto Neurath, Rudolf Carnap, Charles W. Morris's *International Encyclopedia of the Unified Sciences* (1938–1969).

It is on all three of these visions that the present *Encyclopedia of Science, Technology, and Ethics* (*ESTE*) seeks to draw. *ESTE* aims to summarize, in however provisional a manner, emerging bodies of knowledge bearing on the co-construction of an ethical, scientific, and technological world; to promote new collaborative efforts in this interdisciplinary field of thinking and acting; and to stimulate new cross-fertilizations and syntheses between science, technology, and ethics.

The *ESTE* Idea

Moral teachings and ethical inquiries regarding the creation and use of science and technology have been part of religious and philosophical traditions from the earliest periods. Repeated cautions about over reliance on science and technology occur in the primary texts of many religious traditions (see the Tower of Babel, the myth of Daedalus, and the tales of Chuang Tzu) and in classic Western philosophy (Plato's *Gorgias*). By contrast, modern European history displays a rejection of the tradition of caution in favor of a commitment to science and technology as the best means to improve the human condition—even as restatements of caution have appeared especially in the Faust story, *Frankenstein*, *Brave New World*, and some popular science fiction.

Since their rise in the sixteenth and seventeenth centuries, science and technology have nevertheless been increasingly involved with a series of ethical and political challenges. During the eighteenth century, the Enlightenment and Romanticism sparred over the ethical character of the scientific view of the world in both epistemological and metaphysical terms. The nineteenth century witnessed the rise of major political reactions against the evils of the Industrial Revolution, reactions that influenced the military and ideological conflicts of the twentieth century. During the last half of the twentieth century whole new fields of ethical reflection emerged to deal with the technoscientific world of nuclear weapons (nuclear ethics), chemical transformation of the environment (environmental ethics), biomedical advances (bioethics), and computers and information technology (computer ethics). Additionally, the ethics of scientific research and of the engineering practice became specialized areas of study.

As the twenty-first century begins, ethical and political challenges have become global in scope and intensified by the terrorist use of technology and science. Science, technology, and ethics interactions thus transcend disciplinary and cultural boundaries—and promise to play ever more prominent roles in human affairs for the foreseeable future. *ESTE* thus aims to integrate more specialized work in the applied ethics of particular technologies, in the professions of engineering and science, and in science and technology policy analyses, to point toward general themes and grapple with contemporary issues, while including articles that provide historico-philosophical background and promote cross-cultural comparative reflection. Had *ESTE* needed a subtitle, it might well have been "Toward Professional, Personal, and Political Responsibility in the Technoscientific World." The goal is to help us all practice a more informed seeking of the good in the high-tech, deeply scientific world in which we progressively live.

Building Bridges to Promote Reflection

The field of science, technology, and ethics is not mature. As a result this encyclopedia seeks to exercise as much a creative or formative role as it does a reporting or summary one. *ESTE* is an experiment in synthesis. Although it is clear that advances in science and technology are insufficient in and of themselves to constitute true human progress, previous encyclopedic efforts to survey the ethical challenges involved with both advancing and responding to such advances have focused only on specific areas such as biomedical ethics, computer ethics, or environmental ethics—or provided synthesis at the higher level of ethics in general. The present encyclopedia is the first to attempt a mid-level synthesis of the various specializations of applied ethics as they deal especially with science, technology, engineering, and medicine in order to promote interactive scholarly reflection, practical guidance, informed citizenship, and intelligent consumerism.

To meet these diverse but overlapping purposes *ESTE* coverage aims to include (although not exhaust) four themes: (1) types of science and technology; (2) approaches to ethics; (3) types of science, technology, and ethics interactions; and (4) historical and cultural contexts.

(1) The terms "science" and "technology" are somewhat flexible. In the present context "science" indicates the modern sciences of physics, chemistry, biology, and geology—and their numerous extensions: psychology, nuclear physics, biochemistry, cosmology, and more. "Technology" refers primarily to the modern activities of making and using artifacts, especially in applied science, engineering, medicine, decision-making, and management. The merging of science and technology in science that is highly dependent on advanced engineering instrumentation (cyclotrons, electron microscopes, advanced computers) and major capital investments, and in technology that is highly dependent on scientific knowledge or theory (designer materials, computers, biotechnology, genetic engineering, etc.) is sometimes referred to as "technoscience." None of these understandings of science and technology are excluded from *ESTE*, although the encyclopedia has not been able to include everything equally.

(2) Ethics is likewise understood broadly to be concerned with all questions of right and wrong, good and bad, in science, engineering, and technology. Although science provides descriptive knowledge of the world, on its own it is not able to interpret the human meaning of this knowledge, nor to provide full guidance for distinguishing between proper and improper processes in the acquisition of knowledge. Likewise, engineering and technology provide increasingly powerful means, but tell us little about the ends to which they should be dedicated. Ethics, generally speaking, is concerned with identifying proper means and distinguishing good and bad ends. Traditions or schools of ethical reflection and analysis include those of consequentialism, deontology, virtue ethics, natural law, and more.

Adapting a working definition from the *Encyclopedia of Bioethics*, 2nd edition (1995), *ESTE* is concerned with the *multiple moral dimensions—from vision and conduct through decision and policy making at the personal, professional, and governmental levels— of science and technology broadly construed, and employing a diversity of methods in interdisciplinary settings*. This description emphasizes the unity of ethics and politics both within technoscientific communities and in the technoscience-society relationship.

(3) Science, technology, and ethics interactions can take place within technoscientific communities and outside of such communities. Furthermore, interactions outside professional communities may take place at the personal or public levels, thus suggesting the following matrix:

	Professional	**Personal**	**Public**
Science	Professional ethics of doing science	Personal interpretations and uses of science by non-scientists	Political and policy issues raised by science in relation to society
Technology	Professional ethics of doing technology, especially engineering and clinical medicine	Personal interpretations and uses of technology by non-engineers and non-physicians	Political and policy issues raised by engineering and technology in relation to society

External (personal and public) issues may further be divided into those that stress the social-political adjustment to accommodate scientific and technological change or questions about how society should promote, support, or regulate science, engineering, and technology. Science policy (both science for policy and policy for science) and technology policy are specialized approaches.

Each of the six matrix boxes further interact: professional ethics of science and engineering can overlap and influence each other; the social impacts of science and technology are sometimes difficult to distinguish; internalist ethics often has implications for external issues and vice versa. *ESTE* aspires to be cognizant of the full spectrum of this complex diversity in possible relationships.

(4) Science, technology, and ethics interactions in these broad senses have, furthermore, been examined from multiple historical and cultural perspectives: The Continental European tradition, for instance, tends to focus more globally on science and technology as a whole, whereas in the Anglo-American tradition the ethics of particular technologies (as in medical ethics or computer ethics), areas of professional practice (engineering ethics, business ethics), or issues (equity, privacy, risk) dominate. In *ESTE* perspectives from different philosophical schools are to be further complemented by those from diverse religious, political, and cultural or linguistic traditions.

Types of Articles

The Editorial Board considered these four themes in writing scope notes for *ESTE*'s more than 670 articles, using the following four-part categorization scheme:

1. Introductions and overviews
   - 1.1 Specialized introductions
   - 1.2 Overviews
2. Concepts, case studies, issues, and persons
   - 2.1 Key concepts
     - 2.1.1 Concepts, Ethical and Political
     - 2.1.2 Concepts, Scientific or Technological
   - 2.2 Case studies
   - 2.3 Issues
     - 2.3.1 Issues, Historical and Social
     - 2.3.2 Issues, Scientific or Technological
     - 2.3.3 Issues, Phenomena
   - 2.4 Persons and narratives
     - 2.3.1 Persons and figures, premodern
     - 2.3.1 Persons and figures, modern to World War I
     - 2.3.2 Persons and figures, post-World War I
   - 3. Sciences, technologies, institutions, and agencies
     - 3.1 Particular sciences and technologies
     - 3.2 Social institutions
     - 3.3 Organizations and agencies
4. Philosophical, religious, and related perspectives
   - 4.1 Philosophical perspectives
   - 4.2 Religious perspectives
   - 4.3 Political and economic perspectives
   - 4.4 Cultural and linguistic perspectives

The Topical Outline presents the full list of articles organized by these categories.

INTRODUCTIONS AND OVERVIEWS. As this categorization framework indicates, there are two types of introductory articles in *ESTE*. One consists of the thirty-three specialized introductions to existing applied ethics fields such as "Agricultural Ethics," "Bioethics," "Computer Ethics," and "Engineering Ethics." The second is a set of more than a dozen Overview entries that serve two kinds of purpose. In the first instance they are stand-alone articles to review a few central concepts such as Science, Technology, and Ethics themselves. In the second they provide introductions to composite articles. In both instances, unlike all other *ESTE* entries, they give internal references to closely related articles.

CONCEPTS, CASE STUDIES, ISSUES, AND PERSONS. The bulk of *ESTE* articles, as is appropriate in an emerging dialogue, deal with concepts, case studies, issues, and persons. In relation to concepts, the distinction between those classified as Ethical and Political in character (such as "Plagiarism" and "Trust") and those classified as Scientific or Technological ("Efficiency" and "Networks") could in many instances be contested. Why is "Aggression" ethical but "Ethology" scientific? Is not "Human Nature" as much ethical as scientific? But the interest here is simply to make a rough distinction between those more closely associated with ethics or politics and those more easily associated with science or technology. Ethics concepts also tend to have a longer history than scientific or technological ones. In each instance, however, articles aim to bring out both ethical and scientific or technological dimensions.

The distinction between Case Studies and Issues is likewise somewhat arbitrary, since along with such clear instances as the "DC-10 Case" and "DDT" are included the "Apollo Program" and the "Asilomar Conference." But the intuition is that the case studies are modestly more closely tied to historical particulars than are issues. It is also important to note that *ESTE* has avoided attaching the names of persons to cases, at least in article titles, opting instead for more generic descriptors. Since there are an indefinite number of cases, there has also been an attempt to group some kinds of cases together, as in the three entries on "Misconduct in Science." Among the case studies some are more expansive than others, often reflecting a sense that other material relevant to the case is provided elsewhere, but sometimes just as a result of the accidents or oversights that inevitably find their way into such a large compilation.

The separation of Issues into three types is again not meant to be hard and fast but suggestive. But some issues are more Historical and Social than Scientific or Technological. Then there are some Phenomena that have an issue-like dimension related to science, technology, and ethics. For instance, although the notion of elements is covered in the entry on "Chemistry," to provide some historical and phenomenological perspective articles are included on what in the European tradition have served as the four traditional elementary phenomena: "Air," "Earth," "Fire," and "Water."

The classification of Persons and Figures is divided into Premodern, Modern to World War I, and Modern since World War I. The ancient/modern division is quite common. Using World War I as a divide in the modern period recommended itself because of the role the Great War played in stimulating recognition of the destructiveness of modern science and technology, and thus ethical discussion.

SCIENCES, TECHNOLOGIES, INSTITUTIONS, AND AGENCIES. Articles on sciences, technologies, institutions, and agencies are not comprehensive. For instance, although there is an article on "Chemistry" there is none on physics or biology. The reason is that chemistry tends to be an overlooked science when it comes to ethics, whereas physics and biology are dealt with in numerous other articles such as "Nuclear Ethics" and "Bioethics". At the same time, because of the profound significance of the mathematical discipline of probability and statistics, together with its under-appreciation in ethical and political discussions, this topic has been given a somewhat more extensive treatment. The length of this treatment, which includes introductory technical material, reflects a belief in the importance of this new form of thinking that demands both attention and comprehension especially in ethical assessment. In like manner, there might have been articles on a host of social institutions as well as organizations and agencies. The goal was simply representation and illustration of the importance that these realities must play in ethical reflection and practical action that engages the world transforming character of science and technology.

PHILOSOPHICAL, RELIGIOUS, AND RELATED PERSPECTIVES. Finally, the four sets of Perspectives articles—Philosophical, Religious, Political–Economic, and Cultural–Linguistic—aim to give *ESTE* a breadth that would otherwise be lacking. Here special efforts have also been made to secure contributors from throughout the world. *ESTE* represents authors from 28 countries, reflecting the growing interest of scholars worldwide in these important issues.

Organization of the Encyclopedia

Entries vary in length from 250 to 5000 words and are arranged alphabetically. In general structure they begin with a statement of how the topic relates to the theme of the encyclopedia, followed by some background of a historical or developmental character. The main body aims to provide an authoritative exposition of its particular theme, concept, case, issue, person, science or technology, or perspective, and to conclude with critical application or comments.

In selective instances entries are composed of more than one article. For example,

RESPONSIBILITY

Responsibility: Overview

Responsibility: Anglo-American Perspectives

Responsibility: German Perspectives

Since any article is going to exclude as well as include, and this kind of composite occurs only occasionally, references to Related Articles at the end of each entry provide another means for broadening a reader's knowledge. In a synthetic, interdisciplinary encyclopedia like *ESTE* topics invariably have tendrils that reach out into multiple entries.

Bibliographies for each article are another important feature, often complemented by a few Internet Resources. They were prepared by the contributors and verified by a bibliographic editor. Although brief, bibliographies nevertheless serve different purposes from article to article. Seldom are primary sources listed. Some bibliographic items refer readers to sources used or cited by the contributor with internal reference, for example: (Jones 2000, p. 100). In cases where a bibliographic entry is not explicitly used in the text it is often briefly annotated for significance.

The article bibliographies are supplemented by two appendices: a selective, annotated general bibliography; and selective, annotated list of Internet resources. Written entries are further enhanced with more than 300 graphics that range from tables to photographs.

SPECIAL FEATURES. The main body of alphabetical entries is complemented by eight introductory essays. Given the constructive character of the encyclopedia, these essays present selective but fundamental perspectives on the dialogue among science, technology, and ethics. These range from science and technology studies scholar Sheila Jasanoff's argument for new forms of citizen participation in technoscientific governance to engineer-inventor Ray Kurzweil's argument for the ethical responsibility to promote scientific research and technological development. Historian Ronald Kline compares and contrasts developments in research ethics and engineering ethics, while philosophers Deborah Johnson and Thomas Powers set out a new program for research in ethics and technology that would help bridge the divide Kline observes. Computer science philosopher Helen Nissenbaum argues for new practices in science and engineering that would complement the Johnson-Powers program in scholarship. Mathematician Valerie Miké proposes a new ethical use of scientific evidence in the promotion and utilization of both science and technology. Science, technology, and society scholar Carl Mitcham and philosopher and environmental scientist Robert Frodeman note some ethical challenges associated with the expansion of knowledge, both scientific and technological. Philosopher of science and technology Hans Lenk calls attention to a range of emerging, ethically relevant special features in contemporary technologies themselves.

These introductory essays, which are an unusual feature in an encyclopedia, are especially recommended to readers seeking synthetic perspectives. Although they are necessarily limited in their scope, they point the way toward the kinds of interdisciplinary reflection that is crucial to further enhancement of the science, technology, and ethics dialogue.

The Appendices are another special *ESTE* feature. Along with the "Selective, Annotated General Bibliography on Science, Technology, and Ethics," and the annotated list of "Internet Resources on Science, Technology, and Ethics", there is a "Glossary of Terms" often found in discussions of science, technology, and ethics, and a "Chronology of Historical Events Related to Science, Technology, and Ethics." Finally, a set of ethics codes from around the world enhances appreciation of the truly transnational character of the science, technology, and ethics interactions at the levels of both theory and practice.

Comments and Qualifications

As will be immediately obvious to any reader, some topics are treated at greater length than others; some articles are more argumentative or polemical than others; and some articles contain more overlaps than others. Across all such variations, however, the goal has been a balance that would provide an index to emerging bodies of work contributing to the co-construction of an ethical, scientific, and technological world, enhance links between not always collaborative efforts, and further theoretical and practical engagements between science, technology, and ethics. Of course, in making such decisions there is never any one perfect way; there is always room for improvement.

With regard to length: Often less well known topics are treated at greater length than more well known. *ESTE* has, for instance, made no effort to replace other more specialized synthetic works such as the *Encyclopedia of Bioethics* (1978, 1996, 2004), the *Encyclopedia of Applied Ethics* (1998) and its offshoots, or the *Encyclopedia of Ethical, Legal, and Policy Issues in Biotechnology* (2000)—although it has tried to pick up many of the themes and issues found in such works and place them in a distinct and broader perspective. Additionally, in some cases contributors simply submitted articles longer than specified, but that were just so good it would have been a mistake to cut them.

With regard to polemics: There has been a serious effort to allow contributors when appropriate to express their views in stimulating, thought-provoking arguments rather than insist on rigid adherence to uniformly balanced reports that could come across as dull or pedantic. At the same time, efforts have also been made to complement arguments in one article with arguments in others.

With regard to overlaps: It has been judged a positive feature when, for instance, similar themes occur in entries on "Acupuncture," "Confucian Perspectives," and "Chinese Perspectives." Similarly, the importance of the idea of social contract for science justifies related treatments in entries on "Social Contract for Science," "Social Contract Theory," "Governance of Science, and Rawls, John."

The fields of economics and statistics presented special challenges. Ethics today cannot be seriously pursued without appreciation for the achievements in these disciplines, which themselves overlap. Contemporary economics is heavily mathematical, involving extensive use of probability and statistics, and it is for the latter an important area of application. Relations between a number of entries related to economics are highlighted in "Economics: Overview," but a number of approaches were nevertheless slighted. There are two articles each for probability and statistics, with one containing a brief introduction to basic concepts in terms of elementary mathematics. The goal was to include sufficient technical detail and symbolism to serve as a point of entry to further study, but there are many illustrations and adequate narrative text to convey the main concepts to those who may prefer to skip over any unfamiliar mathematics. These technical articles provide useful background for more applied entries based on statistics, such as "Biostatistics," "Epidemiology," and "Meta-Analysis," as well as for the implicit use of statistics in many other articles. They are further complemented by biographical entries on, for example, "Nightingale, Florence" and "Pascal, Blaise."

Conclusion

In the world of high-intensity science and technology, how does one lead the good life? What is the form of the just state? Is it sufficient to practice the traditional virtues in traditional ways? To apply received moral principles to new technological opportunities? Or is it not necessary to rediscover ethical and political practice in forms equal to the radical re-founding of knowledge and power that itself has constituted modern science and technology? Without in any way suggesting the end of tradition or of scientific and technological progress, *ESTE* seeks to make common cause with all persons of good will who see a need for critical ethical reflection in the midst of the new world we are creating—remembering that questions can be asked in order to seek the good with greater diligence. In a pluralistic world it is, in addition, no mean feat to practice such questioning with a tolerance and pursuit of principled compromise that avoids the failures of relativism or self-righteousness. The aspiration here is to provide common ground for scholars in the various disciplines who would place their work in broader perspectives, students desiring to deepen their knowledge of complex issues, scientists and engineers sharing their expertise with a participating public, and citizens who aspire to make intelligent decisions in the increasingly scientific and technological world in which we all now live.

CARL MITCHAM
EDITOR IN CHIEF

INTRODUCTORY ESSAYS

TECHNOLOGIES OF HUMILITY: CITIZEN PARTICIPATION IN GOVERNING SCIENCE

SHEILA JASANOFF

In his prescient 1984 book, the sociologist Charles Perrow forecast a series of "normal accidents" in high-risk technologies. The term applied with precision to events that were strung like dark beads through the later years of the twentieth century—most notably, the 1984 chemical plant disaster in Bhopal, India; the 1986 loss of the *Challenger* shuttle and, in the same year, the nuclear plant accident in Chernobyl, USSR; the contamination of blood supplies with the AIDS virus in Europe and North America; the prolonged crisis over BSE ("mad cow disease") in the United Kingdom; and the U.S. space program's embarrassing, although not life-threatening, mishaps with the Hubble telescope's blurry lens, and several lost and extremely expensive Mars explorers. To these we may add the discovery of the ozone hole, climate change, and other environmental disasters as further signs of disrepair. Occurring at different times and in vastly different political environments, these events nonetheless served collective notice that human pretensions of control over technological systems need serious reexamination.

American theorists like Perrow chalked up these failings of technology to avoidable error, especially on the part of large organizations (Clarke 1989, Short and Clarke 1992, Vaughan 1996), but some European analysts suggested a more troubling scenario. Passionately set forth by the German sociologist Ulrich Beck (1992), the thesis of "reflexive modernization" argued that risks are endemic in the way that contemporary societies conduct their technologically intensive business. Scientific and technical advances bring unquestioned benefits, but they also generate new uncertainties and failures, so that doubt continually undermines knowledge and unforeseen consequences confound faith in progress. The risks of modernity, Beck suggested, cut across social lines and operate as a great equalizer of classes. Wealth may increase longevity and improve the quality of life, but it offers no certain protection against the ambient harms of technological societies. This observation was tragically borne out when the collapse of the World Trade Center on September 11, 2001 ended the lives of some 3,000 persons, not discriminating among corporate executives, stock market analysts, computer programmers, secretaries, firefighters, policemen, janitors, and restaurant workers. In many other contexts, however, vulnerability remains closely tied to socioeconomic circumstances, inequalities persist in the ability of groups and individuals to defend themselves against risk.

"Risk," on this account, is not a matter of simple probabilities, to be rationally calculated by experts and avoided in accordance with the cold arithmetic of cost-benefit analysis (Graham and Wiener 1995). Rather, it is part of the modern human condition, woven into the very fabric of progress. The problem we urgently face is how to live well with the knowledge that our societies are inevitably "at risk." Critically important normative questions of risk management cannot be addressed by technical experts with conventional tools of prediction. Such questions determine not only whether we will get sick or die, and under what conditions, but also who will be affected and how we should respond to uncertainty and ignorance. Is it sufficient, for instance, to assess technology's consequences, or must we also seek to evaluate its aims? How should we choose when the values of science appear to conflict with other fundamental values? Has our ability to innovate in some areas run unacceptably ahead of our powers of control? Will some of our most revolutionary technologies increase inequality, promote violence, threaten cultures or harm the environment? And are our institutions, national or supranational, up to the task of governing our dizzying technological capabilities? (Never far from the minds of philosophers and authors of fiction, some of these concerns were also famously articulated in recent times by Bill Joy, co-founder and chief scientist of Sun Microsystems.)

To answer these questions, the task of managing technologies has to go far beyond the model of "speaking truth to power" that once was thought to link knowledge to political action (Price 1965). According to this template, technical input to policy problems must be developed independently of political influences; the "truth" so generated adequately constrains subsequent exercises of political power. The accidents and troubles of the late twentieth century, however, have called into question the validity of this model: both as a descriptively accurate rendition of ways in which experts relate to policy-makers (Jasanoff 1990), and as a normatively acceptable formula for deploying specialized knowledge within democratic political systems. There is growing awareness that even technical policy-making needs to get more political—or, more accurately, to recognize its political foundations more explicitly. Across a widening range of policy choices, technological cultures must learn to supplement the expert's narrow preoccupation with measuring the risks and benefits of innovation with greater attentiveness to the politics of science and technology.

But how can this expansion in the expert's role be reconciled with well-entrenched understandings of the relations between knowledge and power or expertise and public policy? How should these understandings be modified in response to three decades of research on the social dimensions of science? Can we imagine new institutions, processes, and methods for restoring to the playing field of governance some of the normative and political questions that were too long side-lined in assessing the risks and benefits of technology? And are there structured means for cultivating the social capacity for deliberation and reflection on technological change, much as expert analysis of risks has been cultivated for many decades?

There is a growing need, to this end, for what we may call "technologies of humility." These are methods, or better yet institutionalized habits of thought, that try to come to grips with the ragged fringes of human understanding—the unknown, the uncertain, the ambiguous, and the uncontrollable. Acknowledging the limits of prediction and control, technologies of humility confront "head-on" the normative implications of our lack of perfect foresight. They call for different expert capabilities and different forms of engagement between experts, decision-makers, and the public than were considered needful in the governance structures of high modernity. They require not only the formal mechanisms of participation but also an intellectual environment in which citizens are encouraged to bring their knowledge and critical skills to bear on the resolution of common problems.

The Social Contract between Science and the State

In the United States the need for productive working relations between science and the state was famously articulated not by a social theorist or sociologist of knowledge but by the quintessential technical expert: Vannevar Bush, the distinguished Massachusetts Institute of Technology (MIT) engineer and presidential adviser. Bush foresaw the need for major institutional changes following the intense mobilization of science and technology during the Second World War. In 1945 he produced a report, *Science: The Endless Frontier,* that laid the basis for American policy towards science and technology. Science, in Bush's vision, was to enjoy government patronage in peacetime as in war. Control over the scientific enterprise, however, would be wrested from the military and lodged with the civilian scientific community. Basic research, uncontaminated by industrial application or state ambitions, would thrive in the free air of universities. Scientists would establish the substantive aims as well as the intellectual standards for their research. Bush firmly believed that the bountiful results flowing from scientists' endeavors would be translated into beneficial technologies, contributing to the nation's prosperity and progress. Although his design took years to materialize, and even then was only imperfectly attained, the U.S. National Science Foundation (NSF) eventually emerged as the primary state funder of basic research. (The creation of the National Institutes of Health [NIH] to sponsor biomedical research divided U.S. science policy in a way not contemplated in Bush's original design. In the recent politics of science, NIH budgets have proved consistently easier to justify than appropriations for other branches of science.) The exchange of government funds and autonomy in return for discoveries, technological innovations and trained personnel came to be known as America's "social contract for science."

Signs of wear and tear in the "social contract" appeared in the 1980s. A spate of highly publicized cases of alleged fraud in science challenged the reliability of peer review and, with it, the underlying assumptions concerning the autonomy of science. The idea of science as a unitary practice also broke down as it became clear that research varies from one context to another, not only across disciplines, but—even more important from a policy standpoint—across institutional settings. It was recognized, in particular, that regulatory science, produced to support governmental efforts to manage risk, was fundamentally different from research driven by scientists' curiosity. At the same time, observers of science in society began questioning whether the categories of basic and applied research held meaning in a world where the production and uses of science were densely connected to each other, as well as to larger social and political consequences (Jasanoff, Markle, Petersen, and Pinch 1995).

Rethinking the relations of science with other social institutions generated three major streams of analysis. The first stream takes the "social contract" essentially for granted but points to its failure to work as its proponents had imagined. Many have criticized science, especially university-based science, for deviating from idealized norms of purity and disinterestedness. Despite (or maybe because of) its simplicity, this critique has seriously threatened the credibility of researchers and their claims to autonomy. Others have tried to replace the dichotomous division of *basic* and *applied* science with more differentiated categories, calling attention to the particularities of science done in different settings to meet different objectives. Still others have sought to respecify from the ground up how scientific knowledge is actually produced. This last line of analysis seeks not so much to correct or refine Vannevar Bush's vision of science as to replace it with a more complex account of how knowledge-making fits into the wider functioning of society.

DEVIANT SCIENCE. Scientific fraud and misconduct appeared on the U.S. policy agenda in the 1980s. Political interest reached a climax with the notorious case of alleged misconduct in an MIT laboratory headed by Nobel laureate biologist David Baltimore. He and his colleagues were exonerated after years of inquiry, which included investigations by Congress and the FBI (Kevles 1998). This and other episodes heightened the tendency for policy-makers and the public to suspect that all was not in order in the citadels of basic science and greatly increased federal powers for the supervision of research. Some saw the Baltimore affair as a powerful sign that legislators were no longer content with the old social contract's simple *quid pro quo* of money and autonomy in exchange for technological benefits (Guston 2001). Others, like the science journalist Daniel Greenberg (2001), accused scientists of profiting immoderately from their alliance with the state, while failing to exercise moral authority or meaningful influence on policy. American science, at any rate, was asked to justify more explicitly the public money spent on it. A token of the new relationship between science and government came with the reform of NSF's peer review criteria in the 1990s. The Foundation now requires reviewers to assess proposals not only on grounds of technical merit, but also with respect to their wider implications for society—thus according greater prominence to science's social utility. In effect, the fraud investigations of the previous decade opened up other taken-for-granted aspects of scientific autonomy, and forced scientists to account for their objectives as well as their honesty.

To these perturbations may be added a steady stream of challenges to the supposed disinterestedness of academic science. In areas ranging from climate change to biotechnology, critics have charged researchers with having sacrificed their objectivity in exchange for grant money or, worse, equity interests in lucrative start-up companies (Boehmer-Christiansen 1994). These allegations have been especially damaging to biotechnology, because that industry benefits significantly from the rapid transfer of skills and knowledge from universities. Since most western governments are committed to promoting such transfers, biotechnology is caught on the horns of a particular dilemma: how to justify its promises of innovation and progress credibly, when the interests of most scientists are aligned with those of industry, government or, occasionally, public interest advocates.

While financially motivated, pro-industry bias has attracted the most criticism, academic investigators have also come under scrutiny for alleged pro-environment and anti-technology biases. In several cases involving biotechnology—in particular, that of the monarch butterfly study conducted by Cornell University scientist John Losey (1999) in the United States, and Stanley Ewen and Arpad Puzstai's (1999) controversial rat-feeding study in the United Kingdom—industry critics questioned the quality of university-based research and implied that political orientations had prompted premature release or over-interpretation of results. In April 2002 a controversy erupted over an article in *Nature* by a University of California scientist, Ignacio Chapela, who concluded that DNA from genetically modified corn had contaminated native species in Mexico. Philip Campbell, the journal's respected editor, did not retract the paper, but stated that "the evidence available is not sufficient to justify the publication of the original paper," and that readers should "judge the science for themselves" (*Washington Times* 2002). As in the Losey and Ewen and Puzstai cases, critics charged that Chapela's science had been marred by non-scientific considerations. Environmentalists, however, viewed all these episodes as pointing to wholesale deficits in knowledge about the long-term and systemic effects of genetic modification in crop plants.

CONTEXT-SPECIFIC SCIENCE. The second line of attack on the science–society relationship focuses on the basic-applied distinction. One attempt to break out of that dualism was proposed by Donald Stokes (1997), whose quadrant framework, using Louis Pasteur as the prototype, suggested that "basic" science can be done within highly "applied" contexts. Historians and sociologists of science and technology have long observed that foundational work can be done in connection with applied problems, just as applied problem-solving is often required for resolving theoretical issues (for example, in designing new scientific instruments). To date, formulations based on such findings have been slow to take root in policy cultures.

Another example of the contextualing approach can be found in the work of Silvio Funtowicz and Jerome Ravetz (1992). They proposed to divide the world of policy-relevant science into three nested circles, each with its own system of quality control: (1) "normal science" (borrowing the term from Thomas Kuhn), for ordinary scientific research; (2) "consultancy science," for the application of available knowledge to well-characterized problems; and (3) "post-normal science," for the highly uncertain, highly contested knowledge needed for many health, safety, and environmental decisions. These authors noted that, while traditional peer review may be effective within "normal" and even "consultancy" science, the quality of "post-normal" science cannot be assured by standard review processes. Instead, they proposed that work of this nature be subjected to *extended peer review*, involving not only scientists but also the stakeholders affected by the use of science. Put differently, they saw accountability, rather than mere quality control, as the desired objective when science becomes "post-normal." (A problem with this analysis lies in the very term "post-normal science." When scientific conclusions are so closely intertwined with social and normative considerations as in Funtowicz and Ravetz's outermost circle, one may just as well call the "product" by another name, such as "socially relevant knowledge" or "socio-technical knowledge.")

Sheila Jasanoff's 1990 study of expert advisory committees in the United States provided another perspective on this issue by noting that policy-relevant science (also referred to as "regulatory science")—such as science done for purposes of risk assessment—is often subjected to a special kind of "peer review." Regulatory science is reviewed by multidisciplinary committees rather than by individually selected specialists. The role of such bodies is not only to validate the methods by which risks are identified and investigated, but also to confirm the reliability of the agency's interpretation of the evidence. Frequently, regulatory science confronts the need to set standards for objects or concepts whose very existence was not previously an issue for either science or policy: "fine particulate matter" in air pollution control; the "maximum tolerated dose" (MTD) in bioassays; the "maximally exposed person" in relation to airborne toxics; or the "best available technology" in programs of environmental regulation. In specifying how such terms should be defined or characterized, advisory committees have to address issues that are technical as well as social, scientific as well as normative, regulatory as well as metaphysical. What *kind* of entity, after all, is a "fine" particulate or a "maximally exposed" person, and by what markers can we recognize them? Studies of regulatory science have shown that the power of advisory bodies to definitively address such issues depends on their probity, representativeness, transparency, and accountability to higher authorities—such as courts and the public. In other words, the credibility of regulatory science rests upon factors that have more to do with democratic accountability than with the quality of science as assessed by peer scientists.

NEW MODES OF KNOWLEDGE PRODUCTION. Going beyond the quality and context-dependency of science, some have argued the need to take a fresh look at the structural characteristics of contemporary science in order to make it more socially responsive. Michael Gibbons and his co-authors (1994) concluded that the traditional disciplinary science of Vannever Bush's "endless frontier" has been largely supplanted by a new mode of knowledge production. The salient properties of this new mode, in their view, include the following:

- Knowledge is increasingly produced in contexts of application (i.e., *all* science is to some extent "applied" science);
- Science is increasingly transdisciplinary—that is, it draws on and integrates empirical and theoretical elements from a variety of fields;
- Knowledge is generated in a wider variety of sites than ever before, not just universities and industry, but also in research centers, consultancies, and think-tanks;
- Participants in science have grown more aware of the social implications of their work (i.e., more "reflexive"), just as publics have become more conscious of the ways in which science and technology affect their interests and values.

The growth of this new mode, as Gibbons et al. note, has necessary implications for quality control. Besides old questions about the intellectual merits of their work, scientists are being asked new questions about its marketability, and its capacity to promote social harmony and welfare.

In other work, Helga Nowotny, Peter Scott, and Michael Gibbons (2001) have grappled with the implications of these changes for knowledge production in public domains. Nowotny et al. propose the concept of "socially robust knowledge" as the solution to problems of conflict and uncertainty. Contextualization, in their view, is the key to producing science for public ends. Science that draws strength from its socially detached position is too frail to meet the pressures placed upon it by contemporary societies. Instead, they imagine forms of knowledge that gain robustness from their very embeddedness in society. The problem, of course, is how to institutionalize polycentric, interactive, and multipartite processes of knowledge-making within institutions that have worked for decades at keeping expert knowledge away from populism and politics. The question confronting the governance of science is how to bring knowledgeable publics into the front-end of scientific and technological production—a place from which they have historically been excluded.

The Participatory Turn

Changing modes of scientific research and development provide at least a partial explanation for the current interest in improving public access to expert decision-making. In thinking about research today, policy-makers and the public frequently focus on the accountability of science rather than its quality. As the contexts for science have become more pervasive, dynamic and heterogeneous, concerns about the integrity of peer review have transmuted into demands for greater public involvement in assessing the costs and benefits, as well as the risks and uncertainties, of new technologies. Such demands have arisen with particular urgency in the case of biotechnology, but they are by no means limited to this field.

The pressure for accountability manifests itself in many ways, including demands for greater transparency and participation. One notable example came with U.S. federal legislation in 1998, requiring public access, pursuant to the Freedom of Information Act, to all scientific research generated with public funds (Omnibus Consolidated and Emergency Supplemental Appropriations Act of 1999, P.L. 105–277, 1998). The provision was hastily introduced and scarcely debated. Its sponsor, Senator Richard Shelby (R-Alabama), tacked it on as a last-minute amendment to an omnibus appropriations bill. His immediate objective was to force disclosure of data from a controversial study by the Harvard School of Public Health of the health effects of human exposure to fine particulates. This Six Cities Study provided key justification for the U.S. Environmental Protection Agency's stringent ambient standard for airborne particulate matter, issued in 1997. This sweeping enactment showed that Congress was no longer willing to concede unchecked autonomy to the scientific community in the collection and interpretation of data. Publicly funded science, Congress determined, should be available at all times for public review.

Participatory traditions are less thoroughly institutionalized in European policy-making, but in Europe, too, recent changes in the rules and processes governing expert advice display a growing commitment to involving the public in technically-grounded policy decisions. In announcing the creation of a new Directorate General for Consumer Protection, for example, the European Commission observed in 1997 that, "Consumer confidence in the legislative activities of the EU is conditioned by the *quality and transparency* of the scientific advice and its use on the legislative and control process" (emphasis added). The commitment to greater openness is also evident in the strategies of several new United Kingdom expert bodies, such as the Food Standards Agency, created to restore confidence in the wake of the BSE crisis. Similarly, two major public inquiries—the Phillips Inquiry on BSE and the Smith inquiry on the Harold Shipman murder investigation—set high standards for public access to information through the Internet. All across Europe, opposition to genetically modified foods and crops prompted experiments with diverse forms of public involvement, such as citizen juries, consensus conferences, and referenda (Joss and Durant 1995).

Although admirable, formal participatory opportunities cannot by themselves ensure the democratic and deliberative governance of science. There are, to start with, practical problems. People may not be engaged enough or possess enough specialized knowledge and material resources to take advantage of formal procedures. Participation may occur too late to identify alternatives to dominant or default options; some processes, such as consensus conferences, may be too *ad hoc* or issue-specific to exercise sustained influence on policy. Even timely participation does not necessarily improve decision-making. Empirical research has consistently shown that transparency may exacerbate rather than quell controversy, leading parties to deconstruct each other's positions instead of deliberating effectively. Indeed, the Shelby Amendment reflects one U.S. politician's conviction that compulsory disclosure of data will enable challenges to researchers' own interpretations of their work. It is in this sense an instrument that can be used for fomenting scientific dissent. By contrast, participation constrained by established formal discourses, such as risk assessment, may not admit novel viewpoints, radical critique, or considerations lying outside the taken-for-granted framing of a problem.

Technologies of Humility

Participation alone, then, does not answer the problem of how to democratize technological societies. Opening the doors to previously closed expert forums is a necessary step—indeed, it should be seen by now as a standard operating procedure of democratic politics. But the formal mechanisms adopted by national governments are not enough to engage the public effectively in the management of global science and technology. What has to change is the *culture* of governance, nationally as well as internationally, and for this we need to address not only the mechanics but also the substance of participatory politics. The issue, in other words, is no longer whether the public should have a say in technical decisions, but how to promote more meaningful interaction among policy-makers, scientific experts, corporate producers, and the informed public.

The analytic ingenuity of modern states has been directed for many decades toward refining what we may call the "technologies of hubris." To reassure their publics, as well as to keep the wheels of science and industry turning, national governments have developed a series of predictive methods (e.g., risk assessment, cost-benefit analysis, climate modeling) that are designed, on the whole, to facilitate management and control, even in areas of high uncertainty (e.g. Porter 1995). These methods achieve their power through claims of objectivity and a disciplined approach to analysis, but they suffer from three significant limitations. First, they show a kind of peripheral blindness toward uncertainty and ambiguity. Predictive methods focus on the known at the expense of the unknown, producing overconfidence in the accuracy and completeness of the pictures they produce. Well-defined, short-term risks command more attention than indeterminate, long-term ones. At the same time, technical proficiency conveys the impression that analysis is not only rigorous, but complete—in short, that it has adequately taken account of all possible risks. Predictive methods tend in this way to downplay what falls outside their field of vision, and to overstate whatever falls within (Irwin and Wynne 1996).

Second, the technologies of predictive analysis tend to preempt political discussion. Expert analytic frameworks create high entry barriers against legitimate outsider positions that cannot express themselves in terms of the dominant discourse (Winner 1986). Claims of objectivity hide the exercise of judgment, so that the normative presuppositions of studies and models are not subjected to general debate. The boundary work that demarcates the space of "objective" policy analysis is carried out by experts, so that the politics of making demarcations remains locked away from public review and criticism (Jasanoff 1990).

Third, predictive technologies are limited in their capacity to internalize challenges that come from outside their framing assumptions. Techniques develop and grow more sophisticated, to be sure, but not necessarily in ways that revisit the values on which they were founded. For example, techniques for assessing chemical toxicity have become ever more refined, but they continue to rest on the demonstrably faulty assumption that people are exposed to one chemical at a time. Synergistic effects, long-term exposures, and multiple exposures are common in normal life but have tended to be ignored as too messy for analysis. Even in the aftermath of catastrophic failures, modernity's predictive models are often adjusted only to take on board lessons that are compatible with their initial assumptions. When a U.S.-designed chemical factory in Bhopal released the deadly gas methyl isocyanate, killing thousands, the international chemical industry made many improvements in its internal accounting and risk communication practices. But no new methods were developed to assess the risks of technology transfer between radically different cultures of industrial production.

At the beginning of the twenty-first century, the unknown, unspecified and indeterminate aspects of scientific and technological development remain largely unaccounted for in policy-making; treated as beyond reckoning, they escape the discipline of analysis as well as politics. What is lacking is not just the knowledge to help fill the gaps, but the processes and methods for eliciting what the public wants and for using what is already known. To bring these dimensions out of the shadows and into the dynamics of democratic debate, they must first be made concrete and tangible. Scattered and private knowledge has to be amalgamated, perhaps even disciplined, into a dependable civic epistemology. The human and social sciences of previous centuries undertook just such a task of translation. They made visible the social problems of modernity—poverty, unemployment, crime, illness, disease, and, lately, technological risk—often as a prelude to rendering them more manageable, using what I have termed the "technologies of hubris." Today, there is a need for "technologies of humility" to complement the predictive approaches: to make apparent the possibility of unforeseen consequences; to make explicit the normative that lurks within the technical; and to acknowledge from the start the need for plural viewpoints and collective learning. How can these aims be achieved?

From the abundant literature on technological disasters and failures, as well as from studies of risk analysis and policy-relevant science, we can abstract four focal points around which to develop the new technologies of humility. They are *framing*, *vulnerability*, *distribution*, and *learning*. Together, they generate the questions we should ask of almost every human enterprise that intends to alter society: what is the purpose; who will be hurt; who benefits; and how can we know? On all these points, we have good reason to believe that wider public engagement would improve our capacity for analysis and reflection. Participation that pays attention to these four points promises to lead to richer deliberation on the substance of decision-making.

FRAMING. It is an article of faith in the policy literature that the quality of solutions to perceived social problems depends on the adequacy of their original framing (Schon and Rein 1994). If a problem is framed too narrowly, too broadly, or simply wrongly, then the solution will suffer from the same defects. To take a simple example, a chemical testing policy focused on single chemicals cannot produce knowledge about the environmental health consequences of multiple exposures: the framing of the regulatory issue is more restrictive than the actual distribution of chemical-induced risks, and hence is incapable of delivering the optimal management strategies. Similarly, a belief that violence is genetic may discourage the search for controllable social influences on behavior. A focus on the biology of reproduction may delay or impede effective policies for curbing population growth. When facts are uncertain, disagreements about the appropriate frame are virtually unavoidable and often remain intractable for long periods. Yet, few policy cultures have adopted systematic methods for revisiting the initial framing of issues, despite calls to do so (Stern and Fineberg 1996). Frame analysis thus remains a critically important, though neglected, tool of policy-making.

VULNERABILITY. Risk analysis treats the "at-risk" human being as a passive agent in the path of potentially disastrous events. In an effort to produce policy-relevant assessments, human populations are often classified into groups (e.g., most susceptible, maximally exposed, genetically predisposed, children or women) that are thought to be differently affected by the hazard in question. Based on physical and biological indicators, these classifications tend to overlook the social foundations of vulnerability and to subordinate individual experiences of risk to aggregate numerical calculations (e.g. Irwin and Wynne 1996). Recent efforts to analyze vulnerability have begun to recognize the importance of socio-economic factors, but assessment methods still take populations rather than individuals as the unit of analysis. These approaches not only disregard differences within groups but reduce individuals to statistical representations. Such characterizations leave out of the calculus of vulnerability such factors as history, place, and social connectedness, all of which may play crucial roles in determining human resilience. Through participation in the analysis of their vulnerability, ordinary citizens might regain their status as active subjects rather than remain undifferentiated objects in yet another expert discourse.

DISTRIBUTION. Controversies over such innovations as genetically modified foods and stem cell research have propelled ethics committees to the top of the policy-making ladder in several countries. Frequently, however, these bodies are used as "end-of-pipe" legitimation devices, reassuring the public that normative issues have not been omitted from deliberation. The term "ethics," moreover, does not cover the whole range of social and economic realignments that accompany major technological changes, nor their distributive consequences, as technology unfolds across global societies and markets. Attempts to engage systematically with distributive issues in policy processes have not been altogether successful. In Europe, consideration of the "fourth hurdle"—the socioeconomic impact of biotechnology—was abandoned after a brief debate. In the United States the congressional Office of Technology Assessment, which arguably had the duty to evaluate socio-economic impacts, was dissolved in 1995 (Bimber 1996). President Clinton's 1994 injunction to federal agencies to develop strategies for achieving environmental justice produced few dramatic results (Executive Order 12298, 1994). At the same time, episodes like the rebellion against Monsanto's "terminator gene" demonstrate a deficit in the capacity for ethical analysis in large corporations, whose technological products can fundamentally alter people's lives. Sustained interactions between decision-makers, experts and citizens, starting at the upstream end of research and development, could do much to expose the distributive consequences of innovation.

LEARNING. Theorists of social and institutional learning have tended to assume that what is "to be learned" is never a part of the problem. A correct, or at least a better, response exists, and the only issue is whether actors are prepared to internalize it. In the real world, however, learning is complicated by many factors. The capacity to learn is constrained by limiting features of the frame within which institutions act. Institutions see only what their discourses and practices permit them to see. Experience, moreover, is polysemic, or subject to many interpretations, no less in policy-making than in literary texts. Even when the fact of failure in a given case is unambiguous, its causes may be open to many different readings. Just as historians disagree over what caused the rise or fall of particular political regimes, so policy-makers may find it impossible to attribute their failures to specific causes. The origins of a problem may look one way to those in power, and quite another way to the marginal or the excluded. Rather than seeking monocausal explanations, then, it would be fruitful to design more avenues through which societies can collectively reflect on the ambiguity of their experiences and to assess the strengths and weaknesses of alternative explanations. Learning, in this modest sense, is a suitable objective of civic deliberation.

Conclusion

The enormous growth and success of science and technology during the last century has created difficult contradictions for institutions of governance. As technical activities have become more pervasive and complex, so too has the demand grown for more complete and multivalent evaluations of the costs and benefits of technological progress. It is widely recognized that increased participation and interactive knowledge-making would improve accountability and lead to more credible assessments of science and technology. Such approaches would also be consistent with changes in the modes of knowledge production, which have made science more socially embedded and more closely tied to contexts of application. Yet, modern institutions still operate with conceptual models that seek to separate science from values and emphasize prediction and control at the expense of reflection and social learning. Not surprisingly, the real world continually produces reminders of the incompleteness of our predictive capacities.

To move public discussion of science and technology in new directions, there is a need for "technologies of humility," complementing the predictive "technologies of hubris" on which we have lavished so much of our past attention. These *social technologies* would give combined attention to substance and process, and stress deliberation as well as analysis. Reversing nearly a century of contrary development, these approaches to decision-making would seek to integrate the "can do" orientation of science and engineering with the "should do" questions of ethical and political analysis. They would engage the human subject as an active, imaginative agent in making policy, as well as a source of knowledge, insight, and memory.

BIBLIOGRAPHY

Beck, Ulrich. (1992). *Risk Society: Towards a New Modernity*. London: Sage Publications.

Bimber, Bruce. (1996). *The Politics of Expertise in Congress: The Rise and Fall of the Office of Technology Assessment*. Albany: State University of New York Press.

Boehmer-Christiansen, Sonja. (1994). "Global Climate Protection Policy: The Limits of Scientific Advice, Parts 1 and 2." *Global Environmental Change* 4(2): 140–159; 4(3): 185–200.

Bush, Vannevar. (1945). *Science: The Endless Frontier*. Washington, DC: U.S. Government Printing Office.

Clarke, Lee. (1989). *Acceptable Risk? Making Decisions in a Toxic Environment*. Berkeley: University of California Press.

Ewen, Stanley W. B., and Arpad Pusztai. (1999). "Effect of Diets Containing Genetically Modified Potatoes Expressing Galanthus Nivalis Lectin on Rat Small Intestine." *Lancet* 354: 1353–1354.

Executive Order 12298. (1994). "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations." Washington, DC: February 11.

Funtowicz, Silvio O., and Jerome R. Ravetz. (1992). "Three Types of Risk Assessment and the Emergence of Post Normal Science." In *Social Theories of Risk*, eds. Sheldon Krimsky and D. Golding. New York: Praeger.

Gibbons, Michael; Camille Limoges; Helga Nowotny, et al. (1994). *The New Production of Knowledge*. London: Sage Publications.

Graham, John D., Jonathan B. Wiener, eds. (1995). *Risk versus Risk: Tradeoffs in Protecting Health and the Environment*. Cambridge, MA: Harvard University Press. A preeminent example of the calculative approach.

Greenberg, Daniel S. (2001). *Science, Money, and Politics: Political Triumph and Ethical Erosion*. Chicago: University of Chicago Press.

Guston, David H. (2001). *Between Politics and Science: Assuring the Integrity and Productivity of Research*. Cambridge: Cambridge University Press.

Irwin, Alan, and Brian Wynne, eds. (1996). *Misunderstanding Science? The Public Reconstruction of Science and Technology*. Cambridge: Cambridge University Press.

Jasanoff, Sheila. (1990). *The Fifth Branch: Science Advisers as Policy-makers*. Cambridge, MA: Harvard University Press.

Jasanoff, Sheila; Gerald E. Markle; James C. Petersen; and Trevor Pinch, eds. (1995). *Handbook of Science and Technology Studies*. Thousand Oaks, CA: Sage Publications.

Joss, Simon, and John Durant, eds. (1995). *Public Participation in Science: The Role of Consensus Conferences in Europe*. London: Science Museum.

Kevles, Daniel J. (1998). *The Baltimore Case: A Trial of Politics, Science, and Character*. New York: Norton.

Losey, John E.; L. S. Rayor; and M. E. Carter. (1999). "Transgenic pollen harms monarch larvae" *Nature* 399: 214.

Nowotny, Helga; Peter Scott; and Michael Gibbons. (2001). *Re-Thinking Science: Knowledge and the Public in an Age of Uncertainty*. Cambridge, UK: Polity.

Omnibus Consolidated and Emergency Supplemental Appropriations Act of 1999, P. L. 105-277 (codified at 42 U.S.C. § 1395 *et. seq*.). (1998). The Office of Management and Budget in the Clinton administration controversially narrowed the scope of the law to apply not to *all* publicly-funded research, but only to research actually relied on in policy-making. The issue was not completely resolved as of May 2005.

Perrow, Charles. (1984). *Normal Accidents: Living with High Risk Technologies*. New York: Basic Books.

Porter, Theodore M. (1995). *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life*. Princeton: Princeton University Press.

Price, Don K. (1965). *The Scientific Estate*. Cambridge, MA: Harvard University Press. The locus classicus of the view of the right relations between knowledge and power.

Schon, Donald A., and Martin Rein. (1994). *Frame/Reflection: Toward the Resolution of Intractable Policy Controversies*. New York: Basic Books.

Short, James F., and Lee Clarke, eds. (1992). *Organizations, Uncertainties, and Risk*. Boulder: Westview Press.

Stern, Paul C., and Harvey V. Fineberg, eds. (1996). *Understanding Risk: Informing Decisions in a Democratic Society*. Washington, DC: National Academy Press.

Stokes, Donald E. (1997). *Pasteur's Quadrant: Basic Science and Technological Innovation*. Washington, DC: Brookings.

Vaughan, Diane. (1996). *The Challenger Launch Decision: Risky Technology, Culture, and Deviance at NASA*. Chicago: University of Chicago Press.

Winner, Langdon. (1986). "On Not Hitting the Tar Baby." In his *The Whale and the Reactor*. Chicago: University of Chicago Press.

INTERNET RESOURCES

European Commission. *1997 Communication of the European Commission on Consumer Health and Safety*. COM (97) 183 fin. Available from http://europa.eu.int/comm/food/fs/sc/index_en.html.

Joy, Bill. (2000). "Why the Future Doesn't Need Us." *Wired*. http://www.wired.com/wired/archive/8.04/joy.html.

Washington Times. "Nature Regrets Publication of Corn Study." April 5, 2002. Available from http://www.washingtontimes.com/national/20020405-9384015.htm.

ETHICS AND TECHNOLOGY: A PROGRAM FOR FUTURE RESEARCH

DEBORAH G. JOHNSON
THOMAS M. POWERS

• • •

In this paper we present a program for future study of ethics and technology. Most generally, the analysis involves understanding the role of technology in moral action. On the one hand, technology shapes and is shaped by moral thought and action; on the other, this shaping is rarely acknowledged, let alone understood, by moral philosophers. Thus the program sketched here is aimed at making technology visible as an element of moral philosophy. We lay out a line of reasoning that uncovers the intentionality of the design of technological artifacts, and then we compare human moral action to features of the design and use of technological artifacts. This line of reasoning provides the groundwork for extensive future research. The program description is both a plan of study for our own research as well as a call for other scholars to turn their attention to the issues outlined.

In thinking about the nature of a technology, we argue that traditional philosophical theories of human action and ethics can be usefully extended to technology. Contemporary action theory has suggested a causal model of intentional behavior in humans, and we believe that (with modification) this model is applicable to technology. Indeed, when technology is viewed in relation to a causal model of intentional behavior, the moral nature of technological agency becomes apparent. Similarly, traditional notions from ethics, such as goodness, responsibility, and accountability, can be extended in order to understand technology in a new light.

The Artifactual Platform

The world in which humans act and live is a world filled with human-made objects. In addition to the objects of the natural world, these human-made objects provide an enabling and inhibiting background for human thought and action, and for all of the arrangements of human life. This background influences and informs what we think, how we act, and how we arrange ourselves into units, organizations, and institutions.

By noting the presence of human-made objects, we introduce a distinction between the human-made and the natural world, though we readily admit the two are intertwined. Indeed, they are often so intertwined that it is difficult to separate them. The natural world has been dramatically affected by human activity, and technology is, at least in part, the manipulation of natural potential. Scientific research from the late twentieth and early twenty-first centuries suggests there is very little left of a natural world that is untouched by human agency; the balance, over human history, has clearly shifted toward a relatively larger class of human-made objects. In other words, we are living in the anthropocene, on an increasingly anthropogenic planet (Allenby 2004).

Even though, as a matter of ontology, it will be increasingly difficult to maintain a distinction between the classes of human-made and natural objects, the difference remains significant. The human-made world could be otherwise, and the future human-made world is, to some extent, a matter of human choice and human action. Indeed, work in "normative" design and engineering, seen in the universal design, green engineering, and appropriate technology movements, presupposes that there are morally better (and worse) ways to create the future human-made world. The analysis herein provides these normative enterprises with a philosophical footing.

Moral philosophy has always presumed the natural world as the background for human action and morality, but has failed to recognize the powerful role of the human-made world in moral thought and behavior. Rather than focusing on the background, moral philosophy has concentrated attention on human agency, and the presumption has been that moral action (through human beings) is part of the embodied world. The embodied world has been understood to consist both of natural things and human bodies, though, to be sure, some ethicists have acknowledged that morality might be different if humans had different sorts of bodies or acted in a natural world ordered in a different way. Moral philosophers have considered a typical action to consist of an agent (an embodied being) moving his or her body in some way, even if only in a very small way—a wink, a bit of pressure on a trigger, and so on. If the agent does not move his or her body in some way, then there is no action. Even speech acts require movement of the speech organs, and most philosophers have recognized that humans can commit moral wrongs with mere words.

So our starting place is the idea that human agency operates in an embodied world, noting how the embodied world includes both human-made and natural objects. But we want to call attention to the *normative* features of the human-made part and come to grips with the moral importance of technology in constituting the background for human action. We will call the human-made part of the embodied world, as far as it concerns human action, the *artifactual platform*. This platform is the class of constructed objects and systems of objects that are created by and come to influence human action.

Often, descriptions of action incorporate human-made objects into the action. For instance, when we say "John shot Bill," use of a gun is implicit; when we say "Mary flew to London," use of an airplane is presumed; and so on. This feature of descriptive language is what Joel Feinberg (1970) has called the "accordion effect." We can choose an expanded description that includes the artifact, or a collapsed version that conceals it.

When those who study action from the normative point of view use narrow or collapsed descriptions, the technological component is glossed over. What is missed is that particular movements of an agent's body could not have had their associated effects were it not for an artifact. Noting the artifacts involved in moral behavior is the first step in gaining a better understanding of the role of the artifactual platform in morality. Becoming aware of this platform allows us to see that a good deal of moral behavior is action *with* technology. In this respect, moral actions, agents, and patients are not sufficient for an ontology of morality; artifacts are also part of the moral world. The task of understanding the role of artifacts in morality is, then, a matter of recognizing the difference it makes for humans to live in a world with the particular artifacts that currently exist or might exist in the future.

Nevertheless, realizing that moral action takes place *with technology*, and on or from an artifactual platform, does not go far enough. As indicated, technological artifacts with their particular features are matters of human choice. Just as humans deliberate about and choose their actions, some humans (artisans and engineers) deliberate about and create artifacts; other humans (consumers and users) choose and employ artifacts that enable and constrain moral action. Human agency is significantly affected by technological artifacts. It may be augmented, constrained, or merely altered. The design, availability, and employment of technology shapes what humans can do, and what they end up doing.

What, then, is the significance of technology? Technology expands and constrains the range of human moral behavior, and changes the character of that behavior. Technology is far from neutral in its combination with human behavior. Can one say that it has moral agency? This question can be pursued by considering relations between human moral agency and technology.

The Moral Agency of Technology

The question of the moral agency of technology can be used as an entry point for exploring the role of technology in morality. Grounding it in philosophical concepts, the analysis starts with the traditions of ethical theory and action theory and the accounts of human moral agency they provide. In ethical theory, the standard account of the responsibility of moral persons (acting without technology) says that individuals are primarily responsible for their voluntary, intended behaviors. In action theory, there is a broader account of intentionality, in which intentional states ("intendings" as well as desires, beliefs, plans, etc.) are the causes of action. The intentionality of these states is a property that relates them to states of affairs and objects in the actual world and in possible worlds. Intentionality, then, is "aboutness" or directedness. On this view, voluntary action or intended behavior is understood to be outward behavior caused by a complex of internal mental states. By stipulating the specific kind of intending, desiring, and believing that causes a particular action, philosophers have distinguished moral action from nonmoral behavior. Because the outward behavior in moral action is the result of these internal mental states, it is amenable both to a causal explanation and to a "reason explanation" (see Davidson 2001). That is, when we ask why someone acted in a particular way, he or she can offer antecedent intendings, beliefs, desires, and other intentional states as reasons for the action.

The standard philosophical account is spelled out in contemporary work in ethical theory and action theory, but the roots of the account are much older. The subject matter of moral appraisal even as far back as Aristotle (384–322 B.C.E.) has been understood to be intended, voluntary behavior. This is action, conduct, or the commission of a deed, as opposed to "mere" reaction or nonvoluntary behavior. In contemporary action theory, Aristotle's basic view is elaborated upon, and this produces the following conditions for moral action. First, there is a potential agent with an internal state. The internal state consists of intentional mental states, one of which is, necessarily, an intending to act. Together, the intentional states (e.g., belief that X is possible, desire to X, plus an intending to X) constitute a reason for X-ing. Second, there is an outward, embodied event—the agent does something, moves his or her body in some way. Third, the internal state is the cause of the outward event; that is, the movement of the body is rationally directed and is an action insofar as it is caused by an internal state. Fourth, the outward action has an outward effect. Finally, the effect has to be on a patient—the recipient of an action that can be harmed or helped. Moral patients are typically human beings, but the class may include other beings or things as well. Some ethicists now include higher functioning animals, entire species, and even ecosystems in the class of moral patients, and clearly technology does seriously affect ecosystems and nonhuman animals.

The convergence of these parts of ethical theory and action theory has produced a plausible account of the connection between thought and action, and has helped locate the focal point of moral agency. We adopt this account as the framework in which to consider the moral agency of technology. In other words, whether or not or in what ways technology has moral agency can best be revealed by comparing features of technology with the standard account of moral action as derived from ethical theory and action theory.

Interesting work has been done in the late twentieth and early twenty-first centuries along these lines, as philosophers have turned to consider the possibility of nonhuman moral agents (Allen, Varner, and Zinser 2000, Floridi and Sanders 2001, Brooks 2002, Kurzweil 1999, Danielson 1992). Most attention has been given to artificially intelligent computers as the best candidates for agency. Computers have drawn attention in part because of the interest in the precise nature of intelligence. Some philosophers of artificial intelligence (AI) seem to think that intelligence can emerge out of the complex states of computers. This view implies that the ability of a computer to generate intentional states on its own would go a long way toward making it like a human moral agent. (Researchers in AI are primarily interested in engineering robotic computers to do things such as sense, recognize, navigate, and modify, and not, in the main, concerned with the deeper implications of AI for a philosophical account of intelligence.) A thrust of the account here is to draw attention away from the project of considering intelligence and computers, and instead to explore technological artifacts more broadly, as entities that have intentional states that are not mental states.

At the heart of our argument for the moral significance of technology is the claim that artifacts have intentionality, the property of "aboutness" or directedness toward the actual world and a future designed world. One of the reasons so little attention has been given to ethics and technology seems to be a failure to recognize the intentionality designed into technological artifacts. On the one hand, the only type of intentionality of interest to ethicists has been the type found in the mental states of *human* agents. With its focus on human agents, ethical theory has not recognized the importance and relevance of the design and use of technological artifacts by human agents. On the other hand, scholars in science and technology studies have introduced the idea of technology having a kind of agency (Law 1987, Callon 1986). However, they have not recognized the ethical implications of this move. Nor have they related technological agency to the broader philosophical literature on action. The argument in this essay brings ethical theory and action theory to bear on the moral agency of technology.

Because the program outlined here builds on our claim that artifacts have intentionality, it will be helpful to discuss the theoretical apparatus traditionally used to describe intentionality in moral action. In order for a human action to be both open to "reason explanation" and subject to moral appraisal, there must be in the agent some collection of intentional mental states connected to the action in some fairly specific ways. Agents are subject to moral appraisal in virtue of those intentional acts that have morally relevant effects on moral patients. Intentional acts are caused by a variety of intentional states and/or entities: beliefs, desires, intendings, maxims, plans, and the like. An agent is a being who acts, with the cause of the action originating in the agent's mind as the complex of intentional states. The cause of the action is the primary reason for the action, and the cause as a whole can be seen as a collection of intentional states that serve as a "reason explanation" of the action. Intentional entities are entities that are capable of having intentional states; intentional actions are those actions that are caused by intentional states.

Our extension of this view of agency does not entail that artifacts have mental states or the ability to intend. We claim only that artifacts have intentionality or directedness at users and environments, and that this intentionality is causally efficacious. In proposing that intentionality is designed into technological artifacts, we avail ourselves of a quite general definition of intentionality, according to which it is the property of something, such that it is directed at or represents an object or state of affairs. The term *intentionality* is broadly construed so that intentional entities can be states of mind, sentences, speech acts, maps, or any designed object. Though this view of intentionality is quite broad, we nonetheless agree with the traditional view that humans are intentionality-generating beings. Their states of mind are directed at or about objects and states of affairs, and it is this original power of mind as intentionality generating that accounts for the intentionality in nonmental entities.

Humans have the ability to externalize their intentional states in speaking and writing. Spoken and written declarative sentences are intentional, just as are the beliefs that they express. While sentences and signs originate in the processes of the mental realm, these entities come into being only when they are expressed outwardly. Clearly, some intentional entities remain *internal* to humans, such as mental states of belief, desire, and visual perception. Internal intentional states explain the actions of human moral agents in that the intentional entities cause the actions and count as reasons why the agent committed the act. As for the external intentional entities, once they come into being and are (by definition) physically separated from the human who generated them, they still rely on a community of intentionality-generating beings (interpreters) in order to be intentional—in order for their intentionality to be grasped. Examples are maps, chairs, sentences in a natural language, and works of art. External intentional entities, like their internal counterparts, can cause and explain action. For example, the stop sign causes drivers to step on the brakes and bring their vehicles to a stop; the speech act of commanding individuals to behave in a certain way may cause individuals to do what is commanded; and so on.

The internal/external distinction in intentional entities takes into consideration the kinds of intentionality in human minds, in tangible expressions such as sentences and speech acts, and in representational states that are found in designed artifacts. Internal intentional states are those that necessarily remain mental; external intentional states, by contrast, are expressed in the form of entities that exist outside of the mind. An internal intentional state such as a belief often leads to an external intentional entity by means of a process not yet fully understood, but still assumed to be causal in nature. We argue that designed artifacts such as maps, computer programs, cars, and the like are externalized expressions of internal intentional states. They are intentional entities that cause action with morally relevant effects.

The most difficult part of the account here is the claim that things other than mental states can be about, be directed at, or represent objects and states of affairs. This claim seems noncontroversial when applied to sentences, speech acts, and maps. For instance, John R. Searle (2001) describes maps and house blueprints as intentional entities. Thus it should not be controversial when it comes to technological artifacts. While we claim that technological artifacts are intentional entities, we acknowledge that in the standard account of agency and action, agents have a specific intentional state of intending to perform a particular action, plus some more basic intentional states such as beliefs and desires. Because we claim that artifacts are intentional entities, the obvious question is what kind of intentionality do they have? That is, do they have something akin to the basic intentional states of humans, such as beliefs and desires, or something like the specific states of intending?

The Functionality and Intentionality of Artifacts

Our argument for the intentionality of technological artifacts is based on a particular understanding of the intentional states that artifacts can have. These intentional states cannot be fully understood without reference to the functions of the artifact. Accordingly, our account of the functionality of artifacts will be developed by answering three questions. What are functions in an artifact? How do they get into the artifact? What do users do with functions?

WHAT ARE THE FUNCTIONS IN AN ARTIFACT? Typically artifacts are thought to have functions, and their functionality is framed in terms of purposive or teleological explanation. While we do not reject this approach, we want to suggest a different view—one that allows for the flexibility we find in the design and use of artifacts. We base our understanding of the functionality of artifacts on the model of mathematical functions. An artifact has a function when it takes some input from a domain of human behaviors and produces a result within a range—what we generically call the output. The behavior of the user with the artifact fits the mathematical model of functions in that it consists of a relational triple: input, rule of transformation, and output. In the case of both mathematical functions and artifacts, one of two things can happen in the functional transformation. Either an input maps onto exactly one output (in which case the relation is one-to-one), or many different inputs map onto one output (a many-to-one relation). The definition of a function precludes the possibility that a particular input will deliver varying outputs (except in the case of artifacts such as slot machines whose one output is to produce varying outputs). This is an important condition for mathematical functions as well as artifactual ones. An artifact ceases to be useful (or even sometimes safe) when its output is unpredictable (except, again, when unpredictability is the designed output), and this is exactly what happens when a user gets different outputs for the exact same input on different occasions.

Here is an example of a technological function. A designer of a braking system for cars would model input by considering reaction times, leg position, pedal pressure, and stopping force for drivers who wish to control a typical car by pressing on the brake pedal. This process of design begins to reveal how the artifact becomes intentional; the input model is "about" driver capabilities and driving conditions—what we can gloss as "input" and "environment" aspects of the model. The transformation rule for the function, which is embodied in the mechanical parts of the braking system, turns those anticipated inputs into a result: The car slows at an appropriate speed. This is how the intentional states are actually manifested in the artifact; they are "materialized" in the way the artifact transforms the input. A successful braking system will incorporate realistic reaction times and pressures for the vast majority of drivers, and will reliably transform those inputs into the safe braking of a car under most conditions. A proper braking system will not map the different outcomes "stop the car" and "accelerate the car" to the exact same driver behavior. Design functions, like mathematical functions, are not one-to-many relations.

When an artifact *appears* to function differently with the same inputs, either the artifact is broken or there is a mistake about the sameness of inputs. The input mode for many complex artifacts such as computers is context dependent. For example, when the input of "striking the return key" on the keyboard yields different results at different times, this is because the computer is in different states during the respective inputs. In some programs, a query can be answered affirmatively by striking the return key. In others—word processors, for example—striking the return key places a hard return in a document. The lesson is that inputs are always tied to context. The condition that the artifactual functions borrow from mathematical ones reveals that there will never be more than one output for an *input in a context*. We may get spaces in some word-processing documents when we push the return key, and affirmations to queries when running other programs, but we will never get spaces sometimes and affirmations other times, in the exact same input context.

HOW DO FUNCTIONS GET INTO AN ARTIFACT? Crucial to this account is the fact that transformation rules of functions cannot be built into artifacts without applying intentional models of users and the world in which they operate.

There are two immediate senses in which the intentionality that begins with design is connected to technological artifacts in use. The act of design always requires intentionality—the ability of a designer to represent, model, perceive, and the like. Similarly, the use of an artifact—grasping a tool, following the user's guide—requires typical forms of cognition that feature intentionality. But there are deeper ways intentionality connects to designed functions and uses, ways that go beyond the intentionality of designers and users. When designers design artifacts, they poise them to behave in certain ways. Those artifacts *remain* poised to behave in those ways. They are designed to produce unique outputs when they receive inputs. They are directed at states of affairs in the world and will produce other states of affairs in the world when used. The telephone is "about" typical human fingers and ears, auditory capacities, and the physics of sound—it is intentional with respect to certain organisms and their environments. In a complicated way, the intentionality of the telephone is required to make it work as a communication device. But the telephone is also directed at certain social facts; it is about a world in which individuals want to talk with others who are beyond the reach of (unassisted) human voices. The telephone also requires that users memorize or keep a record of numbers attached to persons. Otherwise, a potential caller will not be able to use the telephone. Long after the designer has poised the artifact, the functions still reside in it and make complex actions possible. The argument here receives support from an analysis by Fred Dretske (1989) of what he terms the "design problem," as exemplified by how to get a mechanical system to do something that its designers find important, such as how to get a temperature indicator to be a switch for turning on a furnace.

WHAT DO USERS DO WITH FUNCTIONS? Users do not merely comply with the behavioral requirements designed into artifacts; they do not merely "satisfy" the model of use. They can add to the functions of an artifact by envisioning an unanticipated input that yields a novel output. This envisioning itself begins as an intentional state in the user, but it is then manifest in outward ways. An example of this is when someone picks up a television and throws it at an attacker to stop the attack. Here the user sees that by providing a particular kind of input (lifting and throwing), the television can be used to produce an output that it was not originally designed to produce.

The intentional states of artifacts are the result of the work of the artifact designer; designers *mold* intentionality into artifacts by concretizing the intentional models so that they enable the transformations promised by the functions. Users then deploy these functions by supplying inputs to the artifacts, under the prescribed conditions. Our argument is thus more than that the intentionality of designers and users becomes operative when artifacts get put to use. Our claim is that artifacts are in some sense chunks of intentionality, externalized by artifact designers and deployed by users in particular contexts.

When the intentionality and functionality of artifacts are seen in this light, it becomes difficult to locate precisely the agency in human actions with technological artifacts. There is intentionality in the mind of the artifact user, in the intentional states and functions of the artifact, and in the designer who created the intentionality and functionality embodied in the artifact. What may begin as the intentional model of a designer gets molded into an artifact and then deployed by the user. Hence, there is a complex of agency with human and nonhuman components.

We thus acquire a picture of moral action with technology as a complex combination of the intentionality of artifact designer, the intentionality of the artifact, and the intentionality of the user. Does this mean that artifacts are moral agents? If we return to the standard account of moral agency, it is now clear that artifacts meet most but not all of the conditions. Remember that on the standard account, human moral agency includes the stipulation of a potential agent with internal mental states, and one of these states is an intending to act. The agent does something, moves his or her body in some way, such that the internal states are the cause of the movement. The internal, mental states are thus also the reason for the action. The movement or behavior has an effect on a moral patient, someone or something that can be harmed (or helped).

Our analysis of human-action-with-artifact overlaps significantly with standard (nontechnological) human action, even though it locates agency in the triad of designer, artifact, and user. We have found that intentional states are spread out over designers, artifacts, and users, so that the action of the human-agent-with-artifact is caused by intentional states in each member of the triad. A complete reason explanation must include an account of the intentional states and functions of the artifact, because these states and functions play a causal role in the eventual action. The causal role of the artifact is necessary, but not sufficient, for the effect on the moral patient. True, artifacts alone are not agents, nor are their intentional states in any way internal mental states. Likewise, artifacts alone do not intend. But the intentional states of artifacts shape and cause external or embodied movement, both in terms of functional inputs of users and in terms of artifactual output. And intentional, caused, embodied movement can have morally relevant effects on patients. Thus, the intentionality and functionality of artifacts are important components of a full picture of moral action.

This account has implications for the notion of moral responsibility. Because philosophers and others may resist the idea of any kind of agency or even intentionality being attributed to technology because it may appear to deflect responsibility from human actors, it is appropriate to consider the issue of responsibility in a case study. Can technological artifacts be said to bear moral responsibility, or even to be morally good or bad entities?

An Illustration: The Moral Evaluation of Computers

At first glance, the idea of artifacts bearing moral responsibility appears implausible. There is, however, a form of human moral responsibility that is applicable to certain kinds of computer systems that may have broader application to other technologies. We refer here to the responsibility of human surrogate agents to their clients. Human surrogate agents are those who act on behalf of others. For example, lawyers, tax accountants, estate executors, and managers of performers and entertainers pursue the interests of their clients. The behavior of these agents is evaluated in terms of how well they pursue their client's interest while staying within the constraints and expectations associated with their roles. Like surrogate agents, computer systems pursue interests of their users; hence, their behavior can be evaluated in terms of how well they pursue the interests of their users.

If computer systems can be understood as surrogate agents for their human users, it would seem that role morality can be extended to computer systems, and this is a reason for attributing moral responsibility to computer systems and for morally evaluating such systems. In essence, the suggestion here is that the concept of role morality can be understood as a set of constraints on behavior, based on the interests of others, and can be applied to the functionality of particular computer systems. Just as human surrogate agents are evaluated in terms of whether they adequately understand and represent the point of view of their clients, one can evaluate computer systems in terms of how they represent and pursue the user's interests. Such an evaluation would involve many aspects of the system, including what it allows as user input and how it goes about implementing the interests of the user.

Consider the search engine surrogate that pursues a user's interest in finding web sites on a particular topic. Whether the search engine lists web sites in an order that reflects highest use, or fails to list some sites, or gives priority to sites for which the owner has paid to be listed—all of this can have moral implications (Introna and Nissenbaum 2000). We might say, then, that the computer system takes on a third-person, interested perspective, either of the user or of someone else. Several important questions arise. Does the system act on the actual user's interests, or on a restricted conception of the user's interests? Does the system competently pursue the user's interests, without pursuing other, possibly illegitimate interests such as those of advertisers, computer hardware or software manufacturers, government spying agencies, and the like? Are faulty or buggy computer systems analogous to misbehaving human surrogate agents? Do they fail to do the tasks (or to adequately do the tasks) that users employ them to do?

The foregoing suggests the kind of moral evaluation that can be made when computer systems are seen as surrogate agents. Tax preparation programs perform like tax advisers; contract-writing programs perform some of the tasks of attorneys; Internet search engines seek and deliver information like information researchers or librarians. Other types of programs and computer systems serve the interests of users, but there are no corresponding human surrogate agents with whom to compare them. Spyware programs uncover breeches in computer security, but when they do so for the user, they do not replace the tasks of a private detective or security analyst. Increasingly, computer systems do more for us than human surrogates could do. This is why it is all the more important to have a framework for morally evaluating computer systems, especially a framework that acknowledges that computer systems can do an incompetent job of pursuing the interests of their users and can misbehave in their work on behalf of users.

To claim that computer systems (and possibly other technologies) have moral responsibility and can be morally evaluated is *not* to claim that the responsibility or blameworthiness of users or system designers is thereby diminished. We anticipate that the standard response to our argument will be that the attribution of responsibility to various agents is a zero-sum situation—that designers are "let off the hook" when we turn to the moral evaluation of computer systems. In response, we deny that moral evaluation is zero sum. Computer systems behave. Their behavior is intentional, and it can have effects on humans and can be morally appraised independently of an appraisal of their designers' behavior. What the designer does and what the computer does (in a particular context) are different, albeit closely related. To think that only human designers are subject to morality is to fail to recognize that technology has intentionality, and its intentionality plays a causal role in the effects that computer systems can have on moral patients.

So the point of emphasizing the moral responsibility and moral evaluation of computer systems is not to deflect responsibility away from system designers or users. Because a computer system is conceptually distinct from the computer system designer and user, all three should come in for moral scrutiny. Computer systems are an interesting case here because they are becoming increasingly sophisticated, in both technical and social dimensions. Though the first computer systems may have been simple utilities or "dumb" technologies designed to help humans connect phone calls, calculate bomb trajectories, and do arithmetic, computer systems are increasingly taking over roles once occupied by human surrogate agents. This continuous change would suggest that, somewhere along the way, computer systems changed from mere tool to component of a complex agent. Now, it can no longer be denied that computer systems have displaced humans—both in the manufacturing workforce, as has long been acknowledged, and more recently in the service industry. It would be peculiar, then, for users to recognize that computers have replaced human service workers who have always been supposed to have moral constraints on their behavior, but to avoid the ascription of similar moral constraints to computer systems.

We introduced this discussion of computer systems as a way of opening up the possibility of technology bearing moral responsibility and being subject to moral evaluation. The challenge of the program we propose is to explore this territory in relation to both smart as well as more mundane (less complicated) technologies. The larger program will have to come to grips with the triad involved in moral action and agency: designers, artifacts, and users.

Conclusion

The line of reasoning developed here sketches an account of the role of technology in moral action. We began with the distinction between natural and human-made objects and noted that moral philosophy has neglected the importance of the artifactual platform in which human action occurs. We argued that artifacts have intentionality and gave an account of this intentionality using the functionality of artifacts and their directedness at states of affairs in the world; in this way, artifacts are comparable to speech acts. Building on our account of the intentionality of artifacts, we considered whether artifacts have moral agency. Here we argued that there are three forms of intentionality at work in moral action with technology: the intentionality of the artifact designer, the intentionality of the artifact, and the intentionality of the artifact user. Allowing for the agency of artifacts does not diminish the responsibility of human actors. To address the issue of the responsibility and moral evaluation of artifacts, we examined computer systems as surrogate agents. We argued that the responsibility of human surrogate agents provides a good model for making sense of the responsibility of computer systems. Computer systems can be morally evaluated in terms of their roles in relation to users. We have long known that computer systems can err; our account suggests that they can also misbehave.

The set of issues discussed here constitute a program for future research. Technology has not been a significant focus in moral philosophy, and yet it shapes the human moral universe in significant ways. Attention to technology promises to open up a range of interesting, complex, and important philosophical issues.

BIBLIOGRAPHY

Allen, Colin; Gary Varner; and Jason Zinser. (2000). "Prolegomena to Any Future Artificial Moral Agent." *Journal of Experimental and Theoretical Artificial Intelligence* 12(3): 251–261.

Allenby, Braden R. (2004). "Engineering and Ethics for an Anthropogenic Planet." In *Emerging Technologies and Ethical Issues in Engineering*. Washington DC: National Academies Press.

Brooks, Rodney A. (2002). *Flesh and Machines: How Robots Will Change Us*. New York: Pantheon.

Callon, Michel. (1986). "Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St. Brieuc Bay." In *Power, Action, and Belief: A New Sociology of Knowledge?* ed. John Law. London: Routledge and Kegan Paul.

Danielson, Peter. (1992). *Artificial Morality: Virtuous Robots for Virtual Games*. London: Routledge.

Davidson, Donald. (2001). *Essays on Actions and Events*, 2nd edition. Oxford: Clarendon Press.

Dretske, Fred. (1989). "Reasons and Causes." *Philosophical Perspectives* 3: 1–15.

Feinberg, Joel. (1970). "Action and Responsibility." Chap. 6 in *Doing and Deserving: Essays in the Theory of Responsibility*. Princeton, NJ: Princeton University Press.

Floridi, Luciano, and J. W. Sanders. (2001). "Artificial Evil and the Foundation of Computer Ethics." *Ethics and Information Technology* 3(1): 55–66.

Introna, Lucas D., and Helen Nissenbaum. (2000). "Shaping the Web: Why the Politics of Search Engines Matters." *Information Society* 16(3): 169–185.

Johnson, Deborah G., and Thomas M. Powers. (2005). "Computers as Surrogate Agents." In *Information Technology and Moral Philosophy*, eds. Jeroen Van Den Hoven and John Wechert. Cambridge: Cambridge University Press.

Kurzweil, Ray. (1999). *The Age of Spiritual Machines: When Computers Exceed Human Intelligence*. New York: Viking.

Law, John. (1987). "Technology and Heterogeneous Engineering: The Case of Portuguese Expansion." In *The Social Construction of Technological Systems*, eds. Wiebe E. Bijker, Thomas P. Hughes, and Trevor J. Pinch. Cambridge, MA: MIT Press.

Searle, John R. (2001). *Rationality in Action*. Cambridge, MA: MIT Press.

RESEARCH ETHICS, ENGINEERING ETHICS, AND SCIENCE AND TECHNOLOGY STUDIES

RONALD R. KLINE

• • •

The fields of research ethics and engineering ethics, as well as programs in science, technology, and society, were established in the United States in the late 1960s and early 1970s amid concerns about fraud in science, engineering-management disasters such as the Ford Pinto gas tank explosions, the role of technologies such as Agent Orange in fighting an unpopular Vietnam War, and environmental degradation. Concerns about scientific scandals and engineering disasters thus shaped the fields of research ethics and engineering ethics. More recent approaches in science and technology studies can complement and supplement methods from moral philosophy to do research in, and teach courses on, social and ethical issues in engineering.

Issues in Research Ethics and Engineering Ethics

The disjunction between the fields of research ethics and engineering ethics is striking. The literature is divided along that amorphous but venerable boundary erected and maintained to separate science from engineering (Kline 1995). Of the dozen or so textbooks on engineering ethics published since the early 1980s, only one, by Caroline Whitbeck (1998), treats research issues in engineering, but sharply divides it from engineering practice. By "practice," Whitbeck means activities other than research, that is, the development, design, testing, and selling of structures and consumer products. The journal *Science and Engineering Ethics*, established in 1995, publishes articles that mainly discuss ethics in science *or* in engineering. Only a few are on matters relating to both science *and* engineering. The Committee on Science, Engineering, and Public Policy, a joint effort of the U.S. National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine, published a little booklet on research ethics entitled *On Being a Scientist: Responsible Conduct in Research*, the second edition of which appeared in 1995. It does not address the product development or design side of engineering, which is of so much concern to professional engineering societies such as the Institute of Electrical and Electronics Engineers (IEEE) and the American Institute of Chemical Engineers (AIChE).

Although writers work hard to maintain these boundaries, publications such as *On Being a Scientist* and engineering codes of ethics (Martin and Schinzinger 1996, appendix; Anderson et al. 1993) list very similar ethical issues, but with the order of importance inverted. This difference is also seen in the amount of attention given to cases involving these issues in research and engineering ethics:

Main Issues in Research Ethics

Integrity of research

Credit and authorship

Conflicts of interest

Welfare of subjects, experimenters, and the environment

Social implications of research

Main Issues in Engineering Ethics

Public's health, safety, and welfare, including the environment

Being a faithful agent of the employer

Conflicts of interest

Credit (e.g., intellectual property provisions)

Integrity of reports

How does one explain the reversal in priority given to these issues by scientific and engineering organizations? An older view in the history of technology held that science and technology, especially engineering, are mirror-image twins. Science values theory and ideas, whereas engineering values practice and the design of products (Layton 1971). This explanation helps one understand how leaders in science and engineering reproduce these stereotypes of the two fields. Yet it is unsatisfactory because it has been common for engineers to do theoretical research (Kline 1992) and for scientists to build instruments (Galison 1997).

Another way to investigate this difference in priority is to look at how the engineering disasters and the scandals in science of the 1970s and 1980s helped shape the issues in the two fields, and how scientific and engineering societies reacted to these threats to their authority and to the public image of science and engineering.

Scandals and Disasters

All of the above issues have been prevalent in science and engineering for a long time. Charles Babbage (1792–1871) spoke about "forging," "trimming," and "cooking" (serving up the best results) in a book on reforming science in England in the early nineteenth century (Babbage 1989 [1830], pp. 90–91). Scientists and engineers have questioned the social implications of science and technology since the United States dropped atomic bombs on Japan in 1945 (Boyer 1985). The American mathematician Norbert Wiener criticized the militarization and secrecy of science after the war, as well as the possible ill effects of cybernetics, the very field he created (Heims 1980). One of the most famous disputes about credit in science was that between Isaac Newton and Gottfried Leibniz in the eighteenth century over the innovation of the calculus (Westfall 1980). Engineers have long been concerned about public reactions to their work, concerns that intensified with the professionalization of their field in the late nineteenth century (Layton 1986 [1971]).

Why was there such a great interest in research and engineering ethics in the 1970s? It seems probable that public concerns were part of a broader critique of cultural authority at the time, which included a general criticism of science and technology, protest against the Vietnam War, the rise of the environmental and appropriate technology movements (Pursell 1993), and the national scandal of Watergate. In the 1970s, charges of misconduct in science and dangerous designs in engineering grew into public scandals about "fraud" in science and amoral calculation in engineering. Accounts of scientific scandals and engineering disasters filled newspapers, calling forth responses from the scientific and engineering communities, as well as from social scientists and philosophers. This public outcry also helped create the fields of research ethics and engineering ethics, as well as programs to study issues in science, technology, and society (Mitcham 2003a, 2003b).

Perhaps the book that did the most to publicize "fraud" in science was *Betrayers of the Truth* (1982), written by the science journalists William Broad and Nicholas Wade. That same year, a young congressman from Tennessee, Al Gore, held congressional hearings on fraud in biomedical research, drawing on many of the cases reported by Broad and Wade in the journal *Science* (Kevles 1998).

Despite its sensational and naive title, *Betrayers of the Truth* discusses subjects that have been of keen interest in science and technology studies, such as differences between ideology and practice in science, problems with replication, and trust relations. The authors severely criticized historians, philosophers and sociologists of science for upholding the myth of science as a rational, autonomous, verifiable producer of certain knowledge. Their main targets seem to be Karl Popper, Robert Merton, and internalist historians of science. They cite Thomas Kuhn appreciatively. In regard to the first issue in research ethics mentioned above, integrity of research, they questioned the objective ideology of science and the autonomy and effectiveness of its system of checks and balances—peer review, refereeing, and replication.

The more sensational part of the book described the prevalence of what they called "fraud" in science, under which they included the issues of integrity of research and credit and authorship. An appendix lists thirty-four cases of fraud, dating from the Greek astronomer Hipparchus in the second century B.C.E., who "published a star catalog taken from Babylonian sources as if it were the results of his observations" (p. 226), to three cases of falsification of data in biomedical research in 1981. Most of the then-recent cases occurred in biology, including that of Mark Spector, a graduate student with "golden hands" working at Cornell University under the biologist Efraim Racker. Racker and Spector announced a novel theory of cancer causation in 1981, only to find out later that Spector had forged experiments. Broad and Wade conclude that "Pride, ambition, excitement at a new theory, reluctance to listen to bad news, unwillingness to distrust a colleague" were the "ingredients that caused the kinase cascade theory to go so far.... Replication was the *last* step in the episode, undertaken when everything else had failed and only after plain evidence of forgery had come to light" (p. 63, their emphasis). In regard to the self-policing mechanism of science, they give a structural explanation. "The roots of fraud lie in the barrel, not in the bad apples that occasionally roll into public view" (p. 87).

The scientific community responded to the publicity surrounding these cases by conducting investigations, issuing reports, and publishing educational materials. The first edition of *On Being a Scientist* appeared in 1989. In 1992 the National Research Council defined misconduct as "fabrication, falsification, and plagiarism in proposing, conducting, and reporting research" (Whitbeck 1998, p. 201; Mitcham 2003a, p. 277). The cold fusion controversy in 1989 (Lewenstein 1992), the David Baltimore case in biomedicine in 1991 (Kevles 1998), and the early 2000s case of data fabrication at Bell Labs by the rising "star physicist" Jan Hendrik Schön in research on organic semiconductors and nanoscience (Levi 2002) have kept the topic in the news and before the scientific community.

The issues raised and discussed during these "scandals" have dominated thinking on research ethics by scientists and ethicists. The booklet *On Being a Scientist* and the journal *Science and Engineering Ethics* both devote much more space to questions of integrity of research and credit and authorship, than to conflicts of interest and social implications of research. This priority existed before the 1970s, but it seems that the charges of fraud and responses to it have reinforced the status of these issues in research ethics and lessened that of other issues, such as gender and other power relations.

The field of engineering ethics has a similar history. In the Progressive Era of the late nineteenth and early twentieth centuries in the United States, professional engineering societies developed codes of ethics in order to raise the status of the field, to make it look more like a learned profession such as medicine, which was considered socially responsible (Layton 1986 [1971], 1978). The codes played this role for a short time around World War I, but they became rather obscure documents thereafter.

How obscure the codes were is revealed in the Bay Area Rapid Transit (BART) case in San Francisco. In late 1971, three engineers working for the BART district brought concerns about the safety of an automated train project to the attention of a member of the board of directors, after getting no satisfaction from a supervisor. Their analysis predicted, for example, that doors would open before the train entered the station. Instead of investigating the engineers' allegations of a dangerous design, the board investigated who the anonymous engineers were and had them fired (Friedlander 1974). The IEEE came to their assistance in early 1975 by filing a "friend of the court" brief. The IEEE proposed the novel argument that BART had violated the employment contract of the fired engineers because, as professional engineers, they were obligated to abide by the code of ethics of their profession and "hold paramount" the public's safety. The IEEE referred to the code of ethics of the Engineers' Council for Professional Development, an umbrella group for all engineers and the predecessor to the current Accreditation Board for Engineering and Technology, because the IEEE did not know it had an existing code on the books, created in 1912. Still unaware of the earlier code, it wrote a new one in 1979 (Kline 2001/2002). The IEEE's argument in the BART case did not set a precedent. The two engineers settled out of court when they realized that some false statements they had made to management would probably hurt their case (Unger 1994).

The BART case is one of a litany of disasters and near disasters used in teaching engineering ethics in the United States. Among them are:

- Gas tank ruptures of rear-ended Ford Pintos that caused burn injuries and deaths in the 1970s. Dozens of lawsuits were subsequently brought against Ford Motor Company (Camps 1981; De George 1981).
- The crash of a Turkish Airlines DC-10 near Paris in 1974, killing all 346 people aboard, attributed to a poorly designed cargo latch system. A test facility in Long Beach, California, said it had completed design changes when it had not (Fielder and Birsch 1992).
- The Three Mile Island nuclear power plant accident of 1979, resulting in a partial meltdown of its core and a lengthy and costly cleanup (Ford 1982).
- The crash of another DC-10, this time upon takeoff from Chicago in 1979 when an engine sepa-

rated from the plane. All 271 people aboard were killed, as well as two persons on the ground. The airline used shortcuts in maintenance procedures (Fielder and Birsch 1992).

- The collapse of a fourth-floor walkway in the atrium of the Hyatt Regency Hotel in Kansas City, Missouri, in 1981, killing 114 partygoers (Rubin and Banick 1986).
- The Union Carbide Corporation Bhopal disaster in India in 1984 (Stix 1989).
- The space shuttle *Challenger* accident of 1986 (Vaughan 1996).
- The space shuttle *Columbia* accident of 2003.

In all of these cases, investigation showed that engineers had known about, and often raised issues about, what they considered to be risky and unsafe designs from an early stage in the design process.

The cases are usually taught as a conflict between engineers wanting to create a safe design and managers wanting to push the products out the door because of time and financial constraints. But as Diane Vaughan (1996) has argued in the case of the space shuttle *Challenger*—a favorite in engineering ethics courses and literature—assumptions of amoral calculation by managers and engineers should be reexamined. Vaughan focuses instead on the construction of acceptable risk in the work-group cultures of day-to-day engineering practices, which led up to the fateful decision to launch the *Challenger*.

These disasters have greatly shaped the field of engineering ethics. The code of ethics of the Engineers' Council for Professional Development (1978) had been rewritten in 1974 to contain the obligation that the engineer "shall hold paramount the safety, health, and welfare of the public." Other engineering professional societies followed suit. This revision aimed to assure the public that engineers, if not their managers, were socially responsible. (See Davis 2001 for an argument that the original codes stressed social responsibility). It was a move to protect the autonomy of the engineering profession as a self-policing group that did not need government oversight. Of course, the increased amount of damages awarded in lawsuits and the rise of strict product liability laws have resulted in another type of oversight.

Most textbooks rely on these large cases to discuss safety, risk, whistle-blowing, conflicts of interest, rights of engineers in corporations, and so forth (Martin and Schinzinger 1996; Whitbeck 1998; Harris, Pritchard, and Rabins 1995; Unger 1994. Herkert 2000 takes a broader approach by including articles on history and policy). They are a major avenue for students to consider the messy complexity of engineering practices in a world of multinational corporations, subcontractors, liability laws, government regulation and deregulation, consumer activities, and what Bryan Wynne has called "unruly technology" (1988).

But the cases have also helped shape the field such that some issues are marginalized. The relationship between gender and product design, lack of access to new technology, and the flexible interpretation of test results are not visible because they have been invisible in the way the disasters have been reported in the newspapers, investigated by government committees, and analyzed by scholars in engineering ethics. Vaughan's participation in the board appointed by the National Aeronautics and Space Administration (NASA) to investigate the *Columbia* space shuttle accident is a recent and much welcomed exception.

Science and Technology Studies

In the late 1990s a movement began aiming to bring science and technology studies (S&TS) to bear on research and teaching in engineering ethics (e.g., Herkert, 2000; Lynch and Kline 2000; Kline 2001/2002). Textbooks on the subject typically show students how to apply moral philosophy to ethical issues, especially to moral dilemmas (see, e.g., Martin and Schinzinger 1996). Consider the hypothetical case of an engineer asked by his supervisor to "do the math backwards" to come up with data to support a design recommendation that, based on engineering judgment, contradicts suspected test results (Kohn and Hughson 1980). Students are often asked to identify the rights, duties, and consequences in this case and weigh them to make a decision. Textbooks usually do not prescribe the correct (ethical) courses of action, but present methods for engineers to use to sort out and identify ethical issues, to understand the basis for their decision, and to consider innovative alternatives to escape the horns of the dilemma (see, e.g., Harris, Pritchard, and Rabins 1995).

Textbooks treat "large cases," the lengthy descriptions of engineering disasters, in much the same way. For example, the complexities of the *Challenger* case are often reduced to the mythic moment of the night before the launch when Jerry Mason, a senior vice president at Morton Thiokol, the maker of the rocket boosters, asked Robert Lund, the vice president of engineering, to take off his engineering hat and put on his management hat to make a decision. The case is presented as one of *amoral calculation* on the part of managers, pressured by time schedulers and political necessities to overturn a *sound* engineering recommendation (Lynch and Kline 2000).

One disadvantage of this approach is that it provides, even in the big cases, a very *thin description* of engineering practice. Work relations among engineers, technicians, and managers are flattened and described from the agent-centered perspective favored by these textbooks, engineering professional societies, accreditation agencies, and moral philosophers. Power relations are often reduced to engineers versus management, and gender relations are virtually ignored. The production of engineering knowledge is usually seen as unproblematic, as are conceptions of risk and safety. The textbook by Mike W. Martin, a philosopher, and Roland Schinzinger, an engineer, is better in some of these respects. It discusses different perceptions of risk and safety, as well as work relations in corporations—under the rubric of rights of engineers in the workplace—and proposes the idea that engineering is a social experiment (Martin and Schinzinger 1996). That idea resonates well with literature in the history and sociology of engineering and technology, but those fields are underutilized in engineering ethics literature.

William T. Lynch and Ronald R. Kline (2000) pointed to the work of Diane Vaughan—her "historical ethnography" of the *Challenger* case—as one approach to take to bring S&TS to bear on engineering ethics. Vaughan (1996) concluded that the acceptable risk of flying with solid rocket booster O-rings that did not seat as they were designed to was constructed by a process of "normalization of deviance" from original design specs in the "production of culture" within engineer-manager work groups. This construction was supported by the "culture of production" of the wider engineering community and the "structural secrecy" of passing information up through bureaucratic channels. Engineers thought they were gaining a better technical understanding of how O-rings behaved in this harsh, complex environment and thus considered the erosion of O-rings by hot gases to be "normal" and under their control. The proposed launching at a low temperature "outside their experience base" brought about the conflict with management during the famous teleconference on the eve of the launch. The engineers' perception that NASA and the managers involved had reversed the ground rules and now asked them to prove the shuttle was *unsafe* to fly brought about the charges of amoral calculation by managers.

Although Vaughan draws on some S&TS ideas, such as the concepts of unruly technology and the interpretative flexibility of test results, she does not cover the entire field of technology studies. In fact, her structuralist approach collides with social constructivists' accounts. Its chief merit is its detailed historical ethnography of engineering practice.

The history, philosophy, and sociology of engineering also provide a wealth of information about engineering practice. There are accounts of the professionalization of engineering, engineering education, the relationship between scientific and engineering research, and the production of engineering knowledge (Leslie 1993; Downey and Lucena 1995); the engendering of engineering as a masculine profession (Oldenziel 1999); and the processes of design and testing (Vincenti 1990; Kline 1992; Latour 1996; Alder 1997; Cooper 1998; Thompson 2002).

S&TS scholars can draw on many concepts to illuminate social and ethical issues in engineering. These include:

- Gender and technology: gender relationships built into buildings; masculinity and technical competence (Wajcman 1991).
- Trust in numbers: why quantitative arguments carry more weight than qualitative ones in a bureaucratic setting (Porter 1995).
- Tacit knowledge: for example, the phenomenon of "golden hands" in research (Collins 1985).
- Risk: construction and communication of risk (Herkert 2000).
- User studies: interpretable flexibility of consumer products (Oudshoorn and Pinch 2003).
- Trust relations: assumptions of trust in research, design, and testing (Shapin 1995).
- Boundary work: separation of science from engineering, experts from laypeople, technology from politics, and so on. (Gieryn 1995).
- Politics of artifacts: by choice of design, "nature" of the design (Winner 1986).

Thick Description and Moral Prescription

One criticism of bringing S&TS to bear on engineering ethics is that is provides a better description of engineering practice, but does not directly address normative concerns. This work is in its infancy, but there are at least three ways in which the theory-based "thick description" provided by history and sociology of science and technology can lead to moral prescriptions.

The first is by telling a moral tale, such as the account of Robert Moses designing low bridges on the Long Island Expressway that prevented buses from the inner city from going to Jones Beach (Winner 1986). Although Moses's motives in this story may not have been racially discriminatory, and African Americans may have found other ways to travel to Long Island (Joerges 1999), more accurate stories of this kind can warn engineers of the unintended political consequences of their designs.

A second way is that thick descriptions can open new avenues of moral inquiry. Although moral philosophers rightly question the amount of ethical reflection permitted by Vaughan's concept of the normalization of deviance (1996), it can, if used properly, alert engineers and teachers of engineering ethics to the moral implications of everyday decisions made in engineering practice.

Finally, thick descriptions can provide a basis, by analogy, for taking a normative position. Martin and Schinzinger's concept of engineering as a social experiment (1996), for example, shows that engineers cannot know the precise technical or social *outcome* of a technology in the design stage, no matter how many computer simulations they run. The normative implications from this description of engineering are that the engineering experiment should be conducted in a morally responsible way, which means—after learning the lessons of the horrors of the Nazi medical experiments of World War II—*monitoring* the experiment, providing a *safe exit,* and ensuring that there was *informed consent* on the part of those being experimented upon.

In these and other ways, S&TS scholars can find ways to collapse or problematize the boundaries between description, analysis, and normative conclusions, to ask how they can relate to or perhaps strengthen each other. By bringing an extensive body of research in the history and sociology of engineering to bear on engineering and research ethics, S&TS scholars can improve humankind's understanding of the complex social and moral issues in science and engineering, and perhaps influence the practice of these fields as well.

BIBLIOGRAPHY

Alder, Ken. (1997). *Engineering the Revolution: Arms and Enlightenment in France, 1763–1815.* Princeton, NJ: Princeton University Press.

Anderson, Ronald E.; Deborah G. Johnson; Donald Gotterbarn; and Judith A. Perrolle. (1993). "Using the New ACM Code of Ethics in Decision Making." *Communications of the ACM* 36(2): 98–107.

Babbage, Charles. 1989 (1830). *Reflections on the Decline of Science in England and on Some of Its Causes.* London: William Pickering.

Boyer, Paul. (1985). *By the Bomb's Early Light: American Thought and Culture at the Dawn of the Atomic Age.* New York: Pantheon.

Broad, William, and Nicholas Wade. (1982). *Betrayers of the Truth.* New York: Simon and Schuster.

Camps, Frank. (1981). "Warning an Auto Company about an Unsafe Design." In *Whistle Blowing! Loyalty and Dissent in the Corporation,* ed. Alan F. Westin. New York: McGraw-Hill.

Collins, H. M. (1985). *Changing Order: Replication and Induction in Scientific Practice.* London: Sage.

Cooper, Gail. (1998). *Air-Conditioning America: Engineers and the Controlled Environment, 1900–1960.* Baltimore: Johns Hopkins University Press.

Davis, Michael. (2001). "Three Myths about Codes of Engineering Ethics." *IEEE Technology and Society Magazine* 20(3): 8–14.

De George, Richard T. (1981). "Ethical Responsibilities of Engineers in Large Organizations: The Pinto Case." *Business and Professional Ethics Journal* 1(1): 1–14.

Downey, Gary Lee, and Juan C. Lucena. (1995). "Engineering Studies." In *Handbook of Science and Technology Studies,* ed. Sheila Jasanoff, Gerald E. Markle, James C. Petersen, and Trevor Pinch. Thousand Oaks, CA: Sage.

Engineers' Council for Professional Development. (1978). "Code of Ethics of Engineers. Approved, October 1, 1974." In *Ethical Problems in Engineering,* ed. Robert J. Baum and Albert Flores. Troy, NY: Rensselaer Polytechnic Institute, Center for the Study of the Human Dimensions of Science and Technology.

Fielder, John H., and Douglas Birsch, eds. (1992). *The DC-10 Case: A Study in Applied Ethics, Technology, and Society.* Albany: State University of New York Press.

Ford, Daniel F. (1982). *Three Mile Island: Thirty Minutes to Meltdown.* New York: Viking.

Friedlander, Gordon D. (1974). "The Case of the Three Engineers vs. BART." *IEEE Spectrum* 11(10): 69–76.

Galison, Peter. (1997). *Image and Logic: A Material Culture of Microphysics.* Chicago: University of Chicago Press.

Gieryn, Thomas F. (1995). "Boundaries of Science." In *Handbook of Science and Technology Studies,* ed. Sheila Jasanoff, Gerald E. Markle, James C. Petersen, and Trevor Pinch. Thousand Oaks, CA: Sage.

Harris, Charles E.; Michael S. Pritchard; and Michael J. Rabins. (1995). *Engineering Ethics: Concepts and Cases.* Belmont, CA: Wadsworth.

Heims, Steve J. (1980). *John von Neumann and Norbert Wiener: From Mathematics to the Technologies of Life and Death.* Cambridge, MA: MIT Press.

Herkert, Joseph R., ed. (2000). *Social, Ethical, and Policy Implications of Engineering: Selected Readings.* New York: IEEE Press.

Joerges, Bernward. (1999). "Do Politics Have Artefacts?" *Social Studies of Science* 29(3): 411–431.

Kevles, Daniel J. (1998). *The Baltimore Case: A Trial of Politics, Science, and Character.* New York: Norton.

Kline, Ronald R. (1992). *Steinmetz: Engineer and Socialist.* Baltimore: Johns Hopkins University Press.

Kline, Ronald R. (1995). "Construing 'Technology' as 'Applied Science': Public Rhetoric of Scientists and Engineers in the United States, 1880–1945." *Isis* 86(2): 194–221.

Kline, Ronald R. (2001/2002). "Using History and Sociology to Teach Engineering Ethics." *IEEE Technology and Society Magazine* 20(4): 13–20.

Kohn, Philip M., and Roy V. Hughson. (1980). "Perplexing Problems in Engineering Ethics." *Chemical Engineering* 87(9): 100–107.

Latour, Bruno. (1996). *Aramis; or, The Love of Technology,* trans. Catherine Porter. Cambridge, MA: Harvard University Press.

Layton, Edwin T., Jr. (1971). "Mirror-Image Twins: The Communities of Science and Technology in Nineteenth-Century America." *Technology and Culture* 12(4): 562–580.

Layton, Edwin T., Jr. (1978). "Engineering Ethics and the Public Interest: A Historical Review." In *Ethical Problems in Engineering,* ed. Robert J. Baum and Albert Flores. Troy, NY: Rensselaer Polytechnic Institute, Center for the Study of the Human Dimensions of Science and Technology.

Layton, Edwin T., Jr. 1986 (1971). *The Revolt of the Engineers: Social Responsibility and the American Engineering Profession.* Baltimore: Johns Hopkins University Press.

Leslie, Stuart W. (1993). *The Cold War and American Science: The Military-Industrial-Academic Complex at MIT and Stanford.* New York: Columbia University Press.

Levi, Barbara Goss. (2002). "Investigation Finds that One Lucent Physicist Engaged in Scientific Misconduct." *Physics Today* 55(11): 15–17.

Lewenstein, Bruce V. (1992). "Cold Fusion and Hot History." *Osiris,* 2nd series, 7: 135–163.

Lynch, William T., and Ronald R. Kline. (2000). "Engineering Practice and Engineering Ethics." *Science, Technology, and Human Values* 25(2): 195–225.

Martin, Mike W., and Roland Schinzinger. (1996). *Ethics in Engineering,* 3rd edition. New York: McGraw-Hill.

Mitcham, Carl. (2003a). "Co-responsibility for Research Integrity." *Science and Engineering Ethics* 9(2): 273–290.

Mitcham, Carl. (2003b). "Professional Idealism among Scientists and Engineers: A Neglected Tradition in STS Studies." *Technology in Society* 25(2): 249–262.

Oldenziel, Ruth. (1999). *Making Technology Masculine: Men, Women, and Modern Machines in America, 1870–1945.* Amsterdam: Amsterdam University Press.

Oudshoorn, Nellie, and Trevor Pinch, eds. (2003). *How Users Matter: The Co-construction of Users and Technologies.* Cambridge, MA: MIT Press.

Porter, Theodore M. (1995). *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life.* Princeton, NJ: Princeton University Press.

Pursell, Carroll. (1993). "The Rise and Fall of the Appropriate Technology Movement in the United States, 1965–1985." *Technology and Culture* 34(3): 629–637.

Rubin, Robert A., and Lisa A. Banick. (1986). "The Hyatt Regency Decision—One View." *Construction Lawyer* 6(4): 20.

Shapin, Steven. (1995). "Trust, Honesty, and the Authority of Science." In *Society's Choices: Social and Ethical Decision Making in Biomedicine,* ed. Ruth Ellen Bulger, Elizabeth Meyer Bobby, and Harvey V. Fineberg. Washington, DC: National Academy Press.

Stix, Gary. (1989). "Bhopal: A Tragedy in Waiting." *IEEE Spectrum* 26(6): 47–50.

Thompson, Emily. (2002). *The Soundscape of Modernity: Architectural Acoustics and the Culture of Listening in America, 1900–1933.* Cambridge, MA: MIT Press.

Unger, Stephen H. (1994). *Controlling Technology: Ethics and the Responsible Engineer,* 2nd edition. New York: Wiley.

U.S. National Academy of Sciences; National Academy of Engineering; and Institute of Medicine. Committee on Science, Engineering, and Public Policy. (1995). *On Being a Scientist: Responsible Conduct in Research,* 2nd edition. Washington, DC: National Academy Press.

Vaughan, Diane. (1996). *The* Challenger *Launch Decision: Risky Technology, Culture, and Deviance at NASA.* Chicago: University of Chicago Press.

Vincenti, Walter G. (1990). *What Engineers Know and How They Know It: Analytical Studies from Aeronautical History.* Baltimore: Johns Hopkins University Press.

Wajcman, Judy. (1991). *Feminism Confronts Technology.* University Park: Pennsylvania State University Press.

Westfall, Richard S. (1980). *Never at Rest: A Biography of Isaac Newton.* Cambridge, UK: Cambridge University Press.

Whitbeck, Caroline. (1998). *Ethics in Engineering Practice and Research.* Cambridge, UK: Cambridge University Press.

Winner, Langdon. (1986). "Do Artifacts Have Politics?" Chap. 2 in his *The Whale and the Reactor: A Search for Limits in an Age of High Technology.* Chicago: University of Chicago Press.

Wynne, Brian. (1988). "Unruly Technology: Practical Rules, Impractical Discourses, and Public Understanding." *Social Studies of Science* 18(1): 147–167.

NANOSCIENCE, NANOTECHNOLOGY, AND ETHICS: PROMISE AND PERIL

RAY KURZWEIL

• • •

Our rapidly growing scientific and technological ability to manipulate matter and energy at ever smaller scales promises to transform virtually every sector of society, a phenomenon that presents manifest ethical responsibilities. There will be increasing overlap between nanotechnology and other technologies, such as biotechnology and artificial intelligence. And as with these previous scientific and technological transformations, we will be faced with deeply intertwined promise and peril.

The Nano-Frontier

Nanoscience and nanotechnology today have been expanded to include essentially any science or technology where the key features are measured in a modest number of nanometers (under 100 by some definitions). By this standard, contemporary electronics has already passed this threshold. Eric Drexler has further developed the concept of building molecule-scale devices using molecular assemblers that would precisely guide chemical reactions by means of information. Moreover, just as technologies related to information develop at an exponential pace, generally doubling in capability and price-performance every year, so the size of technology is itself inexorably shrinking, and most of technology will be "nanotechnology" by the 2020s.

This era will bring us the ability to essentially convert software, that is, information, directly into physical products. We will be able to produce virtually any product for pennies per pound. Computers will have greater computational capacity than the human brain, and we will be completing the reverse engineering of the human brain to reveal the software design of human intelligence. We are already placing devices with narrow intelligence in our bodies for diagnostic and therapeutic purposes. With the advent of nanotechnology, we will be able to keep our bodies and brains in a healthy, optimal state indefinitely. Nanotechnology and related advanced technologies will bring us the opportunity to overcome age-old problems, including pollution, poverty, disease, and aging.

Many object to the intermingling of the so-called natural world with the products of our technology. However, the increasing intimacy of our human lives with our technology is not a new story. Human life expectancy was thirty-seven years in 1800. Most humans at that time lived lives dominated by poverty, intense labor, disease, and misfortune. We are immeasurably better off as a result of technology, but there is still a lot of suffering in the world to overcome. We have a moral imperative, therefore, to continue the pursuit of knowledge and of advanced technologies that can continue to overcome human affliction. There is also an economic imperative to continue .

Nanotechnology is advancing on hundreds of fronts. We cannot relinquish its pursuit without essentially relinquishing all of technology, which would require acts of totalitarianism inconsistent with the values of our society. Technology has always been a double-edged sword, and that is certainly true of nanotechnology. However, we will have no choice but to confront the challenge of guiding nanotechnology in a constructive direction. Any broad attempt to relinquish nanotechnology will only push it underground, which would interfere with the benefits while actually making the dangers worse.

With the human genome project, three to five percent of the budgets were devoted to the ethical, legal, and social implications (ELSI) of the technology. A similar commitment for nanotechnology would be appropriate and constructive. Near-term applications of nanotechnology are more limited in their benefits and more benign in their potential dangers. We cannot say a priori that all nanoengineered particles are safe, nor would it be appropriate to deem them necessarily unsafe. Environmental tests thus far have not shown reasons for undue concern.

I believe that existing regulatory mechanisms are sufficient to handle near-term applications of nanotechnology. As for the long term, we need to appreciate that a myriad of nanoscale technologies are inevitable. The current examinations and dialogues on achieving the promise while ameliorating the peril are appropriate and will deserve increased attention as we get closer to realizing these revolutionary technologies.

The Nano-Background: Models of Technology Trends

Models of technology trends show that nanotechnology and related advanced technologies are inevitable. They are deeply integrated into our society and are advancing on many diverse fronts, comprised of hundreds of small steps, each benign in itself.

INTUITIVE LINEAR AND HISTORICAL EXPONENTIAL VIEWS. Although exponential trends did exist a thousand years ago, they were at that very early stage where it is so flat and so slow that it looks like no trend at all. Today, everyone expects continuous technological progress and the social repercussions that follow. But the future will nonetheless be far more surprising than most observers realize because few have internalized the fact that the rate of change itself is accelerating.

Most long-range forecasts of technical feasibility underestimate the power of future developments because they are based on the "intuitive linear" view of history rather than the "historical exponential" view. We will not experience a hundred years of progress in the twenty-first century; rather we will witness on the order of twenty thousand years of progress (at today's rate of progress). An unexamined intuition provides the impression that progress changes at the rate that we have recently experienced because an exponential curve approximates a straight line when viewed for a brief duration.

But an assessment of the history of technology shows that technological change is exponential. Indeed, we find "double" exponential growth, meaning that the rate of exponential growth is itself growing exponentially. These observations are based on a rich model of diverse technological processes.

THE LAW OF ACCELERATING RETURNS. The ongoing acceleration of technology is the inevitable result of the "law of accelerating returns," which describes the acceleration of the pace and the exponential growth of the products of an evolutionary process, including technology, particularly information technologies.

The law of accelerating returns has three key features. First, evolution applies positive feedback as the more capable methods resulting from one stage of evolutionary progress are used to create the next stage. As a result, the rate of progress of an evolutionary process increases exponentially over time, as the "returns" of that process (e.g., speed or cost-effectiveness) increase exponentially. As an evolutionary process becomes more effective, greater resources are invested in it, resulting in a second level of exponential growth (i.e., the rate of exponential growth itself grows exponentially).

A second feature is "technological paradigm shifts." A specific paradigm (a method or approach to solving a problem) provides exponential growth until the method exhausts its potential. When this happens, a paradigm shift (a fundamental change in the approach) occurs, which enables exponential growth to continue. Each paradigm follows an "S-curve," which consists of slow growth, followed by rapid growth, followed by a leveling off as the particular paradigm matures. During this third phase in the life cycle of a paradigm, pressure builds for the next paradigm shift. The acceleration of the overall evolutionary process proceeds as a sequence of S-curves, and the overall exponential growth consists of this cascade of S-curves.

A third key feature is that the resources underlying the exponential growth of an evolutionary process are relatively unbounded. One resource is the order of the evolutionary process itself. Each stage of evolution provides more powerful tools for the next. The other required resource is the "chaos" of the environment in which the evolutionary process takes place and which provides the options for further diversity. In technological evolution, human ingenuity and the ever-changing market sustain innovation.

The evolution of life forms and technologies constantly accelerates. With the advent of a technology-creating species, the exponential pace became too fast for evolution through DNA-guided protein synthesis and moved on to human-created technology. Technology goes beyond mere tool making; it is a process of creating ever more powerful technology using the tools from the previous round of innovation. The first technological steps took tens of thousands of years. For people living in this era, there was little noticeable technological change. By 1000 C.E., progress was much faster and a paradigm shift required only a century or two. The nineteenth century saw more technological change than in the nine centuries preceding it. Then in the first twenty years of the twentieth century, we saw more advancement than in all of the nineteenth century. Now, paradigm shifts occur in only a few years. The paradigm shift rate is currently doubling every decade. So the twenty-first century will see about a thousand times greater technological change than its predecessor.

MOORE'S LAW AND BEYOND. The exponential trend that has gained the greatest public recognition has become known as "Moore's Law." Gordon Moore, one of the inventors of integrated circuits, noted in the mid-1970s that we could squeeze twice as many transistors on an integrated circuit every twenty-four months. Given that the electrons have less distance to travel, the circuits also run twice as fast, providing an overall quadrupling of computational power.

However, the exponential growth of computing is much broader than Moore's Law. If we plot the speed per price of forty-nine famous calculators and computers spanning the twentieth century, we note that there were four paradigms that provided exponential growth in the price-performance of computing before integrated circuits. Therefore, Moore's Law was the fifth paradigm to exponentially grow the power of computation. When Moore's Law reaches the end of its S-Curve, the exponential growth will continue with three-dimensional molecular computing, constituting the sixth paradigm.

Moore's Law narrowly refers to the number of transistors on an integrated circuit of fixed size. But the most appropriate measure to track is computational speed per unit cost. This takes into account many levels of innovation in computer design. For example, there are many nascent technologies that build circuitry in three dimensions in a way that mimics the parallel organization of the human brain. One cubic inch of nanotube circuitry would be a million times more powerful than the human brain. There are more than enough new computing technologies now being researched to sustain the law of accelerating returns as applied to computation.

Specific paradigms do ultimately reach levels at which exponential growth is no longer feasible. That is why Moore's Law is an S-curve. But the growth of computation will continue exponentially. Paradigm shift, or innovation, turns the S-curve of any specific paradigm into a continuing exponential. A new paradigm takes over when the old paradigm approaches its natural limit.

OTHER TECHNOLOGIES. There are many examples of the exponential growth implied by the law of accelerating returns in technologies as varied as DNA sequencing, communication speeds, brain scanning, electronics of all kinds, and even in the rapidly shrinking size of technology. Exponential growth in communications technology has been even more explosive than in computation. Miniaturization is a trend that will have profound implications for the twenty-first century. The salient implementation sizes of technologies, both electronic and mechanical, are shrinking at a double-exponential rate.

The future nanotechnology age will result not from the exponential explosion of computation alone, but rather from the synergies that will result from intertwined technological revolutions. Every point on the exponential growth curves represents an intense human drama of innovation and competition. It is remarkable that these chaotic processes result in such smooth and predictable exponential trends.

Examples of True Nanoscience and Nanotechnology

Ubiquitous nanoscience and nanotechnology is two to three decades away. One forthcoming achievement will be "nanobots," small robots the size of human blood cells that can travel inside the human bloodstream. There have already been successful animal experiments using this concept.

In addition to human brain reverse engineering, these nanobots will be able to perform a broad variety of diagnostic and therapeutic functions inside the human body. Robert Freitas, for example, has designed robotic replacements for human blood cells that perform thousands of times more effectively than their biological counterparts. His "respirocytes" (robotic red blood cells) could allow one to sprint for fifteen minutes without taking a breath. His robotic macrophages will be far more effective than our white blood cells at combating pathogens. His DNA repair robot would be able to repair DNA transcription errors, and even implement needed DNA changes. Although Freitas' conceptual designs are two or three decades away, there has already been progress on bloodstream-based devices.

Nanobot technology has profound military applications, and any expectation that such uses will be relinquished is highly unrealistic. Already, the U.S. Department of Defense (DOD) is developing "smart dust," or tiny robots to be used for surveillance. Billions of invisible spies could monitor every square inch of enemy territory and carry out missions to destroy enemy targets. The only way for an enemy to counteract such a force is with their own nanotechnology. Nanotechnology-based weapons will obsolete weapons of larger size.

In addition, nanobots will be able to expand our experiences and our capabilities. Nanobot technology will provide fully immersive virtual reality by taking up positions in close proximity to every interneuronal connection related to the senses. If we want to enter virtual reality, the nanobots suppress all of the inputs coming from the real senses, and replace them with the signals that would be appropriate for the virtual environment.

Scientists at the Max Planck Institute have developed "neuron transistors" that can detect the firing of a nearby neuron, or alternatively, can cause a nearby neuron to fire, or suppress it from firing. This amounts to two-way communication between neurons and the electronic-based neuron transistors. The scientists demonstrated their invention by controlling the movement of a living leech from their computer.

The Internet will provide many virtual environments to explore. We will be able to "go" to these virtual environments and meet others there, both real and simulated people. Of course, ultimately there will not be a clear distinction between the two. By 2030, going to a web site will mean entering a full-immersion virtual-reality environment, encompassing all of the senses and triggering the neurological correlates of emotions and sexual experiences.

"Experience beamers" circa 2030 will beam a person's entire flow of sensory experiences and emotions. We'll be able to go to a web site and experience other people's lives. Full-immersion visual-auditory environments will be available by 2010, with images written directly onto our retinas by our eyeglasses and contact lenses. The electronics will be embedded in our glasses and woven into our clothing, so computers as distinct objects will disappear.

The most significant implication of nanotechnology and related advanced technologies of the twenty-first century will be the merger of biological and nonbiological intelligence. Nonbiological intelligence is growing at a double-exponential rate and will vastly exceed biological intelligence well before the middle of this century. However, in my view, this nonbiological intelligence should still be considered human, as it is fully derivative of the human-machine civilization.

Our brains are relatively fixed in design, but brain implants based on massively distributed intelligent nanobots will ultimately expand our memories a trillion fold and improve all of our cognitive abilities. Since the nanobots are communicating with each other over a wireless network, they can create any set of new neural connections, break existing connections, create new hybrid biological-nonbiological networks, and add new nonbiological networks.

Using nanobots as brain extenders is a significant improvement over surgically installed neural implants. Nanobots will be introduced without surgery and can be directed to leave, so the process is easily reversible. They can change their configuration and alter their software. Perhaps most importantly, they are massively distributed and can take up billions or trillions of positions throughout the brain, whereas a surgically introduced neural implant can only be placed in a few locations.

The Economic Imperatives of the Law of Accelerating Returns

The economic imperative of a competitive marketplace is driving science and technology forward and fueling the law of accelerating returns, which, in turn, is transforming economic relationships. We are moving toward nanoscale, more intelligent machines as the result of many small advances, each with their own particular economic justification.

There is a vital economic imperative to create smaller and more intelligent technology. Machines that can more precisely carry out their missions have enormous value. There are tens of thousands of projects that are advancing the various aspects of the law of accelerating returns in diverse incremental ways. Regardless of near-term business cycles, the support for "high tech" in the business community has grown enormously. We would have to repeal capitalism and every visage of economic competition to stop this progression.

The economy has been growing exponentially throughout this century. Even the Great Depression of the 1930s represented only a minor blip compared to the underlying pattern of growth. Recessions, including the Depression, represent only temporary deviations from the underlying curve. Statistics in fact greatly understate productivity growth (economic output per worker), which has also been exponential.

Inflationary factors are offset by the double-exponential trends in the price-performance of all information-based technologies, which deeply affect all industries. We are also undergoing massive disintermediation in the channels of distribution through the Internet and other new communication technologies and escalating efficiencies in operations and administration. Current economic policy is based on outdated theories that do not adequately model the size of technology, bandwidth, megabytes, intellectual property, knowledge, and other increasingly vital constituents that are driving the economy.

Cycles of recession will not disappear immediately. However, the rapid dissemination of information, sophisticated forms of online procurement, and increasingly transparent markets in all industries have diminished the impact of these cycles. The underlying long-term growth rate will continue at a double-exponential rate. The rate of paradigm shift is not noticeably affected by the minor deviations caused by economic cycles. The overall growth of the economy reflects completely new forms of wealth and value that did not previously exist: nanoparticle-based materials, genetic information, intellectual property, communication portals, web sites, bandwidth, software, data bases, and many other new technology-based categories.

Another implication of the law of accelerating returns is exponential growth in human knowledge, including intellectual property, education, and learning. Over the course of the long twentieth century we increased investment in K-12 education by a factor of ten. We have a one hundred fold increase in the number of college students. Automation has been eliminating jobs at the bottom of the skill ladder while creating new and better paying jobs at the top. So, the ladder has been moving up, and we have been exponentially increasing investments in education at all levels.

Promise and Peril

Science and technology have always been double-edged swords, bringing us longer and healthier life spans, freedom from physical and mental drudgery, and many new creative possibilities, while at the same time introducing new and salient dangers. We will need to adopt strategies to encourage the benefits while ameliorating the risks. Relinquishing broad areas of technology, as some critics have proposed, is not feasible, and attempts to do so will only drive technology development underground, which will exacerbate the dangers.

As technology accelerates toward the full realization of biotechnology, nanotechnology and "strong" AI (artificial intelligence at or above human levels), we will see the same intertwined potentials: a feast of creativity resulting from greater human intelligence combined with many new dangers. Nanobot technology requires billions or trillions of such intelligent devices to be useful. The most cost-effective way to scale up to such levels is through self-replication. A defect in the mechanism curtailing nanobot self-replication could be disastrous. There are steps available now to mitigate this risk, but we cannot have complete assurance in any strategy that we devise today.

Other primary concerns include "Who is controlling the nanobots?" and "Who are the nanobots talking to?" Organizations or individuals could put undetectable nanobots in water or food supplies. These "spies" could monitor and even control thoughts and actions. Existing nanobots could be influenced through software viruses and other software "hacking" techniques. My own expectation is that the creative and constructive applications of this technology will dominate, as they do today. But we need to invest more heavily in developing specific defensive technologies.

There are usually three stages in examining the impact of future technology: awe at its potential to overcome problems; then a sense of dread at a new set of dangers; followed by the realization that the only viable and responsible path is to set a careful course that can realize the promise while managing the peril.

Bill Joy, cofounder of Sun Microsystems, has warned of the impending dangers from the emergence of self-replicating technologies in the fields of genetics, nanotechnology, and robotics, or "GNR." His concerns include genetically altered designer pathogens, self-replicating entities created through nanotechnology, and robots whose intelligence will rival and ultimately exceed our own. Who's to say we will be able to count on such robots to remain friendly to humans? Although I am often cast as the technology optimist who counters Joy's pessimism, I do share his concerns regarding self-replicating technologies. Many people have interpreted Joy's article as an advocacy of broad relinquishment, not of all technology, but of the "dangerous ones" like nanotechnology. Joy, who is now working as a venture capitalist with the legendary silicon valley firm of Kleiner, Perkins, Caufield & Byers investing in technologies such as nanotechnology applied to renewable energy and other natural resources, says that broad relinquishment is a misinterpretation of his position and was never his intent. He has recently said that the emphasis should be to "limit development of the technologies that are too dangerous," not on complete prohibition. He suggests, for example, a prohibition against self-replicating nanotechnology, which is similar to the guidelines advocated by the Foresight Institute.

Others, such as Bill McKibben, the environmentalist who was one of the first to warn against global warming, have advocated relinquishment of broad areas such as biotechnology and nanotechnology, or even of all technology. However, relinquishing broad fields would be impossible to achieve without essentially relinquishing all technical development.

There are real dangers associated with new self-replicating technologies. But technological advances, such as antibiotics and improved sanitation, have freed us from the prevalence of such plagues in the past. We may romanticize the past, but until fairly recently, most of humanity lived extremely fragile lives. Many people still live in this precarious way, which is one reason to continue technological progress and the economic enhancement that accompanies it. Should we tell the millions of people afflicted with devastating conditions that we are canceling the development of all bioengineered treatments because there is a risk that these same technologies may someday be used for malevolent purposes? Most people would agree that such broad-based relinquishment is not the answer.

THE RELINQUISHMENT ISSUE. Relinquishment at the right level is part of a responsible and constructive response to these genuine perils. The issue, however, is: At what level are we to relinquish technology? Ted Kaczynski (the Unabomber) would have us renounce all of it. This is neither desirable nor feasible. McKibben takes the position that many people now have enough wealth and technological capability and should not pursue more. This ignores the suffering that remains in the human world, which continued technological progress could alleviate.

Another level would be to forego certain fields (such as nanotechnology) that might be regarded as too dangerous. But such sweeping strokes of relinquishment are untenable. Nanotechnology is the inevitable result of the persistent trend toward miniaturization that pervades all of technology. It is not a single centralized effort, but is being pursued by a myriad of projects with many goals.

Kaczynski argued that modern industrial society cannot be reformed because technology is a unified system in which all parts are dependent on one another. It is not possible to get rid of the "bad" parts of technology and retain only the "good" parts. He cited modern medicine as an example, arguing that progress depends on several scientific fields and advancements in high-tech equipment. Kaczynski was correct on the deeply entangled nature of the benefits and risks, but his overall assessment of the relative balance between the two was way off. Joy and I both believe that technology will and should progress, and that we need to be actively concerned with the dark side. Our dialogue concerns the granularity of relinquishment that is feasible and desirable. Abandonment of broad areas of technology will only push them underground where development would continue unimpeded by ethics and regulation. In such a situation, it would be the less-stable, less-responsible practitioners who would have all the expertise.

One example of relinquishment at the right level is the proposed ethical guideline by the Foresight Institute that nanotechnologists agree to relinquish the development of physical entities that can self-replicate in a natural environment. Another is a ban on self-replicating physical entities that contain their own codes for self-replication. Such entities should be designed to obtain codes from a centralized secure server, which would guard against undesirable replication. This "broadcast architecture" is impossible in the biological world, which represents one way in which nanotechnology can be made safer than biotechnology. Such "fine-grained" relinquishment should be linked to professional ethical guidelines, oversight by regulatory bodies, the development of technology-specific "immune" responses, as well as computer assisted surveillance by law enforcement agencies. Balancing privacy rights with security will be one of many challenges raised by some new nanotechnologies.

Computer viruses serve as a reassuring test case in our ability to regulate nonbiological self-replication. At first, concerns were voiced that as they became more sophisticated, software pathogens had the potential to destroy computer networks. Yet the "immune system" that has evolved in response to this challenge has been largely effective. Although self-replicating software entities do cause damage from time to time, no one would suggest we do away with computers and the Internet because of software viruses. This success is in a highly productive industry in which there is no regulation, and no certification for practitioners.

DEFENSIVE TECHNOLOGIES AND THE IMPACT OF REGULATION. Arguments such as McKibben's for relinquishment have been influential because they paint a picture of future dangers as if they were released into an unprepared world. But the sophistication and power of our defensive technologies and knowledge will grow along with the dangers. When we have "gray goo" (unrestrained nanobot replication), we will also have "blue goo" ("police" nanobots). We cannot say with assurance that we will successfully avoid all misuse. We have been able to largely control harmful software virus replication because the requisite knowledge is widely available to responsible practitioners. Attempts to restrict this knowledge would have created a far less stable situation.

The present challenge is self-replicating biotechnology. By reprogramming the information processes that lead to and encourage disease and aging, we will have the ability to overcome these afflictions. However, the same knowledge can also empower a terrorist to create a bioengineered pathogen.

Unlike biotechnology, the software industry is almost completely unregulated. Although bioterrorists do not need to put their "innovations" through the FDA, scientists developing defensive technologies are required to follow regulations that slow innovation. It is impossible under existing regulations and ethical standards to test defenses to bioterrorist agents on humans. Animal models and simulations will be necessary in lieu of infeasible human trials, but we will need to go beyond these steps to accelerate the development of defensive technologies.

We need to create ethical and legal standards and defensive technologies. It is quite clearly a race. In the software field the defensive technologies have remained ahead of the offensive ones. With extensive regulation in the medical field slowing down innovation, this may not happen with biotechnology.

There is a legitimate need to make biomedical research as safe as possible, but our balancing of risks is skewed. The millions of people who need biotechnology advances seem to carry little political weight against a few well-publicized casualties from the inevitable risks of progress. This equation will become even starker with the emerging dangers of bioengineered pathogens. We need a change in public attitude in terms of tolerance for necessary risk.

Hastening defensive technologies is vital to our security. We need to streamline regulatory procedures to achieve this. However, we also need to greatly increase our investment explicitly in defensive technologies. In the biotechnology field, this means the rapid development of antiviral medications.

The comparable situation will exist for nanotechnology once replication of nano-engineered entities has been achieved. We will soon need to invest in defensive technologies, including the creation of a nanotechnology-based immune system. Such an immune system may itself become a danger, but no one would argue that humans would be better off without an immune system because of the possibility of autoimmune diseases. The development of a technological immune system for nanotechnology will happen even without explicit efforts to create one.

It is premature to develop specific defensive nanotechnologies as long as we have only a general idea of the threat. However, there is a dialogue on this issue, and expanded investment in these efforts should be encouraged. The Foresight Institute, for example, has devised a set of ethical standards and strategies for assuring the development of safe nanotechnology. They are likely to be effective with regard to preventing accidental release of dangerous self-replicating nanotechnology entities. But the intentional design and release of such entities is more challenging.

Conclusion

Protection is not impossible, but we need to realize that any level of protection will only work to a certain level of sophistication. We will need to continue to advance the defensive technologies and keep them ahead of the destructive technologies. The challenge of self-replication in nanotechnology impels us to continue the type of study that the Foresight Institute has initiated. With the human genome project, three to five percent of the budget was devoted to the ethical, legal, and social implications (ELSI) of the technology. A similar commitment for nanotechnology would be appropriate and constructive. Science and technology will remain double-edged swords, and the story of the twenty first century has not yet been written. We have no choice but to work hard to apply these quickening technologies to advance our human values, despite what often appears to be a lack of consensus on what those values should be.

BIBLIOGRAPHY

Drexler, Erik K. (1986). *Engines of Creation*. Garden City, NY: Doubleday.

Drexler, Erik K. (1992). *Nanosystems: Molecular Machinery, Manufacturing, and Computation*. New York: Wiley.

Freitas, Robert, Jr. (1999). *Nanomedicine*. Vol. 1: *Basic Capabilities*. Georgetown, TX: Landes Bioscience.

Joy, Bill. (2000). "Why the Future Doesn't Need Us." *Wired*262.

Kurzweil, Ray. (1999). *The Age of Spiritual Machines: When Computers Exceed Human Intelligence*. New York: Viking.

Kurzweil, Ray. (2005). *The Singularity Is Near: When Humans Transcend Biology*. New York: Viking.

McKibben, Bill. (2003). *Enough: Staying Human in an Engineered Age*. New York: Henry Holt.

RECOGNIZING THE STRUCTURAL FEATURES OF NEW TECHNOLOGIES

HANS LENK

• • •

Any assessment of the ethical issues associated with new technologies must take into account their special structural features. Single-factor theories of technology, highlighting just one trait (such as the domination of nature), are insufficient for grasping the multiple levels and aspects of contemporary technologies or technological societies. This is all the more true in what I have analyzed since the 1970s as our information-and-systems technological era, with its ever more tightly coupled systems and relationships between systems, the linking of information in global networks, and the comprehensive management of technologies in organizational systems defined in terms of abstract procedures and formalized functions.

Traditional analyses have described technologies as human organ projections, sensorimotor skills, applied science, efficient action, the pursuit of power, the physical realization of ideas, and more. (Mitcham 1994 provides one review of such traditional definitions.) In each case the attempt was to identify something "essential." But such one-factor descriptions apply only to some limited aspect of any technology, and fail to appreciate the spectrum of diverse elements now involved. Although traditional analyses may continue to be useful, they are more and more embedded in new trends along with their social, intellectual, material, and ecological contexts. Analyses of the structural features of new technologies oriented toward an ethical assessment would thus do well to consider at least the following emerging and interrelated traits.

1. Operations, Procedures, and Processes

Technology is not comprised only of machines, instruments, and other technical products. Instead there is a growing orientation toward technological processes, operations, and procedures. Process control and managerial phenomena are key features of modern technological and industrial production. This extends an earlier trend in which energy-transforming machines and systems became widespread in assembly-line production. More recently, "the real is the process" has become a characteristic feature of technologies.

2. Systematic Methods and Methodologies

Not only methods but also methodologies are increasingly essential. This trend is found in all science-based technological developments as well as in administration. Such trends increasingly characterize fields that have been captured by operations technologies such as process controls, systems engineering, and operations research.

3. Informatization, Abstraction, Formalization

Computerization and informatization, along with the use of formal and functional operations technologies such as flowcharts and network analyses, create increasingly comprehensive processes, organizations, and interrelations. (One example: the manufacturing–inventory–sales chains characteristic of retail giants.)

4. Systems Engineering and Technology

Different technical realms, including engineering and economics, are increasingly related by means of systems engineering and technology. This creates a positive feedback loop in which initial interactions promote the development of further and more thoroughgoing interactions.

5. Options Identifications Precede Problem Formulations and Needs Generation

In research and development (R&D), systems characteristics have been apparent for some time. R&D work systematically inventories and then exploits potentials, possibilities, and options (see Klages 1967). Only after having identified several products or processes by means of systematic research will investigators formulate a problem to be addressed or discover a new "need" that can be met by the already achieved technological development. In such cases the technological solution or invention precedes the problem or need. (This reversal was already anticipated by Karl Marx in the nineteenth century.)

6. Interdisciplinarity

Interdisciplinarity is promoted by spillovers from one science to another science, and from there to technological invention, innovation, and application—in both the laboratory and society at large. Interdisciplinary interactions are increasingly embedded in developmental processes. Systems technologies require practical interdisciplinarity.

7. Artificiality

The human world is increasingly shaped by technogenic relationships, properties, and artifacts to such an extent that it itself takes on the character of the artificial. The "second nature" or "symbolic universe" described by the German philosophers Helmut Plessner (1892–1985), Arnold Gehlen (1904–1976), and Ernst Cassirer (1874–1945) has now become a *technological* second nature. Moreover, this technologically enacted second nature is characterized by information networks of ever-greater extent and impact. Media technicalize a kind of second-hand reality, which becomes the socially real reality.

8. Virtuality

Humans now experience the virtualization of the artificial and symbolic worlds through information technologies, as well as by means of images and models and the related interpretations they superimpose on real life.

9. Multimedia

Systematic accumulations of technomedia yield multimedia. The manifold technicalizations of the symbolic, of virtual representations and their respective interpretations, lead to a kind of *coaction* or *coevolution* of diverse information technologies and media. There is a progressive universality and commonality of impact as well as systems integration. Humans find themselves increasingly living in a multiple-mediated technogenic world impregnated by multimedia—in short, in a multimedia technoworld.

10. Simulations

Computer hardware, software, and other successful efforts to improve and optimize the relevant information models by way of programming and computer-graphic constructions provide rapid, efficient, and inexpensive simulated solutions to all kinds of design and construction tasks. This includes scientific modeling, as in molecular design, and the technical development and construction of new machines, processes, and systems in the narrow sense.

The computer has turned out to be a universal, easily employable, and representative "can-do-anything" instrument that can identify variable routes for technical and nontechnical action, each described in terms of alternative materials and energy costs. Trial-and-error learning and physical work is reduced to a minimum when models are simulated in advance without real risks.

11. Flexibility

Computerized models allow the virtually risk-free simulation and testing of all kinds of hypotheses, inventions, and constructions in advance. This is generally if not universally true for models in science, planning, and administration. Systems organizing and management are rendered more flexible and variable than in the past.

12. Modularity

In a movement that began with the standardization of interchangeable parts, technology is often structured around modules, functional building blocks, and functionally integrated units. One good example is integrated circuits or microprocessors, which can be inserted by way of open interfaces into larger modules or systems. Such structures promote not only replaceability of obsolete or failed parts but also technical progress as a new peripheral (such as a video display or printer) is purchased to replace an old one or software programs are themselves continuously enhanced with updates.

13. User-Friendliness

New technologies have gradually become more user-friendly, more anthropomorphic in their reactions, often displaying a self-explanatory design that minimizes or even eliminates the need for technical manuals or instruction. One example is the context-dependent help menu in a computer application package. Another is the automated external defibrillator, which when placed on a person's chest can identify sudden cardiac arrest and then voices instructions for use to a responder.

14. Remote Control and Intelligent Sensing

New electronic and multimedia technologies allow remote control and intelligent sensing at a distance or in inaccessible environments. Intelligent sensing involves systems that mimic human senses such as sight, smell, or taste. When coupled with remote control technologies, intelligent sensing allows robot manipulation in nuclear plants or outer space. These devices multiply manipulative and technological power in extension and scope. Intelligent sensing can also involve the creation of "smart technologies" such as buildings that monitor their own structural characteristics.

15. Robotization

Robotization is proliferating and becoming widely disseminated in all fields of technology-guided production.

16. Smart Technology and Systems Autonomy

Feedback control and "intelligent decision-making" techniques and procedures are being introduced not only in sensing and remote control instrumentation, but in a plethora of machines, creating a kind of flexible systems autonomy. (Such developments simply extend a trajectory that can be traced back to the replacement of meters and gauges with warning lights, sometimes coupled with automatic control mechanisms. In some airplanes if a human being tries to override an automatic pilot when it is not safe to do so, the automatic pilot will continue to exercise control.)

17. Meta-autonomy

In the designing, constructing, and monitoring of machines, programs, or technological and organizational systems, there is a tendency to eliminate human interference. Machines can be used to build other machines or to check lower-level machines. It is increasingly programs that control and check machines, and programs that check programs. In effect this involves a meta-level technicalization in terms of a higher-order self-applicability of overarching abstract procedures and programs. This may be described as a sort of "reflexive" or "self-referential" applicability leading to what might be termed "meta-feasibility" or "meta-functionality" with regard to models and metamodels.

18. Computerization and Multifunctionality

Universal machines such as the computer provide a kind of abstract, software-determined processing and control. Along with techno-organizational systems, these are progressively maximizing flexibility, speed, smart machine autonomy, modularity, and more.

19. Mega-information Systems

There is a tendency to conceive of the world as a technology-dominated, manipulatable organization shaped by technosystems. Ecosystems and social systems come to be conceived as subordinate to techno-ecosystems or eco-technosystems and sociotechnical systems, respectively. The trend is toward thinking in terms of mega-information systems or a mega-world machine dependent on the meta-functionality of technological and operational processing or the multiple applicability of machines, processes, and programs.

20. Globalization

The overwhelming global success of technology and the technicalization of almost everything leads to a new technogenic world unity—one that is integrated technologically and informationally and is interactive. Increasingly humans live in a media-electronic global village. Technology appears to take on the character of a fate or destiny, with human survival appearing to be increasingly dependent on technological, social, political, and ecological change. This change or progress thus exhibits its own inner orientations and momentum.

21. Telematization

Telematization, in which everything is ubiquitously present (24/7/365), gives rise to locally separated but functionally coordinated teams working on giant virtual projects, designs, or networks.

22. Information-Technological Historicity

Information technology development has a history. The history of information systems, expert systems, and computerized decision-making systems designed, developed, and controlled by diverse agents mirrors the development of the notion of system itself. *Quod non in systemis non in realitate* (What is not in the systems is not real).

23. Intermingling and Interdependence

The systematized, interdisciplinary, functional integration and interrelation of activities in all aspects of the human lifeworld are weaving together mutual dependencies. These dependencies are at the same time susceptible to informational and operational manipulations, including economic manipulations. (Manipulation, however, does not always equal control. Interdependencies often have their own characteristics that will be asserted as unintended consequences when they are not acknowledged or respected.)

24. Sociotechno-systems

Nature and nurture are interdependent. Systems orientation, systems engineering, and the establishment and maintenance of sociotechnical systems all point toward an inseparable, indissoluble social systems complex characterized by ever-growing, accelerating, and ever-more encompassing technologies. One might even talk of socio-eco-techno systems.

25. Systems-Technocratic Tendencies

Systems-technocratic tendencies will gain in significance. Contemporary political, cultural, and human problems are increasingly conceived in systems-technological terms. But within systems-technological approaches to problems there lurk systems-technocratic dangers. (See entry on *Technocracy*.)

26. Data Protection

With information technologies, social and legal problems of data protection and privacy acquire new urgencies. This urgency carries over as well to concerns for protection of the integrity and dignity of the human person, respect for human values, and even reflection on what it means to be human.

27. Unforeseeable Risks

Technological systems are susceptible to risks that are often in principle not able to be foreseen. Increasing complexities in technological systems and the variability of human responses make predictions difficult if not impossible over certain distances and time frames. The persistence of risk within well-designed systems is illustrated by such simple occurrences as repeatedly occurring electrical blackouts in large metropolitan areas. Some technologically engendered dangers such as radioactivity may even go unobserved by most people who are affected.

28. Miniaturization

The trajectory of technological miniaturization in both part and whole of processes, products, and systems produces another kind of achievement and challenge: the "chipification" of things and functions or, ironically, above almost everything. From microsystems to nanotechnology these trends bring about new levels of manipulability and new degrees of difficulty in understanding and management.

29. Impacts Multiplication

Systems and information technologies multiply both positive and negative impacts, successes and failures. With the nearly unimaginable explosion of human technological powers through the vast extension of energy technologies and information systems, direct and indirect consequences, both successes (domination and control) and failures (accidents, "normal" or otherwise), pose extraordinary problems. They appear to exceed the human grasp, in literal as well as figurative senses.

30. Distributed Responsibility

Who bears responsibilities within ever-extended technological systems? The enlarged powers of multiple-distributed technological systems—systems that in some instances such as the Internet have become global—pose challenging ethical questions. How is it possible to deal with, divide up, or share responsibility in or for such systems? Responsibilities for general systems phenomena, for the detailed consequences of technological entanglements, and even for individual decision-making at strategic points within system contexts are not properly borne by individuals within current legal and moral frameworks. Thus many sociotechnical activities appear to evade responsible decision-making, calling forth the need to develop new forms of distributed responsibility.

As will have been apparent, this nonsystematic review of a series of structural features associated with new technologies has increasingly emphasized ethical and political issues. Perhaps it will eventually be necessary to analyze possible combinations and conditional relationships among the many characteristics mentioned here, and to investigate their associations with particular types of technology or technological fields, as well as with sociotechnical contexts and ethical problems. Such analyses could help refine many ethical and policy debates, which too often attempt to transfer an assessment from one context to another—at times even from one context in which it may well be appropriate to another in which it fails to be as genuinely relevant.

BIBLIOGRAPHY

Klages, Helmut. (1967). *Rationalität und Spontaneität* [Rationality and spontaneity]. Gütersloh, Germany: Bertelsmann.

Lenk, Hans. (1971). *Philosophie im technologischen Zeitalter* [Philosophy in the technological age], 2nd edition. Stuttgart: Kohlhammer.

Lenk, Hans. (1982). *Zur Sozialphilosophie der Technik* [Toward a social philosophy of technology]. Frankfurt am Main: Suhrkamp.

Lenk, Hans. (2003). *Grasping Reality: An Interpretation-Realistic Epistemology*. River Edge, NJ: World Scientific.

Lenk, Hans, and Matthias Maring, eds. (2001). *Advances and Problems in the Philosophy of Technology*. Münster, Germany: Lit.

Lenk, Hans, and Günter Ropohl. (1976). *Technische Intelligenz im systemtechnologischen Zeitalter* [Technical intelligence in the systems-technological age]. Düsseldorf: VDI Verlag.

Mitcham, Carl. (1994). *Thinking through Technology: The Path between Engineering and Philosophy*. Chicago: University of Chicago Press.

THE ETHICS OF EVIDENCE: A CALL FOR SYNTHESIS

VALERIE MIKÉ

As a mathematical scientist engaged in medical research in the 1970s, I became increasingly aware of the poor quality of much clinical research and the need for better assessment of medical technology. Of relevance here was the Hippocratic maxim "help or at least do no harm," the basis of the ethical tradition of Western medicine. If a treatment lacked proper evaluation, then no one could know whether it helped or harmed the patient, and that raised the question of ethics and its connection to statistics. In 1977 I organized an international symposium exploring these issues, "Medical Research: Statistics and Ethics," and articles based on the presentations were published in the journal *Science* (Miké and Good 1977). One of the editors told me that they did not, as a rule, publish conference proceedings, but this was special: "Your theme is in the air." These and related issues were further developed—and later published in book form—at a 1981 weeklong conference, at which I chaired a panel discussion addressing ethical, legal, and psychological aspects of clinical trials (Miké 1982).

A major success achieved by medical technology was the survival of smaller and smaller newborn infants. But many were impaired, and what to do about them became the subject of national debate. The issue centered on whether treatment should be withheld from some of these babies to let them die, and who should decide. Scholars in the new field of bioethics were usually trained in philosophy or law, so that questions of scientific assessment tended to be absent from the discourse. The physiology of the infants' disabilities was often poorly understood, treatments being applied had not been evaluated, and there was no reliable information on prognosis. Opposing conclusions were likely to be based on differing philosophical views of the "sanctity of life" versus the "quality of life." Ideology was taking the place of evidence.

There was also the role of social factors in disease and the outcome of treatment. A stark example concerned a tiny, premature infant at Babies Hospital at Columbia University in New York. A team of neonatal experts provided high-technology intensive care to save the child's life, and after three months and enormous expense the baby was well enough to be sent home to a nearby Harlem apartment. Later the doctors learned that the little boy died during the night when a rat chewed off his nose (Silverman 1980).

I became convinced that the problem was so broad that a new term was needed for the spectrum of related issues involving science, technology, uncertainty, philosophy, and society. Deciding on *Ethics of Evidence,* I used it for the first time in 1987 in the title of a lecture, illustrating it with the treatment of impaired newborns (Miké 1989b).

Medicine places societal concerns in sharp relief, because it is at the interface of technology and the deepest questions of human existence: the meaning of life, of suffering, and death. The Ethics of Evidence, an approach for dealing with uncertainty, had its primary focus on medicine, but was then seen to be more widely applicable. It calls for using the best possible evidence for decision-making in human affairs, in a continuous integration of the emerging results of relevant disciplines, but with recognition of the ultimately irreducible nature of uncertainty. Being well- informed and aware should form the basis of responsible action. The Ethics of Evidence—symbolized by a lighthouse—serves to provide guidance (Miké 2003).

After some general comments on the concept of evidence, this essay focuses on the uncertainties of scientific evidence. It sets the stage with the loss of certainty in mathematics itself, affecting what since ancient times had been considered self-evidently true. It sketches the scope of probability theory and statistical inference, used in the evaluation of scientific evidence. It discusses two important examples. The first one concerns evidence in a contemporary context: risk assessment. The second pertains to evidence in a historical context: evolution. This is followed by a more detailed discussion of the Ethics of Evidence. The final section addresses a long-range goal, the call for a philosophical synthesis, and presents a possible blueprint.

The relationship between statistics and ethics goes back to the late nineteenth century, to the English scientist Francis Galton (1822–1911), founder of modern statistics. Galton's work was inspired by a vision he named *eugenics*—improving the human race through controlled breeding. He championed social Darwinism and the eugenics movement, which would spread to other nations, including the United States. Forced sterilization of those deemed "socially inadequate" became legal in more than 30 states and was declared constitutional by the U.S. Supreme Court in the landmark case of Buck v. Bell (1927). Some 60,000 Americans were subjected to eugenic sterilization over the years, sanctioned by laws based on ideology and deeply flawed science (Reilly 1991).

Another area involving statistics and ethics was experimentation on humans, such as the Tuskegee Syphilis Study and other shocking medical practices reported into the 1970s. There were no pertinent laws in the United States, but at the time of the Nazi atrocities Germany already had legally binding regulations on human experimentation, issued in 1931, and these were more stringent than the subsequent Nuremberg Code (Miké 1990). Professional responsibility, the ethics of research and therapy, informed consent, and quality of proposed research were addressed in detail.

In 1974 the U.S. Congress passed the National Research Act and created a commission to propose ethical principles and guidelines for the protection of human research subjects, to be used in the development of federal regulations. In what came to be known as *The Belmont Report,* the commission identified three basic ethical principles consonant with the major traditions of Western thought: respect for persons, beneficence, and justice (U.S. National Commission 1979).

Ongoing concerns include end-of-life issues, embryo research, cloning, and the fundamental question of what it means to be human. The twentieth century made dazzling advances in science and technology, but it also produced unspeakable horrors, and it discovered the limits of scientific knowledge. To counter the pervasive skepticism of contemporary philosophy, the twenty-first century must accept the challenge of a new intellectual synthesis.

Introductory Remarks on Evidence

Evidence is defined as the data on which a judgment or conclusion may be based. In a court of law, evidence comprises the material objects and the documentary or verbal statements admissible as testimony, to be used by the jury in its verdict to convict or acquit the accused. In criminal cases the prosecution is to prove guilt "beyond a reasonable doubt," whereas in civil court "a preponderance of evidence" produced by the plaintiff is sufficient.

Evidence is often highly technical, presented by expert witnesses, and statisticians may be called to testify concerning the interpretation of empirical evidence (Gastwirth 2000). Tort cases may deal with injury due to exposure to a toxic chemical or drug, with each side offering its own supporting testimony. DNA evidence, not always clear-cut, may be decisive in a criminal trial. But scientific evidence is important in other areas, such as economic, social, and medical affairs, and as a guide in the formulation of public policy. Evidence of safety and effectiveness is critical in the use of drugs to treat or prevent disease.

Because evidence is intended to persuade others to take some action or to convince them of some belief, it has an intrinsic ethical component. Assertions that the evidence proves a claim can mislead and manipulate the uninformed. Evidence is not fixed and permanent; it is whatever is accepted as support for a conclusion by a given community (scholars, jurors, members of society) at a given point in time, and is subject to change with new developments. Statistical DNA evidence, if judged to be of acceptable quality, may exonerate someone convicted of a serious crime, even when the conviction was based on the evidence of eyewitness testimony. Eyewitnesses may identify someone in a lineup who closely resembles the perpetrator actually observed. There is always a subjective element, an element of uncertainty.

Mathematics and Uncertainty

Mathematics can be remarkably effective in the exploration of physical, measurable phenomena. But it is a creation of the human mind. Long-held beliefs about its absolute and certain nature were destroyed by discoveries made in the nineteenth and early twentieth centuries. Albert Einstein (1879–1955) stated it clearly: "As far as the laws of mathematics refer to reality, they are not certain; and as far as they are certain, they do not refer to reality" (1983 [1923], p. 28). Euclidean geometry is no longer seen as a true description of space, nor does mathematical logic claim to grasp all reality. Concurrent with these discoveries was the emergence of the theories of probability and statistics, as a way to assess observed variability and uncertainty.

THE LOSS OF CERTAINTY: NON-EUCLIDEAN GEOMETRY. In the 1820s the Hungarian mathematician János Bolyai (1802–1860) and the Russian Nikolai Lobachevsky (1793–1856) showed independently that by changing a supposedly "self-evident" postulate of Euclidean geometry another logically consistent system of geometry could be developed. This discovery dealt a fatal blow to the notion of Immanuel Kant (1724–1804) that Euclidean geometry inheres in the human mind as a priori knowledge that is necessarily true, imposed by the mind on an unknown and unknowable reality. These geometries were now seen to be human constructs, not intrinsic to the mind, applied as different models to the universe that existed "out there" and was thus observable and real.

In the Bolyai-Lobachevsky system Euclid's fifth postulate, stating that through a point in a plane only a single line can be drawn parallel to a given line, was replaced by the assumption that an infinite number of lines can be drawn through a point parallel to the given line. A few decades later the German mathematician Bernhard Riemann (1826–1866) developed another consistent geometry with the axiom that *no* line can be drawn through a point parallel to a given line—in other words, that all lines intersect. This became the basis of Einstein's general theory of relativity.

Strictly speaking, Euclidean geometry is wrong in the real world; space is curved by gravity. But for practical purposes, because the curvature is very slight even for enormous distances, it is a very good approximation. The philosophical impact of the discovery, however, was radical: For any axiom considered to be self-evidently true in an earlier age, it is wiser to say that it may not be so.

LOSING MORE GROUND: THE INCOMPLETENESS THEOREM. But the twentieth century revealed an ultimate barrier to scientific knowledge of reality. In 1931 the Austrian logician Kurt Gödel (1906–1978) proved what is known as the *incompleteness theorem:* Any consistent mathematical system that includes even as little as the arithmetic of whole numbers contains statements that cannot be proved either true or false within the system. No mathematical system can encompass all truth; there will always be some truths that are beyond it. This result precludes a full grasp by logic of all reality.

ASSESSING UNCERTAINTY: PROBABILITY AND STATISTICS. The theory of probability, with its axiomatic foundation, is a vigorous branch of modern mathematics. Statistical inference, based on probability, reached maturity in the twentieth century and is central to much of modern technology. As induction, its methods of inference pertain to the philosophy of science.

Typically, there is interest in some characteristic of a *population* from which a *representative sample* is selected. It is assumed that the identical experiment of selecting the sample can in principle be *repeated indefinitely*, such as drawing ten balls from an urn containing red and black balls (replacing each after noting its color). Statistical inference provides methods for reaching conclusions about the population from the sample, such as the proportion of red balls in the urn, with predetermined limits of *sampling error*. It is often impossible to sample the actual *target population* of interest, and there remains the difficult step of going from the population sampled to the target population. For example, a drug may be tested on patients selected in a given hospital to assess its response rate, but the target population includes all patients with the disease now and in the future. But even within the hospital, no two patients are identical, so the study has to consider factors that may affect the outcome of the trial, such as age, sex, other medical conditions, and so on. There may also be relevant factors as yet unknown. The simple model of drawing balls from an urn may be assumed by the theory, but it is rarely found in practice.

In classical statistical inference the sample is used to test, and then reject or accept (the latter, strictly speaking, should be *not reject*), a null hypothesis of interest, and confidence intervals are constructed for point estimates. The American statistician Allan Birnbaum (1923–1976) undertook studies to develop principles of *statistical evidence* in this framework (1969). Statistical evidence as part of induction, based on different interpretations of probability, is the subject of ongoing research in epistemology and the philosophy of science (Taper and Lele 2004).

Evidence in a Contemporary Context: Risk Assessment

Risk is the probability that something bad may happen. Much effort is devoted to identifying hazards in the environment and the workplace that are harmful to health, with controversial claims of evidence seeking to affect government regulation. Another area concerns the control of risk, such as the use of drugs for the prevention of disease.

RISK ASSESSMENT: VAST UNCERTAINTY. The uncertainties in the risk assessment of chemical hazards to health were explored at an international workshop held in Italy in 1998, with extensive use of real-life examples (Bailar and Bailer 1999). Uncertainty results from inaccurate and incomplete data, incomplete understanding of natural processes, and the basic ways of viewing the questions. There is uncertainty in hazard identification, exposure assessment, dose–response modeling, and the characterization and communication of risk. There is also true variability in risk across space, time, and among individuals.

Assessments of risk of the same hazard frequently differ by factors of 1,000 or more. For example, four estimates of the added lifetime risk of kidney cancer from the chemical Tris, used as a flame retardant in children's sleepwear, ranged between 7 and 17,000 per million children exposed. Random deviations of a sample from a specified model, addressed by the methods of statistics, are but a small component of uncertainty in risk assessment. In any particular case, the public needs insight into the nature of the uncertainties involved, in order to participate in meaningful discourse.

MENOPAUSAL HORMONE THERAPY: A STARTLING REVERSAL. For decades millions of postmenopausal women were routinely prescribed hormone replacement therapy (HRT), first introduced for the alleviation of menopausal symptoms, then believed to offer protection against coronary heart disease, the leading cause of death for women in most developed countries. Observational studies of HRT, as well as meta-analyses (formally combined evaluations) of these studies, had suggested a 35 to 50 percent reduction in coronary events. But carefully designed randomized clinical trials began to report, culminating in results published in 2002, not prevention, but an increased risk of heart disease, heart attacks, and stroke in HRT users, in addition to the known increased risk of breast cancer. The results indicated that about 1 percent of healthy postmenopausal women on HRT for five years would experience an excess adverse event, a substantial number when applied to the estimated 10 million American women taking hormones. Much research remains to be done, but a subsequent meta-analysis of the earlier observational studies found that HRT users differed from nonusers in important characteristics. Adjusting the data for socioeconomic status, education, and major coronary risk factors eliminated the apparent cardiac protection of HRT, the evidence that had once so firmly convinced the medical community (Wenger 2003).

Evidence in a Historical Context: Evolution

The issue here is not the fact of evolution, but the mechanism of evolution. Are random variation and natural selection sufficient to explain the origin of life and the complexity of living systems, or are there other forces driving evolution? Is there purpose or design in what is observed? Many scientists hold that Charles Darwin's theory of evolution, or a more elaborate version of it, provides a natural explanation for the existence of all living systems. Others are challenging this view, and books published by either side may contain the word *evidence* in their titles.

CLAIMS OF EVIDENCE IN OPPOSING VIEWS. A popular book on the Darwinian view is *The Blind Watchmaker: Why the Evidence of Evolution Reveals a Universe without Design* (1986), by the British zoologist Richard Dawkins, who holds a chair in the public understanding of science at Oxford University. The title refers to the argument for design in the universe by the eighteenth-century English theologian William Paley (1743–1805), who used the analogy that finding a watch would lead one to conclude that it was made by someone, that there was a watchmaker. Dawkins aims to show that evolution took place entirely by chance variation and small changes, by natural forces without purpose, so that the watchmaker is blind. But he assumes that life was already on hand, that it came from entities so simple as to require no explanation. He leaves the details of their origin to physicists, although the latter have in fact encountered high specificity in the systems of modern cosmology.

Other scientists hold that a further evolutionary structure is needed beyond variation and natural selection. Advances in the fields of biochemistry and molecular biology, as well as the new information sciences, are being used to explore the question, with explanations sought in the natural order. A still different view is presented in *Science and Evidence for Design in the Universe* (2000), by the American researchers Michael J. Behe, William A. Dembski, and Stephen C. Meyer, trained in biochemistry, mathematics, and philosophy. Analyzing the latest scientific developments, they argue that the complex specified information encountered in the cosmos, including irreducibly complex biochemical systems, cannot be generated by a chance mechanism, that there is evidence of intelligent design. If patterns are broken down into a series of steps guided by what has gone before, as in evolutionary algorithms proposed by Dawkins and others, then there is built-in purpose or predetermined design.

It is helpful here to review the methodology claiming to provide evidence.

HISTORICAL SCIENCE: INFERENCE TO THE BEST EXPLANATION. The American philosopher Charles Sanders Peirce (1839–1914) distinguished three modes of inference (Peirce 1998 [1923]). These were deduction (reasoning from general to particular), induction (reasoning from particular to general), and what he called *abduction* or *hypothesis* (reasoning from effect to cause). An example of deductive inference is proving the theorems of Euclidean geometry from its axioms. Induction includes the customary use of probability in science, where results from the observed sample can be confirmed in further experiments to describe a natural process or mechanism of action. Abduction is not directly related to probability. The cause is not observed, and the question is which of any rival hypotheses gives the best explanation of the observed effect. As historical science, exploring the origin and evolution of the universe is in this category. It occurred once in the distant past, and the aim is to explain what may have caused it to happen. Probability enters only as the chance of realization of a particular path among all possibilities in assumed evolutionary mechanisms.

Contemporary philosophers of science speak of abduction in terms of *explanatory power* or *inference to the best explanation*, with three proposed criteria. Hypothesis A is the best explanation for observed outcome B if: (1) A is consonant (consistent, in harmony) with B, (2) A adds something to the understanding of B, and (3) A adds more to the understanding of B than its rival hypotheses. Scientific naturalists consider only material hypotheses to explain the visible universe and its living systems. But because the ultimate goal is to understand all of life, the full range of human experience, others argue that it is not rational to arbitrarily exclude any viable hypotheses, including that of intelligent design.

EVIDENCE AND THE LIMITS OF SCIENTIFIC KNOWLEDGE. Caution in making claims of evidence was advised by Ronald A. Fisher (1890–1962), British pioneer of the fields of statistics and genetics and the mathematical theory of evolution. Fisher showed Gregor Johann Mendel's laws of inheritance to be the essential mechanism for Darwin's theory of evolution (Fisher 1930), but as a Christian he saw no conflict between science and his own faith. In a 1955 radio address on the BBC he referred to his own work as "the study of the mode of inheritance of the heritable characteristics of animals, plants and men" (Fisher 1974, p. 351), and spoke of the evil of misleading the public to believe that science is the enemy of religion. He urged scientists to acknowledge the limits of their own discipline:

> In order to know, or understand, better, it is necessary to be clear about our ignorance. This is the research scientist's first important step, his *pons asinorum*, or bridge which the asses cannot cross. We must not fool ourselves into thinking that we know that of which we have no real evidence, and which, therefore, we do not know, but can at

> most accept, recognizing that still we do not actually know it. (pp. 351–352)

The recurring appearance of conflict between the exact sciences and the philosophical search for truth cannot be decided in favor of either side by careless or ignorant trivialization, by attributing to the other side a simplistic conceptual framework, as is especially often the case against believers. Theology has traditionally been defined as *fides quaerens intellectum* (faith seeking understanding), and this means being open to new insights of all human endeavors, including science. As stated, for example, by Pope John Paul II (1920–2005):

> Only a dynamic relationship between theology and science can reveal those limits which support the integrity of each discipline, so that theology does not profess pseudo-science and science does not become an unconscious theology. Our knowledge of each other can lead us to be more authentically ourselves. (1988, p. M14)

To attain consensus in a pluralistic culture, it is necessary to seek common ground, common principles to serve as guide to life in a world of uncertainty.

The Ethics of Evidence

The notion of an Ethics of Evidence, proposed initially for dealing with uncertainty in medicine (Miké 1991, 1999, 2003), applies equally to other difficult issues encountered in daily life.

TWO IMPERATIVES OF THE ETHICS OF EVIDENCE. The Ethics of Evidence can be expressed in two simple rules or imperatives. The first imperative calls for the creation, dissemination, and use of the best possible evidence for decision-making in human affairs. Complementing it, the second imperative focuses on the need to increase awareness of, and come to terms with, the extent and ultimately irreducible nature of uncertainty.

Evidence here means the information obtained and interpreted by the highest standards of scholarship in each relevant field, with the minimal requirement of internal logical consistency. It allows for diverging views within a field, as there is a range of uncertainty, but the points of divergence should be clear. It assumes a philosophy of realism, the conceptual framework of the scientist, who believes in an external world of order that is accessible to human inquiry. It differentiates between two kinds of uncertainty: *Scientific uncertainty*, essentially dynamic, constantly changing with progress in research, but never fully eliminated, because of intrinsic limitations of the scientific method; and *existential uncertainty*, also invariably present, because the question of ultimate meaning, the deepest mystery, is beyond the scope of science.

Evidence is complex and fragile. Proof by experiment covers little beyond the laws of physics. Mathematical models may not apply to reality, and even the logic of mathematics is limited in its scope. Standards for proof of causation vary by field, and it is the consonance of data from diverse sources that provides the strongest evidence.

INVOLVEMENT OF VARIOUS DISCIPLINES. Affirming the complexities of dealing with uncertainty, research in cognitive psychology has shown that intuitive judgments do not follow the laws of probability; people tend to be overconfident in their conclusions (Kahneman, Slovic, and Tversky 1982). Findings in cognitive neuroscience suggest that emotion is an integral part of the reasoning process (Damasio 1994).

Positivist views of objectivity in science were challenged by the physical chemist Michael Polanyi (1891–1976), who turned to philosophy to develop his concept of *personal knowledge*, the vast domain of tacit assumptions, perceptions, and commitments of the persons who hold it (Polanyi 1958). Science must be consistent with the evidence, but the ultimate commitment is that of personal judgment. Hungarian-born like Polanyi, the mathematician George Polya (1887–1985) gained recognition for his skill in sharing insight into the heuristics of plausible reasoning (Polya 1954).

Relevant to contemporary social upheavals is the thought of Viktor E. Frankl (1905–1997), founder of the so-called third Viennese school of psychotherapy (after those of Sigmund Freud and Alfred Adler). Frankl's approach, called logotherapy (after *logos,* the Greek concept of rational principle), was derived from his vast experience as a psychiatrist and as survivor of concentration camps in World War II (Frankl 1992). He held that the search for meaning is the basic motivation of human life. Frankl saw the *existential vacuum* of present times—a pervasive lack of purpose or meaning—as the major cause of the triple plague afflicting society, that of depression, aggression, and addiction. These insights, too, need to be considered in analyzing the troubling issues of the day.

Without a critical attitude to empirical data and insight into the nature of science and evidence, the public is vulnerable to manipulation by special interest groups and the market. The many conflicts of interest and misleading reports in the media, often with improper use of statistics, have been well documented by sociologists and others (Best 2001). Professionals with a poor understanding of statistical concepts may agitate with false charges (Miké 1989a).

An example of a complex problem in need of impartial discussion of the evidence from a variety of sources is that of abortion. Confrontational bandying of slogans for a generation has not resolved the national debate, a standard feature of political campaigns and perhaps the most divisive issue in American society.

The Ethics of Evidence urges focus on what is known about the subject or calls for further study, without the barrier of ideology. What does biomedical science know about the human embryo, from its origin as a single cell? Can direct visualization of the developing organism by contact embryoscopy be made widely available to the public? What are the demographics of the women having abortions? Why do women have abortions? Are many of them pressured into the decision by others? What are the economic issues involved for the women and the abortion industry? What is known about the long-term consequences of abortion? Scholarly research addressing these and related questions by the relevant disciplines could be reported by the mainstream media, including prime-time television, on a regular basis. Given that 45 million abortions have been performed in the United States since the procedure was legalized in 1973, a great deal of source material is available. Objective and ongoing presentation of the best available evidence, with emphasis on quality and completeness, would encourage open discussion and informed judgments by all concerned, especially the young who have not as yet taken sides in the debate.

OVERVIEW. The Ethics of Evidence is a means of consciousness-raising, of urging society to examine all aspects of vexing issues, to be wary of facile claims of evidence, to recognize conflicts of interest. It is consistent with the accepted norms of science that include intellectual integrity, objectivity, doubt of certitude, tolerance, and communal spirit (Miké 1999). More generally, the Ethics of Evidence is supported by the principles of honesty and literacy. No one would question the ideal of honesty, of telling the truth and being trustworthy. But a democratic society must also strive to be a literate, well-informed society, and this includes scientific literacy, with insight into the scope of science and its methods of inference. The Ethics of Evidence implies responsibilities for professionals as well as the public, and a central role for education. Looking to the future, it calls for the creation of a new philosophical synthesis as a central challenge of the twenty-first century.

Toward a Philosophical Synthesis

René Descartes (1596–1650) chose *thought* as the first principle of his philosophy. The discoverer of analytic geometry, he saw in the absolute certainty of mathematics a way to impose the certainty of rational knowledge on all reality. Descartes, a brilliant dreamer, did not know about non-Euclidean geometry (not discovered for another 200 years) or the incompleteness theorem of mathematics (not discovered for another 300). What crystallized in his mind as the first principle, his famous *Cogito, ergo sum* (I think, therefore I am), would lead to rationalism, and had already been analyzed by Saint Augustine of Hippo (354–430) in four of his books. Both used it to counter the skepticism of their age and to develop an ontological argument for the existence of God. But unlike Descartes, Augustine did not adopt the principle as the basis of a philosophical system.

A different perspective was proposed by the French philosopher and medieval scholar Étienne Gilson (1884–1978). In 1936 Harvard University marked the 300th anniversary of its founding, and as part of the celebration Gilson was invited to be a visiting professor. He accepted the lectureship named in memory of William James (1842–1910), the founder of American pragmatism, and his lectures were published in 1937 as *The Unity of Philosophical Experience*.

Gilson sees the unity of philosophical experience in the persistent search for a first principle, by a naturally transcendent human reason, to explain what is given in sense experience. He argues that the many previous attempts in the history of Western philosophy eventually failed, because philosophers took a part of the system for the first principle. He holds that the first principle of human knowledge is *being*, and it therefore has to be the first principle of metaphysics.

Gilson insists: "Man is not a mind that thinks, but a being who knows other beings as true, who loves them as good, and who enjoys them as beautiful" (1999 [1937], p. 255). In the search for philosophical synthesis, he is not suggesting some new system of tomorrow or the reviving of some old system of the past:

> The three greatest metaphysicians who ever existed—Plato, Aristotle and St. Thomas Aquinas—had no system in the idealistic sense of the word. Their ambition was not to achieve philosophy once and for all, but to maintain it and to serve it in their own times, as we have to maintain it and to serve it in our own. For us, as for them, the great thing is not to achieve a system of the world as if being could be deduced from

> thought, but to relate reality, as we know it, to the permanent principles in whose light all the changing problems of science, of ethics and of art have to be solved. (p. 255)

This philosophy of realism is for Gilson a continuous process, a constant analysis of experience:

> A metaphysics of existence cannot be a system wherewith to get rid of philosophy; it is an always open inquiry, whose conclusions are both always the same and always new, because it is conducted under the guidance of immutable principles, which will never exhaust experience, or be themselves exhausted by it. For even though, as it is impossible, all that which exists were known to us, existence itself would still remain a mystery. (pp. 255–256)

BIBLIOGRAPHY

Bailar, John C., III, and A. John Bailer. (1999). "Risk Assessment—The Mother of All Uncertainties: Disciplinary Perspectives on Uncertainty in Risk Assessment." In *Uncertainty in the Risk Assessment of Environmental and Occupational Hazards: An International Workshop*, ed. A. John Bailer, Cesare Maltoni, John C. Bailar III, et al. New York: New York Academy of Sciences.

Behe, Michael J.; William A. Dembski; and Stephen C. Meyer. (2000). *Science and Evidence for Design in the Universe*. San Francisco: Ignatius Press.

Best, Joel. (2001). *Damned Lies and Statistics: Untangling Numbers from the Media, Politicians, and Activists*. Berkeley and Los Angeles: University of California Press. Incisive commentary by a sociologist.

Birnbaum, Allan. (1969). "Concepts of Statistical Evidence." In *Philosophy, Science, and Method: Essays in Honor of Ernest Nagel*, ed. Sidney Morgenbesser, Patrick Suppes, and Morton White. New York: St. Martin's Press.

Damasio, Antonio R. (1994). *Descartes' Error: Emotion, Reason, and the Human Brain*. New York: Putnam.

Dawkins, Richard. (1986). *The Blind Watchmaker: Why the Evidence of Evolution Reveals a Universe without Design*. New York: Norton.

Einstein, Albert. (1983 [1923]). "Geometry and Experience." In his *Sidelights on Relativity*. New York: Dover. Brief article, based on a talk addressed to a general audience.

Fisher, R. A. (1930). *The Genetical Theory of Natural Selection*. Oxford: Clarendon Press; 2nd edition, New York: Dover, 1958. A classic work integrating Mendelian genetics with Darwin's theory of evolution.

Fisher, R. A. (1974). "Science and Christianity: Faith Is Not Credulity." In *Collected Papers of R. A. Fisher*, Vol. 5 (1948–1962), ed. J. H. Bennett. Adelaide, Australia: University of Adelaide. A 1955 talk given in London on BBC radio.

Frankl, Viktor E. (1992). *Man's Search for Meaning: An Introduction to Logotherapy*, 4th edition. Boston: Beacon Press. Originally published in German as *Ein Psycholog erlebt das Konzentrationslager*, 1946.

Gastwirth, Joseph L., ed. (2000). *Statistical Science in the Courtroom*. New York: Springer. A collection of essays by statisticians experienced in giving court testimony.

Gilson, Étienne. (1999 [1937]). *The Unity of Philosophical Experience*. San Francisco: Ignatius Press. Analysis of the history of Western philosophy with a proposed new philosophical synthesis.

Goldstein, Rebecca. (2005). *Incompleteness: The Proof and Paradox of Kurt Gödel*. New York: Norton. A biography of Gödel, with explanation of his famous theorem for the general reader.

Hacking, Ian. (2001). *An Introduction to Probability and Inductive Logic*. Cambridge, UK: Cambridge University Press. Introductory textbook for students of philosophy, explaining different interpretations of probability, with examples from everyday life.

Hayes, Zachary. (2001). *The Gift of Being: A Theology of Creation*. Collegeville, MN: Liturgical Press. A concise introduction to the relationship between modern science and Christian theology, written for the general reader.

John Paul II, Pope. (1988). "Message of His Holiness Pope John Paul II to Conference Participants." In *Physics, Philosophy, and Theology: A Common Quest for Understanding*, ed. Robert J. Russell, William R. Stoeger, and George V. Coyne. Vatican City: Vatican Observatory. Delivered at a Vatican conference marking the 300th anniversary of the publication of Isaac Newton's *Philosophiae Naturalis Principia Mathematica*.

Jones, James H. (1981). *Bad Blood: The Tuskegee Syphilis Experiment*. New York: Free Press. Study sponsored by the U.S. Government, in which 400 black sharecroppers afflicted with syphilis, but not told they had the disease, were kept under observation without treatment, even after penicillin became widely available.

Kahneman, Daniel; Paul Slovic; and Amos Tversky, eds. (1982). *Judgment under Uncertainty: Heuristics and Biases*. Cambridge, UK: Cambridge University Press.

Kline, Morris. (1980). *Mathematics: The Loss of Certainty*. New York: Oxford University Press. Historical analysis of the fundamental changes in the understanding of the nature of mathematics.

Miké, Valerie. (1982). "Clinical Trials: Exploring Ethical, Legal, and Psychological Issues" (panel discussion). In *Statistics in Medical Research: Methods and Issues, with Applications in Cancer Research*, ed. Valerie Miké and Kenneth E. Stanley. New York: Wiley.

Miké, Valerie. (1987). "Saving Money and Improving Health by Evaluating Medical Technology." *Technology Review* 90(3): 22–25.

Miké, Valerie. (1989a). "Philosophers Assess Randomized Clinical Trials: The Need for Dialogue." *Controlled Clinical Trials* 10(3): 244–253.

Miké, Valerie. (1989b). "Toward an Ethics of Evidence—and Beyond: Observations on Technology and Illness." *Research in Philosophy and Technology* 9: 101–113.

Miké, Valerie. (1990). "Ethics, Evidence, and Uncertainty." *Controlled Clinical Trials* 11(3): 153–156.

Miké, Valerie. (1991). "Understanding Uncertainties in Medical Evidence: Professional and Public Responsibilities." In *Acceptable Evidence: Science and Values in Risk Management*, ed. Deborah G. Mayo and Rachelle D. Hollander. New York: Oxford University Press.

Miké, Valerie. (1992). "Quality of Life Research and the Ethics of Evidence." *Quality of Life Research* 1: 273–276.

Miké, Valerie. (1999). "Outcomes Research and the Quality of Health Care: The Beacon of an Ethics of Evidence." *Evaluation & the Health Professions* 22(1): 3–32. Commentary in the same issue by Edmund D. Pellegrino, "The Ethical Use of Evidence in Biomedicine," pp. 33–43.

Miké, Valerie. (2003). "Evidence and the Future of Medicine." *Evaluation & the Health Professions* 26(2): 127–152.

Miké, Valerie, and Robert A. Good. (1977). "Old Problems, New Challenges." *Science* 198(4318): 677–678. Introduction to the Birnbaum Memorial Symposium "Medical Research: Statistics and Ethics." Issue contains articles based on symposium lectures.

Miké, Valerie; Alfred N. Krauss; and Gail S. Ross. (1993). "Neonatal Extracorporeal Membrane Oxygenation (ECMO): Clinical Trials and the Ethics of Evidence." *Journal of Medical Ethics* 19(4): 212–218.

Nuremberg Code. (1949). *Trials of War Criminals before the Nuremberg Military Tribunals under Control Council Law* 10(2): 181–182. Washington, DC: U.S. Government Printing Office.

Paley, William. (1802). *Natural Theology; or, Evidences of the Existence and Attributes of the Deity, Collected from the Appearances of Nature*. London: Faulder.

Peirce, Charles Sanders. (1998 [1923]). "Deduction, Induction, and Hypothesis." In *Chance, Love, and Logic: Philosophical Essays*. Lincoln: University of Nebraska Press.

Polanyi, Michael. (1958). *Personal Knowledge: Towards a Post-Critical Philosophy*. Chicago: University of Chicago Press.

Polya, George. (1954). *Mathematics and Plausible Reasoning, Vol. 2: Patterns of Plausible Inference*. Princeton, NJ: Princeton University Press.

Silverman, William A. (1980). *Retrolental Fibroplasia: A Modern Parable*. New York: Grune and Stratton. Author was director of the neonatal intensive care unit at Columbia University in New York.

Reilly, Philip R. (1991). *The Surgical Solution: A History of Involuntary Sterilization in the United States*. Baltimore: Johns Hopkins University Press.

Taper, Mark L., and Subhash R. Lele, eds. (2004). *The Nature of Scientific Evidence: Statistical, Philosophical, and Empirical Considerations*. Chicago: University of Chicago Press. Collection of essays on scientific evidence based on different interpretations of probability, using ecology as the illustrative science.

U.S. National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research. (1979). *The Belmont Report: Ethical Principles and Guidelines for the Protection of Human Subjects of Research*. Washington, DC: U.S. Department of Health, Education, and Welfare.

Wenger, Nanette K. (2003). "Menopausal Hormone Therapy and Cardiovascular Protection: State of the Data, 2003." *Journal of the American Medical Women's Association* 58(4): 236–239.

TOWARD AN ETHICS OF SCIENCE AND TECHNOLOGY AS KNOWLEDGE

CARL MITCHAM
ROBERT FRODEMAN

• • •

A central feature of science and technology is their character as knowledge. Not only is science commonly described as both cognitive activity and a body of knowledge, but technological power has become increasingly knowledge-dependent. Unlike power, knowledge is often judged an unqualified good. But in a world in which technoscientific knowledge offers along side its manifest benefits unparalleled opportunities for destructive utilization, and in which individuals are increasingly challenged to come to terms with scientific and technological perspectives on the natural world and themselves, the moral status of knowledge deserves substantive consideration.

Knowledge Questions

Knowledge has been defined since Plato as "justified true belief," that is, as true opinion with reason or *logos* (*Theatetus* 201d–210d). Epistemology or the theory of knowledge examines what counts as the reasoning that can convert true opinion (which may be quite accidental) into knowledge. Does epistemic rationality require reference to empirical data, systematic coherence, covering laws, or what?

Precisely because of its various possible justifications, knowledge comes in many forms. Bertrand Russell (1910), for instance, distinguished knowledge by description (scientific propositions) and knowledge by acquaintance (including technical know how). In relation especially to science and technology each type raises ethical as well as epistemological issues that have seldom been addressed in standard philosophical discussions. Is it not possible for certain types of propositional knowledge or their pursuit to distract human beings from more important activities and ends? Might not knowledge by acquaintance be ethically or politically problematic?

The first question has been broached on the margins of philosophy in information science and knowledge management. These contemporary disciplines have, for instance, examined the relations between data, information, knowledge, and wisdom—distinctions first suggested by the poet T. S. Eliot in "Chorus from *The Rock*" (1934). Economist and diplomat Harland Cleveland (1982) and operations research scientist Russell Ackoff (1989) have each proposed different versions of these distinctions that highlight how knowledge and understanding can be obscured by data or information.

The second question has been raised in relation to forms of knowledge as diverse as nuclear engineering and genetic screening. For the master inventor of the atomic bomb, J. Robert Oppenheimer (1947), "In some sort of crude sense which no vulgarity, no humor, no overstatement can quite extinguish, the physicists have known sin." For philosopher Ruth Chadwick (1997), information about genetic abnormalities constitutes a kind of knowledge that patients may have a "right not to know" in order to lead their lives without excessive worry. How did it come about that knowledge, which has so often been seen as a pristine virtue, is now manifest in the contemporary world as both benefit and burden?

Historical Emergence

Reflection on the role of knowledge in society goes back to the origins of European civilization. Pre-Socratic philosophers were largely concerned with the natural world, but by the mid-fifth century B.C.E. this had changed. According to Plato, Socrates suggested that he could learn little of human importance from nature (*Phaedrus* 230d), and in the *Republic* he set up a keen tension between knowledge and politics.

The *Republic* begins with an account of the various ways societies can be governed: through violence, religious authority, tradition, or discursive rationality. The first three play an inevitable role in society. Governments must possess a monopoly over violence, while religious authority and tradition provide the guidance needed to establish social norms. Plato is nevertheless often interpreted as launching the West on a 2500 year trajectory to progressively free rationality from the constraints imposed by these other approaches, a process of disengagement that reached apotheosis in the Enlightenment. In the dialogues, however, Plato repeatedly emphasizes the tension between philosophy and power. Socrates must be (playfully) coerced to reveal what he knows, and even then he carefully reminds his listeners that the philosophic knowledge of the few looks topsy turvy to the many.

The dialogue reaches a climax in the myth of the divided line and allegory of the cave, where Socrates once again yokes knowledge to politics. These images describe the difficulty of distinguishing truth from shimmering illusions, as well as the way that falsehoods can blind a person to the truth. The difficulties are multiplied, however, by Socrates's view that knowledge can also cripple. Inverting the Homeric story in which Odysseus visits the underworld in order to gain the knowledge needed for practical matters, Socrates describes how philosophers can become so dazzled by the brilliance of their insights as to lose any sense of how to relate them to everyday experience.

In his *Nicomachean Ethics* Aristotle also emphasizes the relation between knowledge and desire: "Both the reasoning must be true, and the desire right, if the choice is to be good" (VI, 2; 1139a25). On Aristotle's account, excellence in reasoning and right desire are cultivated through the moral and intellectual virtues. Moral virtues such as courage, generosity, and magnanimity are governed by a principle, the doctrine of the mean, that seeks out the midpoint between the extremes of excess and deficiency. The intellectual virtues—which Aristotle examines in order as *episteme* (science), *techne* (craft skill), *phronesis* (practical judgment), and *nous* (intuition)—identify the different ways human beings can acquire truth.

Crucially, however, there is no principle of the mean to govern these intellectual virtues. There is no discussion of the possibility that there could be an excess as well as a deficiency in any intellectual virtue after the manner of the moral virtues. Nor for that matter is there any account of how the moral and intellectual virtues relate to one another. When Aristotle turns to a fifth intellectual virtue, *sophia* (wisdom), he describes it as the combination of intuition and science—leaving out technical skill and practical judgment. Wisdom consists of theoretical knowledge lacking any clear relation to practical matters. For Aristotle, the highest form of knowledge appears to escape any Platonic problematic.

In the Platonic tradition, which became through Augustine a vehicle for Christian theological reflection, this problematic finds multiple expressions. Consider the story of Leontius (*Republic* IV, 439e ff.). Walking along the wall outside the Piraeus, Leontius spies a corpse from an execution, and desires to feast his sight on the repugnant image. Recognizing this as a degraded use of the most noble and cognitive of the senses, he struggles to resist temptation. Failing in moral stamina, he finally runs toward the rotting body and exclaimed to in sarcastic irony: "Look, you damned wretches, take your fill of the fair sight!"

The problem of the custody of the eyes becomes in fact a major moral issue in the Christian tradition. According to the biblical narrative, the knowledge of good and evil was associated with a tree in the midst of the Garden of Eden that was "a delight to the eyes" (Genesis 3:6), but from which Adam and Eve had been forbidden to eat. When they succumbed to the visual temptation, their eyes were opened in new ways that brought hardship upon them. During the medieval period this notion of dangerous knowledge was elaborated especially in the monastic tradition. In an extended commentary on chapter seven of the *Rule of St. Benedict*, Bernard of Clairvaux, in the *Steps of Humility* (1120), criticizes "curiositas" as a form of pride. Thomas Aquinas, working under the influence of Aristotle, sought to qualify such criticism, although even he admitted that "curiosity about intellective sciences may be sinful" (*Summa theologiae* II-II, Q.167, art.1). But with the coming of the modern age the restriction on knowing was set aside in favor of a view of knowledge as an unqualified good in an even stronger sense than found in Aristotle himself.

In the modern era, traditional boundaries on scientific pursuits began to drop away as interrogation undertook new active forms in dealing with both nature (the performing of autopsies and experimentation) and the sacred (subjecting the Bible to the same kinds of analysis as any other book). René Descartes represents a signal turning point. Offering a distinctively modern scientific sense of reason, he claimed that with his method "there is no need for the mind to be contained within any limits" (*Rules for the Direction of the Mind*, 1620s). For Descartes there were new rules to replace those of the monasteries, and new meditations to replace spiritual reading, through which human beings might become the "masters and possessors of nature" for which they had been divinely predestined. This project approaches fulfillment in the twenty-first century, as scientific and technological advances create possibilities that herald wholesale changes in nature, society, body, and mind.

E. F. Schumacher (1977) in a simple but insightful characterization, describes the transition introduced by Descartes and others as one from the pursuit of "science as understanding" to "science for manipulation." Whereas the former sought to integrate the knower with the known, to raise human beings out of their material state by means of insight into higher things, the latter began with a sense of the knower as separate from the known and sought to assert this separation by means of analysis. The overarching theme concerning knowledge since the 1500s has been the progressive application of the principle of analysis. Descartes provides the classic statement of the analytic method in his *Discourse on the Method for Rightly Conducting the Sciences* (1637). Items were to be understood by being broken into their constituent pieces. The goal was to arrive at the smallest possible elements. Once these "simples" were identified and completely examined knowledge would be reconstructed upon an unimpeachable foundation. Complemented by the empiricist methods developing from Francis Bacon, who also sought new forms of knowledge, there has flowed forth an ever widening stream of results, including but not limited to the growth of academic disciplines.

The New World of Knowledge and Its Production

In the epistemological world opened up by Descartes and Bacon new categories and forms of knowledge multiply without bounds. In the nineteenth century natural philosophy divided into physics, chemistry, and mathematics, while natural history morphed into biology with an experimental component that challenged the traditional emphasis upon description and taxonomy. The social sciences—sociology, psychology, economics, political science, and anthropology—arose to address the new social conditions, applying a scientific approach to the problems of industrialized experience.

The disciplines that become known as the humanities—philosophy, classical languages, modern languages, history, art, and music—formed a rump out of what was left over after the extraction of these other new specialties. The term itself was an adaptation from the Renaissance *studia humanitatus*, when humanist scholars looked to ancient thinkers such as Cicero for inspiration and guidance. A few of these latter day humanists protested the rise of specialization and disciplinarity and the new emphasis on research, but in general the humanities accommodated themselves to the novel paradigms of knowledge. Abandoning the traditional notion of expounding a perennial philosophy, fields such as literature and philosophy now trained specialists whose role was to develop new insights. Having given over the study of nature to the physical sciences, and the study of culture to the social sciences, the humanities were left with conducting meta-analyses or pursuing one or another version of *l'art pour l'art*.

Analytic assumptions concerning knowledge also promoted the concept of expertise. Expertise in the modern sense depends on phenomena being able to be understood in isolation from each other. In politics this makes democracy at once necessary and problematic—necessary to do the relating that can no longer be done by knowledge, and problematic to the degree that intelligent decision making requires specialized knowledge. Specialization and expertise lead to what can be called epistemological myopia, where a powerful understanding of the details of comes at the cost of appreciating the larger implications of a phenomenon. This in turn has led to calls for interdisciplinary approaches to knowledge.

While problematic even within the sciences, the analytic approach to knowledge has had its most destructive effects in the humanities. Even as the intellectual division of labor has become more and more fine-grained, there was no part of knowledge explicitly concerned with the development of and relation of knowledge between and across the disciplines. Philosophy, the traditional location of such knowledge, also embraced specialization and professionalization, and new claimants to interdisciplinarity such as the sociology of knowledge or science, technology, and society studies, have nevertheless in short order come under the gravitational attraction of their own disciplinary formations. Disciplinary myopia in turn has run parallel to and contributed to the progressive loss in public ability to rationally debate the ends of life, which has reached the point that to even speak of "the good life" often invites derisive commentary—or relegation to the private sphere of personal preference.

Disciplinary specialization and its corresponding cognitive productivity have thus been bought at the cost of ignoring the lateral connections between one subject and the rest of the universe of thought and action. The issue here is the dominance of the metaphor of the laboratory, which presumes that it is relatively unproblematic to separate a bench experiment from the world at large: creating conditions that can be replicated, by controlling the materials used and constraining the parameters of the experiment (Frodeman 2003). Even fields quite far from, and in some cases quite disdainful of, science have applied this presumption to their own work. To offer just one example, it is presumed by literary scholars that it is more central to the work of their field to further probe the depths of the *Prelude* than to see how William Wordsworth might illuminate the experience of employees of U.S. National Parks, and through them, the park-visiting public.

The Knowledge Explosion and Its Discontents

Despite the tremendous explosion of knowledge, there is no discipline that takes as its provenance understanding the relation between the disciplines. Knowledge and information workers multiply ever faster. Hundreds of thousands of bachelor degrees and tens of thousands of doctorates are awarded each year; the annual U.S. federal support of science approaches $150 billion (with twice as much more coming from private sources); and a sky-rocketing stream of publications floods the infosphere in hardcopy, electronic, and various other media. As more than one social commentator has repeated, we are increasingly the most information and knowledge-intensive society in history (see Machlup 1962, Rubin et al. 1986, Castells 1996, and Mokyr 2002). To adapt a prescient distinction from Albert Borgmann (1999), knowledge about reality (science) and knowledge for reality (engineering) have morphed into knowledge as reality. But the knowledge society appears to have little or no program for how to live in or with this information rich possibility space other than to affirm the personal construction of meaning, some automatic synthesis (perhaps by means of Adam Smith's "invisible hand" or G. W. F. Hegel's "cunning of reason"), or Vannevar Bush's linear hypothesis from *Science: The Endless Frontier* (1945): just fund basic science and good results will flow for national security, healthcare, and the economy.

In the area of science policy, selective voices have questioned the received view that all knowledge production is good knowledge production. According to Daniel Sarewitz (1996), David Guston (2000), and Philip Kitcher (2001) there are good reasons to doubt that simply giving more money to science is always the best social investment. A few isolated analyses point in rather more radical directions, with provocative studies on the theme of "forbidden knowledge" by Nicholas Rescher (1987), Roger Shattuck (1996), and Agnieszka Lekka-Kowalik and Daniel Schulthess (1996). Among others, Carl Mitcham and Robert Frodeman (2002) have sought to extend the argument for balance in science funding to a broader balance in knowledge production. Subsequent to September 11, 2001, new forms of knowledge restriction have been debated in the sciences themselves. All together, such efforts suggest that the traditional research philosophy in favor of unfettered scientific autonomy and unrestricted knowledge production is running up against both epistemological and political limits. The *epistemological* limits of knowledge production are evident in the increasingly complex nature of both knowledge and societal problems: our lives are becoming more interwoven on global scales, and many of the problems that are most easily isolated have already been addressed. The *political* limits are found in the increasingly public demand that publicly funded research and education clearly show their connections to community needs. Although the repeated call for interdisciplinarity in education and research is often an effort to respond to such problems, in many instances the interdisciplinarity that emerges does little to address such issues since it leads only to more and more refined disciplinarity.

What Is to Be Done?

Existing ethical assessments of science focus on methodological norms in knowledge production. In exceptional cases, critics have contested claims to scientific knowledge on ethical and religious grounds (as in the challenge to evolutionary theory), although they have not questioned the value of knowledge per se. Existing ethical assessments of engineering and technology focus largely on the active use of technical knowledge rather than the knowledge itself. By contrast, the argument here is that knowledge itself deserves ethical analysis and criticism.

What would this involve? To begin with, it will depend on some recognition, however provisional, of knowledge as an ethical issue beyond the belief in knowledge as an unqualified good. But such acknowledgment could also find support from one or more of five complementary approaches to the knowledge question.

First, is phenomenological work on the character of scientific knowledge by philosophers such as Hans Jonas (1966 and 1974) who has argued the inherently practical character of modern natural science. Such an argument poses obvious challenges for any classical defense of knowledge as inherently good or neutral.

Second, is the argument by scientists themselves from the 1970s on who considered the possible dangers in and limitations to scientific research, because of the complexities with which it had become involved. Although some of the early arguments to this effect (e.g., Holton and Morison 1978) were subsequently challenged, later studies in complexity theory (e.g., Pagels 1988) raise related issues that have yet to be fully appreciated.

Third, virtue epistemology makes a case for relating knowledge and virtue that also has implications for relating knowledge and vice. Virtue epistemology is concerned with identifying the virtues that could transform true belief into knowledge that make knowing possible (see, e.g., Zabzebski 1996). But here ethics is simply incorporated into an ethical epistemology, while what is equally called for is an epistemic ethics and metaphysics.

Fourth, information ethics in its two forms—the ethics of library science and the ethics of computer information generation and manipulation—both suggest the need for ethical assessments of knowledge in relation to issues of privacy and equity. How can all knowledge be inherently good when some of it is inherently invasive or promotes inequalities? Moving in the directions of moral psychology, there is also research that suggests certain types of propositional knowledge might limit the exercise of intuitive knowledge (Gladwell 2005). Extending such a notion, is it not possible that certain types of knowledge could distract human beings from more important goods? Is the acquaintance with some types of things on which know how depends never psychologically problematic?

Finally, science studies research on transformations in the social character of knowledge production have developed suggestive analyses that have implications for any ethics of knowledge. A useful reference here is the work of Michael Gibbons and others, *The New Production of Knowledge* (1994), which distinguishes what it terms "Mode 1" and "Mode 2" knowledge. Mode 1 is the standard form of modern knowledge generated in disciplinary and academic frameworks. Mode 2 knowledge is a new kind of knowledge originating outside academic research institutions. Mode 2 knowledge production

- is governed by practical, problem solving concerns (rather than by more academic or epistemic ones),
- is transdisciplinary in character,
- engenders linkages among subfields and heterogeneous sites,
- is subject to economic and social accountability, and
- incorporates social, economic, and political interests.

Although this analysis and a companion volume by Helga Nowotny and others (2001) suggests little more than adaptive strategies in response to such transformations, they open up space for more normative assessments. Deborah Johnson (1999), for instance, has argued that recognition of the new social constructive context of science offers opportunities for reframing the question of forbidden knowledge.

On the basis of these kinds of existing research one may propose the following overlapping questions for any future ethics of science and technology:

1. Historically and socially, what is the moral status of a kind of knowledge with inherently applied characteristics? Is the distinction between ancient, contemplative knowledge and modern, inherently manipulative knowledge defensible? Furthermore, has the character of technoscientific knowledge itself undergone morally relevant change of the types suggested by social studies of science?
2. Conceptually, what are the ethical dimensions of distinctions between the forms knowledge (in the general sense) as data, information, knowledge (in a strict sense), and wisdom?
3. From the political and policy perspectives, what is the proper balance between knowledge and knowledge production in the technosciences, the social sciences, the humanities, and the arts? How do different forms of cognition properly interact, not just to produce knowledge but to promote the good life?
4. Psychologically, what are the moral implications of the proliferation of technoscientific knowledge? Does more knowledge always promote better thinking or acting?
5. Ethically (in a narrow sense): What are the morally relevant consequences of knowledge and knowledge production? Are there no deontological limits on knowledge and knowledge production? With regard to virtue, are there no extremes to epistemological practice that deserve censure?

Although not exhaustive of any future ethics of science and technology as knowledge, responses to these kinds of questions might provide guidance for the co-creative interaction between knowing, making, and doing in the expansively human sense.

BIBLIOGRAPHY

Ackoff, Russell L. (1989). "From Data to Wisdom." *Journal of Applied Systems Analysis* 16: 3–9.

Borgmann, Albert. (1999). *Holding on to Reality: The Nature of Information at the Turn of the Millennium*. Chicago: University of Chicago Press.

Bush, Vannevar. (1945). *Science: The Endless Frontier*. Washington, DC: U.S. Government Printing Office.

Castells, Manuel. (2000). *The Information Age: Economy, Society and Culture*. Vol. 1: *The Rise of the Network Society*. 2nd edition. Oxford: Blackwell.

Chadwick, Ruth; Mairi Levitt; and Darren Shickle. (1997). *The Right to Know and the Right Not to Know*. Brookfield, VT: Aldershot.

Cleveland, Harland. (1982). "Information as Resource." *Futuris* December: 34–39.

Frodeman, Robert. (2003). *Geo-Logic: Breaking Ground between Philosophy and the Earth Sciences*. Albany: State University of New York Press.

Gibbons, Michael; Camille Limoges; Helga Nowotny; Peter Scott; Simon Schwartzman; and Martin Trow. (1994). *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*. London: Sage.

Gladwell, Malcolm. (2005). *Blink: The Power of Thinking without Thinking*. Bostom: Little Brown.

Guston, David. (2000). *Between Politics and Science: Assuring the Integrity and Productivity of Research*. New York: Cambridge University Press.

Holton, Gerald, and Robert S. Morison, eds. (1979). *Limits of Scientific Inquiry*. New York: W.W. Norton.

Johnson, Deborah. (1999). "Reframing the Question of Forbidden Knowledge for Modern Science." *Science and Engineering Ethics* 5(4): 445–461.

Jonas, Hans. (1966). "The Practical Uses of Theory." In *The Phenomenon of Life: Toward a Philosophical Biology*. New York: Harper and Row.

Jonas, Hans. (1974). *Philosophical Essays: From Ancient Creed to Technological Man*. Englewood Cliffs, NJ: Prentice Hall.

Kitcher, Philip. (2001). *Science, Truth, and Democracy*. New York: Oxford University Press.

Lekka-Kowalik, Agnieszka, and Daniel Schulthess. (1996). *Forbidden Knowledge*. Theme issue, *Monist* 79(2) (April). Includes eight articles all questioning the autonomy of science.

Machlup, Fritz. (1962). *The Production and Distribution of Knowledge in the United States*. Princeton, NJ: Princeton University Press.

Mitcham, Carl, and Robert Frodeman. (2002). "The Plea for Balance in the Public Funding of Science." *Technology in Society* 24(2): 83–92.

Mokyr, Joel. (2002). *The Gifts of Athena: Historical Origins of the Knowledge Economy*. Princeton, NJ: Princeton University Press.

Nowotny, Helga; Peter Scott; and Michael Gibbons. (2001). *Re-Thinking Science: Knowledge and the Public in an Age of Uncertainty*. Cambridge, UK: Polity Press.

Oppenheimer, J. Robert. (1947). *Physics in the Contemporary World*. Cambridge, MA: MIT Press.

Pagels, Heinz. (1988). *The Dreams of Reason: The Computer and the Rise of the Sciences of Complexity*. New York: Simon and Schuster.

Rescher, Nicholas. (1987). *Forbidden Knowledge and Other Essays on the Philosophy of Cognition*. Boston: D. Reidel.

Rubin, Michael Rogers; Mary Taylor Huber; and Elizabeth Lloyd Taylor. (1986). *The Knowledge Industry in the United States*. Princteon, NJ: Princeton University Press.

Russell, Bertrand. (1910). "Knowledge by Acquaintance and Knowledge by Description." *Proceedings of the Aristotelian Society* 11: 108–128. Reprinted in *Mysticism and Logic* (1963), pp. 152–167. London: Allen and Unwin.

Sarewitz, Daniel. (1996). *Frontiers of Illusion: Science, Technology, and the Politics of Progress*. Philadelphia: Temple University Press.

Schumacher, E. F. (1977). *A Guide for the Perplexed*. New York: Harper and Row.

Shattuck, Roger. (1996). *Forbidden Knowledge: From Prometheus to Pornography*. New York: St. Martin's Press.

Zabzebski, Linda. (1996). *Virtues of the Mind*. Cambridge, UK: Cambridge University Press.

VALUES IN TECHNICAL DESIGN

HELEN NISSENBAUM

Although their precise parameters and significance are easily debated, it is generally recognized that values influence the design of scientific experiments. Because scientific research is designed to yield answers to specific questions, truth values in operational forms internal to science play prominent roles in the structuring of research activities. Moreover, when experimentation takes place with human subjects or dangerous reagents there are further values of respect for persons and public safety that readily take the stage. It is thus not difficult to argue that values regularly and properly are embodied in scientific activities—and that the practice of science can have value implications for the larger social contexts in which they are pursued.

The idea that values may also be embodied in engineered products, processes, and systems is perhaps more controversial, although the thesis is now commonly argued in a variety of disciplines relevant to questions of science, technology, and ethics (e.g., Winner 1986, MacKenzie and Wajcman 1999). Moreover, a practical turn from what has sometime been a largely descriptive posture sets forth values as a design aspiration, exhorting engineers, producers, and consumers to include values in the criteria by which technological excellence is judged (Mitcham 1995). For those committed to bringing selected values to bear in technical design, the ideal result is a world of artifacts that embody not only such instrumental values as effectiveness, efficiency, safety, reliability, and ease of use, but promote (or at least do not undermine) substantive values to which the surrounding societies or cultures subscribe. In liberal democracies, such values may include, among others, liberty, justice, privacy, security, friendship, comfort, trust, autonomy, and transparency.

But it is one thing to subscribe to such ideals and another to put them into practice. Putting values into practice is often dismissed as a form of political or moral activism irrelevant to the designing of technical systems such as software programs. Experienced software engineers will recall the not too distant past when interface and usability were also overlooked features of software system design (Adler and Winograd 1992). While these and other aspects of design have now entered the mainstream, we are still at the shaky beginnings of thinking systematically about the practice of technical design and values (Norman 2002). Even designers who support the principle of integrating values into systems are likely to have trouble applying standard design methodologies, honed for the purpose of meeting functional requirements, to the unfamiliar turf of values. There are at least two factors that contribute to the difficulty of embodying values in the design of technical systems and devices—one epistemological, the other practical.

Epistemological Challenges

One reason the study of human or social dimensions of technology is so demanding is that the areas of knowledge and relevant methodologies are far-flung and self-contained. This dispersion is reflected in the disciplinary organization of universities, in which science and technology are typically segregated from the social sciences and humanities. Yet the successful embodying of values in technical design demands simultaneous engagement with these distinct areas of knowledge and their respective methodologies. For technical design purposes, what is readily drawn from these fields is sufficient, whereas for others the puzzles raised push beyond standard boundaries. Either case, however, calls for more comprehensive interactions among diverse areas of knowledge than is customary—in the first instance requiring enough knowledge to identify existing, relevant insights; in the second, deliberate efforts to extend what is known in order to address the hard and sometimes novel questions that arise.

In practical terms, these active interdependencies may be understood through the metaphor of "balls in the air." Conscientious designers must juggle and keep in play the results of at least three modes of knowledge: foremost those from the relevant scientific and technical fields; beyond these, philosophical reflections on relevant values; and finally empirical findings regarding relations between values, individuals, and their societies. The balls in play metaphor reflects the need to direct attention to all three aspects simultaneously, keeping an eye not only on each factor but also on how the three factors shift in relation to each other.

TECHNICAL MODES. In the technical mode, a designer or design team brings to bear state-of-the-art scientific knowledge and technical know-how on particular design specifications that realize given values in an overarching design project. In a project to build a hospital patients record system, for example, designers might be charged with the task of building privacy protection into the software. In responding to this charge, they might aim for a design that enables access to particular fields of data only by specific, authorized members of the hospital staff. With this goal in mind, they set about designing system constraints, and selecting or creating mechanisms to attain them.

These steps, comprising the technical ball-in-play, are familiar to technical system designers. The sole departure in the present instance is that they are described as undertaken in the name of values and not, as is typically the case, in the name of technical functionality and efficiency.

PHILOSOPHICAL MODE. While designers and engineers seek and invent mechanisms to meet design specifications for promoting values, the philosophical perspective is generally overlooked. But values are more than simple givens. Values can themselves be examined in terms of their origins and scope of relevance, their meanings, and as the basis for normative influence—especially when it is necessary to resolve conflicts.

At the foundation of such philosophical reflection lies an account values that may be quite contentious. There are extensive debates about the precise character of values, for instance, whether they are subjective or objective. Nevertheless, within a broad construction of values as interests, purposes, or ends in view, those of greatest concern in the present context are values that can be construed as social, moral, or political. This still wide-ranging category includes abstractly conceived values such as freedom, autonomy, equality, justice, and privacy, as well as concrete values such as friendship, safety, sociality, and comfort.

The question of whether any such values are universal to all humans or are always locally defined by nations, societies, cultures, religions, communities, or families deserves to be appreciated for its moderating influence. Designers and developers of technology in the United States (and other technology producing liberal democracies) may confidently reach for constitutional values such as freedoms of speech, association, and religion; protections of property, equality, due process, and privacy; or cultural values such as individualism and creativity. But they should at the very least also consider whether such values are always appropriate to other countries where their products may be distributed. At the same time, taking the Universal Declaration of Human Rights as a guide, it is reasonable to postulate a few basic values as common to all humanity, with specific interpretations subject to local variation—a position that nevertheless remains subject to philosophical analysis and empirical assessment.

In seeking to promote the embodying of values in technologies it is a designer's understanding that will guide how they are "cashed out" as system features. In the case of the electronic patient records example, concerned developers seek specifications that will yield privacy and not something else, and a key factor will be defining privacy. Evaluating the proposal mentioned earlier to operationalize privacy by giving variable access to the different fields of information, a philosophical critic might argue that a different interpretation of privacy would support a system whose default is to give access to the patient only, as a way to embody privacy as control over information about oneself.

An ability to consider and discuss such alternatives is a significant component of what it takes to keep the philosophical ball in play. In some instances this means turning for insights to a long tradition of philosophical and political thought that guides the moral and political systems of the different technology producing liberal democracies. Because many of the most important and contested value concepts have evolved within these traditions, design teams might need to plumb them for sound, workable concepts. Failure to take these concepts seriously can lead to bungled interpretations in the specification of design features.

Two caveats: First, it is unrealistic to expect designers always to work from first principles and grapple directly with abstract conceptions of value. Yet over time, one can imagine an emerging database of analyses specifically developed for the context of technology design. Second, traditional analyses may not be sufficient when technology itself has brought about such radical change in the social and material world that certain values themselves demand reconsideration. In such cases, as with privacy in the wake of information technologies, keeping the philosophical ball-in-play means producing original research analyzing on the concepts at issue.

Finally, the philosophical mode engages with issue of normative force, providing rationale or justification for commitments to particular values in a given device or system. With the electronic patient record system, one might consider why privacy is relevant, important, or necessary. Frequently, the answers to such questions are to be found in surrounding moral and political theories that explain why and when certain values ought to be promoted. This is particularly needed when conflicts among values result from specific design choices. Normative theory can guide resolution or tradeoffs. In the patient records system, finding that access is slowed as a result of privacy constraints, designers might return to the underlying theory of a right to privacy to learn the circumstances under which privacy claims may justifiably be diminished or overridden.

EMPIRICAL MODE. Empirical investigation answers questions that are as important to the goal of embodying values in design as the philosophical and technical. Not only does it complement philosophical inquiry into what values are relevant to a given project, but it is the primary means for addressing, systematically, the question of whether a given attempt at embodying values "worked"—that is, whether the intentions of designers were fulfilled.

Philosophical inquiry can take us only so far in determining the values that ought to be considered in relation to given technological projects. Even if one holds to the existence of a basic set of universal human values, the people affected by these projects are likely to subscribe to a far richer set of values determined by their cultural, historical, national, ethnic, and religious affiliations. It may be even more crucial to attend to these commitments when engineers face choices among design alternatives. Despite the enormous attention philosophers, and others, have given to the problem of systematically resolving values (and rights) conflicts, this remains notoriously difficult. For such situations, ascertaining the preferences of affected parties is a sound practical response, using such methods as surveys, interviews, testing under controlled conditions, and observation in the field. In the conflict between efficient access to information and its confidentiality in a patient records system, for instance, designers should at least consult preferences among affected parties.

Empirical investigation is also necessary for ascertaining whether a particular design embodies intended values. Again in the case of the electronic patient records system, designers might learn from observing patterns of usage if security mechanisms for restricting access to the appropriately authorized personnel are so onerous that many users simply bypass them, thus leaving the records more vulnerable than ever. They might thus discover that their attempts to promote privacy are thwarted by a design that does not achieve its intended results—information crucial to any values in technical design analysis.

VALUES IN PLAY. The metaphor of balls-in-play includes not simply the need to incorporate three distinct modes of knowing into the design context but an effort to iteratively integrate these modes. Because findings from each of the areas affect or feed back into others, members of a design team cannot seek solutions in each area independently. Although the hardest cases might call for innovation within each of the three modes (and hence diverse expertise), many cases will be able to rely on what is already known in at least one or two.

Consider, for example, the task of building a system that provides fair access to information to diverse members of a community. Designers might quickly settle on accessibility to all mentally able individuals as the embodiment of the value of fairness, while it struggles with the technical questions of how to go about doing so and, later, testing empirically whether particular designs have succeeded. It is reasonable, furthermore, to hope that with greater attention to the study of values in technology a body of findings, experience, results, and definitions will develop that gradually will alleviate some of the epistemological burdens.

Practical Challenges

In addition to epistemological challenges, the practical challenge engineers face is the sparseness of methodologies for embodying values in system design, due in part to the newness of the endeavor. If we think of what we need to know constitutes the ingredients for a recipe, then what remains is the equally important method for combining them into a dish. Attempts to fill this methodological gap are new and evolving. Some that have been around longer are restricted to certain specialized areas of application.

One of the best known in the latter category is an approach known as "participatory design." Having evolved in Scandinavia, in the context of the workplace, the methodology is committed to democratic participation by those likely to be affected by new technologies as well as design outcomes that enhance not only efficiency of production and quality of product but the skill and well-being of workers. Emerging methods include value sensitive design, which recognizes the importance of technical, conceptual, and empirical investigations to the purpose of bringing values to bear in the design of information technologies generally. Another approach developed by Mary Flanagan, Daniel

Howe, and Helen Nissenbaum (2006) posits a methodology comprising four constitutive activities for embodying values in design—discovery, translation, resolution, and verification—which, in order to illustrate possibilities, can be considered here.

DISCOVERY. The activity of discovery involves identifying values that are relevant to or might inform a particular design project by looking to key sources of values in the context of technical design and asking what values they bring to the project in question. The specific list of values will vary considerably from project to project. But one promising heuristic is simply to ask "What values are involved here?" and then brainstorm possible answers. Sometimes values are expressed explicitly in the functional definition of a deliverable (as grasped through the technical mode of knowing). But all designs are underdetermined by explicit functional requirements, leaving designers and developers numerous alternatives as they proceed through an iterative design process.

Open-endedness calls forth the implicit values of designers themselves (and thus may be furthered by the philosophical mode of reflection). Sometimes designers unconsciously assume that they are the likely users of their work and act accordingly. But values reflection in technical design can almost always be deepened by efforts to critically identify implicit values in both designers and potential users (as accessed by means of the empirical mode of inquiry), and subsequent critical assessments of and dialogue between such values.

TRANSLATION. In the activity of translation, a design team operationalizes value concepts and implements them in design. The values discovered in the first moment of reflection are not only multiple but they tend to be abstract. To become concretely accessible in the design context they will need to be rendered into operational or functional forms. This translation activity will almost certainly involve some input from the philosophical mode of knowing. No matter how well value concepts are operationalized, the efforts of conscientious designers are easily undermined if the historical traditions and substantive characteristics of particular values are incorrectly interpreted. With values such as privacy, for example, clarity, good intentions, and technical competence can be misdirected when not adequately backed up with sensitive analyses of various philosophical approaches to privacy itself.

RESOLUTION. Translation is key to any implementation of discovered values. But implementation and the corresponding transfer of values into design specifications also calls for the resolution of any potential incompatibilities in a values possibility space. One of the major challenges of implementation is resolving conflicts that arise as a result of specific design choices.

Conflicts arise when designers who have committed to some set of discovered values, further discover that it is practically impossible to embody all of them equally well within some product, process, or system. Engineering is rife with such conflicts: whether to favor safety over cost, transparency over privacy, aesthetics over functionality, with many more appearing at layers of finer granularity. Resolving such conflicts is by no means a challenge for engineering alone, but is manifest as one of the enduring problems of practical ethics, politics, and law. But this means again that the resources of the philosophical mode of thinking may be of special benefit to this moment in practical values design work.

VERIFICATION. Finally, the activity of verification involves assessing whether values have been successfully embodied in design. Verifying the inclusion of values is likely to draw on both technical and empirical thinking. It can easily begin with internal testing by the design team but will not be complete without user testing in controlled environments.

It might be useful in this regard to consider the possibility of some approach analogous to that of clinical trials for pharmaceuticals. In phase one trials the basic question concerns whether a drug is safe. Phase one studies, which are short term, are done to gather preliminary data on chemical action and dosage using healthy volunteers, and there is no comparison with any control group. In phase two trials, which take longer, the basic question is whether the drug works to achieve a desired therapeutic end. Is it an effective treatment? Now the trials are done with patients who exhibit a target disease or illness, and there are control groups for comparison. Finally, phase three trials focus on the long-term effects in larger populations. Only after this phase is complete may a drug be widely marketed. In a like manner one might construct a series of alpha, beta, and gamma testings of new technologies to assess how values may have been embodied in technical designs, using initially small groups of technical volunteers, then non-technical users with the need that a new technology aims to address, and finally longer-term monitoring of larger populations of consumers and users.

Open Questions

It is too early to judge the long-term success of any method for embodying values in technical design, because few projects have proceeded through the various milestones characteristic of the lifespan of technologies—including, sometimes, unintended (often negative) consequences. The method nevertheless deserves serious consideration in any discussion of science, technology, and ethics—not only in relation to the kind of case referenced here (that is, software design) but across the technology spectrum, from machines and structures to systems and software. Moreover, critical consideration may also throw light on the roles of values in design of scientific experimentation.

Two other potentially critical stances are worth mentioning. Taking a social constructivist stance, critics might question the supposition that key social, ethical, and political aspects of technologies are attributable either to their blueprints or physical shape. What imbues technologies with values are not any of their objective functions but their meanings, generated by the interpretive forces of history, culture, politics, and a myriad other social contingencies. An ironically related stance holds that technologies are neutral. The extent to which systems or devices promote values is a function of the individual uses to which they are put; technologies are mere tools of human intention. Although the view of technology as neutral is currently out of favor in scholarly circles, it remains a common presumption with which those interested in values in technical design must contend.

BIBLIOGRAPHY

Adler, Paul S., and Terry Winograd. (1992). *Usability: Turning Technologies into Tools*. New York: Oxford University Press. Seven useful papers.

Agre, Philip E. (1997). "Toward a Critical Technical Practice: Lessons Learned in Trying to Reform AI." In *Social Science, Technical Systems, and Cooperative Work: Bridging the Great Divide*, eds. Geoffrey Bowker, Susan Leigh Star, William Turner, and Les Gasser. Mahwah, NJ: Erlbaum.

Bødker, S., and K. Grønbæk. (1991). "Design in Action: From Prototyping by Demonstration to Cooperative Prototyping." In *Design at Work: Cooperative Design of Computer Systems* eds. Joan Greenbaum and Morton Kyng. Mahwah, NJ: Erlbaum.

Ehn, Pelle. (1992). "Scandinavian Design: On Participation and Skill." In *Usability*, eds. Paul S. Adler and Terry Winograd. New York: Oxford University Press.

Flanagan, Mary; Daniel Howe; and Helen Nissenbaum. (2006). "Values in Design: Theory and Practice." In *Information Technology and Moral Philosophy*, eds. Jeroen van den Hoven and John Weckert. Cambridge, UK: Cambridge University Press.

Friedman, Batya. (1996). "Value-Sensitive Design." *Interactions* 3(6): 17–23.

Friedman, Batya; Peter H. Kahn Jr.; and Alan Borning. (2002). *Value Sensitive Design: Theory and Methods*. Technical Report 02-12-01, Department of Computer Science and Engineering, University of Washington, Seattle, WA. Available from http://www.urbansim.org/papers. Revised version in *Human Computer Interaction in Management Information Systems: Foundations*, eds. Ping Zhang and Dennis Galletta. New York: M. E. Sharpe, 2006.

Friedman, Batya, and Helen Nissenbaum. (1996). "Bias in Computer Systems." *ACM Transactions on Information Systems* 14(3): 330–347.

MacKenzie Donald, and Judy Wajcman, eds. (1999). *The Social Shaping of Technology*, 2nd edition. Milton Keynes: Open University Press.

Mitcham, Carl. (1995). "Ethics into Design." In *Discovering Design*, eds. Richard Buchanan and Victor Margolis. Chicago: University of Chicago Press.

Nissenbaum, Helen. (1998). "Values in the Design of Computer Systems." *Computers in Society*, March: 38–39.

Norman, Donald. (2002). *The Design of Everyday Things*. New York: Basic Books. First published as *The Psychology of Everyday Things* New York: Doubleday, 1990.

Pfaffenberger, Bryan. (1992). "Technological Dramas." *Science, Technology, and Human Values* 17(3, Autumn): 282–312.

Winner, Langdon. (1986). "Do Artifacts Have Politics?" In his *The Whale and the Reactor: A Search for Limits in an Age of High Technology*. Chicago: University of Chicago Press.

LIST OF ARTICLES

• • • B

• • • E

• • • F

• • • M

• • • P

• • • S

• • • T

LIST OF CONTRIBUTORS

Evandro Agazzi, Prof., Philosophy
Univ. of Genoa, Italy
AXIOLOGY

Janaki R. R. Alavalapati, Assoc. Prof., Resource Economics and Policy
Univ. of Florida, Gainesville
MULTIPLE-USE MANAGEMENT

Braden R. Allenby, Prof., Civil and Environmental Engineering
Arizona State Univ., Tempe
EARTH SYSTEMS ENGINEERING AND MANAGEMENT

Andoni Alonso, Prof., Philosophy
Univ. of Extremadura, Cáceres, Spain
CYBERCULTURE; WITTGENSTEIN, LUDWIG

Hussein A. Amery, Assoc. Prof., Liberal Arts and Int'l. Studies
Colorado Sch. of Mines, Golden
WATER

Agustin Araya, Prof., Computer Science
San Jose State Univ., CA
CYBERSPACE; INTERNET

Larry Arnhart, Prof., Political Science
Northern Illinois Univ., DeKalb
ATLANTIS, OLD AND NEW; BACON, FRANCIS; BIOTECH ETHICS; BRAVE NEW WORLD; DESCARTES, RENÉ; EVOLUTION-CREATIONISM DEBATE; EVOLUTIONARY ETHICS;HUMAN NATURE; NATURE, PRESIDENT'S COUNCIL ON BIOETHICS

Christopher Arroyo, Teaching Fellow, Philosophy
Fordham Univ., Bronx, NY
LEIBNIZ, G. W.

Vicki Arroyo, Dir. of Policy Analysis
Pew Ctr. on Global Climate Change, Arlington, VA
PUBLIC POLICY CENERSS

Iñaki Arzoz Karasusan, Freelance writer and artist
Pamplona, Spain
CYBERCULTURE

Peter M. Asaro, Grad. Teaching Asst., Philosophy
Univ. of Illinois at Urbana-Champaign
PARTICIPATORY DESIGN

Mie-Sophia Augier, Post-doctoral Fellow
Stanford Univ., CA
SIMON, HERBERT A.

Marilyn Averill, Ph.D. candidate, Political Science
Univ. of Colorado, Boulder
HIV/AIDS; INTELLECTUAL PROPERTY; UNINTENDED CONSEQUENCES

Ignacio Ayestarán, Assoc. Prof., Philosophy
Univ. of the Basque Country, Donostia-San Sebastián, Spain
BIODIVERSITY COMMERCIALIZATION

Osman Bakar, Malaysia Chair of Islam in Southeast Asia
Georgetown Univ., Washington, DC
ISLAMIC PERSPECTIVES

David Baker, Prof., Politics and Int'l. Studies
Univ. of Warwick, Coventry, UK
FASCISM

Dominic Balestra, Prof., Philosophy; Dean of Arts and Sciences Faculty
Fordham Univ., Bronx, NY
POPPER, KARL

Patrick Ball, Dir., Human Rights Programs
The Benetech Initiative, Palo Alto, CA
FREE SOFTWARE

David P. Barash, Prof., Psychology
Univ. of Washington, Seattle
AGGRESSION; DOMINANCE; ETHOLOGY; SELFISH GENES

Lowell W. Barrington, Assoc. Prof., Political Science
Marquette Univ., Milwaukee, WI
AUTHORITARIANISM; TOTALITARIANISM

Mary Catherine Bateson, Pres.
Inst. for Intercultural Studies, Washington, DC
MEAD, MARGARET

Benjamin Bederson, Prof. Emeritus, Physics
New York Univ., New York
EINSTEIN, ALBERT; OPPENHEIMER, J. ROBERT; TELLER, EDWARD

Jeremy Beer, Ed.-in-Chief
ISI Books, Wilmington, DE
AGRARIANISM

Vicente Bellver Capella, Assoc. Prof., Philosophy of Law
Univ. of Valencia, Spain
ENVIRONMENTAL RIGHTS; ORTEGA Y GASSET, JOSÉ

Juan Bautista Bengoetxea, Visiting Scholar, Philosophy and Science, Technology, and Society
Colorado Sch. of Mines, Golden
CHEMISTRY

Françoise Baylis, Prof., Bioethics
Dalhousie Univ., Halifax, N.S., Canada
GENE THERAPY

Rosalyn W. Berne, Asst. Prof., Science, Technology, and Society
Sch. of Engineering, Univ. of Virginia, Charlottesville
NANOETHICS

Mary Besterfield-Sacre, Asst. Prof., Industrial Engineering
Univ. of Pittsburgh, PA
ETHICS ASSESSMENT RUBRICS

Bruce Bimber, Dir., Ctr. for Information Technology and Society
Univ. of California, Santa Barbara
INFORMATION SOCIETY

Matthew Biniek, Science instructor
Grand Army of the Republic Memorial High Sch., Wilkes-Barre, PA
TECHNOCOMICS

Stephanie J. Bird, Ed., *Science and Engineering Ethics*
Massachusetts Inst. of Technology, Cambridge
MISCONDUCT IN SCIENCE: OVERVIEW; NEUROETHICS; RESEARCH ETHICS; RESPONSIBLE CONDUCT OF RESEARCH

Douglas Birsch, Assoc. Prof., History, Philosophy
Shippensburg Univ., PA
FORD PINTO CASE

Kenneth C. Blanchard, Jr., Prof., Political Science
Northern State Univ., Aberdeen, SD
ARISTOTLE AND ARISTOTELIANISM; FREE WILL; LOCKE, JOHN; MACHIAVELLI, NICCOLÒ; NATURE VERSUS NURTURE; PLATO; STRAUSS, LEO

Robert H. Blank, Prof., Public Policy
Brunel Univ., Uxbridge, UK
FETAL RESEARCH; GENETHICS

Thomas Blau, Prof., National Security Executive Education
Nat. Defense Univ., Washington, DC
MISSILE DEFENSE SYSTEMS

Mark Blitz, Fletcher Jones Prof., Political Philosophy
Claremont McKenna Coll., Claremont, CA
HEIDEGGER, MARTIN

Maeve A. Boland, Assoc. Moderator, McBride Program in Public Affairs for Engineers
Colorado Sch. of Mines, Golden
GEOGRAPHIC INFORMATION SYSTEMS; GLOBAL POSITIONING SYSTEM; MINING; SOFT SYSTEMS METHODOLOGY

Andrea L. Bonnicksen, Presidential Research Prof., Political Science
Northern Illinois Univ., DeKalb
EMBRYONIC STEM CELLS; IN VITRO FERTILIZATION AND GENETIC SCREENING

Albert Borgmann, Prof., Philosophy
Univ. of Montana, Missoula
MATERIAL CULTURE

Ann Bostrom, Assoc. Prof., Sch. of Public Policy
Georgia Inst. of Technology, Atlanta
RISK ASSESSMENT; RISK PERCEPTION

David R. Bonneville, P. E., S. E., Senior Principal
Degenkolb Engineers, San Francisco, CA
EARTHQUAKE ENGINEERING

Jeffrey Boutwell, Exec. Dir.
Pugwash Conferences on Science and World Affairs, Washington, DC
PUGWASH CONFERENCES; ROTBLAT, JOSEPH

Margaret M. Brace, Research Analyst
Vanderbilt Univ. Medical Ctr., Nashville, TN
PSYCHOLOGY: HUMANISTIC APPROACHES

Perry C. Bramlett, Rev.
C. S. Lewis for the Local Church Interstate Ministries, Louisville, KY
ANGLO-CATHOLIC CULTURAL CRITICISM; LEWIS, C. S.; TOLKIEN, J. R. R.

Philip Brey, Assoc. Prof. and Vice Chair, Philosophy
Univ. of Twente, The Netherlands
PROSTHETICS; VIRTUAL REALITY

Søren Brier, Prof., Management, Politics and Philosophy
Copenhagen Business Sch., Denmark
SEMIOTICS: NATURE AND MACHINE

Adam Briggle, Ph.D. candidate
Univ. of Colorado, Boulder
ADVERTISING, MARKETING, AND PUBLIC RELATIONS; ASILOMAR CONFERENCE; BETHE, HANS; BIOETHICS COMMITTEES AND COMMISSIONS; BIRTH CONTROL; BLACKETT, PATRICK; BUSH, VANNEVAR; CULTURAL LAG; DOUBLE EFFECT AND DUAL USE; ENVIRONMENTAL REGULATION; FAUST; FEDERATION OF AMERICAN SCIENTISTS; HOBBES, THOMAS; HORMESIS; HUMANIZATION AND DEHUMANIZATION; HUXLEY, ALDOUS; INFORMATION ETHICS; INFORMATION OVERLOAD; INSTITUTIONAL BIOSAFETY COMMITTEES; INSTITUTIONAL REVIEW BOARDS; LIFE; MANAGEMENT: OVERVIEW; MUMFORD, LEWIS; NORMAL ACCIDENTS; OPEN SOCIETY; POLICE; RELIABILITY; RESEARCH ETHICS: OVERVIEW; SCIENCE: OVERVIEW; SIMON, JULIAN; SPEED; SPENCER, HERBERT; TECHNOLOGY: OVERVIEW; TERRORISM; TERRORISM AND SCIENCE; TRADEOFFS; WATSON, JAMES; WORLD COMMISSION ON THE ETHICS OF SCIENTIFIC KNOWLEDGE AND TECHNOLOGY

Robert Alan Brookey, Assoc. Prof., Communication
Northern Illinois Univ., DeKalb, IL
HOMOSEXUALITY DEBATE

Taft H. Broome, Jr., Prof., Civil Engineering
Howard Univ., Washington, DC
PRAXIOLOGY

Ronald D. Brunner, Prof., Political Science
Univ. of Colorado, Boulder
LASSWELL, HAROLD D.

Richard Buchanan, Prof., Design
Carnegie Mellon Univ., Pittsburgh, PA
DESIGN ETHICS

George Bugliarello, Prof., Civil Engineering; Chancellor
Polytechnic Univ., Brooklyn, NY
BIOENGINEERING ETHICS

Mark A. Bullock, Principal Scientist, Dept. of Space Studies
Southwest Research Inst., Boulder, CO
ASTRONOMY; COSMOLOGY

Radford Byerly Jr., Visiting Fellow, Ctr. for Science and Technology Policy Research
Univ. of Colorado, Boulder
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION; SPACE SHUTTLES *CHALLENGER* AND *COLUMBIA* ACCIDENTS

Edmund F. Byrne, Prof. Emeritus, Philosophy
Indiana Univ., Indianapolis
WORK

Emily Lynn Brumm, Engineering
Univ. of Virginia, Charlottesville
ENTREPRENEURISM

Gregory Caicco, Lincoln Asst. Prof. of Ethics in Architecture and Environmental Design
Arizona State Univ., Tempe, AZ
ARCHITECTURAL ETHICS

J. Baird Callicott, Prof., Philosophy and Religion
Univ. of North Texas, Denton
BIOPHILIA

Luis Camacho, Prof., Philosophy
Univ. of Costa Rica, San José
DEVELOPMENT ETHICS

Nancy D. Campbell, Asst. Prof., Science and Technology Studies
Rensselaer Polytechnic Inst., Troy, NY
DRUGS

Penelope Canan, Exec. Officer
Global Carbon Project, Tsukuba, Japan
MONTREAL PROTOCOL

Nicholas Capaldi, Legendre-Soulé Distinguished Chair in Business Ethics
Sch. of Business Administration, Loyola Univ., New Orleans, LA
MILL, JOHN STUART

Arthur L. Caplan, Emanuel & Robert Hart Prof. of Bioethics; Dir., Ctr. for Bioethics
Univ. of Pennsylvania, Philadelphia
BIOETHICS CENTERS

Joseph Carroll, Prof., English
Univ. of Missouri, St. Louis
DARWIN, CHARLES

William D. Casebeer, Assoc. Prof., Philosophy
U.S. Air Force Academy, CO
SCIENTIFIC ETHICS

Leah Ceccarelli, Assoc. Prof., Communication
Univ. of Washington, Seattle
RHETORIC OF SCIENCE AND TECHNOLOGY

Daniel P. Cérézuelle, Scientific Dir.
P.A.D.E.S, Paris, France
FRENCH PERSPECTIVES

Ruth Chadwick, Prof., Inst. of Environment, Philosophy, and Public Policy
Lancaster Univ., UK
APPLIED ETHICS; EUTHANASIA; RIGHT TO DIE; RIGHT TO LIFE; RIGHTS AND REPRODUCTION; RIGHTS THEORY

Audrey R. Chapman, Dir., Science and Human Rights Program
American Association for the Advancement of Science, Washington DC
HUMAN RIGHTS

Anne Chapman, Teaching Asst., Inst. of Environment, Philosophy, and Public Policy
Lancaster Univ., UK
ARENDT, HANNAH; GREEN IDEOLOGY

Dahlia Chazan, Co-Dir., Sustainability Indicators Program
Redefining Progress, Oakland, CA
ECOLOGICAL FOOTPRINT

Dennis Cheek, Sr. Principal Consultant
Science Applications Int'l. Corp., Exton, PA
ATOMIC BOMB; ENTERTAINMENT; HIROSHIMA AND NAGASAKI; RAMSEY, PAUL; ROADS AND HIGHWAYS

Fan Chen, Prof., Research Ctr. for Philosophy of Science and Technology
Sch. of Humanities and Law, Northeastern Univ., Shenyang, China
THREE GORGES DAM

Joshua L. Cherniss, Ph.D. candidate, Balliol Coll.
Univ. of Oxford, UK
BERLIN, ISAIAH; ETHICAL PLURALISM; LEVI, PRIMO

Jennifer Chesworth, Independent Scholar
Boalsburg, PA
SANGER, MARGARET

William Christian, Prof., Political Science
Univ. of Guelph, Ont., Canada
GRANT, GEORGE

Clifford Christians, Prof., Inst. of Communications Research
Univ. of Illinois at Urbana-Champaign
COMMUNICATION ETHICS

Daryl E. Chubin, Senior Vice Pres. for Policy and Research
Nat. Action Council for Minorities in Engineering, Inc., White Plains, NY
PEER REVIEW

Eric D. Claus, Research Asst., Psychology
Univ. of Colorado, Boulder
CHOICE BEHAVIOR; PSYCHOPARMACOLOGY

Vincent Colapietro, Prof., Philosophy
Pennsylvania State Univ., University Park
PEIRCE, CHARLES SANDERS

Carol Colatrella, Prof., Literature, Communication, and Culture; Co-Dir., Ctr. for the Study of Women, Science, and Technology
Georgia Inst. of Technology, Atlanta
SCIENCE, TECHNOLOGY, AND LITERATURE

Craig Condella, Teaching Fellow, Philosophy
Fordham Univ., Bronx, NY
HEGEL, GEORG WILHELM FRIEDRICH

Daniel Conway, Prof., Philosophy
Pennsylvania State Univ., University Park
KIERKEGAARD, SØREN; NIETZSCHE, FRIEDRICH W.

Martin L. Cook, Prof., Philosophy
United States Air Force Academy, CO
MILITARY ETHICS

Thomas D. Cornell, Assoc. Prof., History
Rochester Inst. of Technology, NY
FORD, HENRY

Ross B. Corotis, Prof., Civil, Environmental and Architectural Engineering
Univ. of Colorado, Boulder
RELIABILITY

Margaret Cosentino, Researcher
Ctr. for Strategic and Int'l. Studies, Washington, DC
BARUCH PLAN; LIMITED NUCLEAR TEST BAN TREATY; NUCLEAR NON-PROLIFERATION TREATY

Jessica L. Cox, Researcher
Ctr. for Strategic and Int'l. Studies, Washington, DC
BARUCH PLAN; LIMITED NUCLEAR TEST BAN TREATY; NUCLEAR NON-PROLIFERATION TREATY

Robert P. Crease, Prof., Philosophy
State Univ. of New York, Stony Brook
EXPERTISE

Kem D. Crimmins, Ph.D. candidate, Philosophy
Fordham Univ., Bronx, NY
LYOTARD, JEAN-FRANÇOIS

Jennifer L. Croissant, Assoc. Prof., Women's Studies
Univ. of Arizona, Tuscon
SOCIAL THEORY OF SCIENCE AND TECHNOLOGY

Marvin J. Croy, Assoc. Prof., Philosophy
Univ. of North Carolina, Charlotte
INCREMENTALISM; SOCIAL ENGINEERING

Ana Cuevas-Badallo, Asst. Prof., Philosophy
Univ. of Salamanca, Spain
MONDRAGÓN COOPERATIVE CORPORATION

Charles M. Culver, Prof., Medical Education
Barry Univ., Miami Shores, FL
THERAPY AND ENHANCEMENT

Stephen H. Cutcliffe, Prof., History; Prof. and Chair, Science and Technology Studies
Lehigh Univ., Bethlehem, PA
SCIENCE, TECHNOLOGY, AND SOCIETY STUDIES

Martin Daly, Prof., Psychology
McMaster Univ., Hamilton, Ont., Canada
CRIME

Marcel Danesi, Prof., Anthropology; Dir., Program in Semiotics and Communication Theory
Univ. of Toronto, Ont., Canada
POPULAR CULTURE; POSTMODERNISM

Peter Danielson, Prof., Dir., Ctr. for Applied Ethics
Univ. of British Columbia, Vancouver, Canada
ARTIFICIAL MORALITY; MONITORING AND SURVEILLANCE; ROBOT TOYS; TURING TESTS

Marcy Darnovsky, Assoc. Exec. Dir.
Ctr. for Genetics and Society, Oakland, CA
SEX SELECTION

Edward B. Davis, Prof., History of Science
Messiah Coll., Grantham, PA
BOYLE, ROBERT

Michael Davis, Prof., Philosophy
Illinois Inst. of Technology, Chicago
CODES OF ETHICS; CONFLICT OF INTEREST; PROFESSION AND PROFESSIONALISM

Juan de Castro, Full-time faculty, Eugene Lang Coll.
New School Univ., New York, NY
COLONIALISM AND POSTCOLONIALISM; JUANA INÉS DE LA CRUZ

José M. de Cózar-Escalante; Prof., History and Philosophy of Science, Education and Language
Univ. of La Laguna, Spain
EFFICIENCY

Inmaculada de Melo-Martín, Assoc. Prof., Philosophy
St. Mary's Univ., San Antonio, TX
ASSISTED REPRODUCTION TECHNOLOGY; BIRTH CONTROL; GENETIC RESEARCH AND TECHNOLOGY

Wesley Dean, Post-doctoral Research Assoc., Veterinary Integrative Biosciences & Rural Sociology
Texas A&M Univ., College Station
EMERGENT INFECTIOUS DISEASES

Thomas R. DeGregori, Prof., Economics
Univ. of Houston, TX
GENETICALLY MODIFIED FOODS

Willard Delavan, Visiting Asst. Prof., Economics
Rochester Inst. of Technology, NY
CAPITALISM; PROPERTY; VEBLEN, THORSTEIN

Christelle Didier, Ethics
Institut Catholique de Lille, France
ENGINEERING ETHICS: EUROPE

Shane Drefcinski, Philosophy
Univ. of Wisconsin, Platteville
HUME, DAVID

Krishna R. Dronamraju, Pres.
Foundation for Genetic Research, Houston, TX
HALDANE, J. B. S.

Ruth E. Duerr, Archive Services Mgr., Nat. Snow and Ice Data Ctr.
CIRES, Univ. of Colorado at Boulder
ANSCOMBE, G. E. M.; ROYAL SOCIETY

Paul T. Durbin, Prof. Emeritus, Philosophy
Univ. of Delaware, Newark
BELL, DANIEL, CONSERVATION AND PRESERVATION; DEFORESTATION AND DESERTIFICATION; PRAGMATISM; RAIN FOREST

Roger W. Dyson, Dir., Ctr. for the History of Political Thought
Univ. of Durham, UK
THOMAS AQUINAS

Frank H. W. Edler, Instructor, Philosophy
Metropolitan Community Coll., Omaha, NE
LUDDITES AND LUDDISM

Fred Edwords, Ed., *Humanist*; Editorial Dir.
American Humanist Association, Washington, DC
HUMANISM

Deni Elliott, Poynter Jamison Chair in Media Ethics and Press Policy
Univ. of South Florida, St. Petersburg
JOURNALISM ETHICS

Edwin M. Elrod, Adjunct Prof., Coll. of Information Science and Technology
Drexel Univ., Philadelphia, PA
INFORMATION ETHICS

Charles Ess, Distinguished Research Prof., Interdisciplinary Studies Ctr.
Drury Univ., Springfield, MO
DISCOURSE ETHICS

Amitai Etzioni, Prof., Sociology, *George Washington Univ.*
Founder and Dir., *The Communitarian Network*
Washington, DC
COMMUNITARIANISM

Dylan Evans, Senior Lecturer, Computing, Engineering and Mathematical Sciences
Univ. of the West of England, Bristol, UK
EMOTION

John R. Fanchi, Prof., Petroleum Engineering
Colorado Sch. of Mines, Golden
OIL

Samar Farage, Sociology
Pennsylvania State Univ., University Park
GALENIC MEDICINE

Darryl L. Farber, Asst. Prof., Science, Technology, and Society
Pennsylvania State Univ., University Park
CHERNOBYL; NUCLEAR REGULATORY COMMISSION; NUCLEAR WASTE

Joshua C. Farley, Asst. Prof., Community Development and Applied Economics; Fellow, Gund Inst. for Ecological Economics
Univ. of Vermont, Burlington
ECOLOGICAL ECONOMICS

Darrell J. Fasching, Prof., Religious Studies
Univ. of South Florida, Tampa
HOLOCAUST; TECHNICIZATION

Marc R. Fellenz, Assoc. Prof., Philosophy
Suffolk County Community Coll., Brentwood, NY
ANIMAL EXPERIMENTATION; ANIMAL RIGHTS

John Fielder, Prof., Philosophy
Villanova Univ., PA
DC-10 CASE

Autumn Fiester, Senior Fellow, Ctr. for Bioethics
Dir. of Graduate Studies, Medical Ethics
Univ. of Pennsylvania, Philadelphia
BIOETHICS CENTERS

Robert Figueroa, Asst. Prof., University Studies
Colgate Univ., Hamilton, NY
ENVIRONMENTAL JUSTICE

Kevin Finneran, Ed.-in-Chief
Issues in Science & Technology, Washington, DC
NATIONAL ACADEMIES

Erik Fisher, Doctoral student, Environmental Studies
Univ. of Colorado, Boulder, CO
TWO CULTURES

Kenneth R. Fleischmann, Asst. Prof., Coll. of Information
Florida State Univ., Tallahassee
MODELS AND MODELING

Luciano Floridi, Assoc. Prof., Philosophy
Oxford Univ., UK and Bari Univ., Italy
INFORMATION

James R. Flynn, Prof., Political Studies
Univ. of Otago, Dunedin, New Zealand
IQ DEBATE

Franz Allen Foltz, Assoc. Prof., Science, Technology & Society
Rochester Inst. of Technology, NY
ENVIRONMENTAL IMPACT ASSESSMENT; POPULATION; SOCIAL CONTRACT THEORY

Rayvon Fouché, Asst. Prof., Science and Technology Studies
Rensselaer Polytechnic Inst., Troy, NY
RACE

Mark S. Frankel, Dir., Scientific Freedom, Responsibility and Law Program
American Association for the Advancement of Science, Washington, DC
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Maarten Franssen, Assoc. Prof., Philosophy
Delft Univ. of Technology, The Netherlands
TECHNICAL FUNCTIONS

Anthony Freeman, Managing Ed.
Journal of Consciousness Studies, Exeter, UK
CONSCIOUSNESS

Volker Friedrich, Prof., Creative Writing
Hochschule Konstanz, Germany
FAUST; RUSSELL, BERTRAND

Robert Frodeman, Assoc. Prof. and Chair, Philosophy and Religion Studies
Univ. of North Texas, Denton
ACID MINE DRAINAGE; DECISION SUPPORT SYSTEMS; GLOBAL CLIMATE CHANGE; KNOWLEDGE; PLACE; TOWARD AN ETHICS OF SCIENCE AND TECHNOLOGY AS KNOWLEDGE

Jun Fudano, Prof., History of Science and Technology; Dir., Office of Int'l. Programs
Kanazawa Inst. of Technology, Japan
JAPANESE PERSPECTIVES

Wilhelm E. Fudpucker, *Massenheim Inst.*
TECHNICISM

Lars Fuglsang, Assoc. Prof., Social Sciences
Roskilde Univ., Denmark
SCANDINAVIAN AND NORDIC PERSPECTIVES

Steve Fuller, Prof., Sociology
Univ. of Warwick, Coventry, UK
KUHN, THOMAS; SOCIAL CONSTRUCTION OF SCIENTIFIC KNOWLEDGE

Giorgio Gallo, Prof., Computer Science
Univ. of Pisa, Italy
OPERATIONS RESEARCH

Arun Gandhi, Founder and Pres.
M.K. Gandhi Inst. for Nonviolence, Memphis, TN
GANDHI, MOHANDAS

José Luís Garcia, Asst. Prof., Sociology
Univ. of Lisbon, Portugal
SPENGLER, OSWALD; THEODICY

Marcos Garcia de la Huerta, Prof., Philosophy
Univ. of Chile, Santiago
JÜNGER, ERNST

Jerry Gaston, Prof., Sociology
Texas A&M Univ., College Station
MERTON, ROBERT

Bernard Gert, Stone Prof. of Intellectual and Moral Philosophy
Dartmouth Coll., Hanover, NH
THERAPY AND ENHANCEMENT

Onkar Ghate, Senior Fellow
Ayn Rand Inst., Irvine, CA
RAND, AYN

Tina Gianquitto, Asst. Prof., Liberal Arts and Int'l. Studies
Colorado Sch. of Mines, Golden
LEOPOLD, ALDO; TREAT, MARY

David W. Gill, Freelance ethics writer, educator, and consultant
Berkeley, CA
BUSINESS ETHICS

Nicholas W. Gillham, James B. Duke Prof. Emeritus, Biology
Duke Univ., Durham, NC
GALTON, FRANCIS

Michael Gilmore, B.S., Fellow of the British Interplanetary Society
SPACE EXPLORATION

Hebert Gintis, Emeritus Prof., Economics
Univ. of Massachusetts, Amherst
DECISION THEORY; ECONOMICS AND ETHICS; GAME THEORY; PRISONER'S DILEMMA; RATIONAL CHOICE THEORY

Ranulph Glanville, Freelance Prof., Cybernetics and Design
CybernEthics Research, Southsea, UK
CYBERNETICS

Andrew J. Goddard, Tutor, Christian Ethics
Wycliffe Hall, Oxford Univ., UK
ELLUL, JACQUES

Sara Goering, Asst. Prof., Philosophy
Univ. of Washington, Seattle
AUTONOMY; COSMETICS

Steven L. Goldman, Andrew W. Mellon Distinguished Prof. in the Humanities
Lehigh Univ., Bethlehem, PA
PROGRESS; SCIENTIFIC REVOLUTION; TECHNOLOGICAL INNOVATION

David L. Goodstein, Vice Provost; Prof. of Physics and Applied Physics
California Inst. of Technology, Pasadena, CA
MISCONDUCT IN SCIENCE: PHYSICAL SCIENCES CASES

Gennady Gorelik, Research Fellow, Ctr. for Philosophy and History of Science
Boston Univ., MA
SAKHAROV, ANDREI

Michael E. Gorman, Prof., Science, Technology, and Society
Univ. of Virginia, Charlottesville
EARTH SYSTEMS ENGINEERING MANAGEMENT; ENTREPRENEURISM

Vitaly Gorokhov, Prof., Philosophy
Universität Karlsruhe, Germany
RUSSIAN PERSPECTIVES

Gabriella Gosman, M.D., Asst. Prof., Obstetrics, Gynecology, and Reproductive Sciences
Univ. of Pittsburgh Sch. of Medicine, Magee-Womens Hospital, PA
ABORTION

John A. Grim, Prof., Religion
Bucknell Univ., Lewisburg, PA
INDIGENOUS PEOPLES' PERSPECTIVES

Jim Grote, Freelance business writer
Louisville, KY
GATES, BILL; GIRARD, RENÉ

Alastair Gunn, Assoc. Prof., Philosophy
Univ. of Waikato, Hamilton, New Zealand
ENGINEERS FOR SOCIAL RESPONSIBILITY; INSTITUTE OF PROFESSIONAL ENGINEERS NEW ZEALAND

Claus Günzler, Prof. Emeritus, Philosophy
Univ. of Education, Karlsruhe, Germany
SCHWEITZER, ALBERT

David H. Guston, Assoc. Prof., Public Policy
Rutgers Univ., New Brunswick, NJ
RESEARCH INTEGRITY; SOCIAL CONTRACT FOR SCIENCE

Edward J. Hackett, Prof., Sociology
Arizona State Univ., Tempe, AZ
PEER REVIEW

Patrick W. Hamlett, Assoc. Prof., Science, Technology, and Society
North Carolina State Univ., Raleigh, NC
CONSENSUS CONFERENCES

Eric T. Hammer, Spiritual Care Coordinator and Chaplain
VistaCare Hospice, Temple, TX
DEATH AND DYING

J. Craig Hanks, Assoc. Prof., Philosophy
Texas State Univ., San Marcos
CRITICAL SOCIAL THEORY; DEWEY, JOHN

Sven Ove Hansson, Prof., Philosophy
Royal Inst. of Technology, Stockholm, Sweden
EXPOSURE LIMITS; RISK ETHICS; SAFETY ENGINEERING: PRACTICES; SAFETY FACTORS

Robin M. Harrap, Adjunct Prof., Geological Sciences and Geological Engineering; Assoc. Dir., Research, GIS Laboratory
Queen's Univ., Kingston, Ont., Canada
DECISION SUPPORT SYSTEMS

Poul Harremoës, Prof., Environment and Resources
DTU Technical Univ. of Denmark, Kongens Lyngby
PRECAUTIONARY PRINCIPLE

Charles E. Harris, Jr., Prof., Philosophy
Texas A&M Univ., College Station
ENGINEERING ETHICS: OVERVIEW

David M. Hart, Assoc. Prof., Sch. of Public Policy
George Mason Univ., Arlington, VA
POLITICAL ECONOMY

John Hart, Researcher, Chemical and Biological Warfare Project
Stockholm Int'l. Peace Research Inst., Sweden
CHEMICAL WEAPONS

Leonard Hayflick, Adjunct Prof., Anatomy
Univ. of California, San Francisco Sch. of Medicine
AGING AND REGENERATIVE MEDICINE

Maril Hazlett, Ph.D.
Independent Scholar
CARSON, RACHEL

Topi Heikkerö, Researcher, Systematic Theology
Univ. of Helsinki, Finland
MATERIALISM; VEGETARIANISM; VON WRIGHT, GEORG HENRIK

Susan Hendler, Assoc. Prof., Sch. of Urban and Regional Planning
Queen's Univ., Kingston, Ont., Canada
PLANNING ETHICS

Bertrand Hériard Dubreuil, S.J. Researcher, Centre de Recherche et d'Action Sociale, Paris
Centre Ethique Technique et Société, Inst. Catholique d'Arts et Metiérs de Lille, France
ENGINEERING ETHICS: EUROPE

Joseph R. Herkert, Assoc. Prof., Program Dir., Science, Technology, and Society
North Carolina State Univ., Raleigh
BHOPAL CASE; INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS; PRODUCT SAFETY AND LIABILITY

Peter D. Hershock, Educational Specialist
East-West Ctr., Honolulu, HI
BUDDHIST PERSPECTIVES

David J. Hess, Prof., Science and Technology Studies
Rensselaer Polytechnic Univ., Troy, NY
CANCER; COMPLEMENTARY AND ALTERNATIVE MEDICINE

Eric Higgs, Dir., Assoc. Prof., Sch. of Environmental Studies
Univ. of Victoria, B.C., Canada
ECOLOGICAL RESTORATION

Thomas C. Hilde, Visiting Asst. Prof., Research Scholar, Inst. for Philosophy and Public Policy
Univ. of Maryland, Washington, DC
COMMUNITY; TOURISM

Kenneth Einar Himma, Assoc. Prof., Philosophy
Seattle Pacific Univ., WA
NATURAL LAW

Andrew P. Hodges, Lecturer, Mathematics
Wadham Coll., Univ. of Oxford, UK
TURING, ALAN

J. Britt Holbrook, Asst. Prof., Philosophy and Religion Studies
Univ. of North Texas, Denton
NATIONAL SCIENCE FOUNDATION SECOND MERIT CRITERION

Rachelle D. Hollander
Baltimore, MD
NATTIONAL SCIENCE FOUNDATION

Alexander E. Hooke, Prof., Philosophy
Villa Julie Coll., Stevenson, MD
FOUCAULT, MICHEL; VIRTUE ETHICS

James P. Horne, P.E., Design Engineer
KL&A, Inc., Golden, CO
EARTHQUAKE ENGINEERING

Gilbert Hottois, Prof., Philosophy
Université Libre de Bruxelles, Belgium
TECHNOSCIENCE

M. Ann Howard, Assoc. Prof., Science, Technology, Society
Rochester Inst. of Technology, NY
NONGOVERNMENTAL ORGANIZATIONS; URBANIZATION

Craig R. Humphrey, Sociology
Pennsylvania State Univ., University Park
SUSTAINABLILTY AND SUSTAINABLE DEVELOPMENT

Morgan J. Hurley, Technical Dir.
Society of Fire Protection Engineers, Bethesda, MD
FIRE

Héctor José Huyke, Prof., Humanities
Univ. of Puerto Rico at Mayagüez
DISTANCE

A. Pablo Iannone, Prof., Philosophy
Central Connecticut State Univ., New Britain, CT
INFORMATION OVERLOAD; POLLUTION; SPEED

Andoni Ibarra, Prof., Logic and Philosophy of Science
Univ. of the Basque Country, Donostia-San Sebastián, Spain
LOGICAL EMPIRICISM

Dolores Ibarreta, Biologist
Inst. for Prospective Technological Studies, Joint Research Centre, European Commission, Seville, Spain
DES (DIETHYLSTILBESTROL) CHILDREN

Don Ihde, Distinguished Prof. of Philosophy; Dir., Technoscience Research Group
State Univ. of New York, Stony Brook
BODY; INSTRUMENTATION

Lucas D. Introna, Prof., Organisation, Technology and Ethics
Lancaster Univ., UK
LEVINAS, EMMANUEL; PHENOMENOLOGY

Bernhard Irrgang, Prof., Technikphilosophie
Technical Univ. of Dresden, Germany
GERMAN PERSPECTIVES

Paul Israel, Dir., Thomas A. Edison Papers
Rutgers Univ., Piscataway, NJ
EDISON, THOMAS ALVA

Fatima L. C. Jackson, Prof., Anthropology
Univ. of Maryland, College Park
TUSKEGEE EXPERIMENT

Struan Jacobs, Senior Lecturer, Sociology
Deakin Univ., Geelong, Victoria, Australia
LIBERALISM

John E. Jalbert, Prof., Philosophy and Religious Studies
Sacred Heart Univ., Fairfield, CT
MONEY

Stephen Janos, Friar
Sts. Peter & Paul RO Rectory, Buffalo, NY
BERDYAEV, NIKOLAI

Lonny Jarrett, M.Ac., Acupuncturist
Stockbridge, MA
ACUPUNCTURE

Sheila Jasanoff, Pforzheimer Professor of Science and Technology Studies
Kennedy Sch., Harvard Univ., Cambridge, MA
TECHNOLOGIES OF HUMILITY: CITIZEN PARTICIPATION IN GOVERNING SCIENCE

Helena Mateus Jerónimo, Univ. Lecturer, Sociology, Inst. of Economics and Business
Administration of the Technical Univ. of Lisbon and Research Ctr. on Economic Sociology and the Sociology of Organizations
Lisbon, Portugal
RISK SOCIETY; WASTE

James V. Jesudason, Assoc. Prof., Liberal Arts and Int'l. Studies
Colorado Sch. of Mines, Golden
SINGAPORE

Sujatha Jesudason, Gender, Justice and Human Genetics Program Dir.
Ctr. for Genetics and Society, Oakland, CA
SEX SELECTION

Deborah G. Johnson, Anne Shirley Carter Olsson Prof. of Applied Ethics; Chair, Science, Technology, and Society
Univ. of Virginia, Charlottesville
COMPUTER ETHICS; ETHICS AND TECHNOLOGY: A PROGRAM FOR FUTURE RESEARCH; HACKER ETHICS; RESPONSIBILITY: ANGLO-AMERICAN PERSPECTIVES; SOCIAL CONSTRUCTION OF TECHNOLOGY

James Turner Johnson, Prof., Religion
Rutgers Univ., New Brunswick, NJ
JUST WAR

Michael E. Johnson-Cramer, Management
Bucknell Univ., Lewisburg, PA
STAKEHOLDERS

Stephen Johnston, Adjunct Prof., Engineering
Univ. of Technology Sydney, Australia
AUSTRALIAN AND NEW ZEALAND PERSPECTIVES

Alicia Juarrero, Prof,. Philosophy
Prince George's Community Coll., Largo, MD
COMPLEXITY AND CHAOS

Matthias Kaiser, Dir.
Nat. Committee for Research Ethics in Science and Technology, Oslo, Norway
INTERNATIONAL COUNCIL FOR SCIENCE

Subhash Kak, Delaune Distinguished Prof. of Electrical Engineering and Prof. of Asian Studies and Cognitive Science
Louisiana State Univ., Baton Rouge
HINDU PERSPECTIVES

Mark A. Kalthoff, Chairman, Assoc. Prof., History
Hillsdale Coll., MI
GALILEI, GALILEO

David M. Kaplan, Visiting Asst. Prof., Humanities and Social Sciences
Polytechnic Univ., Brooklyn, NY
MARCUSE, HERBERT; WORLD TRADE ORGANIZATION

James E. Katz, Prof., Communication
Rutgers Univ., New Brunswick, NJ
TELEPHONE

Antti Kauppinen, Philosophy
Univ. of Helsinki, Finland
HABERMAS, JÜRGEN

Christine Keiner, Asst. Prof., Science, Technology, and Society
Rochester Inst. of Technology, NY
DDT; DUBOS, RENÉ

Evelyn Fox Keller, Prof., Science, Technology, and Society
Massachusetts Inst. of Technology, Cambridge
MCCLINTOCK, BARBARA

Michael R. Kelly, Adjunct Asst. Prof., Philosophy
Boston Coll., MA
HUSSERL, EDMUND

Habibul H. Khondker, Assoc. Prof., Sociology
Nat. Univ. of Singapore
SINGAPORE

Gavin Kitching, Prof., Politics and Int'l. Relations
Univ. of New South Wales, Sydney, Australia
GLOBALISM AND GLOBALIZATION; NATIONALISM; NEOLIBERALISM

Chuck Klein, NRA and TDI certified firearms instructor
Cincinnati, OH
POLICE

Julie Thompson Klein, Prof., Humanities, Interdisciplinary Studies
Wayne State Univ., Detroit, MI
INTERDISCIPLINARITY

Edward H. Klevans, Prof. Emeritus, Nuclear Engineering
Pennsylvania State Univ., University Park
CHERNOBYL; NUCLEAR WASTE; THREE-MILE ISLAND

Ronald R. Kline, Bovay Prof. in History and Ethics of Engineering
Cornell Univ., Ithaca, NY
RESEARCH ETHICS, ENGINEERING ETHICS, AND SCIENCE AND TECHNOLOGY STUDIES; STEINMETZ, CHARLES; WIENER, NORBERT

Arnold Kling, Contributing Ed.
TechCentralStation.com
LIBERTARIANISM; MARKET THEORY

Billy V. Koen, Prof., Mechanical Engineering
Univ. of Texas, Austin
ENGINEERING METHOD

David Kolb, Charles A. Dana Prof. of Philosophy
Bates Coll., Lewiston, ME
EXISTENTIALISM

Katherine J. Komenda Poole, Prof., Religious Studies
Naropa Univ., Boulder, CO
SHINTO PERSPECTIVES

Maria Kostyszak, Ph.D., Adjunct
Inst. of Philosophy, Wroclaw, Poland
CENTRAL EUROPEAN PERSPECTIVES

Steven Kreis, Instructor, History and Humanities
Wake Technical Community Coll., Raleigh, NC
COMTE, AUGUSTE

Manfred Kroger, Prof. Emeritus, Food Science
Pennsylvania State Univ.,University Park
FOOD SCIENCE AND TECHNOLOGY

Wolfgang Krohn, Prof., Sociology
Univ. of Bielefeld, Germany
ENQUETE COMMISSIONS; EXPERIMENTATION

Robert Kugelmann, Prof., Psychology
Univ. of Dallas, Irving, TX
STRESS

Ray Kurzweil, inventor, entrepreneur and author; Pres.
Kurzweil Technologies, Inc., MA
NANOSCIENCE, NANOTECHNOLOGY, AND ETHICS: PROMISE AND PERIL

Gregory Clifford Kunkle, Adjunct Prof., Science, Technology & Society
Lehigh Univ., Bethlehem, PA
OFFICE OF TECHNOLOGY ASSESSMENT

Hugh Lacey, Scheuer Family Prof. Emeritus of Philosophy
Swarthmore Coll., PA
FACT/VALUE DICHOTOMY

Frank N. Laird, Assoc. Prof., Graduate Sch. of Int'l. Studies
Univ. of Denver
ALTERNATIVE ENERGY; DEMOCRACY

Rob Latham, Assoc. Prof., English, American Studies
Univ. of Iowa, Iowa City
SCIENCE FICTION

Peter Augustine Lawler, Dana Prof., Department Chair, Government and Int'l. Studies
Berry Coll., Mount Berry, GA
TOCQUEVILLE, ALEXIS DE

P. Patrick Leahy, Assoc. Dir. for Geology
U.S. Geological Survey, Reston, VA
NATIONAL GEOLOGICAL SURVEYS

Sarah A. Leavitt, Assoc. Historian, Office of NIH History
Nat. Institutes of Health, Bethesda, MD
NATIONAL INSTITUTES OF HEALTH

Hans Lenk, Prof., Philosophy
Univ. of Karlsruhe, Germany
NEW TECHNOLOGIES; RECOGNIZING THE STRUCTURAL FEATURES OF NEW TECHNOLOGIES; RESPONSIBILITY: GERMAN PERSPECTIVES; SCHWEITZER, ALBERT; TECHNOCRACY

Mary Lenzi, Asst. Prof., Philosophy
Univ. of Wisconsin, Platteville
MURDOCH, IRIS; PROMETHEUS; RAWLS, JOHN

Wil Lepkowski, Independent scholar, journalist
Reston, VA
ARSENIC; CORRUPTION; HEAVY METALS; SCIENCE AND ENGINEERING INDICATORS

Peter Lévesque, Deputy Dir., Knowledge Products and Mobilization Division
Social Sciences and Humanities Research Council of Canada, Ottawa
ROYAL COMMISSIONS; SCIENCE SHOPS

Norman Levitt, Prof., Mathematics
Rutgers Univ., New Brunswick, NJ
SOKAL AFFAIR

Tammy L. Lewis, Asst. Prof, Sociology and Anthropology
Muhlenberg Coll., Allentown, PA
SUSTAINABILITY AND SUSTAINABLE DEVELOPMENT

Jon A. Leydens, Writing Program Administrator, Liberal Arts and Int'l. Studies
Colorado Sch. of Mines, Golden
PLAGIARISM

Li Chenyang, Chair and Prof., Philosophy
Central Washington Univ., Ellensburg
CONFUCIAN PERSPECTIVES

Li Shixin , Asst. Prof., Philosophy of Science and Technology
Beijing Inst. of Technology, China
CHINESE PERSPECTIVES

Liu Zeyuan, Sch. of Humanities and Social Science
Dalian Univ. of Technology, China
CHINESE PERSPECTIVES: ENGINEERING ETHICS

Liu Xiaogan, Prof., Philosophy
Chinese Univ. of Hong Kong, Shatin, New Territories
DAOIST PERSPECTIVES

George M. Logan, James Cappon Prof. of English Language and Literature
Queen's Univ., Kingston, Ont., Canada
MORE, THOMAS

José A. López Cerezo, Prof., Philosophy of Science
Univ. of Oviedo, Spain
IBERO-AMERICAN PERSPECTIVES

Michael C. Loui, Prof., Electrical and Computer Engineering
Univ. of Illinois at Urbana-Champaign
ASSOCIATION FOR COMPUTING MACHINERY

Juan Lucena, Assoc. Prof., Liberal Arts and Int'l. Studies
Colorado Sch. of Mines, Golden
HUMANITARIAN SCIENCE AND TECHNOLOGY

Heinz C. Luegenbiehl, Prof. of Philosophy and Technology Studies
Rose-Hulman Inst. of Technology, Terre Haute, IN
JAPANESE PERSPECTIVES; WHISTLEBLOWING

José Luis Luján, Assoc. Prof., Philosophy of Science
Univ. of the Balearic Islands, Palma de Mallorca, Spain
ENVIRONMENTAL REGULATION

James A. Lynch, Doctoral candidate, Comparative Literature; Spanish and Portuguese
Indiana Univ., Bloomington
BENJAMIN, WALTER; BUTLER, SAMUEL; TECHNOCOMICS

Tibor R. Machan, Prof., Argyros Sch. of Business & Economics
Chapman Univ., Orange, CA
SKINNER, B. F.

Robert Mackey, Independent Scholar
Fairlawn, VA
TOOLS AND MACHINES

Janet Malek, Asst. Prof., Medical Humanities
Brody Sch. of Medicine at East Carolina Univ., Greenville, NC
INFORMED CONSENT; MISCONDUCT IN SCIENCE: BIOMEDICAL SCIENCE CASES

Gary E. Marchant, Prof., Dir., Ctr. for the Study of Law, Science & Technology
Arizona State Univ. Coll. of Law, Tempe, AZ
SCIENCE, TECHNOLOGY, AND LAW

Jean-Michel Margot, Pres.
North American Jules Verne Society
VERNE, JULES

Genevieve Maricle, Ph.D. candidate, Environmental Studies
Univ. of Colorado, Boulder
MILITARY-INDUSTRIAL COMPLEX

Allison C. Marsh, History of Science and Technology
Johns Hopkins Univ., Baltimore, MD
MUSEUMS OF SCIENCE AND TECHNOLOGY

Robert Martello, Asst. Prof., History of Science and Technology
Franklin W. Olin Coll. of Engineering, Needham, MA
INDUSTRIAL REVOLUTION

Carol Martin, Assoc. Prof., Drama
Tisch Sch. of the Arts, New York Univ., New York
BRECHT, BERTOLT

Glen A. Mazis, Prof., Philosophy and Humanities
Pennsylvania State Univ., Harrisburg
EARTH

Glenn McGee, John A. Balint Endowed Prof. of Medical Ethics
Alden March Bioethics Inst., Albany Medical Coll., NY
HUMAN CLONING

William C. McGrew, Prof., Zoology
Miami Univ., Oxford, OH
ANIMAL TOOLS

Ross McKitrick, Assoc. Prof., Economics
Univ. of Guelph, Ont., Canada
ECONOMICS: OVERVIEW

Eric McLuhan, Part-time lecturer
York Univ.; Univ. of Toronto; Harris Inst. for the Arts, Toronto, Ont. Canada
MCLUHAN, MARSHALL

Elizabeth C. McNie, Graduate Research Asst., Ctr. for Science and Technology Policy Research
Univ. of Colorado, Boulder
ARCHEOLOGICAL ETHICS; BRENT SPAR; GENOCIDE; SHIPS; WEAPONS OF MASS DESTRUCTION; ZOOS

Samuel C. McQuade III, Asst. Prof., Criminal Justice
Rochester Inst. of Technology, NY
BIOSECURITY; FORENSIC SCIENCE; MONITORING AND SURVEILLANCE

Andy Miah, Lecturer in Media, Bioethics & Cyberculture
Univ. of Paisley, Scotland, UK
SPORTS

Alex C. Michalos, Dir., Inst. for Social Research and Evaluation
Univ. of Northern British Columbia, Prince George, Canada
SOCIAL INDICATORS

Diane P. Michelfelder, Dean, Coll. of Arts and Sciences
Indiana State Univ., Terre Haute
PETS

Valerie Miké, Clinical Prof., Public Health
Weill Medical Coll. of Cornell Univ., Ithaca, NY
BIOSTATISTICS; EPIDEMIOLOGY; ETHICS OF EVIDENCE; NIGHTINGALE, FLORENCE; META-ANALYSIS; PASCAL, BLAISE; PROBABILITY; STATISTICS

Keith W. Miller, Prof., Computer Science
Univ. of Illinois at Springfield
COMPUTER VIRUSES/INFECTIONS; HARDWARE AND SOFTWARE

Fabio Minazzi, Prof., Information and Communication
Università degli Studi, Milan, Italy
ITALIAN PERSPECTIVES

Carl Mitcham, Prof., Liberal Arts and Int'l. Studies
Colorado Sch. of Mines, Golden
Fac. Affil., Ctr. for Science and Technology Policy Research, Univ. of Colorado, Boulder
BIODIVERSITY COMMERCIALIZATION; BIOETHICS COMMITTEES AND COMMISSIONS; BUSH, VANNEVAR; CAPITALISM; CULTURAL LAG; CYBERCULTURE; DEATH AND DYING; DEMATERIALIZATION AND IMMATERIALIZATION; DESSAUER, FRIEDRICH; DIRECT DEMOCRACY; ECONOMICS: OVERVIEW; ETHICS: OVERVIEW; HOBBES, THOMAS; HUMANITARIAN SCIENCE AND TECHNOLOGY; HUMANIZATION AND DEHUMANIZATION; HYPERTEXT; ILLICH, IVAN; LIFE; MISCONDUCT IN SCIENCE: SOCIAL SCIENCE CASES; MUMFORD, LEWIS; OPEN SOCIETY; OPPENHEIMER, FRANK; POLANYI, KARL; PROMETHEUS; RELIABILITY; RESPONSIBILITY: OVERVIEW; RISK AND SAFETY: OVERVIEW; RUSSELL, BERTRAND; SCIENCE: OVERVIEW; SEMIOTICS: OVERVIEW; SIMON, JULIAN; SOCIAL CONTRACT THEORY; SYSTEMS AND SYSTEMS THINKING; TERRORISM; TOOLS AND MACHINES; TECHNOETHICS; TECHNOLOGY: OVERVIEW; TOWARD AN ETHICS OF SCIENCE AND TECHNOLOGY AS KNOWLEDGE; UNCERTAINTY; VALUE AND VALUES

Kristen Renwick Monroe, Prof., Political Science
Univ. of California, Irvine
ALTRUISM

Jensen R. Montambault, Ph.D. candidate, Sch. of Natural Resources and Environment
Univ. of Florida, Gainesville
MULTIPLE-USE MANAGEMENT

Suzanne Moon, Asst. Prof., Liberal Arts and Int'l. Studies
Colorado Sch. of Mines, Golden
HUMANITARIAN SCIENCE AND TECHNOLOGY; GREEN REVOLUTION

Steven A. Moore, Assoc. Prof., Architecture and Planning
Univ. of Texas, Austin
BUILDING CODES

Thomas Mormann, Prof., Logic and Philosophy of Science
Univ. of the Basque Country, Donostia-San Sebastián, Spain
LOGICAL EMPIRICISM

Janice M. Morse, Prof., Nursing; Scientific Dir., Int'l Inst. for Qualitative Methodology
Univ. of Alberta, Edmonton, Canada
QUALITATIVE RESEARCH

Elizabeth J. Mulligan, Psychology
Univ. of Colorado, Boulder
CHOICE BEHAVIOR; PSYCHOLOGY: OVERVIEW; PSYCHOPHARMACOLOGY

Phil Mullins, Prof., Humanities
Missouri Western State Coll., St. Joseph
POLANYI, MICHAEL

Joshua Muravchik, Resident Scholar
American Enterprise Inst. for Public Policy Research, Washington, DC
COMMUNISM; SOCIALISM

Deena M. Murphy-Medley, Ph.D. candidate, Psychology
North Carolina State Univ., Raleigh
BHOPAL CASE

Anna Nagurney, John F. Smith Memorial Prof., Isenberg Sch. of Management
Univ. of Massachusetts, Amherst
NETWORKS

Indira Nair, Prof., Engineering and Public Policy
Carnegie Mellon Univ., Pittsburgh, PA
ETHICS OF CARE

Massimo Negrotti, Prof. of Methodology of Human Sciences
Univ. of Urbino, Italy
ARTIFICIALITY

Annemiek Nelis, Deputy Dir.
Ctr. for Society & Genomics, Nijmegen, The Netherlands
DUTCH PERSPECTIVES

Bryon Newberry, Assoc. Prof., Mechanical Engineering
Baylor Univ., Waco, TX
PROFESSIONAL ENGINEERING ORGANIZATIONS; TECHNOLOGICAL FIX

Francis R. Nicosia, Prof., History
Saint Michael's Coll., Colchester, VT
NAZI MEDICINE

Helen Nissenbaum, Assoc. Prof., Culture and Communication, Computer Science
New York University, New York
VALUES IN TECHNICAL DESIGN

Bryan G. Norton, Prof., Sch. of Public Policy
Georgia Inst. of Technology, Atlanta
BIODIVERSITY; WILDERNESS; WILDLIFE MANAGEMENT

Pelucy Ntambirweki, Advisor, Children Affected by HIV and AIDS
UNICEF, Swaziland
AFRICAN PERSPECTIVES: HIV/AIDS IN AFRICA

Barbara Olds, Prof., Liberal Arts and Int'l. Studies
Colorado Sch. of Mines, Golden
ETHICS ASSESSMENT RUBRICS

Richard Olson, Prof. of History and Willard W. Keith Jr. Fellow in Humanities
Harvey Mudd Coll., Claremont, CA
ENLIGHTENMENT SOCIAL THEORY; SECULARIZATION

Carleton A. Palmer, Asst. Prof. of Psychology
Inst. for the Psychological Sciences, Arlington, VA
DIAGNOSTIC AND STATISTICAL MANUAL OF MENTAL DISORDERS

Eul-Soo Pang, Prof., Liberal Arts and Int'l. Studies
Colorado Sch. of Mines, Golden
POLITICAL RISK ASSESSMENT

Robert J. Paradowski, Prof., Science, Technology, and Society
Rochester Inst. of Technology, NY
FOOD AND DRUG AGENCIES; NUTRITION AND SCIENCE; PAULING, LINUS; TAYLOR, FREDERICK W.

Govindan Parayil, Prof., Ctr. for Technology, Innovation and Culture
Univ. of Oslo, Norway
CHANGE AND DEVELOPMENT

John S. Partington, Ed., *The Wellsian*
The H. G. Wells Society, Reading, UK
WELLS, H. G.

Ernest Partridge, Independent Scholar
Gadfly Enterprises, Cedarpines Park, CA
FUTURE GENERATIONS

Robert T. Pennock, Assoc. Prof., Philosophy
Michigan State Univ., East Lansing
DETERMINISM

Ted Peters, Prof., Systematic Theology
Pacific Lutheran Theological Seminary and the Graduate Theological Union, Berkeley, CA
DIGNITY; PLAYING GOD

Joseph A. Petrick, Prof., Management; Dir., Inst. for Business Integrity
Wright State Univ., Dayton, OH
MANAGEMENT: MODELS OF

Sarah K. A. Pfatteicher, Asst. Dean, Engineering Academic Affairs
Univ. of Wisconsin-Madison
BUILDING DESTRUCTION AND COLLAPSE

Robert Phillips, Assoc. Prof., Sch. of Business Administration
Univ. of San Diego, CA
STAKEHOLDERS

Peter W. B. Phillips, Prof., Political Studies; Dir., Coll. of Biotechnology
Univ. of Saskatchewan, Saskatoon, Canada
CANADIAN PERSPECTIVES

Roger A. Pielke, Jr., Prof., Environmental Studies
Dir; Ctr. For Science and Technology Policy Research
Univ. of Colorado, Boulder
SCIENCE POLICY; SENSITIVITY ANALYSES

Martin T. Pietrucha, Dir., Science, Technology, and Society Program; Assoc. Prof. of Civil Engineering
Penn State Univ., University Park
ERGONOMICS

Rosa L. Pinkus, Prof., Ctr. for Bioethics and Health Law
Univ. of Pittsburgh, PA
CICERO'S CREED

Joseph C. Pitt, Prof., Head, Philosophy; Adjunct Prof., Science and Technology Studies
Virginia Tech, Blacksburg
SPACE TELESCOPES

Louis P. Pojman, Visiting Fellow
Cambridge Univ., UK
DEATH PENALTY; EQUALITY; JUSTICE

Stephen G. Post, Prof. of Bioethics, Case Sch. of Medicine
Case Western Reserve Univ., Cleveland
POSTHUMANISM

William C. Potter, Inst. Prof. and Director, Ctr. for Nonproliferation Studies
Monterey Inst. of Int'l. Studies, CA
ATOMS FOR PEACE PROGRAM

Thomas M. Powers, Research Fellow, Science, Technology, and Society
Univ. of Virginia, Charlottesville
CONSEQUENTIALISM; DEONTOLOGY; ETHICS AND TECHNOLOGY: A PROGRAM FOR FUTURE RESEARCH

Andrew Price, Graduate Researcher
Univ. of Colorado, Boulder
ANTIBIOTICS

Michael S. Pritchard, Prof., Philosophy
Western Michigan Univ., Kalamazoo
ENGINEERING ETHICS: OVERVIEW

Qian Qian, Ed.
China Aerospace Engineering Consultancy Ctr.
POPULATION POLICY IN CHINA

Wang Qian, Prof., Philosophy
Sch. of Humanities and Social Science, Dalian Univ. of Technology, China
CHINESE PERSPECTIVES: RESEARCH ETHICS; POPULATION POLICY IN CHINA

Michael Rabins, Prof. Emeritus of Mechanical Engineering
Texas A&M Univ., College Station
ENGINEERING ETHICS: OVERVIEW

Eric S. Rabkin, Prof., English Language and Literature
Univ. of Michigan, Ann Arbor
FRANKENSTEIN; SHELLEY, MARY WOLLSTONECRAFT; ZAMYATIN, YEVGENY IVANOVICH

Majid Rahnema, Visiting Prof., Int'l and Intercultural Studies
Pitzer Coll., Claremont, CA
UNITED NATIONS EDUCATIONAL, SCIENTIFIC, AND CULTURAL ORGANIZATION

Kim Alaine Rathman, Development Consultant, Los Angeles Accelerated Schools Ctr.
California State Univ., Los Angeles
COMMON HERITAGE OF MANKIND PRINCIPLE

Thomas C. Reeves, Prof., Instructional Technology
Univ. of Georgia, Athens
DIGITAL LIBRARIES

Nancy Reichman, Assoc. Prof., Sociology
Univ. of Denver, CO
MONTREAL PROTOCOL

Jacob Dahl Rendtorff, Assoc. Prof., Social Sciences
Roskilde Univ., Denmark
SCANDINAVIAN AND NORDIC PERSPECTIVES

Matthias Rieger, Adjunct faculty, Sociology
Univ. of Hannover, Germany
MUSIC

Jean Robert, Prof., City Planning and Urban History, State Univ. of Morelos
Prof. of Architecture Theory and History of Ideas, La Salle Univ.

Cuernavaca, Mexico
ALTERNATIVE TECHNOLOGY; ENERGY; SPACE

Jason Scott Robert, Asst. Prof., Sch. of Life Sciences
Arizona State Univ., Tempe
GENE THERAPY; GENETICS AND BEHAVIOR

John B. Robinson, Prof., Sustainable Development Research Initiative
Univ. of British Columbia, Vancouver
GEORGIA BASIN FUTURES PROJECT

Sheila Rock, Senior Lecturer, Computer Science
Univ. of the Witwatersrand, Johannesburg
AFRICAN PERSPECTIVES: COMPUTERS IN SOUTH AFRICA

Antonio Rodríguez de las Heras, Prof., Humanities and Communication
Unversidad Carlos III de Madrid, Spain
HYPERTEXT

Sabine Roeser, Asst. Prof., Philosophy
Delft Univ. of Technology, The Netherlands
RISK AND EMOTION

Bernard E. Rollin, Univ. Distinguished Prof. of Philosophy
Colorado State Univ., Fort Collins
ANIMAL WELFARE

Holmes Rolston III., Prof., Philosophy
Colorado State Univ., Fort Collins
ECOLOGY

Günter Ropohl, Dr.-Ing., Prof. Emeritus of General Technology
Univ. of Frankfurt on Main, Germany
INVENTION

Sue V. Rosser, Ivan Allen Dean's Chair of Liberal Arts and Technology; Prof., History, Technology, and Society
Georgia Inst. of Technology, Atlanta
SEX AND GENDER

David Rothenberg, Prof., Philosophy
New Jersey Inst. of Technology, Newark
AIR

Christina Rudén, Senior Researcher, Philosophy
Royal Inst. of Technology, Stockholm, Sweden
REGULATORY TOXICOLOGY

Michael Ruse, Lucyle T. Werkmeister Prof. of Philosophy
Florida State Univ., Tallahassee
SOCIOBIOLOGY

Martin Ryder, Adjunct Prof., Information and Learning Technologies
Univ. of Colorado, Denver
DIGITAL DIVIDE; POLYGRAPH; SCIENTISM; SEMIOTICS: LANGUAGE AND CULTURE; TECHNOLOGY: OVERVIEW

Tind Shepper Ryen, Ctr. for Science and Technology Policy
Univ. of Colorado, Boulder
BRENT SPAR; COMMUNICATIONS REGULATORY AGENCIES; HUMAN GENOME ORGANIZATION

Wolfgang Sachs, Head of Globalization and Sustainablity Project
Wuppertal Inst., Berlin, Germany
LIMITS; POVERTY

Mark Sagoff, Sr. Research Scholar, Inst. for Philosophy and Public Policy
Univ. of Maryland, College Park
ENVIRONMENTAL ECONOMICS

Silja Samerski, Adjunct faculty, Sociology
Univ. of Hannover, Germany
GENETIC COUNSELING

Sajay Samuel, Instructor, Accounting
Pennsylvania State Univ., University Park
ACCOUNTING; ALTERNATIVE TECHNOLOGY; ENERGY

Stephen K. Sanderson, Prof., Sociology
Indiana Univ. of Pennsylvania, Indiana, PA
MARX, KARL

José Sanmartín, Prof., Philosophy of Science
Univ. of Valencia
Dir., The Queen Sofía Ctr. for the Study of Violence, Spain
VIOLENCE

Amy Santamaria, Psychology
Univ. of Colorado, Boulder
PSYCHOLOGY: OVERVIEW

Daniel Sarewitz, Prof.; Science and Society; Dir., Consortium for Science, Policy, and Outcomes
Arizona State Univ., Tempe
AFFLUENCE; GAIA; GOVERNANCE OF SCIENCE; HAZARDS; PREDICTION; UNCERTAINTY

Mónica Edwards Schachter, Science Education
Univ. of Valencia, Spain
ACTIVIST SCIENCE EDUCATION

A. George Schillinger, Prof. Emeritus, Management
Polytechnic Univ., Brooklyn, New York
AUTOMATION

Lawrence E. Schmidt, Prof., Dept. and Ctr. for the Study of Religion
Univ. of Toronto at Mississauga, Ont., Canada
WEIL, SIMONE

Richard Schmitt, Prof. Emeritus, Philosophy

Brown Univ., Providence, RI
ALIENATION

Johan Schot, Prof., History of Technology
Eindhoven Univ. of Technology, The Netherlands
CONSTRUCTIVE TECHNOLOGY ASSESSMENT

Ernst Schraube, Asst. Prof., Psychology
Roskilde Univ., Denmark
ANDERS, GÜNTHER

H. Morgan Scott, Asst. Prof., Veterinary Integrative Biosciences
Coll. of Veterinary Medicine, Texas A&M Univ., College Station
EMERGENT INFECTIOUS DISEASES

James Seaton, Prof., English
Michigan State Univ., East Lansing
CONSERVATISM

Jerome M. Segal, Senior Research Scholar, Inst. for Philosophy and Public Policy
Univ. of Maryland, College Park
SIMPLICITY/SIMPLE LIVING

Edward Seiler, Author
asimovonline.com
ASIMOV, ISAAC

Evan Selinger, Asst. Prof., Philosophy
Rochester Inst. of Technology, NY
EXPERTISE; PARTICIPATION; TELEVISION

Adil E. Shamoo, Prof.
Univ. of Maryland Sch. of Medicine, Baltimore
ACCOUNTABILITY IN RESEARCH

Suzanne Shaw, Dir. of Communications
Union of Concerned Scientists, Cambridge, MA
UNION OF CONCERNED SCIENTISTS

Helena Sheehan, Senior Lecturer, History of Ideas
Dublin City Univ., Ireland
BERNAL, J. D.; LYSENKO CASE; MARXISM

Garrett Ward Sheldon, The John Morton Beaty Prof. of Political and Social Sciences
The Univ. of Virginia Coll. at Wise
JEFFERSON, THOMAS

Robert Shelton, Lyman Briggs Sch. of Science
Michigan State Univ., East Lansing
UTOPIA AND DYSTOPIA

Richard Sherlock, Prof., Philosophy
Utah State Univ., Logan
BIOETHICS; MEDICAL ETHICS

Michael Shermer,Ed.-in-Chief, *Skeptic* magazine; Contrib. Ed., *Scientific American*
Pasadena, California
PSEUDOSCIENCE; SKEPTICISM

William M. Shields, Science and Technology in Society
Virginia Tech, Blacksburg
FREUD, SIGMUND; JUNG, CARL GUSTAV, SAFETY ENGINEERING: HISTORICAL EMERGENCE

William O. Shropshire, Emeritus Callaway Prof., Economics
Oglethorpe Univ., Atlanta, GA
SMITH, ADAM

Larry Shuman, Assoc. Dean for Academic Affairs; Prof. of Industrial Engineering
Sch. of Engineering, Univ. of Pittsburgh, PA
CICERO'S CREED; ETHICS ASSESSMENT RUBRICS

Alan Sica, Prof., Sociology
Pennsylvania State Univ., University Park
DURKHEIM, ÉMILE; PARETO, VILFREDO; PARSONS, TALCOTT; WEBER, MAX

Murli M. Sinha, Prof., Sociology
Rochester Inst. of Technology, NY
FAMILY; TECHNOLOGY TRANSFER

Dominic A. Sisti, Researcher, Ctr. for Bioethics
Univ. of Pennsylvania, Philadelphia
HEALTH AND DISEASE

Eugene B. Skolnikoff, Prof. Emeritus, Political Science
Massachusetts Inst. of Technology, Cambridge
INTERNATIONAL RELATIONS

Martha M. Smith, Assoc. Prof., Coll. of Information Science and Technology
Drexel Univ., Philadelphia, PA
INFORMATION ETHICS

Martijntje W. Smits, Asst. Prof., Technology Management
Technical Univ. Eindhoven, The Netherlands
CYBORGS; PLASTICS

Marilyn Berlin Snell, Writer/Ed.
Sierra Magazine, San Francisco, CA
SIERRA CLUB; NATIONAL PARKS; UNITED NATIONS ENVIRONMENTAL PROGRAM

Stephen D. Snobelen, Asst. Prof., History and Philosophy of Science
Univ. of King's Coll., Halifax, Canada
NEWTON, ISAAC

Marlene K. Sokolon, Asst. Prof., Political Science
Concordia Univ., Montreal
EMOTIONAL INTELLIGENCE

Wha-Chul Son, Doctoral candidate, Philosophy
Catholic Univ. of Leuven, Leuven, Belgium

AUTONOMOUS TECHNOLOGY

Leonard R. Sorenson, Prof., Politics
Assumption Coll., Worcester, MA
ROUSSEAU, JEAN-JACQUES

Robert J. Sparrow, Lecturer, Sch. of Philosophy and Bioethics
Monash Univ., Melbourne, Australia
ANDROIDS; ROBOTS AND ROBOTICS

Raymond E. Spier, Emeritus Prof. of Science and Engineering Ethics
Univ. of Surrey, Guildford, UK
JEWISH PERSPECTIVES; NUCLEAR ETHICS; REGULATION AND REGULATORY AGENCIES; VACCINES AND VACCINATION

Jeffrey P. Spike, Assoc. Prof., Medical Humanities and Social Sciences
Florida State Univ. Coll. of Medicine, Tallahassee
HUMAN SUBJECTS RESEARCH; PERSISTENT VEGETATIVE STATE

Robert L. Sprague, Prof. Emeritus, Kinesiology
Univ. of Illinois, Urbana-Champaign
MISCONDUCT IN SCIENCE: SOCIAL SCIENCE CASES

Peter Stansky, Frances and Charles Field Prof. of History, Emeritus,
Stanford Univ., CA
MORRIS, WILLIAM

Nicholas H. Steneck, Prof., History
Univ. of Michigan, Ann Arbor
OFFICE OF RESEARCH INTEGRITY

Sharon Stoerger, Human Subjects Research Specialist
Univ. of Illinois at Urbana-Champaign
SOCIOLOGICAL ETHICS

Craig A. Straub, Restoration Ecologist
Straub Ecological Services, Cincinnati, OH
HARDIN, GARRETT

Sytse Strijbos, Prof., Philosophy
North West Univ., Potchefstroom, South Africa
Vrije Univ., Amsterdam, The Netherlands
SYSTEMS THINKING

David Strong, Prof. of Philosophy and Environmental Studies
Rocky Mountain Coll., Billings, Montana
ENVIRONMENTAL ETHICS

John P. Sullins III, Asst. Prof., Philosophy
Sonoma State Univ., California
ARTIFICIAL INTELLIGENCE

Shanna H. Swan, Research Prof., Family and Community Medicine
Univ. of Missouri, Columbia
DES (DIETHYLSTILBESTROL) CHILDREN

James Tansey, James Martin Lecturer in Science and Technology Studies
James Martin Inst. for Science and Civilization, Univ. of Oxford, UK
GEORGIA BASIN FUTURES PROJECT

Herman T. Tavani, Prof., Chair, Philosophy
Rivier Coll., Nashua NH
TRANSACTION GENERATED INFORMATION AND DATA MINING

Bob Pepperman Taylor, Prof., Political Science; Dean, Honors Coll.
Univ. of Vermont, Burlington
ENVIRONMENTALISM; THOREAU, HENRY DAVID

Eugene TeSelle, Emeritus Prof. of Church History and Theology
Vanderbilt Divinity Sch., Nashville, TN
AUGUSTINE

J. Brian Thomas, Lecturer, Engineering
Baylor Univ., Waco, TX
RADIO

J. Mark Thomas, Sociology
Madison Area Technical Coll., Madison, WI
TILLICH, PAUL

Paul B. Thompson, W.K. Kellogg Prof. of Agricultural, Food and Community Ethics
Michigan State Univ., East Lansing
AGRICULTURAL ETHICS

Ole Thyssen, Prof., Management, Philosophy and Politics
Copenhagen Business Sch., Denmark
LUHMANN, NIKLAS

Pieter Tijmes, Prof. Emeritus
Univ. of Twente, Enschede, The Netherlands
EUTHANASIA IN THE NETHERLANDS

Jeffrey R. Timm, Prof., Religion
Wheaton Coll., Norton, MA
BHUTAN

Nancy Tuana, Prof., Philosophy; Dir., Rock Ethics Inst.
Pennsylvania State Univ., State College
FEMINIST ETHICS; FEMINIST PERSPECTIVES

Uday T. Turaga, Independent Scholar
INDIAN PERSPECTIVES

Christine Turner, Research Geologist
U.S. Geological Survey, CO
NAT. GEOLOGICAL SURVEYS

Stephen H. Unger, Prof., Computer Science

Columbia Univ., New York, NY
BAY AREA RAPID TRANSIT CASE

Nicanor Ursua, Prof., Philosophy
Univ. of the Basque Country, San Sebastián-Donostia, Spain
PUBLIC UNDERSTANDING OF SCIENCE

Ibo van de Poel, Asst. Prof., Philosophy
Delft Univ. of Technology, The Netherlands
ENGINEERING DESIGN ETHICS

Jeroen van den Hoven, Philosophy
Delft Univ. of Technology, The Netherlands
PRIVACY

Ton van der Valk, Asst. Prof., Philosophy
Free University, Amsterdam, The Netherlands
JONAS, HANS

Kenneth W. Van Treuren, Assoc. Prof., Engineering
Baylor Univ., Waco, TX
AIRPLANES; AVIATION REGULATORY AGENCIES

Willem H. Vanderburg, Dir., Ctr. for Technology and Social Development
Univ. of Toronto, Ont., Canada
PREVENTIVE ENGINEERING

Jason Venetoulis, Senior Research Assoc.
Redefining Progress, Oakland, CA
ECOLOGICAL FOOTPRINT

Peter-Paul Verbeek, Asst. Prof., Philosophy
Twente Univ., The Netherlands
JASPERS, KARL

Jason M. Vogel, Ph.D. candidate, Environmental Studies
Univ. of Colorado, Boulder
ORGANIC FOODS

Eugene Volokh, Prof. of Law
UCLA Sch. of Law
SLIPPERY SLOPE ARGUMENTS

Rudi Volti, Prof., Sociology
Pitzer Coll., Claremont, CA
AUTOMOBILES

Raban Graf von Westphalen, Prof.
Technische Fachhochschule Berlin, Germany
TECHNOLOGY ASSESSMENT IN GERMANY AND OTHER EUROPEAN COUNTRIES

Leonard J. Waks, Prof. of Educational Leadership and Policy Studies
Temple Univ., Philadelphia, PA
EDUCATION

Henry H. Walbesser, Provost and Chief Operating Officer
Henry Cogswell Coll., Everett, WA
FULLER, R. BUCKMINSTER; VON NEUMANN, JOHN

Jonathan Wallace, Publisher, *The Ethical Spectacle*
www.spectacle.org
ADVERTISING, MARKETING, AND PUBLIC RELATIONS; BRIDGES; DAMS; DEMATERIALIZATION AND IMMATERIALIZATION; MODERNIZATION; MOVIES; NORMAL ACCIDENTS; ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT; RAILROADS; SHIPS; WORLD BANK; WORLD HEALTH ORGANIZATION

William A. Wallace, Prof., Decision Sciences and Engineering Systems
Rensselaer Polytechnic Inst., Troy, NY
MODELS AND MODELING; THOMISM

Brent Waters, Dir., Stead Ctr. for Ethics and Values
Assoc. Prof. of Christian Social Ethics
Garrett-Evangelical Theological Seminary, Evanston, Illinois
CHRISTIAN PERSPECTIVES: CONTEMPORARY ASSESSMENTS OF SCIENCE; CHRISTIAN PERSPECTIVES: CONTEMPORARY ASSESSMENTS OF TECHNOLOGY; CHRISTIAN PERSPECTIVES: HISTORICAL TRADITIONS

Charles Weijer, Assoc. Prof., Bioethics, Medicine and Surgery; Adjunct Prof., Philosophy
Dalhousie Univ., Halifax, NS, Canada
CLINICAL TRIALS

Richard Weikart, Prof., History
California State Univ., Stanislaus
EUGENICS; SOCIAL DARWINISM

Vivian Weil, Prof. of Ethics; Dir., Ctr. for the Study of Ethics in the Professions
Illinois Inst. of Technology, Chicago
CONTRACTS

Daryl J. Wennemann, Assoc. Prof., Philosophy
Fontbonne Univ., St. Louis
FREEDOM; KANT, IMMANUEL

Laura Westra, Prof. Emeritus, Philosophy, Univ. of Windsor
Adjunct Prof. of Social Science, York Univ., Toronto
Ontario, Canada
ECOLOGICAL INTEGRITY

Caroline Whitbeck, Elmer G. Beamer-Hubert H. Schneider Prof. in Ethics
Case Western Reserve Univ., Cleveland, OH
Dir., Online Ethics Ctr. for Engineering & Science, http://onlineethics.org
TRUST

Mark R. Wicclair, Prof., Philosophy and Adjunct Prof., Community Medicine, West Virginia Univ., Morgantown, WV

Adjunct Prof., Medicine and Faculty, Ctr. for Bioethics and Health Law, Univ. of Pittsburgh, Pittsburgh, PA
ABORTION

Per Wikman, MSc., Philosophy
Royal Inst. of Technology, Stockholm, Sweden
INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION; RADIATION

William H. Wilcox, Assoc. Prof., Philosophy
Utah State Univ., Logan
PETS

David R. Williams, Nat. Space Science Data Ctr.
NASA Goddard Space Flight Ctr., Greenbelt, MD
APOLLO PROGRAM

Glenn R. Willis, The Divinity Sch.
Vanderbilt Univ., Nashville, TN
PSYCHOLOGY; TOLSTOY, LEO

Margo Wilson, Psychology
McMaster Univ., Hamilton, Ont., Canada
CRIME

James J. Winebrake, Prof., Science Technology and Society/Public Policy
Rochester Inst. of Technology, NY
POWER SYSTEMS

Gregor A. Wolbring, Biochemist, Adjunct Asst. Professorhips, Ethics, Disability Studies, Community Health,
Univ. of Calgary; Univ. of Alberta, Edmonton, Canada
DISABILITY

Mark J. P. Wolf, Assoc. Prof., Communication
Concordia Univ. Wisconsin, Mequon
SPECIAL EFFECTS; VIDEO GAMES

Harvey Wolfe, Prof., Industrial Engineering
Univ. of Pittsburgh, PA
CICERO'S CREED

Marsha C. Woodbury, Lecturer, Computer Science
Univ. of Illinois, Urbana-Champaign
SECURITY

Edward J. Woodhouse, Assoc. Prof., Science and Technology Studies
Rensselaer Polytechnic Inst., Troy, NY
AFFLUENCE; CITIZENSHIP; CIVIL SOCIETY; CLASS; CONSUMERISM

Russell J. Woodruff, Asst. Prof., Philosophy
St. Bonaventure Univ., NY
NEUTRALITY IN SCIENCE AND TECHNOLOGY; PURE AND APPLIED

Bilge Yesil, Instructor, Communication Studies
New York Univ., New York
BIOMETRICS

Yin Dengxiang, Prof., Philosophy of Science and Technology; Dir., Research Ctr. for Science, Technology and Society
Chinese Academy of Social Sciences, Beijing, China
CHINESE PERSPECTIVES

Stuart J. Youngner, Susan E. Watson Prof., Bioethics
Case Western Reserve Univ., Cleveland
BRAIN DEATH

Jean Pascal Zanders, Dir.
BioWeapons Prevention Project, Geneva, Switzerland
BIOLOGICAL WEAPONS

Yinghuan Zhao, Assoc. Prof., Research Ctr. for Philosophy of Science and Technology
Northeastern Univ., Shenyang, P. R. China
THREE-GORGES DAM

Sheldon Zink, Dir., Program for Transplant Policy and Ethics
Univ. of Program for Transplant Policy and Ethics, Ctr. for Bioethics, Univ. of Pennsylvania, Philadelphia
ORGAN TRANSPLANTS

Hub Zwart, Prof., Philosophy, Science Studies; Dir., Ctr. for Society & Genomics
Radboud Univ. of Nijmegen, The Netherlands
DUTCH PERSPECTIVES

TOPICAL OUTLINE

The following classification of articles provides an analytic summary of the Encyclopedia contents. It is intended to assist the user, whether researcher or browser, in appreciating the scope of coverage and in locating articles broadly related to a given theme. Nevertheless, because the field of science, technology, and ethics is an emerging interdisciplinary effort, it is not as easily parsed as traditional scholarly disciplines. One alternative classification scheme, for instance, would list under each specialized introduction all related articles—an analysis that would, of course, have required extensive repetitions. In the present instance, despite the fact that topic headings are not always mutually exclusive, entries are not listed more than once. It is assumed that any user will supplement use of the topical outline with the list of related articles that follows each article, and with the index.

Introductory Essays

Eight synthetic essays to introduce the encyclopedia as a whole.

Ethics and Technology: A Program for Future Research
The Ethics of Evidence: A Call for Synthesis
Nanoscience, Nanotechnology, and Ethics: Promise and Peril
Recognizing the Structural Features of New Technologies
Research Ethics, Engineering Ethics, and Science and Technology Studies
Technologies of Humility: Citizen Participation in Governing Science
Toward an Ethics of Science and Technology as Knowledge
Values in Technical Design

Introductions and Overviews

SPECIALIZED INTRODUCTIONS

Specialized introductions provide entrances into issues of science, technology, and ethics from the perspectives of recognized fields of study, many in applied ethics, relevant to science, technology, and ethics.

Agricultural Ethics
Applied Ethics
Archeological Ethics
Architectural Ethics
Bioengineering Ethics
Bioethics
Biotech Ethics
Business Ethics
Communication Ethics
Computer Ethics
Design Ethics
Development Ethics
Engineering Design Ethics
Environmental Ethics
Evolutionary Ethics
Genethics
Information Ethics
Journalism Ethics
Medical Ethics
Military Ethics
Nanoethics
Neuroethics
Nuclear Ethics: Industrial Perspectives
Nuclear Ethics: Weapons Perspectives
Planning Ethics
Rhetoric of Science and Technology
Science Fiction
Science Policy
Science, Technology, and Law
Science, Technology, and Literature
Science, Technology, and Society Studies
Scientific Ethics
Sociological Ethics

OVERVIEWS

Overview articles introduce specific themes that either are dealt with by more than one entry or have multiple branches out into other entries.

Economics: Overview
Engineering Ethics: Overview
Ethics: Overview
Management: Overview
Misconduct in Science: Overview
Psychology: Overview
Research Ethics: Overview
Responsibility: Overview
Risk and Safety: Overview
Science: Overview
Semiotics: Overview
Social Institutions: Overview
Technology: Overview

Concepts, Case Studies, Issues, and Persons

KEY CONCEPTS

Analyses of special concepts that often play significant roles in discussions of science, technology, and ethics. Such concepts can often be distinguished in those that arise from an ethical-political or a scientific-technological base.

CONCEPTS, ETHICAL AND POLITICAL

Aggression
Alienation
Altruism
Animal Rights
Animal Welfare
Autonomy
Change and Development
Cicero's Creed
Citizenship
Civil Society
Class
Codes of Ethics
Common Heritage of Mankind Principle
Community

CONCEPTS, SCIENTIFIC OR TECHNOLOGICAL

CASE STUDIES

Presentations of a broad sample of influential, historical cases in science, technology, and ethics discussions.

Mondragón Cooperative Corporation
Montreal Protocol
Nuclear Non-Proliferation Treaty
Nuclear Waste
Pets
Rain Forest
Robot Toys
Robots and Robotics
Science Shops
Singapore
Sokal Affair
Space Shuttles *Challenger* and *Columbia* Accidents
Space Telescopes
Special Effects
Technocomics
Three Gorges Dam
Three-Mile Island
Tuskegee Experiment
Video Games

ISSUES

Issue articles overlap with Key Concepts and Case Studies, by reporting on topics that have received often contentious treatment because of substantial disagreements about their scientific, technological, or ethical aspects. Some issues selected to provide historical perspective. Like concepts, issues often arise from different bases, this time either historical and social or scientific-technological bases. With regard to issues, it is also possible to distinguish a third base in phenomena.

ISSUES, HISTORICAL AND SOCIAL

Activist Science Education
Advertising, Marketing, and Public Relations
Affluence
Automation
Biodiversity Commercialization
Consensus Conferences
Conservation and Preservation
Constructive Technology Assessment
Consumerism
Contracts
Corruption
Death Penalty
Deforestation and Desertification
Digital Divide
Direct Democracy
Entertainment
Entrepreneurism
Galenic Medicine
Green Ideology
Hacker Ethics
Hazards
Homosexuality Debate
Humanitarian Science and Technology
Humanization and Dehumanization
Industrial Revolution
Information Overload
Information Society
IQ Debate
Luddites and Luddism
Material Culture
Materialism
Modernization
Monitoring and Surveillance
Nazi Medicine
Political Risk Assessment
Posthumanism
Product Safety and Liability
Public Understanding of Science
Race
Risk and Emotion
Scientific Revolution
Secularization
Sex and Gender
Simplicity/Simple Living
Social Darwinism
Technicization
Technocracy
Terrorism
Terrorism and Science
Theodicy
Tourism
Urbanization
Vegetarianism
Violence

ISSUES, SCIENTIFIC OR TECHNOLOGICAL

Alternative Energy
Alternative Technology
Animal Tools
Arsenic
Building Codes
Choice Behavior
Clinical Trials
Complementary and Alternative Medicine
Computer Viruses/Infections
Consciousness
Decision Support Systems
Diagnostic and Statistical Manual of Mental Disorders
Ecological Restoration
Embryonic Stem Cells
Emergent Infectious Diseases
Emotional Intelligence
Environmental Impact Assessment
Eugenics
Euthanasia
Evolution-Creationism Debate
Exposure Limits
Fetal Research
Forensic Science
Free Software
Gene Therapy
Genetic Counseling
Genetic Research and Technology
Genetically Modified Foods
Genetics and Behavior
Heavy Metals
Human Cloning
Human Subjects Research
In Vitro Fertilization and Genetic Screening
Nature versus Nurture
Neutrality in Science and Technology
Nutrition and Science
Organ Transplants
Organic Foods
Persistent Vegetative State
Regulatory Toxicology
Sex Selection
Social Contract for Science
Soft Systems Methodology
Space Exploration
Transaction Generated Information and Data Mining
Virtual Reality

ISSUES, PHENOMENA

Air
Body
Cosmetics
Crime
Cyberculture
Distance
Earth
Emotion
Fire
Gaia
Global Climate Change
Holocaust
Hormesis
Hypertext
Instrumentation
Interdisciplinarity
Life
Money
Oil
Place
Plastics

Popular Culture
Prosthetics
Qualitative Research
Risk Society
Safety Engineering: Historical Emergence
Safety Engineering: Practices
Science and Engineering Indicators
Space
Speed
Water

PERSONS AND FIGURES

Biographical entries on persons and a few mythical figures of continuing contemporary relevance to science, technology, and ethics. Includes philosophers, scientists, engineers, and writers. The division into time periods provides a quite appreciation of proportions. Although there are a few exceptions, in the third period the general rule has been to avoid entries on living persons.

PERSONS AND FIGURES, PREMODERN

Aristotle and Aristotelianism
Augustine
Plato
Prometheus
Thomas Aquinas

PERSONS AND FIGURES, MODERN PERIOD TO WORLD WAR I

Bacon, Francis
Boyle, Robert
Butler, Samuel
Comte, Auguste
Darwin, Charles
Descartes, René
Durkheim, Émile
Faust
Frankenstein
Galilei, Galileo
Galton, Francis
Hegel, Georg Wilhelm Friedrich
Hobbes, Thomas
Hume, David
Jefferson, Thomas
Juana Inés de la Cruz
Kant, Immanuel
Kierkegaard, Søren
Leibniz, G. W.
Locke, John
Machiavelli, Niccolò
Marx, Karl
Mill, John Stuart
More, Thomas
Morris, William
Newton, Isaac
Nietzsche, Friedrich W.
Nightingale, Florence
Pareto, Vilfredo
Pascal, Blaise
Peirce, Charles Sanders
Rousseau, Jean-Jacques
Shelley, Mary Wollstonecraft
Smith, Adam
Spencer, Herbert
Steinmetz, Charles
Thoreau, Henry David
Tocqueville, Alexis de
Tolstoy, Leo
Treat, Mary
Verne, Jules
Weber, Max

PERSONS AND FIGURES, POST WORLD WAR I

Anders, Günther
Anscombe, G. E. M.
Arendt, Hannah
Asimov, Isaac
Bell, Daniel
Benjamin, Walter
Berdyaev, Nikolai
Berlin, Isaiah
Bernal, J. D.
Bethe, Hans
Blackett, Patrick
Brave New World
Brecht, Bertolt
Bush, Vannevar
Carson, Rachel
Dessauer, Friedrich
Dewey, John
Dubos, René
Edison, Thomas Alva
Einstein, Albert
Ellul, Jacques
Ford, Henry
Foucault, Michel
Freud, Sigmund
Fuller, R. Buckminster
Gandhi, Mohandas
Gates, Bill
Girard, René
Grant, George
Habermas, Jürgen
Haldane, J. B. S.
Hardin, Garrett
Heidegger, Martin
Husserl, Edmund
Huxley, Aldous
Illich, Ivan
Jaspers, Karl
Jonas, Hans
Jung, Carl Gustav
Jünger, Ernst
Kuhn, Thomas
Lasswell, Harold D.
Leopold, Aldo
Levi, Primo
Levinas, Emmanuel
Lewis, C. S.
Luhmann, Niklas
Lyotard, Jean-François
Marcuse, Herbert
McClintock, Barbara
McLuhan, Marshall
Mead, Margaret
Merton, Robert
Mumford, Lewis
Murdoch, Iris
Oppenheimer, Frank
Oppenheimer, J. Robert
Ortega y Gasset, José
Parsons, Talcott
Pauling, Linus
Polanyi, Karl
Polanyi, Michael
Popper, Karl
Ramsey, Paul
Rand, Ayn
Rawls, John
Rotblat, Joseph
Russell, Bertrand
Sakharov, Andrei
Sanger, Margaret
Schweitzer, Albert
Simon, Herbert A.
Simon, Julian
Skinner, B. F.
Spengler, Oswald
Strauss, Leo
Taylor, Frederick W.
Teller, Edward
Tillich, Paul
Tolkien, J. R. R.
Turing, Alan
Veblen, Thorstein
von Neumann, John
von Wright, Georg Henrik
Watson, James
Weil, Simone
Wells, H. G.
Wiener, Norbert
Wittgenstein, Ludwig
Zamyatin, Yevgeny Ivanovich

Sciences, Technologies, Institutions, and Agencies

PARTICULAR SCIENCES AND TECHNOLOGIES

A selective examination of ethics issues related to specific sciences and technologies.

Acupuncture
Airplanes
Androids
Antibiotics
Assisted Reproduction Technology
Astronomy
Automobiles
Biological Weapons
Biometrics
Biostatistics
Bridges
Chemical Weapons
Chemistry
Cosmology
Cybernetics
Cyborgs
Dams
Decision Theory
Drugs
Earth Systems Engineering and Management
Earthquake Engineering
Economics and Ethics
Epidemiology
Ergonomics
Food Science and Technology
Game Theory
Geographic Information Systems
Global Positioning System
Internet
Management: Models
Meta-analysis
Mining
Movies
Music
Operations Research
Polygraph
Power Systems
Probability: Basic Concepts of Mathematical Probability
Probability: History Interpretation and Application
Psychology: Humanistic Approaches
Psychopharmacology
Radiation
Radio
Railroads
Rational Choice Theory
Roads and Highways
Semiotics: Language and Culture
Semiotics: Nature and Machine
Ships
Sociobiology
Statistics: Basic Concepts of Classical Inference
Statistics: History, Interpretation, and Application
Telephone
Television
Vaccines and Vaccination
Weapons of Mass Destruction

SOCIAL INSTITUTIONS

How a few leading social institutions are influenced by and influence science and technology.

Education
Family
International Relations
Museums of Science and Technology
Police
Sports
Zoos

ORGANIZATIONS AND AGENCIES

Includes government agencies and NGOs at the national and international levels, emphasizing how these institutions are related especially to the creation and management of science and technology.

American Association for the Advancement of Science
Association for Computing Machinery
Aviation Regulatory Agencies
Bioethics Centers
Bioethics Committees and Commissions
Communications Regulatory Agencies
Engineers for Social Responsibility
Enquete Commissions
Environmental Protection Agency
Environmental Regulation
Federal Aviation Administration
Federation of American Scientists
Food and Drug Adminstration
Food and Drug Agencies
Human Genome Organization
Institute of Electrical and Electronics Engineers
Institute of Professional Engineers New Zealand
Institutional Biosafety Committees
Institutional Review Boards
International Commission on Radiological Protection
International Council for Science
National Academies
National Aeronautics and Space Administration
National Geological Surveys
National Institutes of Health
National Parks
National Science Foundation
National Science Foundation Second Merit Criterion
Nongovernmental Organizations
Nuclear Regulatory Commission
Office of Research Integrity
Office of Technology Assessment
Organization for Economic Cooperation and Development
President's Council on Bioethics
Professional Engineering Organizations
Public Policy Centers
Pugwash Conferences
Royal Commissions
Royal Society
Sierra Club
Union of Concerned Scientists
United Nations Educational, Scientific, and Cultural Organization
United Nations Environmental Program
World Bank
World Commission on the Ethics of Scientific Knowledge and Technology
World Health Organization
World Trade Organization

Philosophical, Religious, and Related Perspectives

PHILOSOPHICAL PERSPECTIVES

Articles highlighting how different philosophical traditions, schools of thought, or theories relate to science, technology, and ethics.

Axiology
Consequentialism
Critical Social Theory
Deontology
Discourse Ethics
Ethics of Care
Existentialism
Feminist Ethics
Feminist Perspectives
Logical Empiricism
Natural Law
Phenomenology
Postmodernism
Pragmatism
Rights Theory

Risk Ethics
Social Contract Theory
Thomism
Virtue Ethics

RELIGIOUS PERSPECTIVES

Articles exploring the views of selected religious traditions about issues related to science, technology, and ethics issues.

Anglo-Catholic Cultural Criticism
Buddhist Perspectives
Christian Perspectives: Contemporary Assessments of Science
Christian Perspectives: Contemporary Assessments of Technology
Christian Perspectives: Historical Traditions
Confucian Perspectives
Daoist Perspectives
Hindu Perspectives
Islamic Perspectives
Jewish Perspectives
Shinto Perspectives

POLITICAL AND ECONOMIC PERSPECTIVES

Articles on how science and technology might be assessed by different political or economic movements, ideologies, or theories.

Agrarianism
Atlantis, Old and New
Authoritarianism
Capitalism
Colonialism and Postcolonialism
Communism
Communitarianism
Conservatism
Democracy
Ecological Economics
Enlightenment Social Theory
Environmental Economics
Environmentalism
Fascism
Globalism and Globalization
Governance of Science
Humanism
Liberalism
Libertarianism
Market Theory
Marxism
Nationalism
Neoliberalism
Open Society
Political Economy
Social Construction of Scientific Knowledge
Social Construction of Technology
Social Theory of Science and Technology
Socialism
Totalitarianism

CULTURAL AND LINGUISTIC PERSPECTIVES

Perspectives based in different cultural, linguistic, and/or national traditions on the ethical dimensions of science and technology.

African Perspectives: Computers in South Africa
African Perspectives: HIV/AIDS in Africa
Australian and New Zealand Perspectives
Canadian Perspectives
Central European Perspectives
Chinese Perspectives
Chinese Perspectives: Engineering Ethics
Chinese Perspectives: Research Ethics
Dutch Perspectives
Engineering Ethics: Europe
Euthanasia in the Netherlands
French Perspectives
German Perspectives
Ibero-American Perspectives
Indian Perspectives
Indigenous Peoples' Perspectives
Italian Perspectives
Japanese Perspectives
Population Policy in China
Russian Perspectives
Scandinavian and Nordic Perspectives
Technology Assessment in Germany and Other European Countries

A

ABORTION

In the United States and in some other countries, abortion is one of the most divisive moral and political issues. Developments in abortion techniques, such as medical abortion and intact dilation and evacuation ("partial-birth" abortion), have prompted responses in law, policy, and ethical scholarship, which in turn have influenced abortion technology and provision. The emphasis here will be on the definition of abortion, abortion techniques, ethical issues, and law and public policy, focusing primarily on the United States.

Abortion Definition and Techniques

Abortion is the termination of a pregnancy and the expulsion of pregnancy tissue, including embryo/fetus, placenta, and membranes. In principle, pregnancy begins with conception (in vivo fertilization of an ovum by a spermatozoon). The earliest that a pregnancy can be clinically recognized, however, is when a serum pregnancy test becomes positive (approximately one week to ten days after ovulation). In a spontaneous abortion, also called a miscarriage, the termination of pregnancy is not intentional. In popular usage, as in the present case, the term *abortion* refers solely to an intentionally induced termination of a clinically recognized pregnancy.

References to abortion techniques describing both medication and surgical measures appear in the records of ancient civilizations, including those of China, Greece, and Rome. The modern surgical technique, which was developed in the nineteenth century, involves dilation (opening the cervix) and sharp curettage (removing the uterine contents with a sharp instrument). This procedure had the potential to be safer and more effective than the pre-nineteenth-century alternative that involved the administration of various compounds presumed to have abortifacient properties. When performed with unsterile instruments or by unskilled practitioners, however, surgery involved high risks of infection and uterine damage. In the twentieth century, the introduction of vacuum aspiration curettage improved the safety of surgical abortion. This method for dilation and curettage (D&C) achieved widespread use in the United States in the 1960s and became the dominant method for first trimester abortion. Improvements in effective local anesthesia made it possible to perform the procedure in a medical clinic or office. By 2000, only 5 percent of all abortions were performed in hospitals. These developments in medical technology presented a serious challenge to the claim that abortion poses a significant risk to the health and safety of women.

In the United States, "medicinal" or "pharmacological" abortion using pharmacologic means, which is referred to as "medical abortion," became available as a safe and effective alternative to surgery for early abortions in the mid-1990s. The drugs used for medical abortion are methotrexate or mifepristone, followed by a dose of prostaglandin. Mifepristone (Mifeprex, or RU-486), developed in France in the 1980s, attained U.S. Food and Drug Administration (FDA) approval for this indication in September 2000, by which time more than 600,000 women in Europe had used the drug. In the United States, more than 200,000 women took mifepristone for this purpose during its first three years on the market. Medical abortion involves three doctor's office visits over a two-week span. Patients can expect to bleed and spot for nine to sixteen days. Approximately 1 percent of women will require a D&C for excessive bleeding. Approximately 2 to 5 percent of women will require a D&C because tissue is incompletely expelled from the uterus. In the first few years of mifepristone's use, approximately 2 to 8 percent of eligible women in the United States chose this medical regimen over surgical abortion. European experience with the drug suggests that this may increase gradually with time. Pro- and antiabortion forces alike had predicted that the introduction of mifepristone would increase the availability of abortion. In its first six months on the market, however, mifepristone was administered primarily by physicians who already provided abortions, suggesting that the drug does not dramatically increase abortion access.

Beyond the first trimester, medical abortion methods induce labor-like uterine contractions that result in the expulsion of the fetus and other pregnancy tissues from the uterus. The most common procedure for second trimester surgical abortion is dilation and evacuation (D&E). Surgery is the safer second trimester technique until about eighteen weeks of gestation. A variant of D&E, intact D&E (called by some "partial-birth" abortion or "dilation and extraction" [D&X]) differs with respect to how the fetus is removed from the uterus. In a D&E, the fetal parts are separated before removal. Intact D&E involves a procedure to decompress the fetal skull so that the fetus can be removed in its entirety. Intact D&E accounted for 0.17 percent of all abortions in 2000.

Ethical Issues

Under what conditions, if any, is having and performing an abortion ethically permissible? This deceptively simple question is the subject of often heated controversy and has generated a wide range of answers—from "never" or "only to prevent a pregnant woman from dying," at one extreme, to "whenever a women decides to have one," at the other. In between are a variety of views that distinguish between acceptable and unacceptable reasons and/or draw a line at a particular gestational stage, such as onset of brain activity or viability. That there are several points of contention adds to the complexity of the debate.

One point of contention concerns the moral status of human fetuses (the term *fetus* is used here as a generic term referring to a developing organism between conception and birth). Proponents of the view that abortion generally is ethically unacceptable often claim that human fetuses have full moral standing (i.e., moral status equivalent to that of adult humans) and a right to life beginning at conception. For example, John T. Noonan Jr. (1970) claims that possession of a "human genetic code" is a sufficient condition of full moral standing. Those who deny that abortion generally is unethical often reject the claim that fetuses have full moral standing and a right to life. For example, Mary Anne Warren (1973) argues that to be genetically human is neither a necessary nor a sufficient condition of full moral standing. Only *persons* are said to have full moral standing, and Warren identifies five criteria for personhood: consciousness, reasoning, communication, self-motivated activity, and self-concepts. With the possible exception of consciousness, human fetuses prior to birth fail to satisfy these criteria. As critics have observed, however, human infants also fail to satisfy Warren's criteria. Michael Tooley (1972) proposes a more demanding set of criteria for personhood, which requires complex cognitive capacities, including self-consciousness. Clearly, neither human fetuses nor infants satisfy these criteria, and Tooley presents arguments in support of both abortion and infanticide.

Opponents of abortion sometimes attempt to avoid the controversial issue of whether a living organism with a human genetic code *is* a person by claiming that human fetuses are *potential* persons. This strategy, however, simply shifts the debate's focus from whether fetuses *are* persons to whether *potential* persons have full moral standing and a right to life.

Don Marquis (1989) adopts an antiabortion strategy that does not rely on potentiality. He argues that killing human fetuses is seriously immoral for the same reason that it is seriously immoral to kill adult humans: Killing deprives them of *their futures* (i.e., the experiences, activities, projects, and the like that would have comprised their future personal lives if they were not killed). This line of argument, however, may be vulnerable to the objection that, unlike adult humans, fetuses do not have a *present* as an *experiencing subject,* and therefore fetuses cannot have a future as the same experiencing subject.

Some commentators have claimed that even if human fetuses do not have full moral standing, there still might be grounds for ethical constraints on abortion. For example, Jane English (1975) claims that insofar as fetuses in later stages of development are "person-like nonpersons" (e.g., they resemble babies), failing to ascribe any moral standing to them might undermine our moral commitments. Daniel Callahan (1970) claims that a human fetus has partial moral standing because it is a developing human life.

Other commentators have made the opposite claim, arguing that even if it is assumed that human fetuses have full moral standing and a right to life, it does not follow that abortion generally is unethical. Judith Jarvis Thomson (1971) presents an argument along these lines, claiming that the right to life does not entitle a fetus to use a pregnant woman's body without her permission.

People who believe that abortion is morally acceptable are unlikely to favor restrictive abortion laws and policies. A belief that abortion is unethical, however, is not necessarily linked to support for restrictive abortion laws and policies. For example, a person might believe that such restrictions would result in more harm than good or that the government should not take sides when there are persistent disagreements about fundamental values.

Law and Policy in the United States

U.S. law and public policy regarding abortion are constantly evolving. Because it concerns the practice of medicine, abortion legislation is often enacted on the state level. Through the early nineteenth century, in most states abortion was legal prior to quickening (the time at which the woman senses fetal movement), which occurs at approximately twenty weeks of gestation. Later in that century, however, most states enacted legislation that provided criminal penalties for women and/or practitioners for abortions performed at any time in gestation. Many physicians and the American Medical Association supported this transformation in the law, arguing that abortion endangers women and is immoral.

This approach continued through the early 1960s, when all fifty states had restrictive abortion laws, and many states permitted abortions only to protect the woman's life. During the late 1960s and early 1970s, however, more than ten states liberalized their statutes by permitting abortion not only to prevent a woman's death but also in cases of medical necessity, fetal defect, rape, or incest. During this period, several states passed laws that placed even fewer limits on early abortions. For example, New York allowed abortion on demand up to twenty-four weeks' gestation.

Two 1973 U.S. Supreme Court cases, *Roe* v. *Wade* and *Doe* v. *Bolton,* substantially curtailed the legal authority of states to prohibit abortion. These opinions declared that abortion decisions are protected by a Constitutional right to privacy, the same right that in a 1965 case, *Griswold* v. *Connecticut,* the Court applied to decisions about birth control. In *Roe,* the Court adopted a trimester analysis, ruling as follows: (a) Prior to third trimester viability (the point at which the fetus could survive outside the uterus), a woman's right to an abortion always trumps the state's interest in fetal life. It is only after viability that states *may* prohibit abortion, but such laws *must* include exceptions for cases in which an abortion is necessary to *protect* a woman's life or health. (b) During the first trimester, states *may not* impose any restrictions on abortion. (c) From the beginning of the second trimester, states *may* impose restrictions that are designed to protect maternal health.

In the years following *Roe,* the Supreme Court reviewed a number of state abortion statutes that set limits on legal abortion and struck down the provisions it considered to be incompatible with that decision. For example, the Court invalidated laws that required extensive physician disclosure and counseling procedures, spousal consent, limitations on the facilities where abortions could be performed, and limitations on the specific abortion technique used. Beginning in the late 1980s, however, the Supreme Court became more tolerant of abortion restrictions. State regulations that were upheld include bans on abortions in publicly funded facilities, bans on abortions by publicly paid physicians, and mandatory viability testing prior to abortions. In *Rust* v. *Sullivan,* the Court approved the "gag rule" policy issued by the U.S. Department of Health and Human Services regarding abortion counseling in family planning clinics funded by Title X of the Public Health Services Act. This 1988 policy prohibited clinic employees from providing counseling about, or referring patients to, abortion services. President Bill Clinton suspended the "gag rule" in 1993, and regulations instituted in 2000 revoked the rule.

In the 1992 case *Planned Parenthood* v. *Casey,* a Supreme Court sharply divided five to four affirmed *Roe* v. *Wade.* However, neither *Roe*'s trimester framework nor its reliance on privacy commanded a Court majority. A joint opinion by Justices Sandra Day O'Connor, Anthony Kennedy, and David Souter substituted an "undue burden" test for the trimester framework of *Roe* and cited liberty as the basis of a constitutionally protected right to abortion. As in *Roe, Casey* holds that after viability states may prohibit abortion except when it is necessary to protect the life or health of pregnant women. Prior to viability, state restrictions may not present a "substantial obstacle" to women who seek an abortion. In *Casey,* the Court reviewed five Pennsylvania requirements: informed consent, a twenty-four-hour waiting period, parental consent for minors (with a judicial bypass procedure), spousal notification, and a reporting requirement. Only spousal notification was determined to be an undue burden by a majority of justices. As the Court noted, advances in neonatal care subsequent to *Roe* pushed the onset of fetal viability earlier into gestation. With additional technological advances in neonatology and obstetrics, this trend will continue.

Federal legislative and domestic policy activity related to abortion has addressed access to abortion, antiabortion violence, and the late-term abortion procedure sometimes called partial-birth abortion. The Hyde Amendment, first enacted in 1976, withholds abortion coverage for beneficiaries of Medicaid and other federal programs, with the exception of procedures performed because pregnancy threatens a woman's life or resulted from rape or incest. Since enactment, this amendment has been maintained as a rider to federal appropriations bills. The Supreme Court upheld this law in 1980 in *Harris* v. *McRae*. Nevertheless, a number of states use their public funds to pay for abortions for poor women.

The U.S. Congress responded to escalating antiabortion force and violence, such as blockades, arsons, bombings, and murders, with the Freedom of Access to Clinic Entrances Act (FACE) of 1994. This law makes it a federal crime to use force or threat of force to impede abortion providers and/or potential patients, or to intentionally damage abortion facilities. Many states passed similar laws. Subsequent federal legislation has focused on outlawing the intact D&E or partial-birth abortion procedure. More than half of all states have passed laws banning the procedure. In 2000 the Supreme Court reviewed and rejected Nebraska's law for several reasons: The statute was vaguely worded and could have been interpreted to include a ban on standard abortion procedures; the law had no exception for the protection of a woman's health; and it posed an "undue burden" to women seeking abortions. The U.S. Congress has worked since the mid-1990s to pass similar legislation. President Clinton twice vetoed bills passed by Congress, but President George W. Bush signed the Partial Birth Abortion Ban Act of 2003. This legislation does not include an exception for a woman's health. Additional federal legislative and policy efforts include legislation and federal regulations to give fetuses legal status. Two such laws have been enacted: the Born-Alive Infants Protection Act of 2002 and the Unborn Victims of Violence Act of 2004. A federal regulation extends insurance coverage under the State Children's Health Insurance Program of the Centers for Medicare and Medicaid Services to fetuses.

The abortion controversy and resulting policies have had a far-reaching impact on medical care and research in the United States. Abortion opponents have supported restrictions on research using embryos and fetal tissue. These restrictions have affected care for patients with infertility and have hampered efforts to develop stem cell or fetal tissue transplant treatments for diseases such as spinal cord injury, juvenile diabetes, and Parkinson's.

Internationally, U.S. policy has focused on not subsidizing overseas abortion. The Helms Amendment passed in 1973 prohibited and continues to prohibit the use of U.S. foreign aid money to fund abortions abroad. Presidents Ronald Reagan, George H. W. Bush, and George W. Bush built upon this policy by instituting what opponents call the "global gag rule." Under this rule, international family planning organizations that receive U.S. aid cannot perform abortions (even if funded by other sources), refer patients to abortion services, offer abortion counseling, or advocate for proabortion policies in their country.

Law and Policy Outside the United States

A comprehensive 1999 United Nations report on abortion policies around the world revealed significant differences between abortion law and policy in more and less well developed regions (United Nations, World Abortion Policies 1999, available from http://www.un.org/esa/population/publications/abt/fabt.htm). Out of a total of 48 more developed countries, abortion on request was legally permitted in 31 (65%). By contrast, out of a total of 145 less developed countries, abortion on request was permitted in only 21 (17%). A similar disparity can be seen between more and less developed countries in relation to the legality of abortion in other situations: economic or social difficulty (75% vs. 19%); fetal impairment (81% vs. 26%); rape or incest (81% vs. 30%); to protect mental health (85% vs. 54%); and to protect physical health (88% vs. 55%). The only reason for which there was no significant difference is to prevent the death of the pregnant woman (96% vs. 99%). In many developing countries, maternal morbidity and mortality from unsafe abortions is a significant contributor to overall maternal morbidity and mortality. Policies associated with a decline in abortion morbidity and mortality include the following: increased access to safe abortions, increased contraception, increased abortion provider experience and/or the use of modern medications, and increased availability of life-saving care for women with abortion complications (World Health Organization 1997).

Legal restrictions against abortion in Europe were eliminated or reduced in the last half of the twentieth century, due in part to a concern about mortality and morbidity associated with unsafe illegal abortions. In 1999, out of forty-two European countries, abortion on request was legal in twenty-eight (United Nations World Abortion Policies 1999, available from http://www.un.org/esa/population/publications/abt/fabt.htm). However, most of these countries imposed a limit on gestational age, typically twelve weeks. A majority of the countries that limited abortion on request to a certain gestational age permitted later abortions under specified conditions, such as to protect the physical and/or mental health of the pregnant woman. Malta was the only European country in which abortion was illegal. In four countries (Ireland, Andorra, San Marino, and Monaco) abortion was legal only to prevent the death of the pregnant woman.

In 1999, out of forty-six Asian countries, abortion on request was legal in sixteen (United Nations 1999). All forty-six countries permitted abortion to prevent the death of the pregnant woman; and this was the only permitted reason in seventeen. China's abortion policy was among the most liberal, permitting abortion on request. The primacy of population control concerns in China trump political and ethical arguments against abortion.

In both the United States and internationally, it is to be expected that abortion will continue to provide a paradigm example of the interaction of technology, ethics, law, and public policy.

MARK R. WICCLAIR
GABRIELLA GOSMAN

SEE ALSO *Birth Control; Fetal Research; Medical Ethics; Right to Life.*

BIBLIOGRAPHY

Callahan, Daniel. (1970). *Abortion: Law, Choice, and Morality*. New York: Simon and Schuster. A defense of the view that human fetuses have only *partial* moral standing.

English, Jane. (1975). "Abortion and the Concept of a Person." *Canadian Journal of Philosophy* 5(2): 233–243. A defense of a moderate position on abortion.

Finer, Lawrence B., and Stanley K. Henshaw. (2003). "Abortion Incidence and Services in the United States in 2000." *Perspectives on Sexual and Reproductive Health* 35(1): 6–15.

Marquis, Don. (1989). "Why Abortion Is Immoral." *Journal of Philosophy* 86(4): 183–202. An anti-abortion argument based on the claim that killing fetuses deprives them of their futures.

Mohr, James C. (1978). *Abortion in America: The Origins and Evolution of National Policy, 1800–1900*. Oxford: Oxford University Press. The most comprehensive historical reference on abortion in the United States.

Noonan, John T., Jr. (1970). "An Almost Absolute Value in History." In *The Morality of Abortion: Legal and Historical Perspectives*, ed. John T. Noonan Jr. Cambridge, MA: Harvard University Press. A critique of abortion based on the claim that fetuses have full moral standing starting from the moment of conception.

Paul, Maureen; Steve E. Lichtenberg; Lynn Borgatta; et al. (1999). *A Clinician's Guide to Medical and Surgical Abortion*. New York: Churchill Livingstone. Medical textbook covering all issues relevant to the performance of abortions.

Rubin, Eva R., ed. (1994). *The Abortion Rights Controversy: A Documentary History*. Westport, CT: Greenwood. An annotated collection of excerpts from many of the primary sources relevant to the history of abortion.

Thomson, Judith Jarvis. (1971). "A Defense of Abortion." *Philosophy and Public Affairs* 1(1): 47–66. A defense of abortion based on the claim that a right to life does not entitle one person to use another person's body.

Tooley, Michael. (1972). "Abortion and Infanticide." *Philosophy and Public Affairs* 2(1): 37–65. A defense of abortion and infanticide.

Warren, Mary Anne. (1973). "On the Moral and Legal Status of Abortion." *Monist* 57(1): 43–61. A defense of abortion based on the claim that fetuses lack significant moral standing.

United Nations, Department of Economic and Social Affairs, Population Division. (1999). *World Abortion Policies*. Publication ST/ESA/SER.A/178. New York: United Nations, Department of Economic and Social Affairs, Population Division.

World Health Organization, Department of Reproductive Health and Research. (1997). *Unsafe Abortion: Global and Regional Estimates of Incidence of a Morality Due to Unsafe Abortion, With a Listing of Available Country Data*. 3rd ed. Publication WHO/RHT/MSM/97.16. Geneva: World Health Organization, Department of Reproductive Health and Research.

INTERNET RESOURCES

"Mifeprex: The Early Option Pill." Danco Laboratories. Available from http://www.earlyoptionpill.com. Mifeprex manufacturer's site, containing information about the procedure of medical abortion and the most up to date information about use of the drug in the United States.

"Mifepristone Information." U.S. Food and Drug Administration. Center for Drug Evaluation and Research.

Available from http://www.fda.gov/cder/drug/infopage/mifepristone/. FDA documents relevant to the drug's approval and use appear on this site.

ACCIDENTS

SEE *Normal Accidents; Unintended Consequences*.

ACCOUNTABILITY IN RESEARCH

Accountability is a central issue in ethics and politics, one closely related to other concepts such as responsibility, integrity, and authenticity. In ethics, individuals are held accountable for their actions. In a democracy, citizens of the state ultimately hold politicians accountable. In both instances, however, there are questions about how such accountability is to be practiced, and in reference to what standards. Similar questions arise with regard to accountability in scientific and engineering research. *Accountability in research* or *research accountability* as general terms may thus refer to a range of concerns and practices related to the philosophies, policies, systems, procedures, and standards for analyzing and promoting ethical conduct in research.

In the worlds of business, finance, and government, accountability also implies a more specific reference to accounting in the sense of bookkeeping methods that involve maintaining the financial records of monetary transactions and the regular preparation of statements concerning the assets, liabilities, and operating results of some activity. To assure the accuracy of such financial accounts, one well-developed dimension of the accounting profession is auditing. Audits review and examine accounts to determine whether they are reasonably accurate and presented in an understandable manner. The attempt to adapt such methods from the fields of business and finance to those of scientific research is called data auditing (DA), and constitutes a special effort to assure accountability in research.

Historical Background

In the early history of modern natural science the methodological requirement that experimental results be reported in such a way that they could be reproduced by others, and the practice of accepting into the body of scientific knowledge only those results that had been reproduced, effectively made auditing a standard part of research practice. Even so, William Broad and Nicholas Wade (1982) argue that what is now called *creative accounting* was sometimes practiced in scientific research. For example, there is evidence that physicist Isaac Newton (1642–1727) made experimental data fit his theories, and that chemist John Dalton (1766–1844) cleaned up his data to obtain whole numbers for ratios on chemical reactions. Biologist Louis Pasteur (1822–1895) is alleged to have announced an anthrax vaccine before completing his experiments, and Cyril Burt (1883–1971) may have fabricated intelligent quotient (IQ) test results. Even Nobel Prize winner Robert Millikan (1868–1953) may have fudged his data. Other examples include the fabrication of animal test data by Industrial Biotech Corporation for the Food and Drug Administration (FDA), and the conduct of unethical high-risk experiments on psychiatric patients. In some cases serious adverse events, including deaths, were not reported (Shamoo and Resnik 2003).

A number of surveys indicate that students and researchers suspect that questionable conduct in research is widespread, accounting for 0 percent to 50 percent of all research. The actual percentage of questionable research practices is probably much lower—in the single digits (Shamoo and Resnik 2003, LaFollette 2000). The scientific community was initially slow to call for reforms in dealing with scientific misconduct. In response to media coverage of some serious lapses, commissions were formed and congressional hearings held to discuss accountability in research. Then-senator Albert Gore chaired hearings to examine concerns and urge reforms (LaFollette 1994).

The modern explosion in attainment of knowledge has resulted in profound changes in the social character of science. In 2002, nearly 3 million individuals worked as researchers in the United States alone, with about 1 million holding post-graduate degrees and controlling a budget of more than $250 billion. Science in has become *mass science* in the pattern of mass production and mass culture. Traditional means of apprenticeship and social pressure are not effective ways to uphold high standards for scientific knowledge in the early-twenty-first century. More explicit approaches must be developed.

It was in this context that the term *data audit* first began to be used (for complete references on this topic see Loeb and Shamoo 1989). Following a 1988 conference on the subject, the inaugural issue of the journal *Accountability in Research* announced its intention to "serve as a catalyst for the development of specific procedures and standards for acquiring, analyzing, and auditing" (Shamoo 1989, p. i).

DA Theory and Practice

The concept of auditing has a long history, including efforts in early Egyptian, Greek, and Roman civilizations by governments to develop ways to expose cheating by accountants. Modern accounting and auditing procedures have their immediate origins in response to the enormous expansion in business enterprises since the nineteenth century.

There are several kinds of auditors. External auditors are independent auditors who work in public accounting firms for identified clients. However because third parties use the information in the financial statements generated by these auditors, external auditors can be said to work also in the interests of society. Internal auditors work as employees within organizations; public and private corporations and government agencies have internal auditors. Government auditors are employed by government agencies to audit outside entities and individuals. An example of a government auditor is the Internal Revenue Service (IRS).

In addition, there are various types of auditing. Financial auditing examines the accuracy of an entity's financial statements. The resultant report can be used inside or outside the entity. Operational or performance auditing examines performance, management, or value-added operations, including cost-economy, efficiency, and effectiveness. Compliance auditing examines whether an organization is in compliance with specific rules and regulations, whether issued internally or imposed on the entity by a third party. Attestation engagements are given to public accounting firms for the purpose of examining the representations of an entity other than those that are traditionally included in financial statements, for example, those regarding systems of internal accounting control or investment performance statistics (Loeb and Shamoo 1989).

Auditing is an independent activity that reviews accounting, but is separate and apart from it. Its methods rely on logic, not accounting principles, to evaluate concrete issues. DA, as proposed by Adil Shamoo in the late 1980s, is modeled after financial auditing. The purpose of DA is to check the accuracy of derived research data by comparing it to the original raw data. This method can be used either randomly for a small number of data determined by a statistical method or when the data are suspect. Several publications have outlined the method since its initial introduction (Shamoo and Annau 1987).

The Future of DA

Accountability in research requires reviewing institutional policies (for example, those of universities) and examining the attitudes and behavior of researchers. Institutional policies are key because they dictate the tone and culture of tolerance in research conduct and are major influences on how and why researchers work on particular issues (Shamoo and Dunigan 2000).

Society demands accountability from researchers. This is especially true when the results of particular research affect individuals and communities. In the early-twenty-first century, accountability in research is an important and expanding area of interest to both professionals and the general public.

ADIL E. SHAMOO

SEE ALSO *Misconduct in Science; Peer Review; Research Ethics.*

BIBLIOGRAPHY

Broad, William, and Nicholas Wade. (1993 [1982]). *Betrayers of the Truth: Fraud and Deceit in the Halls of Science*. New York: Simon and Schuster.

LaFollette, Marcel C. (1994). "The Pathology of Research Fraud: The History and Politics of the U.S. Experience." *Journal of Internal Medicine* 235: 129–135.

LaFollette, Marcel C. (2000). "The Evolution of the 'Scientific Misconduct' Issue: An Historical Overview." *Experimental Biology and Medicine* 224: 211–215.

Loeb, Stephen, and Adil E. Shamoo. (1989). "Data Audit: Its Place in Auditing." *Accountability in Research* 1: 23–32.

Shamoo, Adil E, ed. (1989). *Accountability in Research* 1(1). Inaugural issue of the journal; contains complete references.

Shamoo, Adil E., and Zoltan Annau. (1987). Correspondence (Letter to the Editor), June 18, 1987. *Nature* 327(6123): 550.

Shamoo, Adil E., and Cheryl D. Dunigan. (2000). "Ethics in Research." *Experimental Biology and Medicine* 224: 205–210.

Shamoo, Adil E., and David B. Resnik. (2003). *Responsible Conduct of Research*. Oxford and New York: Oxford University Press.

ACCOUNTING

Accounting comprises techniques to record, verify, report, plan, and analyze governmental, commercial, or personal financial transactions. As such, accounting is related to science, technology and ethics in two ways. First, particularly since the early-twentieth century, accounting is understood as a technology rationalized by scientific theories and practiced by professionals requiring ethical guidance (Whitley 1986). Second, both large-scale technological projects and big budget science are increasingly subjected to accounting-based evaluations. Accordingly, both scientific data and procedures, and fiscal accounts of technoscience, are being audited to verify the ethical behaviors of engineers and scientists.

Varieties of Bookkeeping

The emergence of modern accounting in the mid-nineteenth century is symbolically marked by a fire and an avalanche. In 1834 the British House of Commons was razed in a blaze fed by a pyre of wooden tallies, which had been used by the Exchequer since the thirteenth century. Around the same time, the social and natural worlds began to be blanketed by an "avalanche of printed numbers" that only gathered in force over the subsequent two centuries (Hacking 1982, p. 279). Accounting becomes recognizably modern when numbers are exclusively used to ascribe economic value not only to things and events but also to people.

Vernacular Accounting

On the far shore of modern accounting lie the myriad vernacular ways of counting wealth and recording transactions. It is perhaps anachronistic to speak of bookkeeping before books or of accounting before counting. Indeed recent archeological evidence of an *archaic bookkeeping* around 3000 B.C.E. suggests that it is reckoning that gave rise to alphabetic script and homogenous number (Schmandt-Besserat 1992). If bookkeeping refers to the ways of reckoning and recording trade and commerce, its history is overwhelmingly about how the unlettered and the innumerate kept count.

For most of human history, fingers, pebbles, abaci, and counting boards were used for calculating, while transactions were recorded as knots on strings, notches on sticks, inscriptions on tablets, pipe-rolls, and parchment. The diversity of vernacular accounting is exemplified by the tally stick on which peasants and princes, from China to Europe, recorded and verified commercial, tax, and even credit transactions through notches, incisions, and cuts that varied by region, by village, and even within villages and among products (Menninger 1992). Such heterogeneous measures of things and products were bound to place and purpose, and usually rooted in the human form, of which the *foot* remains a dim reminder. A bushel in Cracow was different in girth and height from that in Gdansk; Alpine peasants recorded the sale of sheep with different inscriptions than those for the sale of cheese because sheep were qualitatively distinct from cheese (Kula 1986).

Double Entry Bookkeeping

The homogenization of vernacular counting and recording is related to the emergence of double-entry bookkeeping (DEB), which is also the framework for modern accounting. It was popularized by Luca Pacioli (1445–1514), called the *father of accounting,* largely because his was the first book printed and published on the subject of DEB. For Pacioli, a friar and contemporary of Leonardo Da Vinci, the visual order and quantitative balance of DEB served to justify commerce by showing every transaction as the result of an equal and, therefore, fair exchange. Accounting in the DEB form lent credence to business as an ethical enterprise at a time when commercialism was viewed with some suspicion (Aho 1985).

The technique of DEB involves recording every transaction twice: once each as a debit and a credit in two distinct accounts. For example, purchasing a computer for cash would require recording the increase in the value of an asset by debiting the computer account through a debit and recognizing the reduction in cash by crediting the cash account. It is the sum of such equal and opposing effects of a transaction that produces the famed doubled balance of DEB. At a technical level, the genesis and diffusion of DEB presupposed the replacement of Roman numbers by Hindu-Arabic numerals, the loss of the symbolic power of numbers, and perhaps crucially, the emergence of the text that had to be seen to be read. For example, 0 had to be rethought as a mere numeral instead of evoking the horror of nothingness (Rotman 1987), and the inherently temporal events of giving and taking became reduced to a spatially arranged textual record of equal exchange (Clanchy 1999).

The popular belief that DEB stimulated profit seeking and, therefore, capitalism was first suggested by the sociologist Werner Sombart (1863–1941). However, though the distinction between profit and capital is necessary to regularly calculate the rate of profit, the distinction itself is not necessary for DEB, which emerged no later than the fourteenth century in the time of little, if any, capitalist activity (De Roover 1974). It was disseminated, though spottily, throughout Europe only after the Italian Renaissance. Indeed DEB was not instrumental to the pursuit of profit well into the eighteenth century (Yamey 1964). For the Fuggers of the fifteenth century, the Dutch East India Company of the seventeenth, and numerous factories of the eighteenth, DEB played no part in the quest for profitable trade and commerce. The bilateral, columnar ordering of debits and credits in tables of interconnected parts that balanced is therefore better understood as an instrument of visualization and legitimization rather than one of economic rationalism (Crosby 1997).

Modern Accounting

Only after the early-nineteenth century did accounting became a technique to calculate the economic productivity of all factors of production (Hoskins and Macve 2000). Modern accounting is not mere record keeping of materials used, wages paid, and profits made as it was in the eighteenth century and before. Rather accounting achieves its contemporary status as the *sine qua non* of economic rationalism, which implies the coordination and control of humans, materials, and machines, only when human actions are rendered into a calculable form and people therefore measured as economic resources.

The modern technique for a *system of accountability* was forged in the classrooms of the U.S. Military Academy at West Point. Since 1817, each cadet has been subjected to a regimen of written and graded examinations (Hoskins and Macve 1988). When employed as managers in such companies as the Springfield Armory and the Pennsylvania Railroad during the 1830s, some graduates of West Point used the technique of student grading as a template to measure and calculate human performance in general. For example, the quantity of widgets producible after eight hours of effort, under normal conditions, can be measured and then used as a benchmark to calculate the productivity of a particular worker. Modern accounting thus induces double vision: On one hand, it reduces human action to a countable economic resource, while on the other, it fosters the belief that such accountability is ethical.

This writing of objects, events, *and* persons in financial terms soon spread to both the emerging governmental bureaucracies and large scale corporations during the latter half of the nineteenth century (Hoskins and Macve 1986). Modern accounting is thus coeval with large-scale corporations—the visible hand in modern economies—that manage resources across space and time to harness productivity, reduce costs, and increase profits. Economic rationalism, rooted in management by the numbers, hence came to fruition only by the late-nineteenth century; it is not coincidental that the word capitalism flowers when the invisible hand of markets begins to wither (Braudel 1982).

By the mid-twentieth century, modern accounting as performance evaluation had become a pervasive, if almost unseen, technique for controlling human action and holding people accountable (Hoskins and Macve 2000). Through accounting, governments, schools, hospitals, and even countries, as well as bureaucrats, students, doctors, and elected officials were increasingly described as economic objects and stimulated to behave as economic resources (Miller 1992). One measure of the current ubiquity of accounting is the extent to which the behavior of scientists and engineers are motivated, monitored and controlled through accounting-based techniques. This has been pronounced since the postwar years when both engineering projects and scientific research began to absorb ever increasing sums of money from both public and private sources. Public projects such as highways and dams are routinely subjected to cost-benefit analysis; time and cost overruns and penalties are measured and charged against budgeted figures; laboratory notebooks are maintained and used as evidence of employee input and performance in a manner similar to time cards in factories. despite its many failings, such as using budgets to evaluate inherently unpredictable long term projects, accounting-based techniques seem necessary to manage large institutions, whether governments, corporations, or technoscentific practices.

Accounting Science, Profession, and Ethics

Since the 1970s, accounting techniques have also gained much in the way of scientific respectability. Economic, sociological, and psychological theories of human behavior have transformed the study of accounting into a social science based on mimicking the methods of the natural sciences: the use of mathematical models, experimental tests, and statistical results. However because people are not atoms, the predictive and explanatory power of accounting theories is necessarily far below that of physics. Moreover, because it is based on the fact-value distinction scientific accounting research cannot prescribe changes in accounting techniques to better modify behaviors and decisions. In the breach between low explanatory power and the even lower normative force of scientific accounting, the mass production and *ritual verification* of accounting numbers continues unabated (Power 1999).

The perceived objectivity of numbers is a fundamental vehicle by which accounting techniques spread as a bureaucratic method to manage people in a manner consistent with liberal government (Porter 1995). However, by now, most students of accounting agree that all valuation techniques—whether of things or persons—are the result of conventional rules and not laws of nature. Accordingly the claim to objectivity in accounting should be understood less as an unbiased reflection of natural processes and instead as the adherence to conventional standards of measurement and calculation.

During the twentieth century, the accounting profession used the notion of objectivity as a lever to promote the idea of accountants as disinterested professionals. As part of this attempt at professionalizing accounting practice the newly formed American Institute of Accountants established a code of professional conduct in 1917. Throughout the twentieth century, the code was to become both wider in scope and more specific in detail. For example, what started as a list of eight rules in 1917 had expanded to list of six principles and a series of five rules, each with a host of related "interpretations" (Preston et al. 1995), the elaboration of the code of conduct has been accompanied by a shift in the social status of the accounting professional: Increasingly the profession has disavowed its professionalism and embraced its function as service provider (Zeff 2003). Perhaps the strongest evidence of this shift away from professionalism is that accountants are no longer barred from advertising their services as they were until the 1970s.

In this context corporate bankruptcies and managerial misconduct can be understood. The much-publicized saga of the Enron Corporation reveals that greed and envy continue, with predictable frequency, to prompt fraud and duplicity by corporate chieftains, government officials, and accountants. The response, exemplified by the recently passed Sarbanes-Oxley Act (2002), has been equally predictable: Additional accounting techniques are instituted to engineer valued behaviors, including cost-benefit analyses, risk assessments, audits, and budgets. In the blind spot of this spiraling cycle, the foundational questions of whether it is ethical to reduce human action to a quantity, whether engineered behavior is akin to ethical action, and whether human failings can be eradicated by technical devices remain.

SAJAY SAMUEL

SEE ALSO *Economics and Ethics; Science, Technology, and Society Studies.*

BIBLIOGRAPHY

Aho, James. (1985). "Rhetoric and the Invention of Double Entry Bookkeeping." *Rhetorica* 3: 21–43. An insightful rhetorical analysis of DEB emphasizing its religious underpinnings.

Bailey, Charles N., James R. Hasselback, and Julia N. Karcher. (2001). "Research Misconduct in Accounting Literature: A Survey of the Most Prolific Researchers' Actions and Beliefs." *Abacus* 37: 26.

Braudel, Fernand. (1982). *The Wheels of Commerce*. New York: Harper & Row.

Clanchy, Michael T. (1993). *From Memory to Written Record*. London: Basil Blackwell. A seminal work on the transition in Europe from oral to literate culture, focusing on legal documents, wills and accounting records.

Cohen, Patricia. (1999). *A Calculating People*. New York: Routlege.

Crosby, Alfred. (1997). *The Measure of Reality*. Cambridge, UK: Cambridge University Press. A cultural history of the rise of quantification in different fields ranging from art and music to architecture and commerce. Convincingly argues the textual and therefore visual form of DEB.

De Roover, Raymond. (1974). *Business, Banking and Economic Thought*. Chicago: University of Chicago Press.

Hacking, Ian. (1982). "Biopower and the Avalanche of Printed Numbers." *Humanities in Society* 5: 279–295. Documents the rise of quantification in the newly emerging social sciences of the early nineteenth century.

Hoskins, Keith, and Richard Macve. (1986). "Accounting and the Examination: A Genealogy of Disciplinary Power." *Accounting, Organizations and Society* 11: 105–136.

Hoskins, Keith, and Richard Macve. (1988). "The Genesis of Accountability: The West Point Connection." *Accounting, Organizations and Society* 13: 37–73.

Hoskins, Keith, and Richard Macve. (2000). "Knowing More as Knowing Less? Alternative Histories of Cost and Management Accounting in the U.S. and the U.K." *Accounting Historians Journal* 27: 91–149. A deft and clear summary of the decade-long argument among accounting scholars on the origins of modern accounting. Places the original research presented in the papers listed below within a neatly formulated 'dialogue' with contesting interpretations.

Kula, Witold. (1986). *Measures and Men*, trans. Richard Szreter. Princeton. NJ: Princeton University Press. An indispensable reference for the social history of modern measurement.

Menninger, Karl. (1992). *Number Words and Number Symbols*. New York: Dover Publications. A delightful book on the world history of numbers that includes excellent pages on the prehistory of modern accounting.

Miller, Peter. (1992). "Accounting and Objectivity: The Invention of Calculating Selves and Calculable Spaces." *Annals of Scholarship* 9: 61–86.

Porter, Theodore M. (1995). *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life*. Princeton, NJ: Princeton University Press. A historian's documentation of the uses and abuses of 'objectivity' in the social sciences.

Power, Michael. (1999). *The Audit Society: Rituals of Verification*. Oxford: Oxford University Press. A theoretically informed analyses of the contemporary proliferation of auditing in numerous arenas of life.

Preston, Alistair; David Cooper; Paul Scarbourgh; and Robert Chilton. (1995). "Changes in the Code of Ethics of the U.S. Accounting Profession, 1917 and 1988: The Continual Quest for Legitimacy." *Accounting, Organizations and Society* 20: 507–546.

Rotman, Brian. (1987). *Signifying Nothing: The Semiotics of Zero*. Stanford, CA: Stanford University Press.

Schmandt-Besserat, Denise. (1992). *Before Writing*. Austin: University of Texas Press. Original argument from an anthropologist of the Near East on 'accounting' as a precursor of alphabetic script and numbers.

Whitley, Richard. (1986). "The Transformation of Business Finance into Financial Economics: The Roles of Academic Expansion and Changes in U.S. Capital Markets." *Accounting, Organizations and Society* 11: 171–192.

Yamey, Basil S. (1964). "Accounting and the Rise of Capitalism: Some Further Notes on a Thesis by Sombart." *Journal of Accounting Research* 11: 117–136. Seminal paper arguing against the so-called Sombart thesis about the relation between DEB accounting and capitalism.

Zeff, Stephen. (2003). "How the U.S. Accounting Profession Got Where It Is Today: Part II." *Accounting Horizons* 17: 267–285.

ACID MINE DRAINAGE

Acid mine drainage (AMD), along with acid rock drainage (ARD), is a problem of water quality that is common to rivers and lakes that receive water draining from mine sites. Although not usually viewed as a first-tier environmental problem, AMD is a critical water-quality issue around the world, affecting nations from the Far East to Europe and the Americas. In the United States it occurs in wide areas in the East as a result of coal mining. In the American West several hundred thousand abandoned hard rock mines have contaminated thousands of miles of streams and thousands of lakes. Sites, streams, and lakes that require attention number in the thousands, according to the Mineral Policy Center (1997), which estimates that the cleanup in the United States alone will cost more than $10 billion. Acid mine drainage also provides an object lesson in the complex relationships among engineering, communities, and ethics and values and in the evolving nature of environmental debates.

The Problem

Apart from questions of causation and remediation, the production of acid drainage is a complex process that involves chemistry, geology, and biology. Exposing sulfur-rich rocks to air and water causes sulfide minerals such as pyrite, galena, and sphalerite to oxidize. An example is provided by pyrite (FeS2), also known as fool's gold. Rainwater, snowmelt, and air break this iron sulfate mineral into its constituent parts: ferrous iron and sulfur. The sulfate ions react with the water to produce sulfuric acid, and the iron passes into the water column. By itself this chemical reaction is not energetic enough to produce much acid drainage, but the reaction increases exponentially in the presence of sulfur-oxidizing bacteria (genus thiobacilli), which cause a great expansion of the amount of acid drainage produced.

The pH of a solution is a measure of its acidity, based upon a logarithmic scale; going down the scale, each number represents a tenfold increase in the amount of acidity. Thus the difference between a pH of 7 and one of 3 is four orders of magnitude, or 10,000 times more acidic. The pH in AMD-affected streams can drop as low as 2 and 3 (lower than the pH of vinegar, and about the same as that of a car battery). Trout, for instance, die at pH values below 5.4. Therefore, contaminated mine water passing into streams and lakes can lower the pH of that water to the point where it stunts the development of, or kills, fish and invertebrates. In addition, the lower pH allows heavy metals to stay dissolved in the water column. Those metals can have a variety of effects on the streams: Zinc and copper kill aquatic life through their toxicity, and aluminum and iron settle on stream bottoms and disrupt the physical habitat of bottom-dwelling creatures, such as stone flies and caddis flies, that various aquatic species depend on for sustenance. These damaged waters also can have a negative impact on other species and the human communities living within the watershed.

Scientific, Technical, and Political Challenges

It is important to note that acid mine drainage is the human-caused analog of the natural processes of acid rock drainage. Acid rock drainage results from natural weathering processes, biological activity, and local or regional geology. Distinguishing between AMD and ARD—that is, separating natural background conditions from human-caused acid drainage—can be difficult and contentious, often uniting scientific, political, and ethical perspectives in a single debate.

Restoring streams, lakes, and landscapes damaged by acid mine drainage thus presents a challenge that is simultaneously scientific, technical, political, and philosophic. The issues in this area include the following:

- Scientific: How bad are the conditions? Are they natural or human-caused? What effects do they have on natural and human systems?

- Technical: Can a river, lake, or landscape be restored, and if so, at what cost and with what chance of long-term success?
- Political and philosophic: Who bears the cost of cleanup: the current landowner, the mineral industry, or society at large? Should restoration involve only areas damaged by human activity? Does it even make sense to speak of areas "damaged" by naturally occurring drainage? (Frodeman 2003)

Although they seldom are recognized, philosophical assumptions often guide people's thinking about how and whether to restore damaged landscapes. For instance, the attempt by scientists to distinguish between natural and human-caused acid drainage relates to the unspoken belief that the difference between the two provides a solid criterion for determining which areas should be cleaned up.

Another political and philosophic conundrum arises when parties to an AMD conflict feel that the very idea of "restoring" nature is misconceived, for what results is a dishonest attempt to pass off an artificial landscape as something natural (Elliott 1997). In contrast, scientists and technicians in the field of ecological restoration often fail to see anything wrong with intervening in compromised landscapes, viewing the development of restoration science as a positive sign of increasing technological prowess. Other participants in the AMD debate emphasize the political dimension of restoration, seeing it as offering a chance for a community to build a more harmonious relationship among its members as well as with nature (Gobster and Hull 2000).

Acid mine drainage is emblematic of a new phase in environmental thinking, where scientific, technical, political, and normative questions are tightly interlinked. Moreover, it also highlights the ongoing shift in environmental thinking from the preservation of pristine lands to the restoration of landscapes damaged by human actions.

ROBERT FRODEMAN

SEE ALSO *Ecological Restoration; Environmental Ethics; Mining.*

BIBLIOGRAPHY

Allenby, Brad. (1999). "Earth Systems Engineering: The Role of Industrial Ecology in an Engineered World." *Journal of Industrial Ecology* 2(3): 73–93. An important article arguing that environmental systems should be treated as large scale management tasks.

Elliott, Robert. (1997). *Faking Nature: The Ethics of Environmental Restoration*. Lanham, MD: Roman & Littlefield. Expansion of a classic essay on the philosophic aspects of environmental restoration.

Frodeman, Robert. (2003). *Geo-Logic: Breaking Ground between Philosophy and the Earth Sciences*. Albany: State University of New York Press.

Gobster, Paul H., and R. Bruce Hull, eds. (2000). *Restoring Nature: Perspectives from the Social Sciences and the Humanities*. Washington, DC: Island Press. Contains essays that explore a wide range of political and philosophic questions tied to environmental restoration.

Marshall, John, and Zeke Zanoni. (1996). *Mining the Hard Rock in the San Juans*. Silverton, CO: Simpler Way Press. Offers the miner's perspective on the joys and hazards of mining.

INTERNET RESOURCES

"AMD and Art: Artfully Transforming Environmental Liabilities into Community Assets." Available from http://www.amdandart.org/. Details an example of innovative combination of science, art, and community involvement for addressing AMD.

Mineral Policy Center, 1997. *Golden Dreams, Poisoned Streams*. Washington, DC: Mineral Policy Center. Available from http://www.mineralpolicy.org.

ACID ROCK DRAINAGE

SEE *Acid Mine Drainage*.

ACTIVIST SCIENCE EDUCATION

To what extent should science education in primary and secondary schools promote learning about science, technology, and ethics? At the primary and secondary school levels, ethical theory and issues of professional ethics would be inappropriate. At these levels one of the most common ethical issues has to do with the environment, which may thus serve as a case study here. But it must be recognized that environmental pollution and global climate change are controversial in ways not always easy to examine with primary and secondary school learners. Indeed many environmental education teachers also sometimes fail to critically assess their own beliefs.

Arguments for Activist Education

There are two basic arguments for activist science education to address environmental issues. One is a scientific and public consensus about its importance, another is the importance of democracy.

During the last half of the twentieth century, many environmental and social problems that drew public concern (climatic change, ecosystems degradation, demographic inequalities, migration, and terrorism, among others) expanded from local to global spheres. The situation had become so perturbing that science teachers often adopted the language of planetary crisis (Bybee 1991). During the United Nations Conference on Environment and Development, held in Rio de Janeiro in 1992, educators of every subject were asked to contribute to public awareness and understanding of the problems and challenges relating to the planet's future in order to enable the participation of citizens in well-grounded decision making. At the World Summit on Sustainable Development (2002), the consensus was that education is critical for promoting sustainable development, involving all levels of education in all countries.

Advances in science and technologies, because of their social impact, also call for a democratic debate on knowledge production and use. No members of early-twenty-first-century society can participate intelligently in the community without being familiar with how science and technology affect their daily life and future. Thus science education is considered a fundamental prerequisite for democracy and for ensuring sustainable development. Meaningful science education is more necessary than ever in order to develop and expand scientific and technological literacy in all cultures and sectors of society and thus improve public participation in decision making.

Activist Education Practices

But thirteen years after the Rio Conference, in spite of increasing international recognition of the fact that the challenges associated with environmental degradation and sustainable development have important implications for education, science education continues to demonstrate little concern for the present and future state of the world. There are numerous reasons for this insufficient response.

First, although the attainment of scientific and technological literacy (STL) is the main goal of curricular reforms in most countries, its meaning is still unclear. While some advocate a broadening of the knowledge base of the science curriculum to include greater consideration of interactions among science, technology, and society (STS), with more or less emphasis on environmental issues, others argue that educators must prepare students to compete effectively in the global marketplace (Hodson 2003).

The authors of *Science For All Americans,* for instance, direct attention toward scientific literacy for a more environmentally responsible democracy, stating that science can provide knowledge "to develop effective solutions to its global and local problems" and can foster "the kind of intelligent respect for nature that should inform decisions on the uses of technology" (AAAS 1989, p. 12). The "Standards for Technological Literacy" of the International Technology Education Association (ITEA) also establish requirements for technological literacy for all students; enforcing these standards, according to ITEA, will allow students to develop an understanding of the cultural, social, economic, political, and environmental effects of technology and of the role of society in the development and use of technology. By contrast, the National Research Council does not include such issues in the scientific literacy goals set out in its "National Science Standards."

Second, even when some environmental problems are incorporated in curricula, science education research has uncovered marked differences between the goals of curriculum designers and actual classroom practice. Such differences reveal that changes and reforms are difficult to put into practice and require significant changes in the values and beliefs of teachers.

Third, despite the enthusiasm that initially accompanied the appearance and promotion of environmental education (EE) with its varied proposals and projects, it continues to be a marginal and isolated subject in most education systems. Research frequently cites inadequate teacher preparation as a key obstacle to incorporating EE into school curricula. The situation is typical in a majority of countries (Poitier 1997, Gough 2002). In the United States Rosalyn McKeown-Ice surveyed 715 teacher education institutions and concluded that preservice teacher education programs seldom include EE. She also found that when such programs do include EE, the quality of it varies considerably. Thus EE teacher education is largely inadequate (McKeown-Ice 2000).

Fourth, most EE texts focus exclusively on local problems without addressing the global situation, display a reductionist approach, and ignore the strong connections between natural, environment and social, cultural, political, and economic factors (Tilbury 1995). These perspectives are beginning to change with such new approaches as Environmental Education For Sustainability (EEFS) and Science-Technology-Society-Environment (STSE) teaching materials.

Assessment

But, possibly, one of the main reasons for the inappropriate treatment of the global crisis resides in the perceptions of teachers and researchers. Analysis of articles published in thirty-two journals of research in science education (from 1992 to 2000) reveals that work on this problem is almost nonexistent. There are few contributions (4.5%) on particular problems and references to sustainability reach a scarce 10 percent. Extending this analysis to the contributions made at international congresses and conferences, and in handbooks on research in science education, the results are similar. A study involving science teachers from Spain, Portugal, and Latin America revealed substantially the same results and exposed the perceptions of science teachers as, in general, fragmentary and superficial, displaying a serious lack of knowledge and commitment. Only 5.3 percent of 848 science teachers raised sustainability issues (Edwards 2003). Critics, of course, argue that such attitudes are themselves more realistic than activist advocates would admit.

Despite the evidence of spreading environmental and social problems, the importance of EE has made little headway in the majority of schools. As activist science educator David Orr wrote in 1994, "We still educate the young . . . as if there were no planetary emergency" (p. 27). But this reveals the problem at the heart of any activist science education program: how to get the majority involved. Education is needed to make it happen, but education itself is part of what needs to happen.

MÓNICA EDWARDS SCHACHTER

SEE ALSO *Education; Science, Technology, and Society Studies.*

BIBLIOGRAPHY

American Association for the Advancement of Science (AAAS). (1989). *Science for All Americans: A Project 2061 Report on Literacy Goals in Science, Mathematics, and Technology*. Washington, DC: Author. Also available from http://www.project2061.org/tools/sfaaol/sfaatoc.htm.

Bybee, Rodger W. (1991). "Planet Earth in Crisis: How Should Science Educators Respond?" *American Biology Teacher* 53(3): 146–153.

Edwards Schachter, Mónica E. (2003). *La atención a la situación del mundo en la educación científica* [The attention to the state of the world in science education]. Ph.D. diss.: Servei de Publicacions de la Universitat de València, CD edition. Also available from http://www.tdx.cesca.es/TESIS_UV/AVAILABLE/TDX-0211104-122215//edwards.pdf]

Gough, Annette. (2002). "Mutualism: A Different Agenda for Environmental and Science Education." *International Journal of Science Education* 24(11): 1201–1215.

Hodson, Derek. (2003). "Time for Action: Science Education for an Alternative Future." *International Journal of Science Education* 25(6): 645–670.

Knapp, Doug. (2000). "The Thessaloniki Declaration: A Wake-up Call for Environmental Education?" *Journal of Environmental Education* 31(3): 32–39.

McKeown-Ice, Rosalyn. (2000). "Environmental Education in the United States: A Survey of Preservice Teacher Education Programs." *Journal of Environmental Education* 32(1): 4–11.

National Research Council. (1996). "National Science Education Standards." Washington, DC: National Academy Press. Also available from http://www.nsta.org/standards.

Orr, David W. (1994). *Earth in Mind. On Education, Environment, and the Human Prospect*. Washington, DC: Island Press.

Poitier, Michel. (1997). *Le développement durable: stratégies de l'OCDE pour le XXIè siècle* [Sustainable development: strategies of the OCDE for the twenty-first century]. Paris: OECD.

Tilbury, Daniella. (1995). "Environmental Education for Sustainability: Defining the New Focus of Environmental Education in the 1990s." *Environmental Education Research* 1(2): 195–212.

INTERNET RESOURCE

International Technology Education Association (ITEA). "Listing of *STL* Content Standards." Available from http://www.iteawww.org/TAA/Publications/STL/STLListingPage.htm.

ACUPUNCTURE

All science is based on assumptions that define, a priori, the relative weaknesses and strengths of their practical application. As western science and technology have run up against limits to their comprehension and effectiveness, other approaches to both knowledge and practice have emerged to complement them. Nowhere is this more an issue than in medicine: Acupuncture has become a popular alternative to the drugs and surgeries offered by the biomedical sciences. In its fundamentally holistic approach acupuncture also presents an implicit ethical challenge to western technoscience to see the human patient in his or her entirety and within the context of the patient's life circumstances.

Acupuncture is the practice of inserting thin needles into the body to influence physiological functioning. It is an integral part of Chinese medicine, which also includes herbal medicine, massage, nutrition, and exercise. Chinese medicine began to take form during the Shang dynasty (1766–1050 B.C.E.), and an early form of acupuncture might have been practiced then, with the oldest needles having been made of sharpened stone (Gwei-Djen and Needham 1980, Unschuld 1985). There are bronze needles dating from the Chou dynasty (approximately 600 B.C.E.). By the Warring States period (475–221 B.C.E.) the classic acupuncture text, the *Huang Di Nei Jing Su Wen* [Yellow emperor's classic of internal medicine], had appeared.

Nature and Origins

The practice of acupuncture is thought to have started when shamans used needles to kill evil spirits that were thought to cause illnesses (Unschuld 1985). Over thousands of years the properties of specific points were discovered empirically, and those observations were tied in to traditional theories. What originally began as a superstitious ritual gradually became a flourishing medical field. The practice has grown further since its introduction to the West in the 1970s; there are more than fifty accredited schools of Chinese medicine in the United States, and practitioners are licensed independently in over forty states.

Chinese medicine was first introduced to Europe in the 1600s by Jesuit priests returning from the Orient. By the 1950s major schools of acupuncture were established in England and France. Acupuncture lost state support in China by the late 1800s and languished until a decree by Chairman Mao in 1958 that Chinese medicine should be revived according to the principles of dialectical materialism. Despite the "scientization" of Chinese in China, older traditions more grounded in a spiritual world view have survived both in Europe and in other parts of Asia that were not suppressed by the Chinese totalitarian regime.

Philosophical Orientation

According to the *Shen Nong Ben Cao,* one of China's oldest medical texts (second century C.E.), the highest aspect of healing involves helping patients fulfill their destiny so that they can live out the years allotted to them by heaven. The next highest aspect is the nourishment of people's inborn nature. Finally, the lowest class of healing is to treat specific physical illnesses. In its highest form, then, Chinese medicine focuses on individuals' health in the overall context of their lives. Health is manifested when one lives in harmony with the laws of nature and represents a profound integration of function on all levels: spiritual, mental, and physical. The presence of illness represents a denial and loss of the true self.

As a holistic practitioner an acupuncturist uses several diagnostic methods to determine the overall functional balance of a patient. Diagnoses occur largely within the perspective of the Chinese models of the universal poles of *yin* and *yang* and the five-element system, both of which provide qualitative standards for interpreting a range of physiological phenomena. From the *yin/yang* perspective practitioners consider observations in terms of internal/external, soft/hard, deficient/excess, and cold/hot, all of which point toward understanding the particular thermodynamic state of individuals and the unique manifestations of their illnesses or imbalances. For example, a practitioner might note that cold in nature tends to have a slowing and contracting influence. If the patient's pulse is slow and his or her muscles are tight the practitioner might deduce the presence of cold.

The five-element system (*wuxing*) was elaborated fully around 350 B.C.E. by Zou Yen (Kaptchuk 1983). The term *wuxing* denotes five dynamic movements—water, wood, fire, earth, and metal—that continually transform into each other as the seasons do. The language used by the early Chinese to describe their world was one of simple poetic images rich in allusions. Water is the element associated with winter because of its tendency to freeze and become focused in that season. Wood is associated with spring because it grows rapidly at that time of the year. Fire is associated with summer because of the increased heat during those months as the sun reaches its zenith. Earth is associated with late summer when the fields are full of the earth's bounty. Minerals are a natural expression of the metal element because they lie hidden beneath the ground; they symbolize the essential, precious, and rarefied aspects of life. Metal is associated with the fall, when what is of value must be harvested by the farmer's knife and everything else must be left to wither in the fields (Connelly 2002, Jarrett 1999).

Over the course of thousands of years laws were discovered and codified that described the functional dynamics of natural change. The five-element model is one example of these laws. Relating physiological functions to these qualitative standards, an acupuncturist is able to generate a diagnosis that is unique to each individual. The goal of treatment is to harmonize individuals both internally and within the context of their natural environment. The internal health of the

FIGURE 1

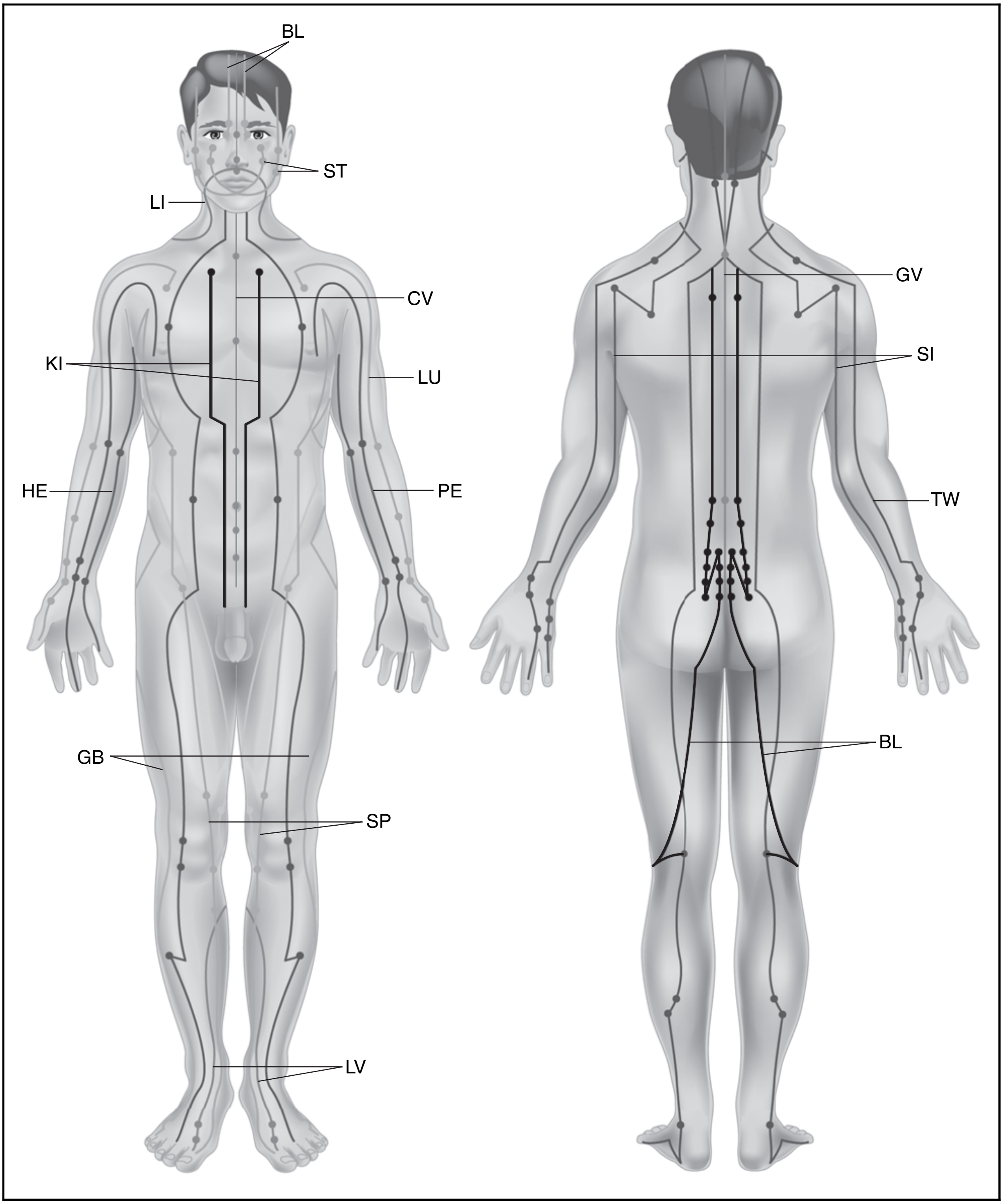


Diagram showing acupuncture meridians on a male body. A meridian is a group of acupuncture points all associated with the function of a particular internal organ system. *(Electronic Illustrators Group. Reproduced by permission of the Gale Group.)*

individual and the integrity of the natural environment are seen as mutually dependent, a worldcentric view that is especially relevant at a time when technoscience has achieved the power to destroy much of nature.

How Acupuncture Works

The attempts by Western scientific research to describe how acupuncture works rely on modern biomedical concepts. Popular theories include the notion that the mode of efficacy of acupuncture can be attributed to its influence on the structure and function of the body's different systems, including the nervous, circulatory, and immune systems (National Institutes of Health 1997, World Health Organization 2002). However, to appreciate acupuncture on its own terms one must understand the traditional explanations of how acupuncture works.

Western biomedicine focuses on the quantitative analysis of physical structure; it is mechanistic and reductionist in character. By contrast, Chinese medicine focuses on the qualitative analysis of function; it is holistic and synthetic in nature (Jarrett 1999, 2003). Over four millennia the Chinese have developed a rigorous language for discussing the subtleties of human physiological function. The central physiological concept is predicated on the notion of *qi* (*chi*), a universally present influence that maintains the functional integrity not only of the organism but of all natural processes (Porkert 1982, Jarrett 1999). The functions of *qi* are manifest in five forms: movement, transformation, protection, retention, and warming. Any dysfunction of these attributes in any aspect of being, whether physical, psychological, or spiritual, is said to be an imbalance of *qi*.

Acupuncture points are discrete locations on the external surface of the human body where the internal function of the organs can be influenced and the quality and directionality of their *qi* can be mediated. Points that are functionally related are said to constitute a specific meridian. Each meridian is associated with the function of an internal organ system or "official." Rather than naming specific organs anatomically, the ancient Chinese conceived of each organ as being an official with a specific duty to fill. When each official did his duty, health and harmony resulted. In the *Huang Di Nei Jing Su Wen* each organ is personified as being in charge of specific functions (Larre and de la Vallée Rochat 1987). For example, the fourteen points most closely associated with the function of the liver official constitute the liver meridian. The liver traditionally is likened to a military general in charge of planning and decision making. Its function is associated with growth, vision, and flexibility in all aspects of being. Hence, visual disturbances, poor planning, frustration, and tightness in the tendons that limits flexibility all can be treated through acupuncture points on the liver meridian.

Each point harmonizes an unbalanced aspect of function on a continuum ranging from deficient to excessive. For example, if a patient's heart rate is too slow or too fast, an acupuncture point such as Heart-7 (*shenmen*, or "Spirit Gate") can be used to increase or decrease the pulse to achieve the correct rate. Similarly, a point such as Liver-14 (*qimen*, or "Gate of Hope") can be used to help calm a belligerent person or enhance self-esteem in a timid person.

Acupuncture has evolved as a sophisticated science of human function for at least 2,500 years. As Chinese medicine is integrated into Western cultures, patients are afforded the benefits of both biomedical and functional medicine. The worldcentric and holistic view of Chinese medicine holds special promise for helping humanity face the unique challenges of the dawn of the twenty-first century.

LONNY S. JARRETT

SEE ALSO *Complementary and Alternative Medicine; Confucian Perspectives; Daoist Perspectives; Galenic Medicine; Medical Ethics.*

BIBLIOGRAPHY

Connelly, Dianne M. (2002). *Traditional Acupuncture: The Law of the Five Elements*. Columbia, MD: Traditional Acupuncture International.

Gwei-Djen, Lu, and Joseph Needham. (1980). *Celestial Lancets: A History and Rationale of Acupuncture and Moxa*. Cambridge, UK, and New York: Cambridge University Press.

Jarrett, Lonny S. (1999). *Nourishing Destiny: The Inner Tradition of Chinese Medicine*. Stockbridge, MA: Spirit Path Press.

Jarrett, Lonny S. (2003). *The Clinical Practice of Chinese Medicine*. Stockbridge, MA: Spirit Path Press.

Kaptchuk, Ted J. (1983). *The Web That Has No Weaver: Understanding Chinese Medicine*. Chicago: Congdon & Weaver.

Larre, Claude, and Elisabeth Rochat de la Vallée. (1987). *The Secret Treatise of the Spiritual Orchid*. East Grinstead, UK: International Register of Oriental Medicine.

Porkert, Manfred. (1982). *The Theoretical Foundations of Chinese Medicine*. Cambridge, MA: MIT Press.

Unschuld, Paul U. (1985). *Medicine in China: A History of Ideas*. Berkeley: University of California Press.

World Health Organization. (2002). *Acupuncture: Review and Analysis of Reports on Controlled Clinical Trials*. Geneva: Author.

INTERNET RESOURCE

National Institutes of Health. (1997). *Acupuncture*. NIH Consensus Statement 15(5): 1–34. Available from http://odp.od.nih.gov/consensus/cons/107/107_intro.htm

ADVERTISING, MARKETING, AND PUBLIC RELATIONS

The relationships between advertising, marketing, and public relations are not well defined. In general, however, advertising and public relations are considered components of marketing. Marketing is the craft of linking producers of a product, service, or idea with existing and potential consumers. Marketing techniques are most generally associated with transactions in capitalist economies, but they are also applied in religion, politics, and other aspects of public life. Advertising is part of an overall marketing strategy, and it involves the paid promotion of goods, services, ideas, and companies by an identified sponsor. Public relations connotes a broad spectrum of communication either within a group (e.g. company, political party, scientific community) or between that group and specific publics with the intent of informing and influencing their behavior and perceptions in ways that are favorable to that group.

Technology, Science, and Advertising

Advertising, like any transmission of information, requires a medium, and the biggest impact that technology has had on advertising is the expansion of media outlets. Initially vendors had to rely only on the spoken word and hand written signs. Then the printing press allowed for the first rudiments of mass media marketing, as advertisers could reach wider audiences through handbills and the inclusion of advertisements in books. Radio, television, and the Internet have further expanded media options for advertisers. In addition, logos printed on clothing and other products, billboards, and even skywriting ensure that our world is increasingly saturated by advertisements and brand names. In fact, it is estimated that the average North American child views roughly 40,000 television commercials per year (Strasburger 2001). As advertising becomes more sophisticated and the products more technologically complex, consumers today are less able to judge quality than they were even 100 years ago, when they themselves were involved in the production of simple crafts and thus more skilled in judging the quality of the things they bought. So as advertising becomes a more pronounced element of our cultural environment, the context of a global system of production causes our understanding of the goods being advertised to decline. This in turn means that we rely more heavily on regulatory agencies and advertising codes of ethics to ensure fairness and truth in advertising.

Technology has not only changed media and the societal dimensions of advertising but it has changed the nature of advertising as well. Handbills and other printed materials are relatively passive and static, whereas television commercials, and to an increasing extent internet advertisements, tend to be dynamic, employing rapidly changing images. The increasing pace of modern, technological societies and rising costs of marketing tend to condense both political and product advertisements into short clips. Improvements in information technology allow marketers to more quickly and flexibly respond to changes in consumer behavior. On the downside, however, increasingly complex technological tools and information systems can overload marketing managers and distract them from the creativity and judgment that remain central to successful advertising strategies.

The emergence of advertising on a large scale coincided with the rise of consumerism-fueled industrial capitalism. Although the development of new technologies for transmitting advertisements and managing marketing strategies is a key element of this process, so too is the continuing creation of marketing as a science. The traditional advertiser's dilemma was expressed in this way, "I know half my advertising is wasted, but I don't know which half!" In response to this inefficiency and the demand to create new markets to increase sales (or in politics, the demand to win over more voters), various social and behavioral sciences have been applied to advertising. Marketing research and motivation analysis are just two of the terms that signify the rise of a systematic science of advertising. Techniques include mathematical models, game theory, multivariate analyses, econometric analyses, psychometric approaches, and choice models (see Sutherland and Sylvester 2000). Several institutions carry out this research, including the Academy of Marketing Science, which publishes the journal *Academy of Marketing Science Review* (AMS).

Advertising is open to several interpretations, but one of the most influential remains Vance Packard's indictment of the advertising industry, *The Hidden Persuaders* (1957). Packard examined the use of psychoanalysis and other scientific techniques to understand human behavior and guide campaigns of persuasion and manipulation. These image-building campaigns are launched at both consumers and citizens; they are both about what to buy in the market and how to act in the polis. He labels these efforts "hidden," because they take place beneath our level of awareness. Packard claims that we are duped into believing that rather than buying lipstick, oranges, and automobiles we are acquiring hope, vitality, and prestige. Although sometimes constructive or amusing, most of these practices "represent regress rather than progress for man in his long struggle to become a rational and self-guiding being" (p. 6). This Orwellian interpretation is probably hyperbolic, but Packard is more convincing in his modest claim that "These depth manipulators are . . . starting to acquire a power of persuasion that is becoming a matter of justifiable public scrutiny and concern" (pp. 9–10). This power raises several ethical concerns about deception, the manipulation of behavior and self-image, and the exploitation of weaknesses and fears.

Ethical and Societal Issues of Marketing

Early advertising and marketing techniques were disreputable due in part to the lack of established laws and codes of conduct, which allowed deceptive advertising practices to flourish unchecked. In the United States, early development of the industry was largely driven by the marketing of patent medicines and "nostrums," and by spectacles such as P.T. Barnum's circus and museum. In later years, rather than traveling with his circus, Barnum concentrated on advertisement, creating a whole new species of marketing rhetoric that persists to this day. His colorful descriptions of sideshow mermaids and white elephants (the first a stuffed monkey sewed to a fish-tail, the latter a white-washed gray elephant) are classics in the psychology of marketing. Although Barnum commented that "the people like to be humbugged," he also said that "you may advertise a spurious article and induce many people to buy it once, but they will gradually denounce you as an impostor" (Ogilvy 1988, p. 156).

After the turn of the century, some members of the nascent advertising industry wished to distinguish themselves from their less reputable colleagues, and the first trade associations and codes of practice were established. Around 1900, the Curtis Code of magazine publishers stated: "We exclude all advertising that in any way tends to deceive, defraud or injure our readers." In 1910, the Association of Advertising Clubs of America adopted "Truth in Advertising" as its slogan. Four years later, the Audit Bureau of Circulations was formed, with the job of verifying the circulations reported by magazine publishers, on which ad space prices were based. In 1917, the American Association of Advertising Agencies issued a code that included a prohibition on copy "knocking" a competitor's product and on ads with "immoral or suggestive" content; banned the use of the word "free" unless the item offered was actually free; and declared that installment plans were inherently suspect.

These and other efforts by the marketing industry were attempts at self-regulation, partially motivated by the desire to avoid Congressional regulations. Nonetheless, Congress did become involved with the 1914 Federal Trade Commission Act, which empowered a commission to enforce rules designed to prevent deceptive and unfair practices in advertising. With the passage of the 1938 Wheeler-Lea Amendment the jurisdiction of the Federal Trade Commission (FTC) was broadened to include the advertisement of food, drugs, cosmetics, and therapeutic devices. The truth in advertising rules of the FTC not only require advertising to be fair and nondeceptive, but also hold advertisers responsible for producing evidence to substantiate their claims. FTC rules apply to all media, including the Internet.

Despite drastic political and technological changes through the history of modern advertising, ethical concerns about advertisements that misrepresent the capabilities of products and negative or "attack advertising" have remained constant (see *The Ethical Problems of Modern Advertising*, 1978). This suggests that in marketing, new technologies may exacerbate perennial ethical problems more than raise entirely novel ones. Additionally, some of the same industries have sustained a steady level of controversy pertaining to ethics in advertising. A good example is the tobacco industry, which caused conflict even during the 1930s. All does not stay the same, however, since new technologies give new form to old ethical problems. A good example is pornographic "pop-up" advertisements on computers linked to the Internet.

Ambiguity enters the ethical debates, because advertising need not be based on facts alone. Indeed a certain appeal to emotion is ethical and even necessary for successful marketing. Likewise, there is no formula for determining when omission constitutes deception. Thus the charge that a group owes the public "truthful" advertising requires significant acts of judgment as general rules must be interpreted within specific cases. There is clearly a spectrum of ethical severity involved, from advertising new car models that have only cosmetic but no functional improvements, to the increasing commercialization of public schools, to advertising a new drug without fully studying or disclosing possible harmful effects. Foregoing some practices, such as negative or attack ad campaigns, may be based more on marketing strategies than ethics, as managers (or politicians) attempt to gauge whether their target audience will be offended by aggressive attacks on the competition. However, even in these cases ethical concerns cannot be wholly avoided. One classic example from the 1930s was the ad campaign that enticed its audience to "reach for a Lucky instead of a sweet," which angered the candy industry because of the unfounded insinuation that smoking cigarettes is more healthy than eating candy.

A certain element of popular opinion views advertisements as socially invidious, leading to shallow, self-absorbed behavior, fostering negative body-image issues and poor self-esteem, and wrecking devastation on the natural environment and the larger social fabric via large-scale consumerism. Yet even among those who feel these concerns, behavior is seldom altered, as the experience of an individual purchase is difficult to link to these larger effects. Several academic analysts have attempted to confirm and articulate the corrupting influence of advertising on individuals and society. Many, like Packard, portray it as psychic manipulation, exploiting human insecurity to drive product sales. It is a truism in such writing, for example, that problems such as bad breath and body odor, considered normal and tolerable in the nineteenth century, were recast as unalloyed evils, sources of personal shame and social isolation, by twentieth century advertising in the service of product sales.

Richard Pollay (1986) provides a taxonomy of academic complaints about advertising. It can be simplified into two multifaceted claims that advertising is: (a) "intrusive, environmental, inescapable, and profound" and reinforces "materialism, cynicism, irrationality, selfishness, anxiety, social competitiveness, sexual preoccupation, powerlessness and/or a loss of self-respect" (Pollay, p. 18); and (b) "essentially concerned with exalting the materialistic virtues of consumption by exploiting achievement drives and emulative anxieties.... generally reducing men, women and children to the role of irrational consumer" (Pollay, p. 21). He cites a National Science Foundation study from 1978, which found that advertising encourages unsafe behavior, inappropriate standards for choice, and parent-child conflict; models hazardous behavior, such as malnutrition and drug abuse; and reinforces sex-role stereotypes, cynicism and selfishness. Pollay concludes that advertising in our age has become a ritualistic "social guide," promoting ideas about "style, morality, behavior."

Feminist analysts claim that some advertising causes harm by educating young girls to covet unnaturally thin bodies and driving anorexia and bulimia as unintended side-effects. They see advertising as a tool of social repression, keeping women subservient. "The female body is represented as the dream image that disguises her own exclusion.... But the ideals sold us are impossible to live, creating a hunger that keeps us unsatisfied and forever buying" (Schutzman 1999, p. 3). Mady Schutzman says that advertising makes women neurotic: "What advertising prescribes, women regurgitate in rage, histrionics, amnesia and paralysis" (p. 115).

Jean Kilbourne argues that advertisements create an image of women as "sophisticated and accomplished, yet also delicate and child-like" (1999, p. 137). Kilbourne collects print advertisements that share a common theme of encouraging young women to be silent and let their nail polish, clothes, perfume or make-up do their communicating, a message which she states has a "serious and harmful" impact. In their drive to sell products, ads communicate messages, which put young women in severe conflict, promising them "fulfillment through being thin and through eating rich foods" (p. 145), or through being virginal yet sexually wild. While she does not believe that ads directly cause anorexia, the "images certainly contribute to the body-hatred so many young women feel" (p. 135). She points out that in Fiji, well-fleshed women constituted the feminine ideal, and eating disorders were unknown until the introduction of television.

These critiques raise questions about how far the ethical obligation of advertisers should extend. But they also echo Packard's concerns about the degree to which our self-image and behavior are influenced by the environment of advertisements. They are made all the more important by the ability of modern technology to saturate our surroundings with advertisements, each not only promoting a product or idea but also transmitting cultural messages about what is appropriate and desirable. The technologically enhanced barrage of advertisements recalls Langdon Winner's (1986) insight that "technologies are not merely aids to human activity, but also powerful forces acting to reshape that activity and its meaning" (p. 6). Advertising shapes our shared world and thus to some extent it orients us within a web of meanings and influences our identity.

David Ogilvy, advertising executive, presents an optimistic take on the social benefits of advertising. He quotes Franklin Delano Roosevelt:

> If I were starting life over again, I am inclined to think that I would go into the advertising business in preference to almost any other. . . .The general raising of the standards of modern civilization among all groups of people during the past half century would have been impossible without the spreading of the knowledge of higher standards by means of advertising. (1988, p. 150)

He then quotes Winston Churchill: "Advertising nourishes the consuming power of men. . . . It spurs individual exertion and greater production" (p. 150). Ogilvy was a proponent of informative advertising and an extremely honest man, so his personal traits certainly provided a rose color to the advertising industry.

Yet he also admitted some of the negative aspects of advertising. For example, Ogilvy considered the economic effects of advertising and concluded that ads probably result in lower prices by driving sales volume. At the same time, they may contribute to monopolization by companies large enough to afford their costs. Ogilvy detested the trend of using Madison Avenue techniques to sell politicians. He addressed the criticism that ads influence the editorial content of magazines and newspapers, and argued that advertising serves as a force of social cohesion, building community and national identity.

James B. Twitchell (1996) argues that our culture is not just driven by advertising; it *is* advertising. Indeed he maintains that culture is just advertising's way of ensuring its own survival. He traces an unbroken line from religion and rituals to advertising: "[B]y adding value to material, by adding meaning to objects, by branding things, advertising performs a role historically associated with religion" (p. 11). "[A]dvertising is the gospel of redemption in the fallen world of capitalism" (p. 32). Advertising is "an ongoing conversation within a culture about the meaning of objects" (p. 13). Globally, "Adcult," the powerful, pervasive social, psychological, and cultural phenomenon of worldwide advertising, homogenizes cultures and exploits human doubt and insecurity and, accordingly, has become "the dominant meaning-making system of modern life because of our deep confusion about consumption, not only about what to consume, but how to consume" (p. 253).

The world described by Twitchell is very different than the future envisioned by Ogilvy. The information-filled ads championed by the latter are largely a thing of the past, with modern television ads relying largely on emotion and desire, based on numerous, almost subliminal rapid images and sounds of the lifestyle the audience is urged to associate with the product. The time is long gone when consumers care about the type of stitching or fabric used in a shirt; the sale today relies on the way the shirt will make you feel about yourself, the members of the opposite sex it will attract, and the access it will grant you to a better life.

Twitchell, like Packard, believes that the implications of modern advertising for human freedom, especially freedom of speech, are bleak. He argues that advertisers are the primary censors of media content in the United States. *Adbusters*, a monthly magazine, attempts to raise these issues to the consciousness of consumers by criticizing, deconstructing, and parodying ads. Twitchell asks if advertising is an inherently unethical medium and concludes that it is best conceived as amoral rather than immoral. Advertisers primarily want to sell products; their main goals are not reinforcement of stereotypes, or the exploitation of insecurities, which are often, however, secondary effects of what they do. If advertisers believe they can sell more products by portraying strong, independent women rather than childlike, dependent ones, they will do so; the ads for Charlie perfume were an early example, presenting a self-assured businesswoman, to whom the men in the ads were subservient. (However, she was also young, thin, and beautiful.)

Public Relations of Science

Since at least the mid-nineteenth century, scientists and scientific institutions have engaged in public relations activities in order to improve their social status, sway public policy with respect to science and technology, and promote greater public support of research and science in general. Although this attempt to improve the relationship between the public and science usually benefits science, it has also been couched in arguments that are less directly self-serving. These arguments are often grouped under the general labels of "public understanding of science" or "scientific literacy." Some of the more common justifications for enhanced public understanding of science are that it can bring benefits to national economies, boost national power and influence, improve individuals' chances in the job market, inspire greater intellectual, aesthetic, and moral achievements, and benefit democratic government and society in general. Jacob Bronowski (1974) voiced this last justification in terms of a "democracy of the intellect," in which the distance between power and the people can be closed only if scientific knowledge is dispersed broadly.

Though indirect, almost all of these reasons for enhanced public understanding of science will benefit science by leading to greater public support and investment. The opposite effect is possible, however. Greater understanding of science can lead to increased public scrutiny and skepticism or even control over research agendas and practices. Partly in response to just such a possibility, Steve Fuller argues that "science may be popular *precisely* because it is misunderstood. Thus, a movement genuinely devoted to 'public understanding of science' may have some rather unintended consequences for the future of science" (1997, p. 33). Dorothy Nelkin (1995) adds that "While scientists see public communication of scientific information as necessary and desirable, they are also aware that it extends their accountability beyond the scientific community" (p. 148).

Own a practical level, the public relations of science arose from the insight that peer review is not sufficient to maintain research support and favorable public policies. Thus information must be directed not just at peers, but also at corporations, policy makers, and the general public, highlighting the fact that science cannot survive as an autonomous enterprise. Nelkin traces the history of science public relations and argues that government science agencies, scientific journals, science-based corporations, and individual scientists have developed sophisticated ways to utilize and even manipulate the media to put a positive image on their work. These tactics span a spectrum from employing public relations officers to directly restricting journalists' access to information. The restrictions placed on reporters at the 1975 Asilomar Conference on recombinant DNA research are an example of the latter form of image control. Another problem that can arise from public relations efforts in the medical sciences is the improper inflation of hopes that a cure for the disease under research is immanent. This is exacerbated by the increasing pressure on journalists to be the first to report the most sensational claims, rather than well-researched and balanced news. In general, as fiscal and societal pressures mount on scientists to demonstrate the relevance, safety, and importance of their work, it becomes more difficult to see through tactics of self-promotion in order to gain a balanced understanding of the issues.

JONATHAN WALLACE
ADAM BRIGGLE

SEE ALSO *Business Ethics; Communication Ethics.*

BIBLIOGRAPHY

Bronowski, Jacob. (1974). *The Ascent of Man*. London: Little Brown. Companion to a television series, argues for the extension of scientific knowledge to the general public.

Fuller, Steve. (1997). *Science*. Minneapolis: University of Minnesota Press. Explores the normative and social aspects of science in order to undermine naïve assumptions about scientific realism.

Kilbourne, Jean. (1999). *Deadly Persuasion: Why Women and Girls Must Fight the Addictive Power of Advertising*. New York: Free Press. How advertising plays to the neurotic preoccupations of girls and women.

National Science Foundation. (1978). "Research on the Effects of Television Advertising on Children: A Review of the Literature and Recommendations for Future Research." Washington, DC: Author.

Nelkin, Dorothy. (1995). *Selling Science: How the Press Covers Science and Technology*. New York: W.H. Freeman. Analyzes the coverage of science and technology in the popular media. Contains a chapter on the public relations of science, pp. 124–143.

Ogilvy, David. (1988). *Confessions of an Advertising Man*. New York: Atheneum. First printed in 1962 and re-issued with minimal revisions. The autobiography of an ethical advertising man, with reflections on the culture of advertising.

Packard, Vance. (1957). *The Hidden Persuaders*. New York: David McKay. Argues that advertising science is manipulating human behavior and threatening to undermine our free will.

Pollay, Richard. (1986). "The Distorted Mirror: Reflections on the Unintended Consequences of Advertising" *Journal of Marketing*, vol. 50 (April), pp. 18–36. A review of the available literature on the social impact of advertising.

Schutzman, Mady. (1999). *The Real Thing: Performance, Hysteria and Advertising*. Hanover: Wesleyan University Press. How advertising caters to neurosis and insecurity in women.

Strasburger, Victor C. (2001). "Children and TV Advertising: Nowhere to Run, Nowhere to Hide," *Journal of Developmental and Behavioral Pediatrics*, vol. 22, no. 3, pp. 185–187.

Sutherland, Max, and Alice K. Sylvester. (2000). *Advertising and the Mind of the Consumer*. 2nd edition St. Leondards, Australia: Allen and Unwin. Aimed at both advertisers and consumers to explain which strategies work and why.

The Ethical Problems of Modern Advertising. 1978. New York: Arno Press. A reprint of an early twentieth century collection of essays on ethics in advertising.

Twitchell, James B. (1996). *Adcult USA: The Triumph of Advertising in American Culture*. New York: Columbia University Press. A cynical and influential book on the new language and psychological effectiveness of advertising.

Twitchell, James B. (2000). *Twenty Ads That Shook the World: The Century's Most Groundbreaking Advertising and How It Changed Us All*. New York: Crown Books. An overview of the most influential ads and why they were so effective.

Winner, Langdon. (1986). *The Whale and the Reactor: A Search for Limits in an Age of High Technology*. Chicago: University of Chicago Press. Presents a philosophy of technology as a form of life and argues that technologies have politics.

AFFLUENCE

If affluence is defined as an abundance of money and material goods, more humans than ever before are affluent beyond what could have been imagined a few generations ago. This growth and diffusion of affluence has been made possible in large part by advances in science and technology. Indeed, the political, social, and economic viability of contemporary market democracies has become linked to a considerable extent to the ability of scientific research and technological innovation to catalyze the growth of affluence. But technologically enabled material success brings with it substantial contradictions, in terms of distributional equity, environmental impacts, and the very notion of what "quality of life" means. These contradictions in turn challenge conventional thinking about the pursuit of affluence and the role of science and technology in society.

Economist Robert Solow (1957) estimated that technological innovation accounts for about half of all economic growth, and subsequent research has reinforced the idea that fields such as solid-state physics, computer science, material science, aeronautics, and genomics are the primary forces creating the new and diverse products and services associated with an affluent way of life (Nelson 1996). Government support of research and development tends to be justified on this basis.

Distributional Implications

The central role of science and technology as the engine of economic growth obscures other important outcomes. For example, the complex processes by which innovation translates into growing industrial productivity also can lead to the disruption or destruction of labor markets and social networks. Controversy in the United States over the outsourcing of high-tech jobs to developing nations is the most recent example of such disruption, whose devastating social consequences were portrayed compellingly in the nineteenth-century fiction of Charles Dickens (1812–1870). Economic theory views such conditions as an unfortunate consequence of a process of "creative destruction" that "incessantly revolutionizes the economic structure *from within*" (Schumpeter 1975, p. 83) to generate more jobs and more affluence. What is being destroyed in the process may be entire sectors of the economy and the livelihoods that depend on them.

Moreover, the distribution of benefits may be extremely uneven, inasmuch as wealth creation may be accompanied by increasing unemployment or underemployment, decreasing or stagnant real wages, enormous wage inequality, and increasing concentration of wealth both within nations and between nations (Noble 1995, Arocena and Senker 2003). Between 1960 and 1997 the income gap between the top and bottom 20 percent of the world population increased from 30:1 to 74:1, meaning that the poorest fifth of humanity now earns a little more than one percent of that earned by the wealthiest fifth (United Nations Development Programme 1999).

Although the exact causes of these trends can be debated, there is little question that they reflect the capacities of some individuals, sectors of society, and nations disproportionately to capture the benefits of scientific research and technological innovation. This asymmetry is now being reinforced by international rules governing intellectual property and other aspects of innovation policy (Commission on Intellectual Property Rights 2002).

Environmental Implications

Rising consumption has increased use of natural resources and generation of wastes. At least since the work of economist Thomas Malthus (1766–1834), many people have doubted that increasing production and consumption could be sustained indefinitely because of limited resources, and observers in our day have echoed the concern that ever-increasing material affluence is an unsustainable endeavor (Meadows, Randers, and Meadows 1972). To date, however, technologists have pushed back whatever limits may exist by improving resource extraction, by using less material inputs per unit of output, and by substituting artificial products for natural ones. These processes have permitted not only the exponential growth of human populations, but increasing material standards of living for many.

Technological optimists believe this can continue indefinitely as eco-efficiency improvements are enabled by ongoing innovation (Lomborg 2001). Less optimistic observers point to species extinctions, increasing production and proliferation of toxic materials, and other threats to long-term sustainability. If the technological optimists are ultimately proven wrong, and the environment does not sustain endlessly increasing material affluence, major shifts would be required in economic thought, in technological R&D, and perhaps even in the basic political rationale for contemporary market democracies, where worries about inequality have been swept aside by a focus on the pursuit of greater material affluence (Daly 1991).

Quality of Life Implications

A basic tenet of this rationale is that a growing gross domestic product per capita leads to a higher material standard of living, which in turn translates into a higher overall quality of life. All modern societies embrace this formula, though perhaps not to the same degree; this was captured memorably in the phrase that underlay the 1992 campaign strategy of presidential candidate Bill Clinton: "It's the economy, stupid." When economic growth slows or stops, political upheaval often follows.

The contribution of science and technology to the growth of affluence must be understood not just in terms of increased efficiency and diversity of production but also in terms of the willingness, even ardor, of people to consume the results of this productivity. As Rosenberg and Birdzell (1986, p. 264) note, "the long growth in scientific and technical knowledge could not have been transformed into continuing economic growth had Western society not enjoyed a social consensus that favored the everyday use of the products of innovation." This consensus feeds back into the economy to promote more innovation and growth but also feeds back into society, which is transformed continually in ways both expected and surprising by the introduction of new products and systems of technology. To remark that science and technology have resulted in a society that bears little resemblance to that of a century ago is a truism, but hidden beneath the obvious is the more subtle reality that commitment to this path of technological self-transformation is founded on a belief in the equivalence of affluence and quality of life.

But are they equivalent? Research on subjective well-being in countries throughout the industrialized world demonstrates that people's happiness and satisfaction with their lives have not increased during the historically unprecedented scientific, technological, and economic advancement of recent decades. Indeed, there has been a decline in some measures of life satisfaction (Lane 2000). Many people are richer and live longer, healthier lives; but most do not *feel* better off (Diener and Suh 1997).

These results should not be surprising, for moral traditions and common wisdom long have emphasized spiritual and social relationships over material ones as sources of satisfaction and meaning. Who would really suppose that marginal increases in affluence in already affluent societies would greatly enhance the quality of life? What luxury expenditures could add as much to people's comfort as did indoor plumbing, central heating, and related innovations of an earlier era?

What Goals for an Affluent Civilization?

If affluence raises both ethical and practical issues about how to use technical capacities wisely and fairly, what sorts of inquiries and deliberations might be warranted about the future relations of science, technology, and affluence? One source of inspiration for such queries can be found in John Kenneth Galbraith's *The Affluent Society*, first published in 1958, which posed fundamental questions about the "social balance" between private and public spending.

Galbraith argued that "the affluent society" was on the wrong track by continuing to behave as if it were living in an age of scarcity, rather than reshaping goals in accord with new priorities appropriate for an age of affluence. A preoccupation with unending increases in "the production of goods . . . (is) compelled by tradition and by myth," Galbraith said, not by thoughtfully chosen goals that "have a plausible relation to happiness" (Galbraith 1958, pp. 350–351). In effect, he argued that what economists call "diminishing marginal returns" had set in, such that additional increments of private affluence would not bring very much net gain in people's sense of well being. In contrast, he asserted, great gains in a society's overall quality of life could be obtained by aiding the poor, making work life more enjoyable, investing in scientific research, and generally shifting priorities away from private consumption and toward public purposes. For example, Galbraith recommended instituting larger sales taxes, both to reduce consumption and to assure that those who consume large quantities of private goods contribute commensurately to public services.

That the pursuit of technology-driven affluence remains the political raison d'être of the modern market economy may be less a reflection of "human nature" than one of enormously successful salesmanship by business executives, government officials and politicians, technologists, and economists. As Galbraith concluded, "To furnish a barren room is one thing. To continue to crowd in furniture until the foundation buckles is quite another. To have failed to solve the problem of producing goods would have been to continue man in his oldest and most grievous misfortune. But to fail to see that we have solved it and to fail to proceed thence to the next task, would be fully as tragic" (Galbraith 1958, pp. 355–356).

DANIEL SAREWITZ
EDWARD J. WOODHOUSE

SEE ALSO *Consumerism; Money.*

BIBLIOGRAPHY

Arocena, Rodrigo, and Peter Senker. (2003). "Technology, Inequality, and Underdevelopment: The Case of Latin America." *Science, Technology, & Human Values* 28(1): 15–33. Argues that technology-based wealth creation is not enough to reduce pervasive and persistent economic inequality, and that government interventions into economic life are required to alleviate poverty.

Daly, Herman E. (1991). *Steady-State Economics*, 2nd edition. Covelo, CA: Island Press. A systematic analysis of the possibility of operating an affluent economy sustainably, without net growth, based on the principle that "enough is best."

Diener, Ed, and Eunkook Suh. (1997). "Measuring Quality of Life: Economic, Social, and Subjective Indicators." *Social Indicators Research* 40: 189–216. Argues that measuring quality of life requires a combination of social indicators such as health and levels of crime, subjective well-being measures, and economic indices.

Galbraith, John Kenneth. (1958). *The Affluent Society*. Boston, MA: Houghton Mifflin. A classic mid-century analysis of problems and opportunities confronting affluent societies, focusing primarily on the U.S.

Lane, Robert E. (2000). *The Loss of Happiness in Market Democracies*. New Haven, CT: Yale University Press. A painstaking review of psychological research showing that increasing affluence does not bring much net improvement in life satisfaction, once a family is beyond poverty level.

Lomborg, Bjørn. (2001). *The Skeptical Environmentalist: Measuring the Real State of the World*. Cambridge, UK: Cambridge University Press. A careful, well documented, and thoroughly partisan argument that the global environment has been improving during recent decades.

Meadows, Donella H., Jorgen Randers, and Dennis L. Meadows. (1972). *Limits to Growth*. New York: Universe. One of the original warnings about environmental deterioration and the desirability of curtailing economic growth.

Nelson, Richard R. (1996). *The Sources of Economic Growth*. Cambridge, MA: Harvard University Press.

Noble, David F. (1995). *Progress without People: New Technology, Unemployment, and the Message of Resistance*. Toronto: Between the Lines.

Rosenberg, Nathan, and L. E. Birdzell, Jr. (1986). *How the West Grew Rich: The Economic Transformation of the Industrial World*. New York: Basic Books. The fundamental causes of the West's unprecedented affluence were not technological innovation and business entrepreneurship per se, but were the political pluralism and flexible institutions that encouraged scientific, cultural, and political freedoms.

Schumpeter, Joseph A. (1975 [1942]). *Capitalism, Socialism, and Democracy*. New York: Harper. A classic analysis of innovation, economic growth as creative destruction, and the interpenetration of market and democracy.

Solow, Robert M. (1957). "Technical Change and the Aggregate Production Function." *Review of Economics and Statistics*, August, pp. 214–231.

United Nations Development Programme. (1999). *World Development Report*. New York: Oxford University Press.

INTERNET RESOURCE

Commission on Intellectual Property Rights. (2002). *Integrating Intellectual Property Rights and Development Policy* London: Author. Available at http://www.iprcommission.org/graphic/documents/final_report.htm.

AFRICAN PERSPECTIVES

Computers in South Africa
HIV/AIDS in Africa

COMPUTERS IN SOUTH AFRICA

With its history of apartheid and its current mix of third- and first-world values, facilities, and services, the role of computer technology and the associated science in South Africa is different from most other countries, both in Africa and on other continents. Ethical considerations include such standard ones as employment, job losses, and social inclusion, but there are differences due to economic distortions caused by the legacy of apartheid.

Apartheid Legacy

Unemployment figures can be misleading in this economy. In the formal sector, unemployment seems to be at non-critical levels, but in the informal sector, joblessness is extremely high—2004 estimates are 40 percent—leading to crime and other social problems. South Africa nevertheless is very attractive to immigrants from other parts of sub-Saharan Africa, and there has been an influx of people seeking work.

Most students from disadvantaged backgrounds who are studying computer science are under some pressure to earn an income as soon as possible after they gain their first qualification, as they may have families to support, often families that have scrimped and saved to send a chosen member to university. Hence the desire to continue with any research or postgraduate study is disproportionately clustered in the privileged community, which historically is mainly white. In addition, it is comparatively easy in this field for individuals with degrees to obtain well-paid jobs, further lessening the incentive to contribute to research in computer science. This trend exacerbates the predominantly white presence of academics. A similar situation was faced by women in the 1980s. At the same time, at the beginning of the twenty-first century there is a great spirit of entrepreneurial activity among individuals while they are students, and small and medium-sized enterprises are being developed in response to a diverse range of needs, from computerizing legal records to computer control of traffic lights, all of which were largely ignored because the apartheid machinery had no need to optimize them.

Ethical Applications and Issues

South Africa's history of apartheid has left the country with an unusual technological infrastructure. During the apartheid years, it built an intensive war economy, supported by research and development in universities and in industry. Educators in liberal educational institutions faced the dilemma that their students would end up as engineers and computer scientists supporting this industry, engaged in activities of, at best, dubious morality. This dilemma no longer exists, but the legacy of the infrastructure still does, and so there is an imbalance in appropriate technology and expertise that is yet to be resolved. Furthermore, there are many areas, including high-density ones such as the historical townships, where electrical and telephonic infrastructure remains underdeveloped, impacting the ability to use technology—it is relatively easy to obtain old computers that are still usable, but there are no power sockets into which to plug them.

The most extensive legacy of apartheid is, of course, a huge gap between rich and poor, which actually continues to increase. Computer technology has a role to play, both in contributing to the gap and in lessening it. Because South Africa has traditionally had a labor-intensive economy, with labor being cheap and plentiful, the computerization of various work functions readily removes unskilled workers from the labor force, thus increasing unemployment and poverty. At the same time, the innovative use of computer technology and the development of local industry such as the excellent mobile phone network tend to bridge the rich-poor divide. Indeed, mobile telephony is especially appropriate in a country that is geographically large and whose fixed line telephonic network has been concentrated exclusively in wealthy urban areas. Mobile telephony has also empowered entrepreneurs by allowing them easy and efficient communications without the need to invest in anything more than a prepaid mobile phone.

For similar reasons, free and open source software is being embraced in South Africa, as in many other countries (especially in the developing world). Some of these motivations have an ethical or political component, such as the desire to promote the local software industry rather than enrich foreign corporations, while the free software movement has always claimed an ethical basis for shunning proprietary code. The collaborative maintenance model of open source software also seems to have opened up new possibilities—for example, translations to languages ignored by mainstream software manufacturers: In the South African context, the work of The Translate Project (http://translate.org.za) stands out. The appropriate application of computational linguistics techniques also has the potential for fostering social inclusion, by using machine translation to enable text in only English or Afrikaans (historically the two official languages) to be translated to the other nine official languages of South Africa, which include Zulu, Xhosa, Sotho, and other indigenous tongues.

One issue that might not otherwise be thought related to computers is that of the HIV/AIDS epidemic in South Africa: Between 20 percent and 40 percent of the population is directly affected by the disease, with a significant fallout effect on those indirectly connected. Some educational institutes have taken the stance that all subject areas have an ethical responsibility to educate about and mitigate the effect of the epidemic. While HIV might seem to have no direct impact on areas such as computer science, this is not actually the case. Research is currently underway in areas such as bioinformatics (http://www.sanbi.ac.za), including, for example, the modeling of the development of viral activity. Additionally, the epidemic affects educational institutions on a daily basis simply because it affects individuals on a daily basis. Many university students are already supporting extended families, on wages from part-time employment, and when a parent has the virus, the burden falls on the supportive child to look after younger children. In education this can often have the effect that completing practical assignments or studying for exams is relegated to the second tier of priority, once the caring for others has been done, resulting in poor performance from otherwise capable students.

In a country where a lot of dialogue about constitutional issues has been taking place since the 1990s, it is appropriate that the new South African constitution gives strong rights to individuals to access all information, including electronic information, held about themselves, especially by government bodies. In August 2002, the Electronic Communications and Transactions

Act became law. This is a wide piece of legislation pertaining to e-commerce and e-government, whose aim is to facilitate business, and it is descriptive rather than prescriptive. In contrast to the Data Protection Act of the UK, for example, there is no requirement for compliance. The chapter regarding personal information and privacy protection describes a voluntary regime that data collectors may subscribe to if they wish, so issues of personal privacy are still of concern.

SHEILA ROCK

SEE ALSO *Computer Ethics; Digital Divide.*

BIBLIOGRAPHY

Stallman, Richard M. (2002). *Free Software, Free Society: Selected Essays of Richard M. Stallman*, ed. Goshua Gay. Boston: GNU press. This is a collection of essays and speeches about open source by Richard Stallman—one of the primary pioneers of the free software movement.

INTERNET RESOURCE

Electronic Communications and Transactions Act (2002), South Africa. Available from (http://www.internet.org.za/ect_act.html). The ECT act describing appropriate use of computer technology in commerce and government.

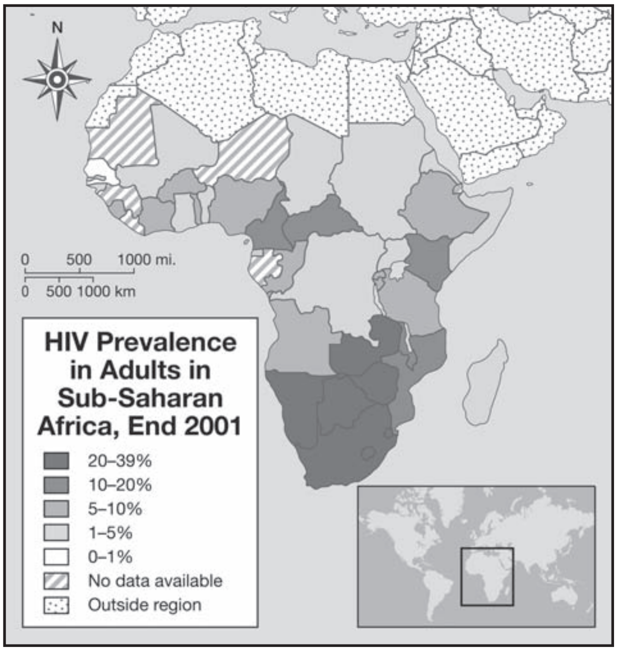
HIV/AIDS IN AFRICA

From the perspective of Africa, HIV/AIDS is one of the most significant ethical and political issues involved with science and technology. The spread of HIV/AIDS in Africa has the potential to undermine almost any other positive benefits of, for example, scientific education and research or sustainable technological development. Of particular importance is the fact that increasing numbers of children are being orphaned and made vulnerable by HIV/AIDS, and the traditional extended family is being strained to the breaking point. To appreciate the extent of the challenge, it is necessary to have some appreciation of the origins, spread, and impact of HIV/AIDS in Africa, and of the debates regarding response and treatment.

African Origins and Impact

HIV is sexually transmitted, and can be passed on through direct blood contact (for example, blood transfusion). In addition to blood, semen, and vaginal fluids, there are sufficient amounts of HIV in breast milk to cause transmission from mother to child. The genesis of HIV is not clear; however, some postulate a link between the virus and oral polio vaccines distributed in the Democratic Republic of Congo in the late-1950s that may have been contaminated by the simian immunodeficiency virus (SIV). Though the theory is largely discredited, the possibility of a connection between the two viruses is still debated (Worobey et al. 2004).

FIGURE 1



While more than 70 percent of HIV infection worldwide is through heterosexual sex, in sub-Saharan Africa the percentage is higher (Jackson 2002). The second most important route of transmission in the region is from an HIV-infected mother to her child. In Africa transmission via sex among men is far less common, and infection by drug users through sharing contaminated needles is relatively infrequent. Other means of transmission are through use of non-sterile needles and cutting implements in medical procedures, unscreened blood, and inadequate hygiene precautions in the care of AIDS patients. The map below shows the concentration levels over the continent.

Seventy-nine percent of AIDS deaths worldwide have occurred in sub-Saharan Africa. An estimated 71 percent of all adults and 87 percent of all children living with the disease in the early-twenty-first century reside in this region. Eighty-eight percent of all children who have been orphaned by AIDS live in sub-Saharan Africa (AIDS Epidemic Update 2002).

Researchers debate the reasons for the patterns of HIV/AIDS infection in different parts of Africa. Some believe that these patterns are influenced by whether the population is affected by HIV-1, HIV-2, or other strains of the virus, some of which are more virulent than others. Other observers focus on the social and cultural differences among countries. Researchers Jack Caldwell and Pat Caldwell, for example, see a coincidence between low infection rates and male circumcision, which improves personal hygiene and corresponds to low rates of sexually transmitted disease (STDs). Muslim countries in North Africa have relatively low rates of infection, as do Muslim populations within countries that are highly infected.

Factors Contributing to the Spread of HIV/AIDS

Since the sixteenth century, violence and disorder have upset the political and social culture of Africa. To understand the devastating spread of HIV/AIDS on the continent, one must consider events including war and desperate poverty that continue to be familiar and persistent conditions in many African nations.

MIGRATIONS. Massive migrations of displaced persons due to war, social unrest, and economic disadvantage are key contributors to the spread of the virus. In some cases, refugees flee their homelands to countries where the infection rate is already high. Upon resettlement, the refugees bring the disease home with them.

Due to economic depression, workers are forced to look for jobs far from home. For example, many from eastern and southern Africa went to work in the mines of South Africa, living in conditions of poverty and social unease. Poor hygiene, multiple sexual partners, and other social and economic factors that affect such workers promote infection at an accelerated rate.

WAR. Wars and other conflicts raged across Africa in the late-twentieth century and continued into the early-twenty-first century. Refugees help spread the epidemic. But the various armies involved in these conflicts are even more efficient sources of infection. Military personnel, both combatants and peacekeepers with regular pay, are more likely to contract HIV than civilians; in addition, they have higher rates of STDs, a factor known to correlate with easier transmission of the virus. Resolving these conflicts is key to a sustained, effective response to HIV/AIDS (Mills and Sidiropoulous 2004).

POVERTY. At the beginning of the twenty-first century, sub-Saharan Africa accounted for 32 of the 40 least developed UN member states. The region's total income is about the same as that of Belgium. (World Bank 2000).

Poverty leads to health conditions that promote spread of the disease, including chronic, severe malnutrition. In addition, people living in poverty have less access to basic education and health services. Extreme poverty is linked to an increase in commercial sex among women, who have the fastest growing infection rate.

SILENCE, STIGMA, AND DISCRIMINATION. Some African governments have denied the extent of the problem or that it exists at all. In addition, stigma attached to the infection has caused many people to refuse to become involved in finding solutions (Campbell 2003). For example, for several years in the 1980s former Kenyan president Daniel Arap Moi denied that HIV/AIDS infection existed in his country for fear of destroying the tourist industry, a key source of national income. As a result, there was little if any effort to promote precautions against transmission of the virus and the disease spread unabated (Singhal and Rogers 2003).

Social Impacts

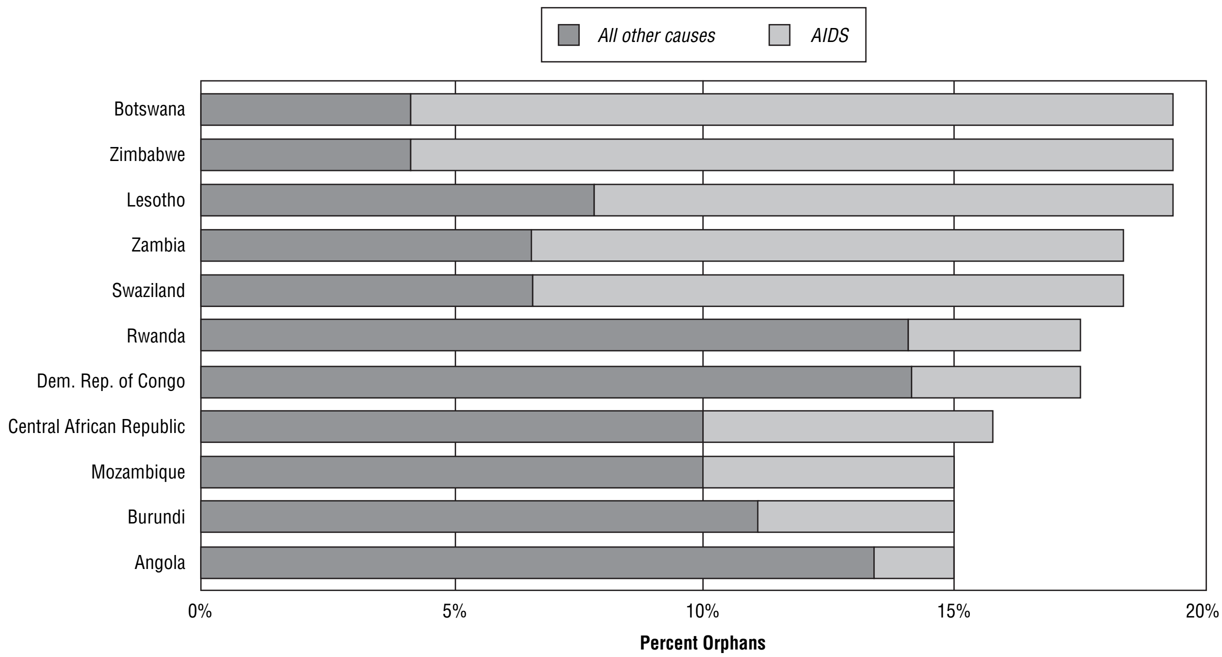
HIV/AIDS will have enormous implications for the future of Africa. This entry will address just a few of the most pressing issues at the beginning of the twenty-first century.

ORPHANED CHILDREN. The main impact of the disease is felt through the loss of economically active people in their child rearing years, between the ages of fifteen and forty-five. UNICEF's *Africa's Orphaned Generations* (2003) puts the number of African children orphaned by AIDS at 11 million, with an estimate that the disease will ultimately rob 20 million children of their parents. Figure 2 shows the increasing numbers of children who will become orphans as a result of the epidemic.

IMPACT ON GOVERNMENT AND SERVICES. Many countries in eastern and southern Africa are already burdened by weak government infrastructures and inadequate human resources, compounded by the migration of skilled professionals due to economic reasons. The epidemic has exacerbated the situation with the attendant loss of workers in their most productive years. Staff attrition in key sectors such as education and agriculture outpaces replacement, causing a loss of institutional memory and low morale. Nongovernmental organizations (NGOs), which have been central to the struggle to control the disease, are focusing more energy on caring for the sick and less on education, prevention, and self-help initiatives in the community. Disintegration of national institutions such as the army and police threaten the security and political stability of many nations. Effects of the disruption of governance, such as displacement, food insecurity, and conflict, spur transmission of the disease, and contribute to the continent's downward cycle.

FIGURE 2

Countries by Highest Percent of Children Who Were Orphans, 2003



SOURCE: UNAIDS, UNICEF, and USAID. *Children on the Brink 2004*, p. 8.

IMPACT ON NATIONAL ECONOMIES. The World Bank (2001) estimates that per capita growth in half of Africa's countries is falling by 0.5 to 1.2 percent annually as a direct result of HIV/AIDS; by 2010, GDP in some of the countries most affected will drop as much as 8 percent. According to the Food and Agricultural Organization of the United Nations (FAO) (2004), two-person years of labor are lost for each AIDS death. In addition to the stark loss of life, HIV/AIDS deaths contribute to the loss of local knowledge of farming practices and forces communities to opt for less labor-intensive, less productive cropping patterns (FAO 2001).

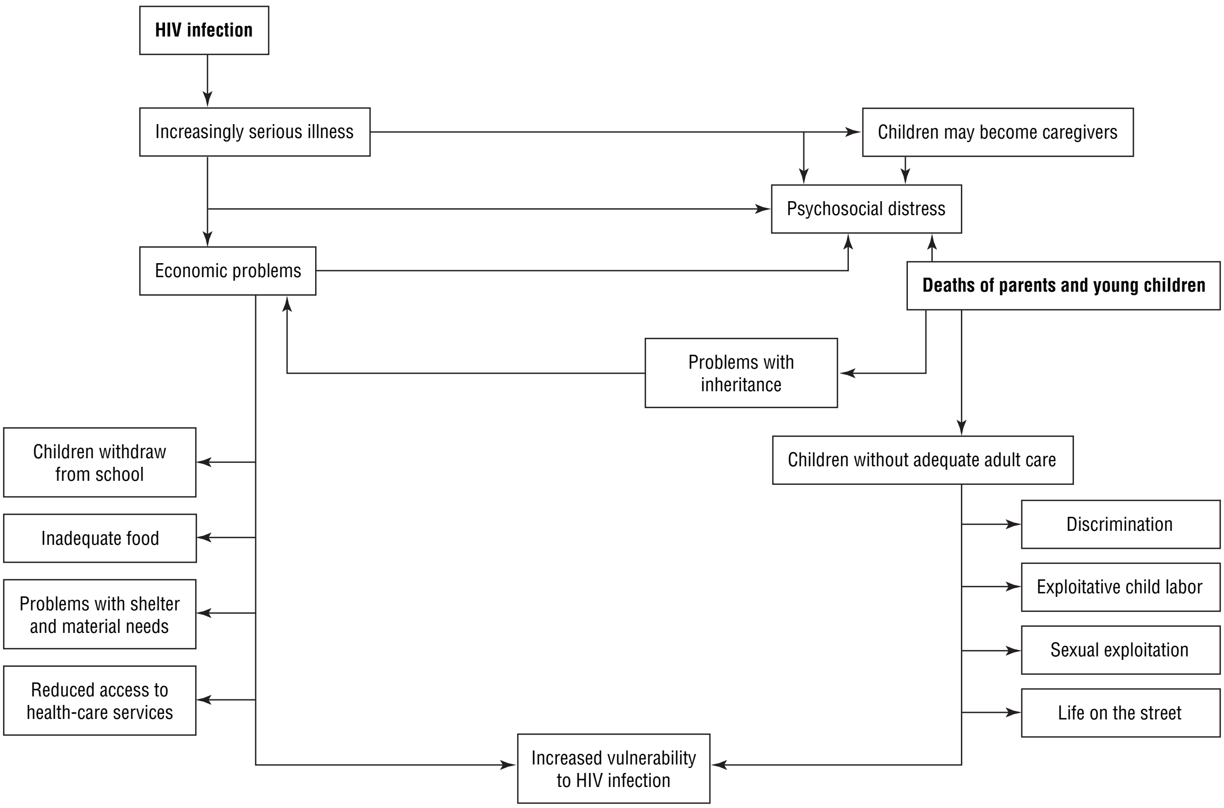
WOMEN. According to the United Nations Programme on HIV/AIDS (UNAIDS) AIDS Epidemic Update for 2004, 76 percent of all young people (ages fifteen to twenty-four) in sub-Saharan Africa who are infected with HIV are female. Females are three times more likely to be infected than males in this age range. Gender inequality is the most important reason that HIV/AIDS infection has transformed into an epidemic that affects women and girls in disproportionate numbers. Women in Africa hold a lower socioeconomic position than do men. They are likely to be poorer and have less education and less access to social services than men do. Women faced with limited options to earn money sometimes turn to commercial sex; in some cases, for example in areas affected by sustained drought, women and girls resort to exchanging sex for food or other basic survival needs. Other factors related to the imbalance in power between men and women including sexual violence, early marriage, and poor access to information about transmission of the disease (even as relates to mother-child transmission) contribute to the infection rate. Adding to the problem is the fact that women are physiologically more vulnerable to being infected with the virus.

Response and Treatment Debates

Antiretroviral drugs (ARVs) are a great advance in the treatment of HIV/AIDS patients. Such drugs do not prevent infection or cure the virus. They do, however, disrupt the life cycle of the virus, preventing its reproduction. ARVs can reduce the patient's viral load tenfold within eight weeks, and lower it to undetectable levels

FIGURE 3

Problems Among Children and Families Affected by HIV and AIDS



SOURCE: Williamson, Jan. (2004). *A Family Is for Life* (draft), USAID, and the Synergy Project.

within six months. For those infected with HIV, the onset of AIDS can be delayed indefinitely. Patients live longer, gain weight, and feel better.

ARVs were unaffordable in Africa until 2001 when an Indian drug company, Cipla, offered to provide a year's supply for $350, one-fortieth the cost in countries such as the United States. Although the price of ARVs has fallen dramatically, few Africans have access to the drugs. In addition, ARVs work most effectively when people are well nourished and have acceptable hygiene standards. In Africa the provision of ARVs is linked not only to challenges to improve the living conditions of sufferers, but to improving distribution of the drugs by strengthening public health systems.

The World Health Organization (WHO) plans to distribute ARVs to 3 million people in Africa by the end of 2005 through its "3 by 5" initiative. In addition to prolonging lives, this effort will slow the rate of orphanhood of the children of HIV/AIDS victims. Major drug companies, due to pressure from the global community, have recognized the need to reduce the cost of life-saving treatments. In an attempt to undo a public relations nightmare caused by the public perception of avarice, some companies provide the drugs free of charge; others have built medical clinics.

However there are those who argue that ARVs will not address HIV/AIDS in Africa due to the scope of the problem and the price of the therapy, and that an effective vaccine is necessary. Where to test such a vaccine, who to test it on, and what treatment should be provided to vaccine subjects who are already infected (where the vaccine is not a preventative but works to slow replication of the virus) are all questions with both medical and ethical importance.

Other efforts continue. Of particular note is the work of the Bill and Melinda Gates Foundation. The foundation's top global health priority is to stop transmission of the HIV virus and it has given more than 1.4

billion dollars toward that goal since 1994 (Gates Foundation).

Conclusion

In the early-twenty-first century, many African governments finally declared the HIV/AIDS epidemic national emergencies—a necessary first step to beginning HIV-prevention programs. Progress to control the epidemic has been made, but spread of the virus continues to outpace such efforts. Denial of the scope of the problem and stigmatization of victims continue. The most daunting task is to acquire the funds and means necessary to develop proven interventions, and provide them to sufferers. Promoting education, developing treatments, and providing relief to victims of the disease in Africa poses ethical challenges to scientists and technicians, not just in the field of medicine, but in host of other fields as well.

PELUCY NTAMBIRWEKI

SEE ALSO *Development Ethics; Equality; HIV/AIDS.*

BIBLIOGRAPHY

Barnett, Tony, and Alan Whiteside. (2002). *AIDS in the Twenty-First Century: Disease and Globalization*. Hampshire: Palgrave Macmillan.

Caldwell, Jack C., and Pat Caldwell. (1996). "The African AIDS Epidemic." *Scientific American* 274(3): 62–68.

Campbell, Catherine. (2003). *Letting Them Die: Why HIV/AIDS Prevention Programmes Fail*. Oxford: International African Institute.

Guest, Robert. (2004). *The Shackled Continent: Africa's Past, Present and Future*. Oxford: Macmillan.

Hunter, Susan, S. (2000). *Reshaping Societies HIV/AIDS and Social Change: A Resource Book for Planning, Programs and Policy Making*. New York: Hudson Run Press.

Hunter, Susan, S. (2003). *Who Cares?: AIDS in Africa*. New York: Palgrave Macmillan.

Jackson, Helen. (2002). *AIDS Africa: Continent in Crisis*. Zimbabwe: SAfAIDS.

Madraa, Elizabeth, and Major Ruranga-Rubamira. (1998). "Experience from Uganda." In *Partners in Prevention: International Case Studies of Effective Health Promotion Practise in HIV/AIDS*, eds. Anne Malcolm and Gary Dowsett. Geneva: UNAIDS.

Mills, Greg, and Elizabeth Sidirpoulos, eds. (2004). *New Tools for Reform and Stability: Sanctions, Conditionalities and Conflict Resolution*. Johannesburg: South African Institute of International Affairs.

Root-Bernstein, Robert S. (1993). *Rethinking AIDS: The Tragic Cost of Premature Consensus*. New York: Free Press.

Singhal, Arvind, and Everett M. Rogers. (2003). *Combating AIDS: Communication Strategies in Action*. New Delhi: Sage Publications.

Topouzis, Daphne. (1994). *Uganda: The Socio-Economic Impact of HIV/AIDS on Rural Families with an Emphasis on Youth*. Rome: Food and Agriculture Organization of the United Nations.

UNICEF. (2003). *Africa's Orphaned Generations*. New York: Author.

Wakhweya, Angela, et al. (2002). *Situation Analysis of Orphans in Uganda: Orphans and Their Households: Caring for the Future–Today*. Kampala: Uganda AIDS Commission.

Whiteside, Alan, and Clem Sunter. (2000). *AIDS: The Challenge for South Africa*. Cape Town: Human and Rousseau.

World Bank. (2000). *Can Africa Claim the 21st Century?* Washington, DC: Author.

World Bank. (2001). *Turning the Tide Against HIV/AIDS: Time for Global Action to Match a Global Threat*. Washington, DC: Author.

Worobey, Michael, et al. (2004). "Origin of AIDS: Contaminated Polio Vaccine Theory Refuted." *Nature* 428: 820.

INTERNET RESOURCES

Committee on World Food Security. "Food Security and HIV/AIDS: An Update." Food and Agricultural Organization of the United Nations (FAO). Available from http://www.fao.org/DOCREP/MEETING/006/Y9066E/Y9066E00.HTM. Report of the Committee's Twenty-Ninth Session, May 12–16, 2003, Rome.

Food and Agriculture Organization of the United Nations (FAO). "HIV/AIDS and Food Security." Available from http://www.fao.org/hivaids/.

Gates Foundation. Available fromwww.gatesfoundation.org.

Joint United Nations Programme on HIV/AIDS. "AIDS Epidemic Update: December 2002." UNAIDS. Available from http://www.unaids.org/html/pub/publications/irc-pub03/epiupdate2002_en_pdf/epiupdate2002_en_pdf_1.jpg.

Joint United Nations Programme on HIV/AIDS. "AIDS Epidemic Update: December 2003." UNAIDS. Available from http://www.unaids.org/html/pub/publications/irc-pub06/JC943-EpiUpdate2003_en_pdf/JC943-EpiUpdate2003_en_pdf_1.jpg.

Joint United Nations Programme on HIV/AIDS. "AIDS Epidemic Update: December 2004." UNAIDS. Available from http://www.unaids.org/wad2004/EPIupdate2004_html_en/epi04_00_en.htm.

Joint United Nations Programme on HIV/AIDS. "Children on the Brink." UNAIDS. Available from http://www.unaids.org/EN/resources/epidemiology/epi_recent_publications/childrenonthebrink.asp.

Joint United Nations Programme on HIV/AIDS. "Ethical Considerations in HIV Preventive Vaccine Research." UNAIDS. Available from http://www.unaids.org/html/pub/publications/irc-pub01/JC072-EthicalCons_en_pdf/JC072-EthicalCons_en_pdf_1.jpg.

AGGRESSION

The word aggression comes from the Latin roots *ag* (before) and *gred* (to walk or step). Hence to aggress is to step before or in front of someone, to initiate something, commonly an attack. Aggression—whether by a state or an individual—refers to an unprovoked, offensive action against another. It is useful to contrast aggression with violence, which derives from the Latin root *vio,* which refers to force. Dictionary definitions include "rough, unjust, unwarranted and injurious physical force or treatment," as well as "immoderate vehemence, typically causing injury, pain or gross distortion." It is possible to talk about a violent storm, or an earthquake of exceptional violence, but the term is most often applied to human actions, in which case it generally implies that pain or injury is intentionally inflicted on someone or something.

By contrast aggression is not necessarily hurtful: A person may promote a viewpoint aggressively, for example, which implies initiative, forcefulness and assertiveness, but without injury. It is admirable to conduct an aggressive campaign against cancer, poverty, or illiteracy. One may even seek to aggressively oppose violence. Nonetheless aggression as such is not highly regarded; it, like its frequent concomitant, violence, is typically considered undesirable, at least from the perspective of most ethicists.

Aggression Among Animals

Aggression is widespread among animals, especially those living in social groups. Although it sometimes takes the form of clear, outright violence, aggression is more often subtle, involving intimidation and the displacement of one individual by another, typically in the context of established dominance hierarchies. Early scientific studies of animal behavior emphasized that animal aggression very rarely results in serious injury or death, and that most living things with the capacity of inflicting serious harm on one another have evolved inhibitory mechanisms that prevent them from doing so. As ethological studies have gotten more sophisticated, however, it has become clear that these generalizations were idealized and exaggerated. In fact animals, even members of the same species, do kill one another. There is, however, some truth to the generalization that many living things have evolved behaviors that make lethal aggression less frequent than might otherwise be expected.

Increasingly sophisticated field studies of animal behavior show that animal aggression is not limited to inter-individual events; inter-group aggression has also been documented—for example, between lion prides or chimpanzee groups. Lethal aggression, in these cases, is most likely when the groups in question consist of genetically unrelated individuals, just as within-group aggression is also significantly modulated among close relatives, as predicted by *selfish gene theory*.

Aggression Among Human Beings

There has been considerable research into the causes of aggression, especially among human beings. Aggression is caused by many different factors; indeed, virtually every scientific specialty has its own *take* on which factors are especially important. For psychoanalysts, aggression derives largely from innate human destructiveness, what Freud called *thanatos,* or the *death instinct*. Although biologists are particularly unconvinced by this approach (it is difficult to imagine a situation for which a death instinct—especially when directed toward one's self—would be selected), there are parallels between this and another instinctivist approach, best articulated by the ethologist Konrad Lorenz (1903–1989). Lorenz hypothesized that aggression has evolved in a variety of circumstances, including spacing and population control, and provides an opportunity for competition within a species, as a result of which the most fit members will emerge to produce the next generation, and also establishes a means whereby the pair bond is strengthened, when, for example, a mated pair demonstrates shared aggression against competitors.

Sociobiology and evolutionary psychology provide updated biological explanations for human and animal aggression, emphasizing the degree to which aggression is adaptive rather than somehow mandated by the genome. This approach focuses on the way particular behavior patterns are maintained and promoted in a population because they contribute to the reproductive success of individuals (and their genes), as opposed to groups or species. For example, the *adaptionist* evolutionary view of aggression examines such phenomena as ecological competition, male-male competition, and the role of kinship patterns in directing aggressive behavior in particular ways. It also focuses on aggression as a *response* to circumstances rather than an innate need. Adaptionists do not argue that aggressiveness will emerge despite affirmative constraints. Rather, proponents maintain that living things have the capacity to behave aggressively when such behavior maximizes their fitness, and to behave pacifically when that response is in their best evolutionary interest.

It should be emphasized that predatory behavior—hunting—is different from aggressive behavior. The fact that certain Australopithecines and other prehuman species were evidently meat-eaters does not in itself mean that they were aggressive. Aggressive behavior is most prominent within a species, not between species. Lions, for example, often behave aggressively toward other lions, in which case they make themselves conspicuous and threatening; by contrast, when hunting zebras, lions employ very different behavior patterns, making themselves inconspicuous until the actual attack, and not relying on bluff or other means of aggressive intimidation.

The mainstream view among social scientists is that aggression is almost entirely a response to specific circumstances. So-called *frustration theory* has been especially influential; it posits that whenever aggressive behavior occurs, there must be frustration, and similarly, whenever frustration occurs, it always produces aggression of some kind. Other psychological approaches focus on the role of social learning, such as conditioning theory in which aggressiveness—by groups as well as individuals—is more likely when such behavior has been *positively reinforced*, and less likely when *negatively reinforced*. In short aggression is crucially modified by its consequences.

Social psychologists, by contrast, focus on the degree to which individuals can be socialized to aggressiveness, just as sociologists examine the role of social structures (religion, family, work ethos, mythic traditions) in predisposing toward aggression. Special consideration has been given to matters of ethnic, racial, and religious intolerance. Ironically, although most scientists agree that race has no genuine biological meaning, theories that focus on the importance of stereotyping and of *in-group amity, out-group enmity* have gained increasing attention.

For anthropologists interested in cross-cultural comparisons of human aggression, a paramount consideration is the extent to which aggression may be *functional* in acquiring land, access to mates, or status, as well as in regulating population, organizing social relationships within the group, and even influencing the pressure that tribal units place upon agricultural productivity and/or human population or the wild game on which they may depend. The prehistory of human aggressiveness remains shrouded in mystery, although most specialists agree that primitive human groups engaged in substantial violence as well as cannibalism.

For many political scientists, relevant considerations include the role of rational calculations of state benefit and national power. An important underlying assumption is that states behave aggressively when it is in their perceived interest to do so, perhaps because of the prospect of enhancing their influence and power (*realpolitik*), minimizing potential decrements to it, or enhancing the political viability of national leaders, among other reasons. Approaches run the gamut from mathematical models created by game theoreticians to analyses of historical cycles, matters of national prestige, and economic/resource based considerations.

Aggression and Ethics

Ethical analyses of aggression are nearly as diverse as efforts to explain its occurrence. Although aggression among animals is not susceptible to ethical judgments, human aggression certainly is. Indeed ethical assessments—often negative—may be especially directed toward cases of aggression. Such judgments may be absolute, on the order of philosopher Immanuel Kant's (1724–1804) *categorical imperative*, which maintains that any act or aggression is acceptable only if it could be reasonably seen to be based on general principles of behavior. However *situational ethics* typically emphasize that aggression should be evaluated with regard to the conditions in which it occurs. Thus self-defense—whether by an individual or a group—is enshrined in most legal and moral codes, whereas aggression is widely considered to be unacceptable when it occurs without adequate provocation, or preemptively.

The degree to which such ethical judgments are supported or undermined by scientific studies is open to debate. For instance, some believe that scientific knowledge of the biological mechanisms of aggressive behavior demonstrates that cultural moderation, in the form of moral sanctions, is a continuation of nature in nurture. Others argue that the widespread presence of aggression among animals legitimates its presence among humans. In the end, the tensions between these arguments point toward granting moral judgments or values some degree of independence in assessing human behavior, although such judgments will, by necessity, be refined as science advances additional theories to explain the complexities of aggression. Finally, the discussion of whether and to what extent science and technology can be characterized as aggressive activities, although again somewhat independent of scientific research, is furthered by reflection on the scientific study of the phenomena of aggression.

DAVID P. BARASH

SEE ALSO *Darwin, Charles; Ethology; Just War; Nature versus Nurture; Sociobiology; Violence.*

BIBLIOGRAPHY

Barash, David P. (2001). *Understanding Violence*. Needham Heights, MA: Allyn & Bacon. Contains many crucial pieces concerning violence, from a variety of disciplines.

Barash, David P., and Charles P. Webel. (2002). *Peace and Conflict Studies*. Thousand Oaks, CA: Sage Publications. A comprehensive textbook that introduces the field of peace and conflict studies.

Eibl-Eibesfeldt, Irenaus. (1979). *The Biology and Peace and War: Men, Animals and Aggression*. New York: Viking. Presents traditional ethological ideas concerning aggression, with special attention to human peace and war.

Lorenz, Konrad Z. (2002). *On Aggression*. New York: Routledge. A readable and only slightly outdated account of the classical ethological approach to animal and human aggression.

Moynihan, Martin H., and Michael H. Robinson. (1998). *The Social Regulation of Competition and Aggression in Animals*. Washington, DC: Smithsonian Institution Press. A technical compendium of source material concerning causes of, and constraints upon, aggressive behavior in animals.

AGING AND REGENERATIVE MEDICINE

Advances made in research on the biology of aging and on the repair, replacement, and regeneration of tissues and organs (regenerative medicine) have drawn attention to old and new ethical issues. The principal concern among those who anticipate intervention in the aging process is whether or not attaining the power to do so is a desirable goal. The issues for those who are concerned about using human cells or tissues for research or therapeutic purposes are as follows: (1) whether the donor is, or is not, capable of giving informed consent; (2) if not, whether it is ethical for others to make that decision; and (3) whether the taking of one or a few potential lives for the benefit of many is ethically sound. When the source of the cells or tissues is a fetus or embryo, debate centers on the ethics of using tissue from induced or spontaneous abortion and when human life begins.

Where some see only benefit in the ability to slow, stop, or even reverse the aging process, others see an array of unintended consequences. There have been efforts made to intervene in the aging process throughout recorded history, and also warnings given that doing so could lead to undesirable consequences (Hayflick 2000).

The only way humans have succeeded in extending their longevity is by eliminating or delaying the appearance of disease or pathology. The greatest success occurred during the twentieth century when actuaries recorded the largest increase in human life expectancy at birth in developed countries.

The thirty-year increase from about forty-seven years in 1900 to about seventy-seven years in 2000 resulted from the implementation of public health measures for the control of acute infectious diseases, the discovery of antibiotics and vaccines, and the great advances made in other medical and health care disciplines. The result has been an enormous reduction in mortality rates in early life and a concentration of deaths in later years. In the early-twenty-first century, in developed countries, infectious diseases are no longer a leading cause of death. They have been replaced by cardiovascular disease, stroke, and cancer.

The maximum number of additional years attainable by the elimination of deaths caused by disease or pathology is between fifteen and twenty (Hayflick 2000). Once the leading causes of death are resolved, immortality will not occur, but we will have revealed the underlying, inexorable aging process that leads to causes of death attributable to the loss of function in some vital organ.

The Aging Process and the Ethics of Intervention

The process of aging is the inevitable loss of molecular fidelity that occurs randomly in the molecules of most animals after reproductive maturation. The status of biomolecules before they undergo age changes determines potential longevity or degree of resistance to age changes. No intervention that increases the stability of biomolecules before they undergo the aging process is known, nor is any method that can slow, stop, or reverse the aging process in humans.

The fundamental aging process increases vulnerability to what is written on the death certificates of older people. There seem to be no ethical issues that would oppose the goal of eliminating all causes of death attributable to pathology, violence, or accidents. But ethical issues do arise when considering interventions in either the aging process or the determinants of longevity. However, at this time, these can only be considered in the abstract.

Those who favor intervention in either the aging process or the determinants of longevity see a benefit in increasing the chronological time during which life satisfaction and good health are at their maximum levels. Critics see an array of ethical issues. These include the determination of when to intervene, because in order to determine when life satisfaction is at its greatest one must experience that time of life. If subsequent events reduce life satisfaction, choosing to return to a former happier state will depend on methods known to occur only in science fiction. It is also science fiction to expect that the environment that contributed to such better conditions will remain unchanged (Hayflick 2004).

Of the many bizarre scenarios that can be imagined, one would not be surprised to find families in which adult children, who chose not to slow or stop the aging process, are themselves biologically older than their parents, who did. Finally people who are highly satisfied with the quality of their lives are those most likely to contemplate arresting the aging process. It is not likely to be an attractive option for a substantial part of the world population, that is, the poor, oppressed, and sick.

Hundreds of thousands of septagenarians, and even older people, who are in relatively good health say that their current age is the happiest time of their lives. They contend that arresting the aging process at an earlier age would have either denied or delayed for them the contentment of retirement, travel, freedom from child-rearing responsibilities, and time to pursue personal interests that do not demand income generation. Human interactions depend to a substantial degree on perceptions of relative age. The destruction of those relationships could have enormous negative personal and societal consequences.

Presumably any method for intervening in the aging process would first become available to those able to afford expensive treatment and would be unavailable to those who could not. The intervention would also become available to antisocial and asocial persons, as well as those who do not harm or who benefit human civilization. The effect of manipulating the aging process could be disastrous for many human institutions.

Proposals to circumvent aging by replacing all old parts with younger parts are unlikely to be an option. For example, replacement of the brain could not only compromise one's sense of self-identity but the attendant loss of memory would erase the most essential part of what makes one human. Absent unrealistic scenarios in which a computer might be used to first upload the contents of an aging brain, cleanse it of old thoughts, and then download it to a new erased brain, it is unlikely that replacement of one's brain would ever be an attractive option. Also the eventual replacement of all old parts with younger or new parts in both animate and inanimate objects would result in both the physical and philosophical dilemma of having lost the original entity.

If it is true that mental processes continue to change for the better with age, one might equate the goal of arresting the aging process with that of arresting developmental processes. Arrested mental development in childhood is viewed universally as a serious pathology. If it is undesirable to retard the physical and mental development of a seven-year-old for ten years in order to gain an equivalent increase in longevity, arresting one's aging processes in later life should not be attractive for the same reasons.

Perhaps the least imperfect scenario would have each person live to be 100, while remaining in good physical and mental health, and then quickly and painlessly die at the stroke of midnight (as in "The Deacon's Masterpiece or The Wonderful One Hoss Shay" by Oliver Wendell Holmes [1857–1858]).

Humankind will probably not face these ethical issues in the near future because it is unlikely that biogerontologists will find ways to intervene in the fundamental aging and longevity determining processes for several reasons. First, most research done under the rubric of aging research in humans is done on age-associated diseases, the resolution of which cannot extend human longevity more than fifteen years. This accomplishment will not provide any insight into the fundamental aging process. The resources devoted to research on the underlying aging process are, by comparison, infinitesimal. Second, there are no generally acceptable criteria for measuring whether or not an intervention in humans is affecting either the aging process or the determinants of longevity. Finally, although the determinants of longevity might be altered, the aging process, because it is a fundamental property of all matter, is unlikely to be changed.

Regenerative Medicine Research and Ethical Considerations

The ethical issues that derive from research in regenerative medicine are more immediate than those that might result from intervening in the aging or longevity determining processes. In the early twenty-first century, several major advances are close to, or have become, reality (Cibelli, Lanza, Campbell, and West 2002).

The central ethical issue in regenerative medicine is whether the taking of human cells or tissues for research or therapeutic purposes is acceptable when a donor is incapable of giving informed consent. If no informed consent is possible, does consent by others, for the purpose of promoting research that will benefit society, outweigh the taking of what some believe to be a potential life?

When the potential source of cells or tissues is a fetus or embryo, ethical considerations usually center on the pros and cons of induced abortion. The arguments are frequently based on some arbitrary time in embryonic or fetal development when it is thought that human life begins. Many biologists argue that human life does not have a beginning (except on an evolutionary timescale) because both sperm and egg cells must be alive from the start and fusion of the two is simply another of the many critical steps that, if successful, can lead to the development of a viable offspring. Others contend that the potential for human life only occurs at the moment of conception. This is another arbitrary point because equally critical events must occur both before and after fertilization to insure that the potential for human life is realized. This issue could become even more clouded if it is shown, as it has been in some animals, that a jolt of electricity or a needle prick can stimulate an unfertilized egg to develop—a process known as parthenogenesis.

However the vast majority of sperm and eggs produced never fuse to form a zygote and if they do, a substantial number of zygotes subsequently are lost naturally. Yet this enormous loss of potential human life that far exceeds the number of successful births is rarely deplored.

In order to circumvent some ethical objections, the use of somatic cell nuclear transfer (SCNT) has been shown to be a practical alternative. Here the nucleus from a body cell (other than a gamete or its precursors) is inserted into an egg whose nucleus has been removed. This is done in vitro with the resulting dividing cells used for research or for potential therapy in the nuclear donor where problems of immunological incompatibility are reduced. Like the fusion of a sperm and egg in vitro, it is not possible for this cluster of cells to become a viable embryo unless the zygote is implanted into a uterus. Despite the fact that the nucleus used in SCNT comes from a single donor, the cells that form the zygote, or later developmental stages, could be used therapeutically when compatibility problems are overcome.

What must be weighed in considering the taking of human fetal cells or tissue is if anyone has the right to make the decision and whether or not the benefit that might accrue to many potential recipients outweighs the loss of one or a few potential lives. One significant precedent for making this decision in the affirmative is the often overlooked fact that, in the last forty years, hundreds of millions of people throughout the world have benefited from the use of many common virus vaccines, all of which were produced (and are still produced) in cells obtained from one or two surgically aborted human fetuses on which research had been publicly supported (Hayflick 2001).

LEONARD HAYFLICK

SEE ALSO *Biotech Ethics; Medical Ethics; Posthumanism; President's Council on Bioethics.*

BIBLIOGRAPHY

Binstock, Robert H. (2003). "The War on 'Anti-aging Medicine.'" *The Gerontologist* 43(1): 4–14. A scholarly analysis of how mainstream biogerontologists are countering the practitioner's of anti-aging medicine who biogerontologists believe are exploiting the publics' ignorance of the science for financial gain.

Cibelli, Jose; Robert P. Lanza; Keith H. S. Campbell; and Michael West. (2002). *Principles of Cloning.* San Diego, CA: Academic Press.

Gruman, Gerald J. (1966). "A History of Ideas about the Prolongation of Life." *Transactions of the American Philosophical Society* 56, Part 9. Probably the best history ever written on the evolution of human thought about longevity from the first written records until 1800.

Hall, Stephan S. (2003). *Merchants of Immortality.* New York: Houghton Mifflin. Developments in the fields of research on aging, stem cells, regenerative medicine and cloning are considered in this well-written and carefully researched history of these fields. Biological advances, political positions, and ethical debates are covered in detail.

Hayflick, Leonard. (1994). *How and Why We Age.* New York: Ballantine Books. An overview of the aging process written for the lay reader with a chapter on the probability and desirability of intervention.

Hayflick, Leonard. (2000). "The Future of Aging." *Nature* 408: 37–39.

Hayflick, Leonard. (2001). "A Brief History of Cell Substrates Used for the Preparation of Human Biologicals." In *Developments in Biologicals* Vol. 106: *Evolving Scientific and Regulatory Perspectives on Cell Substrates for Vaccine Development*, ed. Fred Brown, Keith Peden, Philip Krause and Andrew M Lewis. Basel, Switzerland: Karger.

Hayflick, Leonard. (2004). "'Anti-aging' Is an Oxymoron." *Journal of Gerontology* 59A(6): 573–578. The failure to define common terms in the field of gerontology has contributed to the many conceptual misunderstandings that have hindered progress and contributed to serious communication failures.

Hayflick, Leonard; Stanley Plotkin; and Robert E. Stevenson. (1987). "History of the Acceptance of Human Diploid Cell Strains as Substrates for Human Virus Vaccine Manufacture." In *Developments in Biological Standardization* Vol. 68, eds. John C. Petricciani, and W. Hennessen. Basle, Switzerland: Karger Publishing. Also published in Bookchin, Debbie, and Jim Schumacher. (2004). *The Virus and the Vaccine.* New York: St. Martin's Press. How the struggle to have normal human fetal cells used for the production of many of the world's human virus vaccines was ultimately won. The early use of primary monkey kidney cells for this purpose revealed contamination with several dangerous viruses. Yet it took more than a decade to overcome the scientific, political, and economic resistance to have them replaced with the safe, normal, human fetal cell strain WI-38 discovered by Leonard Hayflick. Now many safe and efficacious vaccines made in Hayflick's human fetal cells have been administered to almost one billion people.

Olshansky, S. Jay; Leonard Hayflick; and Bruce A. Carnes. (2002). "No Truth to the Fountain of Youth." *Scientific American* June: 92–95. A declaration with much supporting evidence that, in the early-twenty-first century, there is no way of intervening in the fundamental aging process in humans. Signed by fifty-one of the world's leading researchers on aging.

AGRARIANISM

Agrarianism may be defined as the view that the practices of the agricultural life, and the types of technology on which that life has historically been based, are particularly effective in promoting various important personal, social, and political goods. The precise character of these goods—and the respective roles of science, technology, government, society, and individuals in procuring them—varies according to which thinker or stream of agrarian thought one wishes to consider. Two different sources of modern agrarian thinking will be considered here: (1) the agrarianism of the "Old Whig," antifederalist American founders, itself a self-conscious effort to retrieve the agrarian and republican values of the classical world; and (2) the agrarianism promoted by antimodern thinkers of the twentieth and twenty-first centuries. A third stream of agrarian thought and practice may be found among dissenting religious groups such as the Amish and other Anabaptist sects. However, with the exception of their theologically-grounded suspicion of scientific inquiry, these religious groups' ethical critique of science and technology is more fully articulated by the antimodern agrarians. Indeed, the antimodern agrarians' political-ethical critique of modern science and technology, though not especially well known, is one of the more original to have emerged in the last century and is arguably becoming more influential.

From Old Whig to Antimodern Agrarianism

As every schoolchild knows, Thomas Jefferson contended for an agrarian vision of America. As unsystematic in his approach to this subject as he was to most others, Jefferson scattered his brief observations about the value of the agricultural life throughout his letters and other documents. Most famously, in query XIX of his *Notes on the State of Virginia* (1781–1782), Jefferson argued that agriculturalists were especially apt to be virtuous: "Those who labour in the earth are the chosen people of God, if ever he had a chosen people, whose breasts he has made his peculiar deposit for substantial and genuine virtue. . . . Corruption of morals in the mass of cultivators is a phenomenon of which no age nor nation has furnished an example." By virtue, Jefferson and most of the other anti-federalists had foremost in mind a certain spirit of self-reliance that made economic—and therefore genuine political—independence possible. Yeoman farming was the indispensable support of republican government.

Jefferson was a reliable spokesman for republican agrarianism, but its most penetrating theorist was probably John Taylor of Caroline (1753–1824), a leading Virginia planter whose agrarian treatise *Arator* was first published as a series of newspaper articles in 1803. Much of the book consists of Taylor's practical suggestions, based on his own analysis, observation, and experiments, for improving American agriculture (eight numbers alone are devoted to Taylor's thoughts on the topic of "manuring"), the condition of which he lamented ("Let us boldly face the fact. Our country is nearly ruined").

Taylor's defense of republican agrarianism rests on much the same ground as Jefferson's. Political independence, Taylor agrees with Jefferson, cannot be secured by "bankers and capitalists." But not only does he place more emphasis than does Jefferson on the role of agriculture as "the mother of wealth" as well as "the guardian of liberty," he goes further in articulating the personal benefits afforded by life on the land. Farming, he maintains, brings more pleasure than other modes of employment. It provides continual novelty and challenges to the mind. It meets the physical needs of the body. It promotes the virtue of liberality and rewards almost every other virtue. It is an aid in the quest for eternal life, for it feeds the hungry, clothes the naked, and gives drink to the thirsty. And because it is a vocation inevitably more concerned with practical affairs than abstract speculations, it is the "best architect of a complete man." Virtually every claim for the farming life to be made by agrarian thinkers in the following centuries is anticipated here.

As M. E. Bradford points out in his introduction to a 1977 reissue of *Arator*, Taylor, Jefferson, and their fellow Old Whigs, such as Edmund Ruffin (1794–1865), quite consciously saw themselves as retrieving the classical agrarian tradition represented by figures such as Hesiod (c. 600 B.C.E., in *Works and Days*), Marcus Porcius Cato (234–149 B.C.E., in *De Agri Cultura*), Marcus Terentius Varro (116–27 B.C.E., in *Re Rustica*), and Virgil (70–19 B.C.E., in *Georgics*). Such figures were, like the Old Whigs, concerned with the relationship between politics and farming, and they therefore also tended to celebrate the personal and civic virtues associated with farming—economic independence, willingness to engage in hard work, rural sturdiness, hatred of tyranny—that the Old Whig founders saw themselves as protecting through the American Revolution.

The celebration of the farmer's life in America at the time of the founding of the nation was not limited to southern Republicans. One must note, for instance, J. Hector St. John Crèvecoeur's *Letters from an American Farmer* (1782). But the approach of someone such as Crèvecoeur (or, in the nineteenth century, writers such as Donald Grant Mitchell [1822–1908]) is that of the pastoral—which is to say, the use of farming principally as a literary device or metaphor for the exploration of other themes. In Crèvecoeur's case, this would include the nature of Nature, with a capital and Rousseauean N. *Letters from an American Farmer* is thus a literary more than an agrarian classic, and philosophically Crèvecoeur is more nearly a forerunner of later environmentalists than he is of the agrarians, who typically display a more profound awareness than he of the imperfectability of the human and natural world.

Although republican agrarianism would continue to permeate American politics and literature for many years—and indeed, continues to find resonance in contemporary works such as Victor Davis Hanson's influential *The Other Greeks: The Family Farm and the Agrarian Roots of Western Civilization* (1995)—by the mid- to late-1800s defenses of agrarian ways had become entangled with populist politics and as such were less explicitly focused on the goods of the farming life per se than on the interests of farmers. But with the closing of the North American frontier at the end of the nineteenth century, and with the concomitant slow decline in the number of Americans living on farms (the U.S. farm population began to decrease as a proportion of the whole after 1917), a new generation of self-consciously agrarian thinkers began to emerge. These included the American economist Ralph Borsodi (1888–1977), the founder of the Country Life movement Liberty Hyde Bailey (1858–1954), and the Harvard sociologist Carle Zimmerman (1897–1983), all of whom—along with several others—are profiled in Allan Carlson's indispensable history, *The New Agrarian Mind: The Movement Toward Decentralist Thought in Twentieth-Century America* (2000).

As Carlson shows, this group heralds the advent of a new and distinct type of agrarianism. Although its proponents' political affiliations varied widely (some were radical progressives, some liberals, some conservatives, and at least one a self-described reactionary), they all shared a deep dissatisfaction with many aspects of modern economic, political, social, and religious structures. The urbanized, mass consumerism of industrial society had come into focus for them as a characteristic feature of modernity in a way that it could not have for the earlier republican agrarians. Some form of resistance to modernity, some alternative, was therefore needed.

The men and women associated with the so-called Southern Agrarians arguably constituted the most important group of antimodern agrarian thinkers. Their manifesto, *I'll Take My Stand,* was published in 1930. An oft-overlooked sequel, *Who Owns America?* (which also featured contributions from prominent English distributists like Hilaire Belloc [1870–1953] and Douglas Jerrold [1803–1857]), appeared six years later. The leaders of the Southern Agrarians—John Crowe Ransom (1888–1974), Donald Davidson (1893–1968), Allen Tate (1899–1979), and Andrew Nelson Lytle (1902–1995)—would continue to develop agrarian themes and arguments for some years, although Ransom bowed out of the struggle earlier than the others. While they shared the republican concerns of their southern forebears Jefferson and Taylor, they also charged modern industrialism with promoting irreligion, extinguishing great art and high culture, degrading the quality of human relations, and, not least, destroying the old rural, aristocratic southern culture they preferred to the industrial culture of the North.

The Southern Agrarians hoped to spark a "national agrarian movement," in Ransom's words. In this they failed spectacularly, but they did leave behind some successors, most notably the University of Chicago rhetoric professor Richard M. Weaver, the literary critic and American founding scholar M. E. Bradford, and the novelist, essayist, poet, and farmer Wendell Berry, unquestionably North America's leading contemporary agrarian writer.

Although Berry belongs to some extent to the Southern Agrarian tradition, his agrarianism has several other sources, as well. He represents the agrarianism associated with radical and progressive movements—the mid-century "Back to the Land" movement, the eco-agrarianism loosely associated with the postwar counterculture (Berry has been active, for instance, in antinuclear efforts), and the movement toward green or organic farming and against agribusiness and genetically modified foods. In Berry the common ground held by all of these sources of modern agrarian discontent becomes clear.

Agrarians, Science, and Technology

Agrarianism, in its republican version, was generally associated with a positive view of the ability of science and technology to aid agriculture in its effort to bring about a wealthier and more comfortable existence. "If this eulogy should succeed in awakening the attention of men of science to a skilful practice of agriculture," wrote Taylor of his *Arator*, "they will become models for individuals, and guardians for national happiness." Classical in inspiration, even the practical Taylor's republican agrarianism conformed to the rationalism of the Enlightenment.

Indeed, even the antimodern agrarianism of people such as Borsodi and Bailey, who were more concerned with the urbanization and centralization of modern life than they were with its secularization and the cultural ascendance and authority of science, represented a version of Enlightenment rationalism. But a few agrarians developed rather sophisticated and original critiques of scientific rationality and technological society. Most worthy of mention in this regard are Ransom, Tate, and Berry. For them, mass technological-industrial society was the consequence and analog of the scientific mode of thinking.

Some of Ransom's best work on this subject is included in his first two books, *God Without Thunder* (1930) and *The World's Body* (1938), in which he argued that reality does not inhere in the abstract, universal laws proposed by science as a way of "explaining" all phenomena, but rather in concrete, particular objects. These particular objects cannot be known as particulars via scientific reason, because science depends on the method of abstraction, which sees a particular only as an instance of a more universal category. A poetic or aesthetic approach, by contrast, does justice to the world by attempting to create a vision of the whole of reality with all its messy and mysterious particularity. In Ransom's historiography, the world had moved first from the perceptual (or premodern) "moment," thence to the "conceptual/scientific," and finally must now progress to the "aesthetic."

Tate makes a similar argument in "Remarks on the Southern Religion," first published in *I'll Take My Stand*. Where Ransom posits poetry or the aesthetic mind as conserving the "whole" object (or, in his vocabulary, "the world's body") for consideration, Tate posits a religious approach as the antithesis of abstraction. Modern science, writes Tate, reduces objects to those qualities they share with other objects of the same type, and to what they can do or how they work—"the American religion" to which the southern religion of his title is opposed. For Tate, an obsessively quantitative way of seeing the world had become characteristic of the modern Western mind.

Among agrarians, Berry has articulated the most radical critique of scientific rationality and technological progress. Like Ransom and Tate, he defends the validity of a particularist epistemology and maintains that only a limited portion of the truth of experience can be known by the reductionist methods of science. His ethical critique of modern society rests, like his epistemological critique, on the argument that mass technological industrialism collaborates with science to enshrine a view of human beings and the natural world that treats objects and people as essentially interchangeable. Such arguments can be found throughout Berry's corpus, but they are brought together most systematically in his *Life Is a Miracle: An Essay Against Modern Superstition* (2000), which attacks the scientism promoted by E. O. Wilson in *Consilience: The Unity of Knowledge* (1998). The skepticism displayed by Ransom, Tate, and Berry with regard to the truth claims of science has obvious resonances with postmodern thought while resisting temptations to indulge in relativism.

Agrarianism Outside America

It is difficult to generalize about the relationship between agrarianism and science and technology as that relationship has taken shape outside the North American context. Often, the so-called agrarian social movements of Latin America, Asia, and Eastern Europe have been allied with, or inspired by, anarchist or Marxist revolutionary ideologies (for example, most repulsively, Mao Zedong's Cultural Revolution and Pol Pot's Khmer Rouge). In the case of Marxist or neo-Marxist agrarians, their accompanying attitudes toward scientific rationality have hardly been similar to those of the antimodern agrarians.

Yet few non-American thinkers or activists commonly associated with agrarianism seem especially worthy of mention. Prince Pyotr Alekseyevich Kropotkin (1842–1921) was beloved by many on the American left in the late nineteenth and early twentieth centuries, including radical agrarian-oriented writers such as Dorothy Day (1897–1980), who saw Kropotkin and Leo Tolstoy as promoting essentially the same sociopolitical vision espoused by the English distributists. Both groups advocated the decentralization of economic power and associated agrarian ideals of one kind or other. But by and large these Russian and British thinkers did not share deeply in nor anticipate the kind of antimodern critiques of science and technology discussed above. Kropotkin was in fact a scientist, an accomplished geographer whose anarchism was at least in part the consequence of his scientific view that the natural, animal, and social worlds were not inevitably grounded in the law of competition, as the Darwinists (social and otherwise) taught, but cooperation and mutual aid. And neither G. K. Chesterton (1874–1936) nor Belloc, though certainly not philosophical "modernists," was as skeptical of the epistemological power of discursive rationality as were antimodern American agrarians such as Ransom or Berry. Frankly, the social philosophies of the English distributists and Russian anarchists were too broad and diffuse to be called properly "agrarian," although they certainly had agrarian components. The same could probably be said of Mohandas Gandhi (whose agrarian views were much inspired by Tolstoy).

In his specifically agricultural writings, there may be no one whom Berry cites more frequently than Sir Albert Howard, the English scientist whose *An Agricultural Testament* (1940), which was chiefly concerned with the rehabilitation of soil fertility, played an important role in creating the organic farming movement. The new agricultural science—and, hence, agriculture—promoted by Howard and those he influenced, including the American organic gardening/farming pioneer J. I. Rodale (1898–1971) and The Land Institute founder and director Wes Jackson, may possibly be considered as constituting yet another stream of agrarian thought.

But note that this tradition of agricultural thought does not concern itself so much with the larger philosophical question of how agrarian practices and culture contribute to the good life, as with attempting to deepen our understanding of what kind of farming techniques are truly sound, arguing on a scientific basis that, for instance, small, family-owned and -operated organic farms are more practical in the long run. There tends to be a confluence between it and antimodern agrarianism because it tends to reject the scientific specialization characteristic of the modern West, and especially its close relationship to industrialism. Although Berry, for one, has clearly been heavily influenced by this tradition, he is typically much more skeptical of the epistemological sufficiency of science and the social beneficence of technology than are the representatives of scientific agrarianism.

Conclusion

At the beginning of the twenty-first century, in North America and Europe at least, political radicals and progressives are most usually identified with resistance to the large-scale agriculture embodied by contemporary agribusiness and the technological triumph it symbolizes: think, for instance, of Theodor Shanin's work in peasant studies or José Bové, the southern French farmer and activist famous for his attacks on McDonald's and the globalization of the food market generally. However, the fact that Berry's work has registered appeal across the political spectrum indicates that concern for the fate of the independent farmer and the land of which he is the steward continues to draw on popular agrarian ideals. Thus, to the modern republican agrarian, agribusiness represents the application of commercial and industrial techniques to farming. And to the antimodern agrarian, genetic engineering represents a misplaced faith in the beneficence of technological experimentation. It seems likely that the intellectual future of agrarianism lies in the success with which it is able to put forth a political and ethical philosophy that grounds such arguments convincingly, a task all the more difficult in a profoundly non-agrarian culture.

JEREMY BEER

SEE ALSO *Agricultural Ethics; Jefferson, Thomas.*

BIBLIOGRAPHY

Berry, Wendell. (1977). *The Unsettling of America: Culture and Agriculture*. San Francisco: Sierra Club Books. Without question, the most important agrarian work to be published in America during the last half of the twentieth century.

Berry, Wendell. (2002). *The Art of the Commonplace: The Agrarian Essays of Wendell Berry*, ed. Norman Wirzba. Washington, DC: Counterpoint. A well-selected collection of Berry's most important essays on agricultural themes.

Carlson, Allan. (2000). *The New Agrarian Mind: The Movement Toward Decentralist Thought in Twentieth-Century America*. New Brunswick, NJ: Transaction. Essential volume includes profiles of largely forgotten antimodern agrarians such as Father Luigi Ligutti, Frank Owsley, Troy Cauley, and Herbert Agar.

Freyfogle, Eric T., ed. (2001). *The New Agrarianism: Land, Culture, and the Community of Life*. Washington, DC: Island Press. Fine collection of essays by contemporary agrarian writers, including Gene Logsdon, Scott Russell Sanders, and David Kline, made all the more valuable by Freyfogle's learned and informative introduction.

Malvasi, Mark G. (1997). *The Unregenerate South: The Agrarian Thought of John Crowe Ransom, Allen Tate, and Donald Davidson*. Baton Rouge: Louisiana State University Press. Best book-length explication of the ideas of these three most important Southern Agrarians.

Shi, David E. (1985). *The Simple Life: Plain Living and High Thinking in American Culture*. New York: Oxford University Press. Highly regarded intellectual history provides a broader context for the consideration of American agrarian thought.

Smith, Kimberly K. (2003). *Wendell Berry and the Agrarian Tradition: A Common Grace*. Lawrence: University Press of Kansas. Only monograph to date to explore Berry's social and political thought; contains an excellent sketch of the intertwined histories of environmentalism and agrarianism in America.

Taylor, John. (1977). *Arator: Being a Series of Agricultural Essays, Practical and Political: In Sixty-Four Numbers*, ed. M. E. Bradford. Indianapolis, IN: Liberty Fund. Taylor, more than Jefferson, is the representative republican agrarian of the post-revolutionary period.

Twelve Southerners. (1930). *I'll Take My Stand: The South and the Agrarian Tradition*. New York: Harper & Brothers. The antimodern agrarian touchstone, suffused with intelligence, still proves inspiring to agrarians and irritating to critics.

AGRICULTURAL ETHICS

Agriculture is among the earliest, most enduring, and most fundamental domains of technology. Although associated primarily with the cultivation of food crops such as wheat, maize, and rice, the term *agriculture* covers a wide variety of activities, including animal husbandry, dairy production, fiber production (for example cotton, flax), fruit and wine production, and aquaculture, as well as the harvesting, storage, processing, and distribution of food and fiber commodities. Agriculture frequently is understood to include all forms of food, fiber, and subsistence production, including forestry and fishing, especially with respect to the organization of scientific research institutes and government regulatory agencies. For example, government ministries such as the United States Department of Agriculture (USDA), the United Kingdom Ministry of Agriculture, Food and Fisheries (MAFF), and the United Nations Food and Agricultural Organization (FAO) have a responsibility for forestry and fisheries in their mandates. In all cases agriculture is both deeply involved with technology and science and subject to technical reflection.

Technology and Science in Agriculture

What is the relationship between agriculture and technology? That question reflects the way agriculture has faded into the cultural background in contemporary life, as if foods naturally appeared on supermarket shelves without technological intervention. It also reflects the way technology is associated strictly with machinery, manufacture, and engineering. Yet even in this narrow view agriculture has been influenced deeply by mechanization and chemical technology for 250 years.

It is more informative to see the crop varieties that farmers plant as technological artifacts, along with the systems they develop for cultivating soil, applying water, controlling weeds and other pests, harvesting, and storing and distributing agricultural products. In any broad interpretation of technology, agriculture is fundamentally a technological activity, and a technically sophisticated approach to the production, harvesting, and distribution of food is a hallmark of all civilizations.

Technical innovation in agricultural practice has been continuous throughout human history. The simple act of cultivating plants and domesticating animals, as distinct from scavenging, marks a fundamental technical advance. Prehistoric innovations in agricultural technology include achievements such as the domestication of animals, the construction of complex systems for irrigation and water management, and the development of tools for turning and maintaining the soil. Farmers also developed sophisticated techniques for maintaining desirable traits in their crops long before the underlying genetic basis of those methods was understood. Recent research (see Richards 1985, Brush 1992, Bellon and Brush 1994) on traditional farming systems has documented the sophistication farmers have applied in adapting cultivation methods and the genetic stock of their crops and animals to local conditions. Seeing traditional agricultural methods as "pretechnological" is unwarranted in light of this research. Indeed, the "agricultural revolution" equals and may exceed the industrial revolution with respect to its impact on environment and subsequent human history.

Traditional agricultural systems take a wide variety of forms. Improving or maintaining soil fertility, for example, has a number of possible technical solutions, including the composting and application of human, animal or vegetable wastes. Alternatively, pastoralists can develop symbiotic relationships with settled cultivators, who allow animals in their fields to graze (especially on stubble) and derive the benefit of the animals' manure in exchange. Swidden or "slash and burn" agriculture involves the use of fire to release nutrients from indigenous vegetation followed by cultivation at the site until fertility created by this technique has been exhausted. Other key technical elements involve water, soil loss, and genetic diversity. Much traditional agriculture is rain fed, but massive irrigation systems were developed in ancient Egypt and China. Construction of terraces provided an ancient solution to erosion. Genetic diversity was traditionally enhanced by farmer observation of unique types (or sports) and subsequent experimentation with small plots until new traits were understood and could be integrated into the main crop (see Wilken 1987).

Technical innovation in agriculture continued in the modern era and has been continuous with the development of modern science. The link between science and agricultural improvements was mentioned prominently by the philosopher Francis Bacon (1561–1626). The agriculturist Jethro Tull (1674–1741) published a scientific treatise on tillage in 1733. Thomas Jefferson (1743–1826) made improvements to the moldboard plow and advocated the inclusion of agriculture in university curricula. Cyrus McCormick (1809–1884) developed a mechanical reaper that is regarded as one the signature technologies of the nineteenth century. The German chemist Justus von Leibig (1803–1873) often is identified as the founder of modern agricultural science. Von Leibig pioneered the use of controlled experimental approaches in soil chemistry and crop improvement.

In the early twenty-first century, many traditional agricultural practices coexist with highly industrialized production methods. Commercial fertilizers and insecticides are synthetic, petroleum based products that were developed in junction with military technologies (Russell 2001). Modern crop varieties (discussed below) provide the genetic basis for large scale monocultures. In contrast to plants from traditional crop varieties, which may vary greatly in size, shape, color and response to climatic conditions, plants from modern varieties are uniform in size. They germinate, flower and produce grain or fruit at the same time. As such they are well suited to mechanical cultivation and harvesting, as well as to large-scale management and marketing practices. They also require intensive management of factors (such as water, nutrients, diseases and insect pests) that would be highly variable under traditional conditions. All these characteristics of industrial agriculture tie it closely to an extensive science and technological support system.

Agricultural science became institutionalized in industrialized countries in the late nineteenth century with the establishment of government stations dedicated to agricultural research. The system in the United States combined the federally based Agricultural Research Service with existing state-based land grant universities that were chartered in 1862 as institutions dedicated to agriculture and engineering. In addition to offering education in agronomy and animal husbandry, land grant universities conducted research on local soil, climate, and crop interactions. Their findings were made available to farmers through state-operated extension services whose agents conducted demonstrations of new crop varieties, machinery, and management systems. That system was responsible for a number of technical advances of regional importance in the first half of the twentieth century, including new methods for testing soil chemistry and recommendations for the efficient application of fertilizer.

The historian Charles Rosenberg's *No Other Gods* (1976) argues that the early success of agricultural research conducted and disseminated through this three-way partnership of experiment stations, universities, and extension was responsible for the rising status of science in the United States during the early twentieth century. The example of agricultural technology also encouraged Americans to support the provision of public funds for science and engineering. The U.S. system of partnership between agricultural universities, experiment stations, and local extension services to develop technology for the benefit of citizen farmers continues to serve as a model for publicly funded and publicly managed approaches to the development and dissemination of technology.

Main Problems in Agricultural Ethics

The potential range of ethical issues in agricultural technology is extraordinary. Those issues can be conceptualized in three categories: (1) issues relating to human health and security; (2) issues relating to the broader environment; and (3) issues relating to the cultural, historical, and social significance of agriculture as a way of life and a system of connected institutions. The first category includes the availability of basic foods, diet, nutrition, and questions concerning food safety. The second category includes the philosophical status of agricultural ecosystems and their relationship to nature, along with questions about the standing of animals and human obligations to them. The third category concerns the social organization of agriculture and has focused on questions associated with the industrialization of farming. These categories clearly overlap, and the three-way division should be understood as a heuristic device rather than a philosophical classification scheme with ontological or ethical significance.

Hunger and food security usually are thought of as particularly compelling cases of the ethics of distributive justice: What constitutes a fair, just, or morally acceptable pattern of access to wealth and resources? Key problems include the ethical basis for framing moral obligations relating to food access: Is there a basic human right to food, as the International Declaration of Human Rights (1948) alleges, or do utilitarian models of human welfare provide a better approach to understanding the ethics of hunger? How should moral entitlements to food security be operationalized now and in the future? This question ties the discussion of food security to broad issues in economic development and especially to the challenge of population growth.

Problems related to nutrition are closely interwoven with the development of scientific nutrition in animal science departments at the end of the nineteenth century. Methodological issues figure importantly in ethical discussions of appropriate nutritional advice. Other issues involving food system risk and safety are closely tied to science and technology in two ways. First, risks frequently are associated with agricultural technologies such as chemical pesticides, food irradiation, and biotechnology. Second, scientific risk analysis is central to the debate over the appropriate response to those risks. Risk optimization, informed consent, and the precautionary principle represent three philosophical approaches to the way in which risk analysis should be applied in determining the acceptability of food system risks.

Similar risk issues are associated with the environmental consequences of agricultural technology, and transgenic crops and animals have been important case studies for risks to nonhuman organisms and ecosystem integrity. With respect to environmental impact, ethical analysis draws on debates in environmental ethics about the moral standing of nonhuman animals, wild nature, and the structure of ecosystems as well as duties to future generations. Sustainability has been proposed as a way to frame the ecologically desirable features of any agricultural system, and disputes over the appropriate specifications for a sustainable agriculture have been a major focus in agricultural ethics.

In the United States and Canada discussion of the sociocultural aspects of agricultural production systems often has been framed in terms of "saving the family farm." In Europe the debate has been framed in regard to the need to preserve traditional agriculture, and internationally the issues have been framed in terms of the industrialization and intensification of farming methods that continue to rely on a great deal of human and animal labor. These questions can be looked at strictly in terms of environmental and human well-being, but the structure of agriculture and the centuries-long transition that has seen fewer and fewer people employed in agriculture highlights an important dimension of the sociocultural aspects of agriculture as well as a significant link to the philosophy of technology.

Ethical Issues in Agricultural Science and Technology

The influence of publicly organized research conducted at experiment stations in industrialized countries and the organized attempt to extend those results throughout the world provide the basis for viewing agricultural science and technology as an applied science with explicit value commitments. Those values derive from the importance of food and fiber in meeting human subsistence needs, the vulnerability of virtually all people to food-borne risk, and the dependence of the rural countryside on agriculture as its key industry and dominant cultural force.

Although farming practice sometimes has adopted the stance of maintaining traditions and social institutions, modern agricultural science more typically has been guided by the maxim of increasing yield: Make two plants grow where one grew before. Thus, the underlying ethic of agricultural technology has been one of increasing efficiency. This ethic is can be interpreted most readily as a fairly straightforward application of utilitarianism: Research and technology development should aim to produce "the greatest good for the greatest number," primarily by increasing the efficiency of agricultural production.

This general orientation to science and technology has been challenged by the view that agricultural science should serve the specific interests of farmers and that researchers should be mindful of this constraint. The development of high-yielding varieties of hybrid maize is a case in point. In the 1950s Paul Mangelsdorf (1899–1989) of Harvard and Donald Jones (1890–1963) of the Connecticut Agricultural Experiment Station discovered and patented cytoplasmic male sterility as a method for producing hybrid varieties. Many technical advances of the early twentieth century had been distributed to farmers free of charge through state extension services, but hybrid seeds had to be produced anew for each growing season. Jones was censured publicly by his colleagues for seeking to patent his discovery despite the fact that, or perhaps because, its chief value was to the commercial seed industry. Mangelsdorf's affiliation with a private university shielded him from his colleagues' censure. Contrary to medicine and engineering, in which publicly funded research has been commercialized routinely through the use of patents, publicly sponsored agricultural research has been seen by some as a public good for the express benefit of farmers (see MacKenzie 1991).

The economist Willard Cochrane (b. 1914) developed an analysis of efficiently increasing agricultural technology that extended the scope of this concern. In referring to "the technology treadmill," Cochrane showed that because the market for food is limited in size, more efficient production always will lead to a reduction in prices. Farmers who adopt technology quickly can earn profits before prices adjust, but as prices come down, they will have "run harder just to stay in place" (produce more to earn the same level of income they had at the higher commodity price). Cochrane's analysis suggests that agricultural research typically does not benefit farmers; instead, the benefit goes almost exclusively to consumers in the form of lower food prices. It also implies that there is an underlying economic necessity to the trend for fewer and ever larger farms (see Browne et. al. 1992).

The technology treadmill argument places the utilitarian argument for efficiency against the idea that agricultural scientists have special moral duties and loyalties to rural communities. One still might argue for yield-enhancing technological improvements on the grounds that they provide small but universally shared (and hence additively large) benefits to food consumers. Those benefits almost certainly will outweigh the losses in the form of farm bankruptcies and depopulation of the rural countryside. However, this argument undercuts the populist ethical rationale for agricultural research as benefiting rural communities and preserving the family farm.

Cochrane's interest was in American farmers, but the economic logic of the technology treadmill plays out in developing countries as well. Perhaps the most controversial application of agricultural science in the twentieth century was the Green Revolution, an initiative sponsored by the Rockefeller Foundation in the 1950s and 1960s to make high-yielding crops available in depressed regions of developing countries. The program was rationalized in part as a response of the capitalist world to the growing influence of Soviet bloc socialism after World War II.

As a technical program the Green Revolution was a mixed success, with early efforts at improved crops foundering over local resistance to new methods and aesthetic differences in taste and cooking quality. Over time, however, improved varieties won out in most parts of the world, especially in India. Green Revolution rice and wheat varieties lie at the basis of a decade of surplus in India's total food production and one of best-fed populations outside the industrial West.

However, these increases in food availability came at a price. The use of Green Revolution varieties led to more food at lower prices, but the farmers with the smallest farms could not survive on lower profit margins. Furthermore, Green Revolution varieties were developed to be used with fertilizers and sometimes chemical pesticides as well. Poor farmers could not afford to purchase those inputs, and their use also created environmental problems in rural areas. The growing scale of farming in the developed world put farmers on a path toward the use of technology for weed control and harvest, whereas in the past those tasks had been performed by very poor landless laborers. Although one could argue that in the end the benefits of the Green Revolution have outweighed the costs, those costs were borne primarily by the poorest people in developing societies. The Green Revolution thus ran directly counter to the "difference principle" of justice elaborated by the philosopher John Rawls (1921–2002), which holds that social policies are justified to the extent that they tend to improve the lives of the group that is worst off. Vandana Shiva (1993; 1997) has been particularly influential in criticizing the Green Revolution on grounds of environmental damage and social inequality.

The environmental critique of Green Revolution technology addresses the utilitarian orientation to agricultural research in a different way. In treating the decision to develop new technology as an optimization problem, the utilitarian approach has a tendency to ignore impacts that are difficult to quantify. Environmental impacts are often externalities that do not figure in the costs a producer considers when deciding whether to use a particular technology. Furthermore, there are often no markets or forums available for those who bear environmental costs most directly to register their complaints. This is the case for future generations, for example, but also for animals, which can be placed in intolerable conditions in modern confined animal feeding operations. Thus, to be truly justified as producing the greatest good for the greatest number, agricultural technologies must not be plagued with externalities, and those who develop, evaluate, and utilize such technologies face a philosophical challenge in reflecting externalities in their decision making.

Since 1985 many of these issues have been revisited and revised in connection with the use of recombinant DNA techniques for transforming the genetic basis of agricultural plants and animals. Disputes over the patenting and ownership of genetic resources and intellectual property have been an especially prominent feature of this debate.

History of Agricultural Ethics

In one sense agricultural ethics is among the oldest philosophical topics. Classical figures such as Xenophon (444–375 B.C.E.) and Aristotle (384–322 B.C.E.) wrote lengthy discussions of agriculture and its relationship to the values and social institutions of Greek society. There is little doubt that those classical authors saw agriculture as a systematic human adaptation and modification of the natural environment rather than a natural system lacking a significant technological component. Furthermore, they saw the material basis of their society as playing a significant role in both shaping the *ethos* of Greek life and shaping the opportunities and requirements for political institutions. Brief and less systematic discussions of agriculture occur throughout the history of philosophy, though those discussions frequently involve technological changes in agricultural production methods. A typical example is the philosopher John Locke's (1632–1704) rationale for the enclosure of common lands as a strategy for increasing agricultural production through intensive farming in the *Second Treatise of Government* (1689).

The Baron de Montesquieu (1689–1755) made agriculture a main theme of his *Spirit of the Laws* (1748), arguing that climate and agricultural methods form the basis for population patterns, social institutions, and national identity. The philosopher Georg Wilhelm Friedrich Hegel (1770–1831) also offered extensive discussions of agriculture as a clue to the manifestation of Spirit. Hegel's account of the Greek food system, for example, notes that it was marked by rocky hills and mountains alternating with lowlands suitable for crop farming. Hegel noted that unlike China or India, the Greek landscape lacks a major inland waterway conducive to large-scale irrigation projects or the transport of harvested grain. In the place of centrally managed systems for irrigating and moving foodstuffs the Greeks developed a complex farming system that included a mix of tree and vine crops and did not depend on large pools of human labor for planting and harvesting. Hegel argued that this system favors democracy and the development of individuals who can see themselves as authors of moral judgment. This work in the Greek and European traditions of philosophy anticipates contemporary debates over the character of rural areas and the preservation of the family farm.

Ethical debate over hunger and food availability was comparatively rare until the eighteenth century, when important studies appeared in the work of the economists François Quesnay (1694–1774) and Adam Smith (1723–1790). The topic of hunger was of central importance for Thomas Malthus (1766–1834) and was discussed by Jeremy Bentham (1748–1832) and John Stuart Mill (1806–1873), all of whom were occupied at one time by the problem of "surplus population" and reform of England's corn laws. Malthus argued that the race between agricultural improvement and population growth would make hunger a continuing ethical issue.

In the twentieth century philosophers such as Peter Singer, Peter Unger, Onora O'Neill, and Amartya Sen were among the many who wrote about the ethics of hunger, questioning the moral basis of the obligation to address hunger and examining the moral implications of various economic regimes in light of hunger. Other recent work has been contributed by scientists such as Garrett Hardin (1915–2003) and Norman Borlaug, who have extended the Malthusian tradition of stressing the tension between the technical capacity for food production and population growth. With the exception of Sen, twentieth-century philosophical work on hunger seldom was attentive to science and technology.

Although philosophers writing before 1900 did not organize their work in terms of scientific or technological ethics, there is little doubt that they understood agriculture as a form of technology and were interested in the normative problems and implications of agricultural practice. For the most part the agricultural writings of past philosophers have been neglected. Singer's seminal article on world hunger in 1972 has virtually no discussion of agriculture and typically is not read as an exercise in either scientific or technological ethics. Recent work on hunger, as well as even more recent studies of agricultural biotechnology, makes virtually no reference to the philosophical-agricultural writings of the past. There is thus a large hiatus in the philosophical history of agricultural ethics as it relates to technology.

A few agricultural specialists contributed ethical studies on agriculture during the period from roughly 1900 to 1975. Liberty Hyde Bailey (1858–1954) was a leading American agricultural scientist who was known especially for his contributions to plant taxonomy. He chaired the Country Life Commission under President Theodore Roosevelt and was the main author of its report, which was an argument for egalitarian improvement of rural America through technological advance and social reform. Sir Albert Howard (1873–1947) was an English agronomist who conducted research on soil fertility. His books *An Agricultural Testament* (1940) and *Soil and Health* (1956) anticipated many contemporary ethical critiques of industrial agriculture and served as an inspiration for figures such as J. I. Robert Rodale, founder of the Rodale Press, and Wes Jackson, founder of the Land Institute. The anthropologist Walter Goldschmidt conducted a critical study of the social consequences associated with large-scale farming in California for the USDA in 1947, but many of his results were suppressed until they were published under the title *As You Sow: The Social Consequences of Agribusiness* in 1978. Rachel Carson (1907–1964) was the author of *Silent Spring* (1962), a polemical critique of agricultural pesticides that sometimes is credited with creating a popular environmental movement in the United States. The turn toward concern about the social and environmental effects of industrial agriculture paved the way for a rebirth of philosophical attention to agriculture as a form of technology in the last quarter of the twentieth century.

Aside from work by philosophers such as Singer, Unger, and O'Neill, who did not think of themselves as working in agricultural ethics, philosophical studies in agricultural ethics began anew around 1975 when Glenn L. Johnson (1918–2003), an agricultural economist, produced a series of articles on positivist influences in the agricultural sciences and called for renewed attention to normative issues. Agricultural issues came to the attention of philosophers largely through the work of Wendell Berry, a poet and novelist whose *The Unsettling of America* (1977) offered an extended philosophical critique of industrial agriculture, land grant universities, and modern agricultural science while putting forth an impassioned defense of the family farm. For a decade Johnson was known only to specialists in the agricultural science establishment, whereas Berry was regarded there as a meddling outsider with little credibility.

Johnson's call for normative reflection in the agricultural sciences was answered by Lawrence Busch, William Lacy, and Frederick Buttel, three sociologists who separately and in collaboration published many studies on the political economy of agricultural science during the last quarter of the twentieth century and also called for a philosophical and ethical critique of agricultural science and technology. They mentored a generation of sociologists who have examined normative issues, including Carolyn Sachs, who produced one of the first feminist studies of agriculture, and Jack Kloppenburg, Jr., author of *First the Seed* (1989), a normative history of plant breeding. Busch and Lacy brought the philosopher Jeffrey Burkhardt into their research group at the University of Kentucky in 1980. Paul B. Thompson was the first philosopher with an appointment in an agricultural research institution at Texas A&M in 1982. Thompson as well as a group at California Polytechnic University, including the philosopher Stanislaus Dunden, the agronomist Thomas Ruehr, and the economist Alan Rosenfeld, began to offer regular coursework in agricultural ethics in the early 1980s.

Institutional growth of agricultural ethics was stimulated by the W.K. Kellogg Foundation, which made many grants in that field in the 1980s and supported Richard Haynes in founding the journal *Agriculture and Human Values* and forming the Agriculture, Food and Human Values Society in 1988. In the 1990s Gary Comstock conducted a series of workshops on agricultural ethics at Iowa State University that brought the field to a larger audience. European interest in agricultural ethics lagged by about ten years. Led by Ben Mepham the agricultural research group at the University of Nottingham sponsored a seminal meeting on agricultural ethics in 1992. The European Society for Agricultural and Food Ethics was founded in 1998, and *The Journal of Agricultural and Environmental Ethics* became its official outlet in 2000. The first indication of interest in agricultural ethics beyond the West occurred with the launch of a series of papers on ethics at the FAO in 2000. Virtually all this work is focused closely on the ethical and policy implications of technological innovation and science-based decision making. The public debate over agricultural biotechnology has stimulated even more widespread interest in agricultural technology, and many individuals are conducting ongoing research.

PAUL B. THOMPSON

SEE ALSO *Agrarianism; Animal Rights; Animal Welfare; DDT; Deforestation and Desertification; Food Science and Technology; Genetically Modified Foods; Green Revolution; Environmental Ethics.*

BIBLIOGRAPHY

Bailey, Liberty Hyde. (1911). *Report of the Commission on Country Life*. With an introduction by Theodore Roosevelt. New York: Sturgis and Walton Co.

Bellon Mauricio R., and Stephen B. Brush. (1994). "Keepers of Maize in Chiapas, Mexico." *Economic Botany* 48(2): 196–209.

Berry, Wendell. (1977). *The Unsettling of America: Culture and Agriculture*. San Francisco: Sierra Club Books.

Browne, William; Jerry Skees; Louis Swanson; Paul Thompson; and Laurian Unneveher. (1992). *Sacred Cows and Hot Potatoes: Agrarian Myths and Policy Realities*. Boulder, CO: Westview Press.

Brush, Stephen B. (1992). "Ethnoecology, Biodiversity, and Modernization in Andean Potato Agriculture." *Journal of Ethnobiology* 12(2): 161–185.

Busch, Lawrence, and William B. Lacy. (1983). *Science, Agriculture, and the Politics of Research*. Boulder, CO: Westview Press.

Carson, Rachel. (1962). *Silent Spring*. Boston: Houghton, Mifflin.

Goldschmidt, Walter. (1978). *As You Sow: Three Studies in the Social Consequences of Agribusiness*. Montclair, NJ: Allenheld, Osmun.

Howard, Sir Albert. (1940). *An Agricultural Testament*. New York: Oxford University Press.

Howard, Sir Albert. (1956). *The Soil and Health: Farming and Gardening for Health or Disease*. New York: Devin-Adair.

Johnson, Glenn L. (1976). "Philosophic Foundations: Problems, Knowledge and Solutions." *European Review of Agricultural Economics* (July): 1–10.

Kloppenburg, Jack Ralph, Jr. (1988). *First the Seed: The Political Economy of Plant Biotechnology, 1492–2000*. New York: Cambridge University Press.

MacKenzie, David. (1991). "Agro-Ethics and Agricultural Research." In *Beyond the Large Farm: Ethics and Research Goals for Agriculture*, ed. Paul B. Thompson and Bill A. Stout. Boulder, CO: Westview Press.

Mepham, Ben., ed. (1996). *Food Ethics*. New York: Routledge.

O'Neill, Onora. (1986). *Faces of Hunger: An Essay on Poverty, Justice and Development*. London: Allen & Unwin.

Richards, Paul. (1985). *Indigenous Agricultural Revolution: Ecology and Food Production in West Africa*. Boulder, CO: Westview Press.

Rosenberg, Charles E. (1976). *No Other Gods: On Science and American Social Thought*. Baltimore: Johns Hopkins University Press.

Russell, Edmund. (2001). *War and Nature: Fighting Humans and Insects from World War I to Silent Spring*. New York: Cambridge University Press.

Sen, Amartya. (1988). *Poverty and Famine: An Essay on Entitlement and Deprivation*. Oxford: Oxford University Press.

Sen, Amartya. (1999). *Development as Freedom*. New York: Knopf.

Shiva, Vandana. (1993). *Monocultures of the Mind: Perspectives on Biodiversity and Biotechnology*. London: Zed Books.

Shiva, Vandana. (1997). *Biopiracy: The Plunder of Nature and Knowledge*. Boston: South End Press.

Singer, Peter. (1972). "Famine, Affluence and Morality." *Philosophy and Public Affairs* 1(Spring): 229–243.

Thompson, Paul B. (1995). *The Spirit of the Soil: Agriculture and Environmental Ethics*. New York: Routledge.

Unger, Peter. (1996). *Living High and Letting Die: Our Illusion of Innocence*. New York: Oxford University Press.

Wilken, Gene C. (1987). *Good Farmers : Traditional Agricultural Resource Management in Mexico and Central America*. Berkeley: University of California Press.

AIR

Air (and its variant spellings *eir*, *eyr*, *aier*, *ayre*, *eyir*, *eire*, *eyer*, *ayer*, *aire*, *ayere*, and *ayr*) all stem from the Latin *aer*. It is the most transparent but immediately necessary of all the classical Greek elements. It surrounds the Earth as atmosphere and was considered a mediating element, somewhere between fire and water, both warm and moist, the driving force behind the birth of the cosmos. As a spiritual element it pushed along the soul—the Greek work for spirit, *pneuma*, also means breath—and spread messages and ideas across the world in its guise as wind. In the early twenty first century, as gas, air represents one of the fundamental states of matter (the others being solid and liquid), while its pollution by technological activities constitutes a fundamental ethical challenge.

Air in Science

Air figures prominently in both physics and chemistry, and as atmosphere is subject to its own special science. Indeed among the achievements of early modern natural science was the distinction between air and atmosphere. In 1644 Evangelista Torricelli, a student of Galileo Galilei, invented the barometer and thereby discovered the phenomenon of atmospheric pressure. Later in the century it was shown that air/atmosphere is a mechanical mixture of at least two gases, and in the period from 1773 to 1774, Carl Wilhelm Scheele and Joseph Priestly are credited with identifying oxygen as one such element.

In 1784 Henry Cavendish published the first accurate information about the composition of naturally occurring air in the atmosphere, which is approximately 78 percent nitrogen and 21 percent oxygen. The remaining 1 percent is mostly argon (.9%) and carbon dioxide (.03%), with even smaller trace amounts of hydrogen, water, ozone, neon, helium, krypton, and xenon. Atmospheric air extends to approximately 350 miles above the Earth, is divided into a number of different layers (from the troposphere to the stratosphere and beyond), and undergoes tidal motions like the oceans. The study of those motions and other atmospheric phenomena, especially the weather, is known as meteorology. Of increasing importance as well is atmospheric chemistry and the study of air pollution.

Technologies of the Air

Even before the advent of humans the air served as a medium of communication for animals, a possibility that has been progressively developed by humans through speech and music. From early periods of human history the motion of air in the form of wind was been harnessed to power ships for transportation. During the late Middle Ages wind became a source of mechanical motion in windmills. And in the late-eighteenth and early-twentieth centuries it became a medium of transportation with the invention of balloons and the airplane, which has led to the science of aerodynamics and the technology of aeronautical engineering.

Air in the from of wind has also been a design problem, especially in the construction of tall buildings.

Since the late-twentieth century wind has again been exploited as a source for the creation of electrical power. From the earliest periods of human history, the heating of air has been a major technological issue, and as such air is closely associated with fire. With the advent of the Industrial Revolution the circulation and eventually the cooling of air became further technological design issues.

Toward an Ethics of the Air

The human ability to inhabit the world in a fashion that is sensitive toward the environment is reflected in the air people breathe. Throughout the course of the day each person consumes between 3,000 and 5,000 liters of air. But especially in the industrialized world, the air is full of notoriously harmful pollutants such as benzene, toluene, and xylenes, which are found in gasoline; perchlorethylene, which is used by the dry cleaning industry; and methylene chloride, which is used as a solvent by a number of industries. Examples of air toxics typically associated with particulate matter include heavy metals such as cadmium, mercury, chromium, and lead compounds; and semivolatile organic compounds such as polycyclic aromatic hydrocarbons (PAHs), which are generally emitted from the combustion of wastes and fossil fuels.

The latter (aromatic hydrocarbons) have to do with the formation of ground-level ozone. This is different from the stratospheric ozone that protects the Earth from ultraviolet radiation. Ozone is the same molecule regardless of where it is found, but its significance varies. Ozone (the name is derived from a Greek word meaning to smell) is a highly reactive, unstable molecule formed by reacting with nitrogen oxides from burning automobile fuel and other petroleum-based products in the presence of sunlight. It is also produced during lightning storms, which is why the air has that peculiar electrical odor during a storm. This type of ozone, however, is very short lasting and does not represent a significant risk to health. The real problem stems from certain volatile organic compounds such as those produced by the shellac of furniture finishing plants, cleaning solvents used by dry cleaners and computer manufacturers, and terpenes from trees; these atmospheric chemicals linger in the air and prevent the break up of the ozone molecule back into oxygen.

High concentrations of ground-level ozone may cause inflammation and irritation of the respiratory tract, particularly during heavy physical activity. The resulting symptoms may include coughing, throat irritation, and breathing difficulty. It can damage lung tissue, aggravate respiratory disease, and cause people to be more susceptible to respiratory infection. Children and senior citizens are particularly vulnerable. Inhaling ozone can affect lung function and worsen asthma attacks. Ozone also increases the susceptibility of the lungs to infections, allergies, and other air pollutants.

The greatest ethical issues concerning air involve the collective reluctance of humankind to take responsibility for the negative effects its way of life has upon the air, this essential element that has been recognized and harnessed for thousands of human years. Since the 1800s industry has been slow to admit that its technologies have seriously compromised the health of the air. In 1948 a *killer fog* caused the death of twenty and sickened 6,000 residents of the industrial town of Donora, Pennsylvania. For years local steel and zinc plants refused to admit that their effluents could have had anything to do with this *Act of God*. Thousands more died over the following decade. Even in the early twenty-first century industries tend to avoid taking responsibility for air pollution fatalities and illnesses caused by their routine operations.

This tendency to shirk responsibility extends to human obligations regarding the atmosphere as a whole, especially where the United States is concerned. Global climate change is one of the greatest harmful consequences of human industrial activity on Earth, and can only be controlled by managing air pollution.

DAVID ROTHENBERG

SEE ALSO *Earth; Environmental Rights; Fire; Water.*

BIBLIOGRAPHY

Abram, David. (1996). *The Spell of the Sensuous: Perception and Language in a More-Than-Human World.* New York: Vintage. Chapter 7 presents a phenomenological description of "The Forgetting and Remembering of the Air."

Davis, Devra. (2002). *When Smoke Ran Like Water: Tales of Environmental Deception and the Battle Against Pollution.* New York: Basic Books.

Olson, John. (2003). "Inebriate of Air." In *Writing on Air,* ed. David Rothenberg and Wandee J. Pryor. Cambridge, MA: MIT Press.

AIRPLANES

December 17, 2003, marked the 100th anniversary of the first heavier-than-air flight, or as pilot Orville Wright put it, "the first in the history of the world in which a machine carrying a man had raised itself by its own power into the air in full flight, had sailed forward without reduction of speed, and had finally landed at a point as high as that from which it started" (Anderson 1985, p. 2). Although their absolute priority has been contested—many were on the verge of heavier-than-air flight in the early 1900s—with their invention Orville and Wilbur Wright clearly helped change the world. Yet just as there are benefits of this technology, there are negative consequences. This article defines the airplane, examines historical developments, and introduces some of the ethical, political, and legal issues surrounding its future.

Definition and Developments, Military and Civilian

An airplane (or aircraft) is defined as a heavier-than-air machine that produces an upward thrust (lift) by passing air over its fixed wings and is powered by propellers or jet propulsion (thrust). As with any new technology, inventors immediately wanted to improve on the original design of the Wright Brothers and to develop versions of the airplane that would go higher, faster, and farther. During World War I, military planners used the airplane for war, first as reconnaissance platforms, but soon after as weapons. The two decades after the war saw the airplane become a more efficient military machine, as well as a commercial passenger carrier.

Charles Lindbergh, on May 20–21, 1927, captured public imagination by being the first person to fly alone non-stop across the Atlantic Ocean. Soon passenger airplanes were regularly making this transatlantic trip. World War II saw the golden age of piston airplanes. One of the most famous aircraft of the era, the Supermarine Spitfire, had a distinctive elliptical wing design and a remarkable maneuverability, which defended England during the Battle of Britain. Other fighter airplanes, such as the North American P-51 Mustang, designed and built in 140 days, were the technological pinnacles of the aircraft industry with speeds that topped 450 miles per hour.

Bomber airplanes showed it was possible to carry large payloads for long distances. These technological achievements directly led to the post-war development of commercial aviation. In the early 1950s, commercial piston-engine airplanes, such as the Lockheed Constellation, made travel by air practical and affordable for many people in developed countries.

One of the most significant advances in airplane technology occurred during World War II: the beginning of the jet age. Jet power greatly improved speed, by more than one hundred miles per hour. In 1952, the

The DeHavilland Comet. In 1952, it became the world's first jet-powered aircraft. *(© Bettmann/Corbis.)*

British DeHavilland Comet became the first jet powered commercial airliner but two fatal Comet crashes caused the public and commercial airlines to loose confidence in jet travel. Yet scarcely three years later, with the introduction of the Boeing 707 and the Douglas DC-8, commercial passenger jet service quickly revived. Since then a wide variety of commercial airplanes has satisfied the need to travel.

Military airplanes also improved after World War II and on October 14, 1947, Capt. Charles Yeager flew the Bell X-1 faster than the speed of sound. The quest for improved performance airplanes that flew higher, faster, and farther would continue into space flight.

One of the more unique commercial aircraft was the Concorde, which was developed by a French-British consortium and flew from 1976 until 2003. It could carry approximately 128 passengers at more than twice the speed of sound. Funding for development of a similar supersonic transport (SST) was rejected by the U.S. Senate in 1973 because of concern for environmental damages from noise and stratospheric pollution. The SST was also very expensive and available only to the wealthy.

In the early twenty-first century, costs of manufacture, design, and operation, more than performance, influence many new designs, both civilian and military. It takes approximately five years to design and build an airplane from conception to rollout. Building a new gas turbine propulsion system takes longer, approximately ten years. As an example of current technology, a Boeing 747 cost approximately $160,000,000 in 2003 and

A British Airways Concorde taking off from London's Heathrow Airport. The Concorde was in use from 1976 to 2003 and flew at more than twice the speed of sound. *(© Kieran Doherty/Reuters/Corbis.)*

burned roughly 7,500 gallons of fuel on a typical 1,500 mile flight. Newer designs pose distinct commercial and technological risks.

From Propulsion to Application

Airplanes are often classified not only by their propulsion systems—propellers or jets—but also by application. Military airplanes can be classified by function: fighter, bomber, and reconnaissance; while civilian airplanes fall into two general categories: private and commercial. Private airplanes range from piston engine airplanes used for pleasure flying to private business jets carrying four to six passengers.

The future of commercial aircraft faces several issues highly influenced by technology. Cost often decides which technology will be incorporated into new or existing airplanes. In 2001, Airbus Industries announced a radical new design, the Airbus 380, expected to carry 550 passengers. To achieve this, the airplane features a twin-deck passenger compartment. More passengers should result in lower operating costs for the airlines and lower fares for customers.

The same questions that faced the Boeing 747 in 1968 must again be asked: Should an airplane carrying so many passengers be built? The A380 is technologically feasible, but is it safe? What if the A380 crashes? Is the public willing to accept loss of life on this scale? The collision of two Boeing 747s on the runway in Santa Cruz de Tenerife, Canary Islands, on March 27, 1977, resulted in 582 deaths, and is just one example of the large loss of life possible. Safety is a crucial issue in airplane design, but finances often influence decisions. As long as airlines see the need for these large airplanes to lower costs, they will be built.

Another controversial question is whether pilots or a computer should have the ultimate control authority over a commercial jetliner as the plane approaches its design limits in an emergency. The fly-by-wire flight control system of the Airbus A380 does not allow the pilot to override the computer, whereas a similar system on the Boeing 747 does allow for aviator override. Some forms of this technology provide "cues" that tell the pilot when the plane is approaching certain speed, load or attitude limits but allow the pilot to exceed these limits. For example, much more force is needed to pull back on the control column as an aircraft reaches its stall speed.

Economics, Safety, and the Environment

The need for new commercial airplanes is also the result of problems associated with an aging commercial airplane fleet. Fatigue and corrosion take their toll. Costs associated with replacement overshadow the timetable to replace these aircraft. Should old airplanes be repaired or new ones purchased? It often depends on the financial stability of an airline. New techniques need to be developed to detect structural problems before they become life-threatening. Development costs money. Should the government be responsible for such development? Are the airlines financially able to develop techniques and ethically equipped to enforce standards without government supervision?

On January 31, 2000, an MD-83 plunged into the Pacific Ocean, killing all eighty-eight people on board. Accident investigations pointed to substandard maintenance procedures causing the horizontal stabilizer to jam. Subsequent inspections of similar airplanes found twenty-three more with the same problems. Operators must make safety inspections regardless of cost. They are ethically bound to accomplish the proper repairs. The public deserves no less, but there are always temptations to cut corners and reduce cost.

The quest for more economical airplanes has driven the airplane industry to reduce airplane weight. Reducing weight improves fuel efficiency. To achieve this reduction, the industry is using materials such as composites, with which the military has some experience that is migrating to the civilian aircraft industry. But the crash of an Airbus 300 airliner on November 12, 2001, in a residential section of Queens, New York, has been blamed in part on the failure of composite material in the vertical tail. When is a technology sufficiently mature and when should it be applied in commercial airplanes? Often the answer is left to a private company or government regulatory agency that may not fully understand the technology. Airplane manufacturers and their suppliers also have an ethical obligation to ensure quality parts. Oversight and enforcement are difficult but necessary.

The future of large, commercial airplanes clearly shows two companies dominant: Boeing from the United States and Airbus Industries from Europe. Boeing traditionally had the majority of commercial passenger airplane sales in the world, but in 2003, Airbus superseded Boeing in the number of airplanes sold. Some believe the shift is due to a subsidy of Airbus by its parent countries. Boeing, not having direct subsidies, has protested that Airbus is able to undercut prices to attract business. At the same time, Boeing is directly supported by U.S. military contracts in ways Airbus is not.

Airplanes have been blamed for a number of environmental problems. The first is noise. Technological improvements have satisfied noise restrictions imposed by regulatory agencies. Compliance is mandatory, and older airplanes are either refitted with newer, quieter engines or "hush kits" are retrofitted to older engines. Engine emissions are also thought to impact the ozone layer and contribute to global climate change. Particulate emissions, such as carbon, can cause residues. While it might be possible to reduce the problems of pollution, it is often not economically feasible to fix older airplanes. The possibility of different propulsion systems, such as nuclear power, could solve some environmental problems, but would create others. Nuclear powered airplanes flying over populated areas would certainly cause public alarm.

Military Applications and New Civilian Options

Airplanes will continue to be used in military applications. The development of military airplanes and engines generally supports technological progress, which then finds commercial application. Fuel efficiencies and performance standards of contemporary commercial engines are a direct result of this technology transfer.

Other military technologies are maturing rapidly. Stealth technologies have given the United States an advantage in air warfare. In the Iraq conflicts (1992 and 2003), stealth airplanes were able to destroy command and control networks and anti-aircraft batteries prior to ground conflict. However, drug runners and other undesirable individuals could also use stealth to evade capture.

In 2003 another new airplane technology for the military was the remotely piloted Unmanned Aerial Vehicle (UAV). The military has successfully used these airplanes, such as the Predator or Global Hawk, to gather information and even launch attacks. The technology is reliable and may lead to UAV operation in U.S. airspace along with other airplanes. Automatic collision avoidance on UAVs and other airplanes would undoubtedly be part of such a development.

Is the public ready for the next step: Unpiloted Aerial Commercial Vehicles? It is possible to operate airplanes without pilots, because most of the systems on commercial airplanes are already fully automated. To eliminate the pilots would save the cost of their large salaries. Will the technology cost more?

Precedents for replacing crewmembers with technology already exist. Airplane manufacturers designed and built airplanes with advanced cockpits for two crewmembers in the 1980s. The traditional third crewmember, the flight engineer, was eliminated by improvements in system automation. This increased the workload for the two-person crew but the workload proved manageable. Perhaps the next step is a single pilot crew. However, what if this one pilot fell ill or died in flight? A totally automated system is feasible, but would face some acceptance issues.

Terrorism

Another aspect of aviation safety concerns terrorism. In the aftermath of September 11, 2001, efforts have been made to enhance the security of the commercial air travel system, including airplanes, against terrorism. Cockpit door reinforcements have been the most visible and immediate development, but some see this modification as ineffective. Allowing pilots to carry weapons is controversial. What else can be done to protect against terrorism?

One technology being discussed is the addition of infrared countermeasures to deter possible ground launched missiles. Israel's El Al airline has flare detection equipment installed on its aircraft but no active countermeasures. The estimated cost to equip the U.S. commercial aircraft fleet with countermeasures is $10 billion (Israel High Tech and Investment Report 2003). In 2003, the Bush administration committed $100 million to the first phase development of such a system in the United States. Another serious weakness is the absence of commercial cargo inspection on passenger airplanes. Clearly, more needs to be done, but economics will strongly influence the outcome.

Airplanes have proved indispensable to the contemporary world in ways the original inventors could not have predicted. Nor could they have predicted some of the negative consequences. Increased air travel has revolutionized how people think about the world and been a major contributor to globalization, which has created problems for both cultures and the environment. Safety, through responsible design, must be the main emphasis in the aviation industry, from the design and construction of new airplanes by the industry to the operation of the airplanes by the airlines. Professional engineers, as part of their ethical responsibility, must make sure that designs are safe. Industry also has a responsibility to the public to provide a quality product and to use that product responsibly. Trusting aircraft and aircraft related industries to accomplish this task without supervision would be naïve, but government regulation alone will not insure the desired outcome. Public awareness of and action on these issues may yet prove to be the most important factor in deciding the future of aviation.

KENNETH W. VAN TREUREN

SEE ALSO *Aviation Regulatory Agencies; DC-10 Case; Military Ethics.*

BIBLIOGRAPHY

Anderson, John. (2002). *Introduction to Flight,* 4th edition. New York: McGraw-Hill.

INTERNET RESOURCE

Israel High Tech and Investment Report. (2003). "Is $10 Billion for Protection Worth It?" From the October issue. Available from http://www.ishitech.co.il/1003ar2.htm.

ALIENATION

The word *alienation* has a checkered history. Drawn originally from the vocabulary of the law, the word later appeared in connection with the treatment of persons who were, as ordinary people say, "not themselves." In the eighteenth and nineteenth centuries, property given away or sold was said to have been "alienated." This usage survives in the expression "inalienable rights"—rights that cannot be taken away, given away, or traded. The physician who treated the mentally ill was formerly called an "alienist." In contemporary usage, one speaks of being alienated from a former friend for whom one's affection has cooled or from a group in which one feels no longer comfortable. Alienation, in everyday English, refers to a specific loosening of ties to another person or a sense of estrangement from a group.

Philosophies of Alienation

In philosophy, by contrast, the word alienation has been used in a different sense to refer to estrangement from *oneself,* a profound disturbance within persons, their selves, and their lives. There is conflict or disconnection at the very heart of the alienated person's existence. Alienated lives do not form an intelligible whole; the alienated cannot tell a coherent story about their lives. Their lives lack meaning.

Philosophers have always said that human lives are more than a series of unconnected episodes, that they should form an intelligible whole. Hence people might ask whether human life as a whole, and especially their own, makes sense and whether it is a good life that serves a purpose and is meaningful. At the beginning of Plato's *Republic,* Socrates raises those questions in conversation with an old man nearing the end of his life. Plato's answer is that a good life is a just one. A just life, he also thinks, can be lived only in a just society, and thus the conversation about one's life, seen as a whole, leads to a long investigation into the just society. Aristotle gives a different answer to the question: A good life is dedicated to acquiring a set of moral virtues such as courage, temperance (self-discipline), and wisdom.

Beginning in the eighteenth century, new answers surfaced about what makes a life good. What matters in human life, according to the French philosopher Jean-Jacques Rousseau (1712–1778), is not only its moral character, but whether a person manages to be an individual rather than a conformist—dominated by the beliefs, values, and practices of everyone else. Most persons, Rousseau complained, craved acceptance by their fellows and were willing, for the sake of this, to sacrifice any independent identity.

Since Rousseau, philosophic views of the good life have become divided. Many Continental European philosophers have demanded that human lives be not only morally good but also coherent and meaningful. The majority of Anglo-American philosophers, by contrast, have continued to think only about the moral rectitude of human lives, ignoring the question of alienation. The utilitarians, beginning with the Englishmen Jeremy Bentham (1748–1832) and John Stuart Mill (1806–1873), explicitly reject the possibility of alienation. They insist that a life is a good one if it contains more pleasant episodes than unpleasant ones; the connection between these different episodes is of no interest. Thus there are disagreements among philosophers—rarely articulated and more rarely debated—about the importance of the concept of alienation.

But many thinkers have taken the idea of alienation very seriously (even though not all used the word alienation to name the condition). Georg Wilhelm Friedrich Hegel (1770–1831), in *The Phenomenology of*

Spirit, described some forms that alienation takes in human lives. The alienated suffer from inner conflict and self-hatred. As a consequence, they are unhappy.

The Danish philosopher Søren Kierkegaard (1813–1855) agrees with Hegel on the self-hatred of the alienated and develops the idea further. Alienated lives are not disorganized by accident or because persons do not try to unify their lives, but because at the heart of alienation lies the unwillingness to be oneself. It is difficult for the alienated to accept themselves for who they are; it is more pleasant for one who is alienated to escape into fantasy and imagine oneself different: richer, more powerful, more intelligent, or more beautiful than one is. It is also difficult to accept responsibility for one's life. Alienation, Kierkegaard believes, cannot be overcome, but can be mitigated if one is fully in one's life by dedicating oneself to a single project in such a way that every part of one's everyday existence is affected by it. Kierkegaard also believed that this needed to be a Christian project—to live so as to manifest God's presence in even the smallest details of one's life, such as taking a walk in the park and thinking about what there will be for Sunday dinner.

The German philosopher and social critic Karl Marx (1818–1883) focused on alienation in a different aspect of life—namely at work. For Marx, working for wages was inevitably alienating. Wageworkers under the command of employers have no control over their work or even whether there is work for them at all. Employers are—for the majority of wage earners—able to hire and fire them at will. It is impossible to have a meaningful life if such a large part of it is under the control of another whose goals are at odds with one's own. The employer's goal is to make as much money as possible; workers want to earn as much as they can. But they also want their work to be clean, pleasant, and interesting. Employers care nothing about this as long as the money keeps rolling in. Spending a significant portion of one's life pursuing goals that are not one's own, alienates. It makes it impossible to be one's own person—one who pursues goals of one's own choosing.

The German philosopher Friedrich Nietzsche (1844–1900) elaborates on the theme of conformism in his discussion of the "last man." Such persons want above all to be comfortable; they eschew all effort and anything that is even faintly unpleasant. Hence it is important for them to get along. In order not to stir up controversy by disagreeing with others, they have no ideas of their own. They do not think for themselves. There is nothing they believe in fervently and nothing they are willing to stand up and fight for. They want life to be easy and pleasant. Avoiding all challenges is the only challenge that remains. Although Nietzsche did not use the term, his "last man" is clearly suffering from alienation.

Writing after World War I, the Hungarian philosopher György Lukács (1885–1971) returned to Marx and elaborated on the claim that alienation is intimately connected with capitalism. Persons who sell their ability to work in the labor market treat themselves or at least important aspects of their persons as commodities—things meant to be exchanged for money. The skills and talents of persons thus become commodities that can be bought and sold—"alienated" in the old, legal sense. One's person and how it develops is no longer one's proper project, but is governed by the impersonal forces of the labor market. People are not able to study what most interests them because expertise in Egyptology, for example, does not promise to bring in a lot of money. Instead they go to business school and prepare themselves for the life of a junior executive and will, if they are lucky and sufficiently pliable (that is, a "team player"), end up as senior managers with a good income. They are forced to live where the work takes them. They dress the part of the executive. If they happen to have unpopular opinions, they will be wise to keep those to themselves. After a few years they may well forget they ever held them.

Martin Heidegger (1889–1976), destined by his Bavarian family for the Catholic priesthood, became a secular philosopher instead. He rediscovered alienation when reading Kierkegaard and Nietzsche. In *Being and Time,* Heidegger argued that most people are not themselves. Their opinions ape everyone else's; they are addicted to all things new. There is nothing they stand for unless they manage to overcome the pressures toward alienation and win through to being "authentically" themselves.

The French existentialist Jean-Paul Sartre (1905–1980) argued in his early work, *Being and Nothingness,* that alienation is not merely commonly chosen—a view he ascribes to Heidegger—but is inherent in the structure of human beings. People do not only think and act but are observers and critics of themselves. They can never be fully engaged in any activity or relationship because a part of them always stands aside to observe and judge. Being split against oneself is essential to being human.

In the years after World War II, numbed by a new, hitherto unknown level of prosperity paired with insistent demands for political conformity, writers in the United States produced a sizable literature concerned with alienation. Philosophically inclined writers, such as Erich Fromm (1955) and Paul Tillich (1952), brought the previously unknown ideas of Continental existentialism to the English-speaking world. Poetry, novels, and popular works in social science deplored conformism. Variants on Marxist themes attracted considerable interest and discussion in the 1970s and 1980s when a number of authors, including Bertell Ollman (1976), István Mészáros (1975), and Richard Schmitt (1983) published studies on alienation that were clearly anchored in the Marxist tradition.

Origins of Alienation

Sometimes technology is named as the source of contemporary alienation. Because technology is always a means to some end, the dominance of technology in society assures that all attention is given to means while ends remain unexamined. In such a situation, human lives lack goals and purposes because, absorbed in technological efforts, humans are unable or unwilling to reflect about the purposes of their activities (Ellul 1967). This thesis, however, portrays human beings as the impotent playthings of technology and overlooks that technology is not only used by humans but is also our creation.

The question about the origins of alienation have occasioned other controversies. For many years, philosophers have debated whether alienation is intrinsic to human nature or the effect of specific social conditions. Kierkegaard, Heidegger, and Sartre place the origin of alienation in the structure of human existence. Marx and, in different ways, Nietzsche blame the existence of alienation on social and economic conditions. Existing social conditions produce alienation, but in a happier future alienation may well disappear. Neither side to this debate seems to have understood that the two alternatives—alienation as intrinsic to human nature or alienation as the product of social conditions—are not exclusive: Alienation is anchored in human nature, but it exists more acutely in some social settings than in others. Alienation is always possible. But in some societies it is well-nigh unavoidable, whereas in others it is only a remote possibility.

Alienation springs from human nature insofar as it is characteristic of human beings to reflect about their lives as a whole. They ask whether their lives have a purpose, or whether their identity is well integrated. Gifted with certain capacities for reflection and the need to be able to tell a coherent story about their lives, they are, therefore, susceptible to alienation. But these general human characteristics do not inevitably produce actual alienation. Alienation arises when societies, as does America's, make conflicting and irreconcilable demands, for instance, when it asks one to love one's neighbor as oneself at the same time as it exhorts people to be aggressive competitors who give no quarter in the great contest for wealth and power. American society asks its citizens to be free and autonomous beings after hours but, during the day, to work in hierarchical organizations, in which one must be subservient and obedient to employers and supervisors. Surrounding daily life is a chorus of voices telling people to buy this, to buy that, to look like this model, or to have their house look like some dream house. Americans are told how their children must appear and how they themselves must spend their days and enjoy their leisure. Throughout one's waking life, these voices are never silent. Consequently, it is no wonder that there is a pervasive sense among Americans that their lives are not their own (Schmitt 2003). A variety of aspects of American society make it extremely difficult for Americans to live lives that are coherent and to be persons who pursue goals of their own choosing. American society fosters alienation.

Questioning Alienation

However interesting, such historical discussions of alienation remain extremely general. A number of original thinkers have provided a range of insights into alienation, but professional philosophers have mostly been content to repeat and embroider these original insights instead of developing them in greater detail. As a consequence, many important questions about alienation remain unanswered.

The concept of alienation refers to important characteristics of the modern social world. But it also directly refers to each person separately. If alienation is pervasive in modern society, as many authors have alleged, people must reflect, each with respect to their own person, whether they are conformists and therefore alienated or whether they lead lives of their own. But such questions about one's own conformism or independence are not easily answered. Humans are social beings, learning from others and sharing ideas with them. As a social process, is that participation in thinking a sign of conformism and hence of alienation? For example, Western people share the belief that freedom is important and that democracy is preferable to tyranny. Does that make Westerners conformists and manifest their alienation? Surely, there is an important distinction between sharing the ideas of one's fellow citizens and being conformist. But that difference remains unclear, and the discussions of philosophers do not provide much help. The idea of conformism, as one finds it in the literature about alienation, is not sufficiently specific to be useful to the individual's self-examination with respect to conformism and alienation.

Conformism is only one of several constituent concepts of alienation that have not been sufficiently developed. The alienated are often described as not being themselves with lives lacking unity and identities fragmented. But postmodern thought has provided an important reminder: that selves are multiple and complex (Flax 1987). Most people have more capabilities than they are able to develop; in different contexts—as their parents' child or as the boss at work—their personalities differ. People change over a lifetime and are rather different persons at seventy than at seventeen. Are all these diversities within one person signs of alienation? Are there not important differences between the alienated personality, which is vague and poorly delineated, and the complexities of the multiple aspects that well-constituted persons display in the different contexts of their lives and over an entire lifetime?

Traditional discussions of alienation have concealed the complexity of alienation in another respect. Human beings are very different from one another; they lead different kinds of lives because they are born into different conditions, have different abilities and defects, think in different ways, and have different character structures. The general symptoms of alienation mentioned in the literature will manifest themselves differently in different lives. Aimlessness leads to complete idleness in some lives, whereas in others it takes the form of frantic busyness—all of it trivial. The self-hatred of the alienated appears in some persons as constant self-deprecation and jokes at one's own expense, and in others as pompous self-importance. One does not really understand alienation until one is able to tell many concrete stories about the alienation of different persons, differently situated and therefore manifesting alienation in very different, sometimes, flatly contradictory ways.

The possibility of alienation flows from the human need to reflect about one's life (to ask whether it is coherent and has a purpose) and about one's person (whether one is autonomous or conformist). It is tempting to evade these reflections because their results are often confusing or discouraging when one finds that one's life is aimless or one's person ill delineated. As Kierkegaard pointed out forcefully, one can evade the pain of reflection about one's life by discoursing abstractly about alienation while refusing to try to apply this abstract philosophical discourse to one's own person and one's own life. The refusal to take one's own life and person sufficiently seriously to reflect about their meaning and coherence is one form of being alienated, of being a fractured person leading a haphazard life. Philosophical discussions of alienation foster this form of alienation because the very generality and lack of precision of many philosophical discussions of alienation make it difficult to engage in serious self-reflection.

RICHARD SCHMITT

SEE ALSO *Existentialism; Freedom; Hegel, Georg Wilhelm Friedrich; Kierkegaard, Søren; Marx, Karl.*

BIBLIOGRAPHY

Aristotle. (1999). *Nichomachean Ethics*, 2nd edition, trans. Terence Irwin. Indianapolis, IN: Hackett.

Ellul, Jacques. *The Technological Society*. New York: Vintage Books, 1967.

Flax, Jane. (1987). "Postmodernism and Gender Relations in Feminist Theory." *Signs* 12(4): 621–638.

Fromm, Erich. (1955). *The Sane Society*. New York: Rinehart.

Gilman, Charlotte Perkins. (1979). *Herland*. New York: Pantheon.

Hegel, Georg Wilhelm Friedrich. (1952). *Phänomenologie des Geistes* [Phenomenology of spirit]. Hamburg, Germany: Felix Meiner.

Heidegger, Martin. (1953). *Sein und Zeit* [Being and time]. Tübingen, Germany: Max Niemeyer.

Kierkegaard, Søren. (1941). *Sickness unto Death*, trans. Walter Lowrie. Princeton, NJ: Princeton University Press.

Kierkegaard, Søren. (1954). *Fear and Trembling*, trans. Walter Lowrie. Garden City, NY: Doubleday.

Lukács, György. (1971). *History and Class Consciousness: Studies in Marxist Dialectics*, trans. Rodney Livingstone. Cambridge, MA: MIT Press.

Marx, Karl. (1964). *Early Writings*, ed. and trans. T. B. Bottomore. New York: McGraw-Hill.

Mészáros, István. (1975). *Marx's Theory of Alienation*, 4th edition. London: Merlin Press.

Mill, John Stuart. (1949 [1863]). *Utilitarianism*. In *The English Utilitarians*, ed. John Plamenatz. Oxford: Blackwell.

Nietzsche, Friedrich. (1954). *Thus Spoke Zarathustra*. In *The Portable Nietzsche*, ed. and trans. Walter Kaufmann. New York: Viking.

Ollman, Bertell. (1976). *Alienation: Marx's Conception of Man in Capitalist Society*, 2nd edition. Cambridge, UK: Cambridge University Press.

Plato. (1920). *Plato's Republic*. In *The Dialogues of Plato*, 2 vols., trans. Benjamin Jowett. New York: Random House.

Rousseau, Jean-Jacques. (1950). *Discourse on the Origin and Foundation of the Inequality of Mankind*. In *The Social Contract, and Discourses*, trans. G. D. H. Cole. New York: Dutton.

Sartre, Jean-Paul. (1956). *Being and Nothingness*, trans. Hazel E. Barnes. New York: Philosophical Library.

Schmitt, Richard. (1983). *Alienation and Class*. Cambridge, MA: Schenkman.

Schmitt, Richard. (2003). *Alienation and Freedom.* Boulder, CO: Westview.

Tillich, Paul. (1952). *The Courage to Be.* New Haven, CT: Yale University Press.

ALTERNATIVE ENERGY

The very notion that some sources of energy make up *alternative energy* demonstrates the way people impute normative values to technologies. For decades, proponents of alternative energy have done more than advocate particular technologies: They maintain that their proposed technologies are socially and morally better. These social and moral claims show that advocates regard alternative energy technologies as different in profound ways from existing conventional energy technologies.

Social Contexts

Alternative energy must be understood against a background of conventional energy. Conventional energy is not conventional just because it is in wide use. It is conventional in that it underlies the functioning and embodies the values of the conventional society. Thus coal, oil, and natural gas are conventional both because they dominate energy production in industrialized countries and, even more, because they make possible a high-consumption society and require large-scale industrial systems to extract, convert, and distribute the energy.

Advocates of alternative energy seek more than simply technological replacements for fossil fuels. They seek technological systems that will reinforce and embody alternative values, such as avoiding the exploitation of nonrenewable resources and people, favoring smaller scale production, and, most importantly, living in a manner more in concert with natural systems, in the early twenty-first century often termed *living sustainably*.

This normative orientation sets alternative energy advocates apart from people who simply advocate new technologies but have no interest in an alternative society. For example, consider the case of nuclear power. From World War II on, many scientists and others advocated the use of nuclear power plants to replace fossil fuels. They sought a new technology, one that was not then in widespread use. However their purpose was to reinforce, maintain, and enhance the existing social and economic system, with all the values that went with it, including a reliance on large-scale resource extraction and production. They simply thought that nuclear technology would do the job better, more cheaply, and for a longer period of time than fossil fuels. Since the 1990s, proponents of nuclear energy have also argued that it will meet what has become another more or less conventional goal, reduction in carbon emissions.

Dam with power lines in the background. Hydropower as a source of alternative energy is considered problematic by enviromental groups, as dams often have adverse effects on their surrounding ecosystems. *(© Royalty-Free/Corbis.)*

The alternative label does not necessarily apply to all people and groups who advocate renewable energy technologies, such as solar, wind, and biomass. Since the 1950s, many of those advocating such technologies have simply seen them as ways to preserve the social status quo and its values. For such advocates, photovoltaic panels (often called solar cells) are just another way of producing electricity, and biomass-derived alcohol is just another way of producing liquid fuels for internal combustion automobiles. In contrast, for others photovoltaic panels offer the means to live *off the grid*.

Alternative energy advocates thus make up a subset of advocates for particular energy technologies. These are advocates who seek not only different technologies but also to promote different social values to go along with them.

The Ethical Dimension

The driving ethical concern that motivates most alternative energy advocates is a particular type of environmental ethics. These people feel that the relationship of industrial society to nature is fundamentally flawed. They come out of the more radical wing of the environmental movement and the broader alternative (or appropriate or intermediate) technology movements. To understand this alternative it is therefore necessary to consider the conventional societal attitudes toward nature.

For an industrial society, nature offers a set of resources to be exploited. Material consumption and the use of natural resources that go with it are good things, ethically desirable, as well as pragmatically important. Even so, people committed to this industrial ethos recognize that resource exploitation causes certain problems. From the late 1960s onward, conventional political groups accepted the need to curb pollution from industrial production, and governments around the world passed numerous environmental laws and established new agencies to carry them out. The oil embargo of 1973 and the resulting shortages and price increases demonstrated clearly the financial and security risks of U.S. dependence on imported oil. But for conventional society, and most political elites, environmental pollution and security risks were no more than manageable problems to be solved. They did not cast doubt on the basic normative commitments to exploiting nature and maximizing material growth.

Alternative energy advocates, however, see the society-nature relationship quite differently. They believe that human beings must understand themselves as parts of ecosystems and that, therefore, human well-being depends on the health of those ecosystems. They want societal values to be more consonant with the way that ecosystems work and to regard ecosystems as things of inherent value, not just resources to be exploited. For these advocates it is not enough to put scrubbers on the smokestacks of coal-fired power plants or to reduce the emissions coming out of automobile exhausts. They seek instead a society that puts much less emphasis on high levels of material consumption, epitomized by the use of individual automobiles. Such a society would be organized very differently, with different values guiding both individual behavior and social and political institutions. These normative commitments lead them to advocate different energy technologies, ones that use renewable resources that could provide the foundation for a different type of society. However these commitments also lead them to make fine distinctions among these technologies, rejecting some, and to carry on vigorous debates about the merits of particular technologies and energy sources.

Alternative Energy Options

Against this background, it is thus possible to consider at least three proposed alternative energies: solar, hydro, and wind.

SOLAR ENERGY. Numerous technologies use sunlight directly to produce either heat or electricity. During the 1970s, ecologically oriented alternative energy advocates pushed for certain of these technologies and opposed others. In general, the more high-tech and large-scale the technology, the less such advocates liked them. They favored solar panels that use sunlight to heat air or water. Such panels consist of little more than a black metal plate, which absorbs sunlight, encased in a box with a glass cover. Air or water flows over or through the plate, heating it up, and then enters the building to supply heat or hot water.

The principles of such technologies are not complicated, although it is not easy to make panels that last a long time and function well. The fact that they are easy to understand, small, and seemingly unrelated to large industrial systems and produce no pollution in their operation appeals to the ecological ethic of alternative energy advocates.

At the other extreme are proposals for solar power satellites (SPS). The idea is to launch a satellite into a stationary earth orbit and to attach to it many acres of photovoltaic panels, semiconductor solar cells that convert sunlight directly into electricity. The satellite could produce electricity almost twenty-four hours per day and beam it back to a receiving station on earth. This is the ultimate high-tech solar technology. Alternative energy advocates are hostile to the SPS system because it both requires and supports the conventional industrial system. As a system that could produce large quantities of electricity around the clock, SPS could substitute in a straightforward way for conventional power plants, making it just another conventional technology, albeit a solar, nonpolluting one. Due mostly to cost considerations, no one has yet put such a satellite into orbit.

HYDROPOWER. Controversies over hydropower again demonstrate conflicts over values. Many environmental groups opposed the hydropower dams the federal government sponsored in the 1950s and 1960s. While their operation produced no emissions, as would a coal plant, the dams flooded large areas and dramatically changed the ecosystems in which they were located. Besides the scientifically measurable damage they did, for many environmental advocates the dams represented a problematic relationship, of dominance and exploitation, to nature.

Therefore alternative energy advocates in the 1970s talked favorably about hydropower only when referring to low-head hydro (very small dams) or what was called *run-of-the-river* hydro. This latter technology consists of power-generating turbines that are put directly into rivers, without any dam at all. These technologies have the virtue of being smaller in size, more modest in environmental disruption, and less like large-scale industrial production.

Assessing Values

In the 1970s advocates of alternative energy did so in the hopes of moving toward a different society. They sought energy-producing technologies that were smaller in scale and simpler to understand, promoted local self-reliance instead of global dependence, and embraced an ecocentric environmental ethic. They thought that such technologies would provide the means to live in a society that was not only environmentally more sustainable but also more socially harmonious and cooperative, with less domination, hierarchy, and inequality. The ecocentric environmental ethic was particularly important to this view. Advocates thought that human domination of nature got reproduced in the domination of people. The energy crisis of the 1970s raised public awareness of the importance of energy to every social and economic function. For this reason, alternative energy advocates regarded changes in energy technologies as central to realizing their social vision. A final argument often made for alternative energy is that it supported projects in the developing world.

Were they correct? For the most part, no. The alternative energy advocate's vision of a new society based on a new energy source embraces the notion of technological determinism: Build the right technology, and one can get the desired society. Numerous studies show that this theory is false. Society does not simply evolve from technological choices. Many different societies can come out of similar technological choices.

However one should not entirely discount the advocates' ideas about energy. Technological choices do have profound effects on society, which in turn affects future technological choices. Moreover those choices are often not easy to change. If a society invests trillions of dollars in an energy system, as the industrial countries have done, they are reluctant to make rapid changes, a phenomenon historians call path dependence or technological momentum. So energy choices are heavily value-laden, long-term choices. It is difficult, however, to know just how those choices will interact with complex societies.

The case of wind energy illustrates this. Alternative energy advocates embraced wind energy in the 1970s, believing that wind turbines could produce electricity on a small scale and enable homes or communities to be less dependent on central-station power plants and the massive electrical grid that distributes the electricity. Those advocates were critical of federal research programs on wind turbines because such programs sought to build large wind turbines that the utility industry could use instead of smaller, off-the-grid turbines. These large turbines eventually achieved economies of scale that reduced the price of wind-generated electricity toward price-competitiveness. In the early-twenty-first century the wind industry is growing rapidly, with ever-larger turbines coming online as part of the large-scale electric utility industry. This technology is certainly cleaner than coal-fired power plants, but other than that, it bears no resemblance to the social vision held by alternative energy advocates of the mid-1970s.

The history of wind energy emphasizes another point about normative values and energy. Alternative energy advocates in the 1970s thought that society was in deep crisis and that its core values were debatable. The signs seemed to be everywhere. The economy was in a long decline during the 1970s after dramatic growth and prosperity in the 1950s and 1960s. Along with economic stagnation came social problems such as rising crime rates and declines in urban fiscal health, symbolized by the fiscal crisis in New York City. The oil embargo, along with the end of the Vietnam War and other problems abroad, seemed to indicate a loss of international influence for the United States. Faced with these realities, alternative energy advocates thought they were in a position to push for a society based on radically different values.

But they clearly miscalculated. In particular, the value of economic efficiency, an important ethical norm for conventional society, one that valorizes markets, has been an important, though not the only, driver of energy technology. In the early-twenty-first century virtually all advocates of renewable energy seek ways in which such technologies can succeed in competitive markets. Alternative energy advocates of the 1970s pushed a social vision that was greatly divergent from existing society. They never produced a narrative compelling enough to lead to widespread acceptance of their normative values and consequently to their technological system. Their values rather than their technologies kept them marginalized.

FRANK N. LAIRD

SEE ALSO *Alternative Technology; Automobiles; Environmental Ethics; Sierra Club.*

BIBLIOGRAPHY

Laird, Frank N. (2001). *Solar Energy, Technology Policy, and Institutional Values.* New York: Cambridge University Press. Studies federal government policy for renewable energy from 1945–1981, with an emphasis on the ways in which values drove policy debates.

Laird, Frank N. (2003). "Constructing the Future by Advocating Energy Technologies." *Technology and Culture* 44 (1): 27–49. Examines the values that alternative energy advocates used in their works from World War II through the energy crisis, with a heavy emphasis on the 1970s.

ALTERNATIVE MEDICINE

SEE *Complementary and Alternative Medicine.*

ALTERNATIVE TECHNOLOGY

Any reflection on *alternative technology* (AT) prompts the question, Alternative in what sense? According to one AT theorist, there are three dimensions to this question (Illich 1997). The alternatives can be technical, ethical, or political. In the first case the divide is between hard (oversized machines) and soft (smaller, local tools), in the second between heteronomy and autonomy in technology, and in the third between centralized (right) and decentralized (left) technological systems.

Technical Alternatives

In 1917 D'Arcy Wentworth Thompson published *On Growth and Form,* a study of the relation of *shape* and *size* in living beings and artifacts. His *law of similitude* states that every natural and technical shape is *scale-variant,* that is, shape or form is strongly influenced by size. According to J. B. S. Haldane (1956), for instance, the form of all natural organisms is covariant with their scale: A cow the size of an elephant would need legs as strong as columns and could hardly support its horns. The Austrian economist Leopold Kohr (1967) applied these ideas to economics and the study of societies and is therefore the pioneer of *social morphology*. For Kohr, the size of a political unit entails a certain kind of polity, that is, a correspondence between the form of government and the scale to be governed. He was a major influence on, and a friend of, the German-born British economist Ernst Fritz Schumacher (1911–1977), whose phrase *small is beautiful* has become a world-famous lemma.

Schumacher is deservingly considered the father of the AT movement. In 1961 he took a trip to India that changed his vision. Impressed by the inherent viability of Indian agriculture, he firmly opposed replacing the traditional ox-drawn cart by tractors (Dogra 1983). Instead he imagined the carts equipped with ball bearings and rubber tires. On his return to England, he founded the journal *Intermediate Technology,* which would popularize the concepts of *appropriate technology* and later AT. Though superficially similar, the word appropriate points to something the other terms do not: the fitness of shape and size; the balance of power between autonomous action and what is done for one; and the importance of subjecting the relation between means and ends to political deliberation.

During the 1970s and 1980s, the AT movement gathered strength through numerous journals, publications, and associations. The *Whole Earth Catalog* in the United States and *Resurgence* in the United Kingdom became leading periodicals. Informative and influential books and articles appeared on alternative or appropriate technologies in general (Darrow and Pam 1976), on improvements to traditional rural practices (Devender 1978), on ecological houses (Farallones 1979), and on alternatives to energy-intensive industrial technology (Lovins 1977). As individuals and small groups of citizens retooled their homes and villages, nongovernmental organizations (NGOs) began to proliferate and spread the good news that there were better means to meet ends than energy-intensive industrial technologies. Yet insofar as the AT movement restricted attention to the technical choice between *hard* and *soft,* it was often dubbed the *soft technology* movement—and had little more than decorative influence over the technological world.

Ethical Alternatives

In the twenty-first century distributive justice often takes the industrial system for granted and strives to allot its outputs according to some equalitarian scheme. The alternative to this justice by arithmetic is *equity*, sometimes inaptly called *participative justice*. An equitable society is founded on an architecture of *civil liberties* that protects everyone's freedom to act. In an equitable society, each contributes threads to the weave of the social fabric rather than passively claims *outputs* from society. The enhancement of productive liberties does not mean a blind refusal to all claims of consumption. Rather it implies the recognition of a hierarchy: Just as autonomy is higher than heteronomy so also civil liberties are superior to social rights.

Many activists of the AT movement have argued that this hierarchy demands some limits on tools. In contrast to the automobile, the bicycle is an example of an industrial product that fosters the autonomy of its users: It increases access without driving others off the road. Just as the automobile enchains drivers to highways, the flush toilet, once the glory of industrial hygiene, turns its users into compulsive elements of the sewer system. Clean, cheap, and often ingenious alternatives to the costly industrialization of waste removal suggest the possibility of freedom from other heteronomous systems insofar as they can be intelligently worked out. Starting with Dr. Duc Nguyen's Vietnamese latrines in the 1960s, there have been a great variety of high quality dry toilets that unplug their users from the sewage pipes, reduce the destruction of land and waters, and cut a home water bill by more than half (Nguyen 1981, Lehmann 1983, Anorve 1999).

Political Alternatives

Proponents of alternatives to the service industry have emphasized that civil liberties can only be perverted by bureaucratic and professional government for the people. For example, from 1955 on, a group of Peruvian activists, builders, and lawmakers were joined nonconformist architects and sociologists from Europe and the United States to collectively give shape and credibility to an alternative understanding of poor neighborhoods (Turner 1968). They suggested that there were two ways of looking at a neighborhood. One is to evaluate the neighborhood in terms of its material characteristics as a bundle of *goods and services* that satisfy people's *housing needs*. This will, almost inevitably, identify what people lack and petrify corrective measures into scientifically established and bureaucratically managed standards. It is associated with centralism, authoritarianism, professionally diagnosed needs, and institutional services.

But a neighborhood can also be understood as a set of productive relationships among its inhabitants. Such a commonsense view of people is sensitive to what people can do—their abilities rather than their deficits—and will generate flexible rules that protect free people acting to fulfill their self-defined ends. The British architect John Turner became the most articulate voice of *housing by people* (rather than for them) as the paradigmatic example of an activity that is not a need, and proved the feasibility of subordinating heteronomous tools to autonomous initiatives (Turner 1978).

Assessment

AT has had technical, ethical, and political defenders. Contrary to what might be expected, ethical commitments based on faith have supported many of the more sustained AT efforts. Schumacher's essay on "Buddhist Economics" and Servants in Faith and Technology (SIFAT), a Christian evangelical NGO founded in 1979 in Tennessee, are two cases in point.

During the late 1980s, however, AT began to be envisioned as a means rather than an end—as a cheap alternative to high cost services rather than a replacement for such services. Governments started to support the NGOs that promoted AT when they presented themselves as development professionals who could diffuse AT to the third world as underdeveloped versions of high-tech educational, medical, transportation, or sanitary packages. Advocates of distributive justice fought for the right of the poor to an equal share of industrial outputs. Though it had inspired the pioneers of the AT movement, equity, conceived as the civil liberty to decide what to do and how, was progressively neglected. ATs were not only conceived as alternative ways to satisfy needs, but increasingly as first steps toward the *real thing:* Communal literacy was simply the first step toward schooling, barefoot doctors were unshod versions of those in white coats, bicycles were cheap imitations of cars, dry commodes were training tools for flush toilets, and muscles were painful alternatives to fuels.

In the high Middle Ages, Hugh of Saint Victor defined tools as appropriate remedies for the natural imperfections of human beings. In this sense, appropriateness, Latin *convenentia*, refers to the *proportional* relationship between the radius of action circumscribed by a person's innate powers and the power deposited in hands or under buttocks by tools. Appropriate technology is the search for the fitting and proper relationship between means and ends. Accordingly it has become more urgent to distinguish the alternative from the appropriate. Often the alternative is neither appropriate nor intermediate.

JEAN ROBERT
SAJAY SAMUEL

SEE ALSO *Alternative Energy, Engineering Design Ethics; Engineering Ethics.*

BIBLIOGRAPHY

Añorve, Cesar. (1999). *Remar contra corriente: Conversaciones para animar a los espíritus del tiempo.* Cuernavaca, Mexico: Centro de Innovaciòn Tecnólogica.

Borgstrom, Georg. (1971). "The Green Revolution." In *Focal Points.* New York: Macmillan.

Borremans, Valentina. (1979). *Guide to Convivial Tools,* Library Journal Special Report No. 13. New York: Bowker.

Darrow, Ken, and Rick Pam. (1976). *Appropriate Technology Sourcebook: For Tools and Techniques that Use Local Skills, Local Resources, and Renewable Sources of Energy.* Stanford, CA: Volunteers in Asia.

Devender, Kumar. (1978). "Further Reading: A Select and Relevant Bibliography on the Rural Challenge." *Seminar* 227: 44–48.

Dogra, Bahrat. (1983). "Traditional Agriculture in India: High Yields and No Waste." *Ecologist* 13: 2–3.

Farallones Institute. (1979). *The Integral Urban House.* San Francisco: Sierra Club Books.

Haldane, J. B. S. (1985). *On Being the Right Size and Other Essays,* ed. John Maynard Smith. Oxford: Oxford University Press. Essay originally published in 1928.

Illich, Ivan. (1973). *Tools for Conviviality.* London: Calder and Boyars.

Illich, Ivan. (1977). "Disabling Professions." In *Disabling Professions,* eds. Ivan Illich et al. London: Marion Boyars.

Kohr, Leopold. (1967). "Critical Size." *Resurgence* 1(8): 8–11.

Lehmann, Pierre. (1983). *Essais avec des toilettes à compostage: Gestion de l'eau et de "déchets" organiques dans l'habitat* [Essay on compost toilets]. Vevey, Switzerland: SEDE.

Lovins, Amory. (1977). "Soft Energy Paths: Towards a Durable Peace." In *Disabling Professions,* eds. Ivan Illich et al. London: Marion Boyars.

McKnight, John. (1977). "Professionalized Service and Disabling Help." In *Disabling Professions,* eds. Ivan Illich et al. London: Marion Boyars.

Nguyen, Dang Duc, et al. (1981). *Human Feces, Urine, and Their Utilization.* Bangkok: Environmental Sanitation Information Center (ENSIC).

Sachs, Wolfgang, ed. (1992). *The Development Dictionary: A Guide to Knowledge as Power.* London: Zed.

Schumacher, Ernst Fritz. (1973). *Small is Beautiful: Economics as if People Mattered.* New York: Harper Torchbooks. Contains the essay "Buddhist Economics."

Theophilus, Prysbter. (1961). *The Various Arts,* trans. Charles R. Dodwell. New York: T. Nelson.

Thompson, D'Arcy Wentworth. (1971). *On Growth and Form.* Cambridge, England: Cambridge University Press.

Turner, John. (1968). "Housing Priorities, Settlement Patterns, and Urban Development in Modernizing Countries." *Journal of the American Institute of Planners.* November: 354–363.

Turner, John. (1978). "Housing in Three Dimensions: Terms of Reference for the Housing Question Redefined." In *World Development,* ed. Ron Burguess. London: Development Planning Unit, University College.

ALTRUISM

Altruism often is defined as an action intended to benefit another person even when that action could lead to sacrifices to the welfare of the actor. Altruism thus presents an issue for ethical reflection and a thorny problem for many scientific models of human behavior. It does not fit easily into the dominant theoretical paradigms of most behavioral sciences, which assume that self-interest is the drive that underlies human behavior. When presented with examples of altruism, analysts often dismiss them as too rare to be of practical significance or as representing self-interest in disguise. Scientific frameworks that continue to struggle with the theoretical challenge presented by altruism include evolutionary biology, whose paradigm suggests that altruistic behavior should be driven out by behavior guaranteed to produce greater evolutionary fitness; economics, which assumes that actors, whether they are people, firms, or countries, pursue perceived self-interest subject to information and opportunity costs; and rational choice theory, which was derived from economic theory but has become prevalent throughout social science and decision-making theory in the form of the cost-benefit model.

Explaining Human Altruism

Because altruism should not exist according to the basic premises of these theoretical models, much early work on altruism attempted to explain it away as a disguised form of self-interest. Economists minimized altruism by explaining it as behavior that is engaged in to provide psychic gratification, deferred material gain, or group welfare (group altruism). Using similar concepts, often under slightly different names, biologists dismissed altruism as acts designed to encourage similar behavior in the future (reciprocal altruism) or further the transmission of genetic material (kin selection). Some work on animal behavior (DeWaal 1996) suggesting that animals demonstrate strong evidence of cooperation and altruism and that human altruism may be part of people's makeup as primates has been ignored by most theorists in evolutionary biology.

Among scientists who have taken human altruism seriously as an empirical reality, not merely an aberration, much of the best work has been based on experimental laboratory experiments such as that by Daniel Batson (1991) on empathic altruism. However, experimental work cannot simulate fully the more complex interactions in the sociopolitical world. This is where political analyses, even those based on small samples, provide rich insight.

Nonlaboratory analyses of human altruism include work on why people give blood (Titmuss 1997) and extensive work on philanthropists and heroes who save others (Latané and Darley 1980, Monroe 1996). Some of the most interesting studies focus on rescuers of Jews, a group of individuals who have intrigued scientists both because of the extremity of their potential sacrifice—their families also were doomed to execution if the altruists were caught—and because they represent altruism in a situation in which their immediate society as a whole condemned their acts.

Altruism Personified

Much of the early work on rescuers is autobiographical, written by rescuers (Gies 1987) or survivors (Wiesel 1986 [1960]), and consists of anecdotal portraits designed to document rescue activity. Little early work was focused on rescuers' motivations until Perry London's 1970 book. Early social science works on altruism were correlational and inquired about a wide variety of sociocultural factors, such as religion (Hunecke 1981), social class (Klingemann and Falter 1993), and gender (Fogelman 1994). Analysts slowly zeroed in on the psychological underpinnings of rescue behavior, focusing first on general psychological factors such as the thrill of adventure involved in rescuing or a sense of social marginality in which the rescuer felt an empathic bond with the persecuted because of the rescuer's own feeling of being an outsider.

A focus on the self began with Nechama Tec (1986), whose work highlighted personality factors, arguing that rescuers had a strong sense of individuality or separateness. Tec concluded that rescuers were motivated by moral values that did not depend on the support or approval of other people as much as it did on their own self-approval. The first important systematic analysis of rescuers established personality as the critical explanation. Samuel and Pearl Oliner's *The Altruistic Personality: Rescuers of Jews in Nazi Europe* (1988) located the drive for altruism in habitual behavior, encouraged by parents or other significant role models, that led to habits of caring that effectively became structured as an altruistic personality. In the same year a filmed documentary in which survivors as well as rescuers were interviewed argued that rescuers "had to do it because that's the kind of people they were" (Immanuel Tanay in *The Courage to Care*, a 1988 Academy Award–nominated documentary by Rittener and Myers [1986]).

Later analysts (Fogelman 1994, Monroe 1996) also noted the psychological importance of reinforcing empathic and humane behavior and stressed critical psychological factors related to the sense of self in relation to others. The values associated with altruism always included tolerance for differences among people and a worldview characterized as "extensivity" (Reykowski 2001).

Altruism, Cognition, and Categorization

The critical variable in explaining altruism seems to be the actor's internal psychology, and analysts interested in human altruism focus on the internal cognitive forces that drive altruism, asking how the altruistic personality or an altruistic worldview can influence altruistic acts. The psychological process seems to be as follows: People use categories to organize experience. The vast literature on social identity theory makes it clear that people categorize themselves in relation to others and then compare themselves with those critical others. However, there are many ways in which people may make that comparison. This means that analysts must ask not just how people construct categories but how they accord moral salience to them. Rescuers of Jews, for example, did draw distinctions between Jews and Nazis, but those categories were not relevant for the rescuers. They did not accord moral salience to those categories; both Jews and Nazis were supposed to be treated as human beings. Instead, rescuers constructed a broader or alternative category that was deemed morally salient. For rescuers the morally salient category was the human race, not ethnicity, religion, or political affiliation.

This raises an important question and gives altruism importance for more general ethical concerns: Is it the recognition of common membership in a category that is necessarily relevant for people's treatment of others? Or is it merely that shared membership in a category makes it more likely that one will treat other members of the same category well? The cognitive recognition of a shared category may tend to accord moral salience, but that is not necessarily the case. The empirical evidence from altruists suggests that it is not enough to say that people divide the world into divisions of in-group and out-group. One must ask how the categories are constructed and then how they are invested with moral salience.

The rescuers' categorization schema, for example, seemed to be one in which all people could exhibit individual and group differences but still be placed in the common category of human being. That category took on a superordinate moral status in which all people deserved to be treated with respect and dignity. The cognitive process by which rescuers viewed others—their categorization and classification of others and their perspective on themselves in relation to those others—had a critical influence on rescuers' moral actions. The cognitive process included an affective component that served as a powerful emotional reaction to another person's need. It created a feeling, possibly arising from heightened hormonal activity akin to the biochemical changes in the amygdala during fear or flight situations, that made altruists feel connected to people in need. That reaction provided the motive to work to effect change.

Is there a "scientific" process through which the psychology of altruism affects the ethical treatment of others? A critical part of the process appears to involve identity. Something in the external situation triggers a perception by the altruist that there is a shared bond: Perhaps the person in need is a helpless child or reminds the altruist of someone she or he once knew and liked. Perhaps someone with the potential altruist indicates a sense of concern for the needy person. This perception causes the altruist to place the needy person in the category of someone who needs help and whose situation of neediness is relevant for altruism. The categorization and perspective on the needy person in relation to the actor cause the altruist to feel a moral imperative to act, to move beyond feeling sympathy and become involved in an active sense.

Altruism thus is related to the manner in which the external environment taps into the altruist's core self-concept, which is distinguished by the altruist's self-image as a person who cares for others. As a general rule it is this perspective that links the altruist's self-image to the circumstances of others by highlighting the situation of the person in need in a way that accords a moral imperative to the plight of others. When one taps into this self-concept, the suffering of others becomes morally salient for altruists in the way the plight of one's child or parent would be salient for most people.

Because the values of caring for others are so deeply integrated into altruists' self-concepts, these values form a self-image that constitutes the underlying structure of their identities. This means that the needs of others frequently are deemed morally salient for altruists. This self-concept transforms altruists' knowledge of another person's need into a moral imperative that requires them to take action. Their self-concepts are so closely linked to what is considered acceptable behavior that altruists do not merely note the suffering of others; that suffering takes on a moral salience, a feeling that they must do something to help. Even in the extreme situation of the Holocaust the suffering of Jews was felt as something that was relevant for the rescuers. It established a moral imperative that necessitated action.

Although hard data are difficult to obtain, the fact that those rescuers felt a moral imperative to help is evident in statements that reveal their implicit assumptions about what ordinary decent people should do. The unspoken expectations are embedded deep in a rescuers' psyche and are revealed in rescuers' descriptions of what was and what was not in their repertoire of behavior. For rescuers all people within the boundaries of their community of concern were to be treated the same, and their circle of concern included all human beings. That perception of a shared humanity triggered a sense of relationship to the other that made the suffering of another person a concern for the rescuers. Significantly, this extensivity included Nazis, with the rescuers demonstrating an extraordinary forgiveness of Nazis. It is the role of perspective to classify and categorize people and then to work through a cognitive process of salience that provides the link between the lack of choice and identity and the variation in a person's treatment of others.

The scientific literature thus suggests that the empirical evidence linking identity to altruism follows these critical links: (1) the innate human desire for self-esteem and the need for continuity of self-image; (2) core values stressing the sanctity of life and human well-being that are integrated into altruists' underlying concept of who they are; and (3) external stimuli that trigger critical aspects of altruists' multifaceted and complex identity in a way that compels them to notice and accord moral salience to the suffering of others.

KRISTEN RENWICK MONROE

SEE ALSO *Evolutionary Ethics; Game Theory; Selfish Genes.*

BIBLIOGRAPHY

Batson, Daniel C. (1991). *The Altruism Question: Toward a Social Psychological Answer.* Hillsdale, NJ: Erlbaum. A thorough empirical examination that focuses on determining whether altruism exists and emphasizes empathy as a critical predictor.

DeWaal, Frans. (1996). *Good Natured: The Origins of Right and Wrong in Humans and Other Animals.* Cambridge, MA: Harvard University Press. A noted zoologist and ethologist specializing in the study of primate behavior argues that ethical behavior is rooted in people's nature as primates.

Fogelman, Eva. (1994). *Conscience and Courage.* New York: Anchor. A survey of data on rescuers of Jews during the Holocaust emphasizes demographic correlates.

Gies, Miep. (1987). *Anne Frank Remembered: The Story of the Woman who Helped to Hide the Frank Family.* New York: Simon & Schuster. A memoir that describes how the Frank rescue was attempted.

Hunecke, Douglas K. (1981–1982). "A Study of Christians Who Rescued Jews During the Nazi Era." *Humboldt Journal of Social Relations* 9(1): 144–149. Emphasizes the demographic characteristics of rescuers, such as religion.

Klingemann, Ute, and Jurgen Falter (1993). *Hilfe fuer Juden waehrend des Holocaust.* Rheinland-Verlag GmbH Koeln. A comprehensive survey of rescuers that emphasizes demographic correlates.

Latané, Bibb, and John M. Darley. (1980). *The Unresponsive Bystander: Why Doesn't He Help?* New York: Appleton-Century-Crofts. A classic social psychological work on the importance of others for bystander/rescue behavior.

London, Perry. (1970). "The Rescuers: Motivational Hypotheses about Christians Who Saved Jews from the Nazis." In *Altruism and Helping Behavior,* ed. Jacqueline Macauley and Leonard Berkowitz. New York: Academic Press. The first important empirical examination of rescuers.

Monroe, Kristen Renwick. (1996). *The Heart of Altruism: Perceptions of a Common Humanity.* Princeton, NJ: Princeton University Press. Links empirical examination of altruism to social theories based on self-interest to argue that such theories offer only a partial account of human conduct.

Oliner, Samuel P. (2003). *Do Unto Others: Extraordinary Acts of Ordinary People.* Boulder, CO: Westview Press. Expands earlier work on rescuers into everyday life to reveal altruists at work.

Oliner, Samuel P., and Pearl Oliner. (1988). *The Altruistic Personality: Rescuers of Jews in Nazi Europe.* New York: Free Press. A comprehensive survey of rescuers during the Holocaust that emphasizes the ingrained habits of caring that form an altruistic personality.

Reykowski, Janusz. (2001). "The Justice Motive and Altruistic Helping: Rescuers of Jews in Nazi-Occupied Europe." In *The Justice Movement in Everyday Life: Essays in Honor of Melvin J. Lerner,* ed. Michael Ross and Dale T. Miller. New York: Cambridge University Press. Explains and advances extensivity as the psychological phenomenon that critically influences altruism.

Rittner, Carol, and Sondra Myers. (1986). *The Courage to Care.* New York: New York University Press. A moving documentary and photo book on rescuers during the Holocaust.

Tec, Nechama. (1986). *When Light Pierced the Darkness: Christian Rescue of Jews in Nazi-Occupied Poland.* New York: Oxford University Press. Builds on the author's experiences to explain the importance of the self-concept for altruism.

Titmuss, Richard M. (1997). *The Gift Relationship: From Human Blood to Social Policy.* New York: New Press. One of first serious social science explanations of altruism.

Wiesel, Elie. (1986 [1960]). *Night.* New York: Bantam. One of many books by a Nobel laureate on the Holocaust.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

• • •

The American Association for the Advancement of Science, or AAAS (triple A-S), founded in September 1848, began as an organization to establish a national identity and forum for U.S. scientists. It has become the largest federation of scientific societies in the world, with more than 250 affiliated institutions and 130,000 individual members. AAAS publishes the peer reviewed journal *Science,* and sponsors programs that include collaborations with organizations representing scientists and non-scientists throughout the world.

Science in Service of Society

Throughout its history, AAAS has addressed issues at the intersection of science and society. During World War I, as advances in science and technology created public expectations for progress, AAAS committed itself to "the use of science for public good" (Benson and Maienschein 1999, p. 3). In 1946, AAAS affirmed a commitment to bridging science and society by revising its Constitution to include objectives "to improve the effectiveness of science in the promotion of human welfare, and increase public understanding and appreciation of the importance and promise of the methods of science in human progress" (AAAS Constitution 1946).

The 1950s brought concerns due to increasing government secrecy restrictions, growing controversies over nuclear weapons, and anti-communist suppression of dissenting views. In 1958 the AAAS Board created the

Committee on Science in the Promotion of Human Welfare to recommend responses to the issues that concerned society. The Committee urged AAAS and the scientific community to fulfill "an obligation to call to public attention those issues of public policy which relate to science, and to provide for the general public the facts and estimates of alternative policies which the citizen must have . . . to participate intelligently in the solution of these problems" (AAAS Committee on Science in the Promotion of Human Welfare 1960, p. 71).

Scientists' Rights and Responsibilities

Social unrest in the 1960s and 1970s, fueled by anti-nuclear, environmental, and anti-Vietnam War movements, which argued that science was complicit in creating national problems rather than in solving them, led to public demands for greater accountability by scientists. In response AAAS created an ad hoc committee in 1970 to report on the "conditions required for scientific freedom and responsibility" (Edsall 1975, p. v). In its report the committee recommended that AAAS establish a more permanent committee to reassess boundaries of scientific freedom and responsibility in a world where science is increasingly "inextricably intertwined with major political, social, and economic problems" (Edsall 1975, p. ix).

As a result, the Association created a new standing Committee on Scientific Freedom and Responsibility in 1976 to "encourage and assist the AAAS . . . and other scientific groups to develop statements of principles governing professional conduct, and to . . . encourage scientists to accept their professional responsibilities both with regard to safeguarding the integrity of science and with regard to the application of science in the promotion of human rights and general welfare" (AAAS Committee on Scientific Freedom and Responsibility Internet site). In 1977 AAAS amended its Constitution to include "to foster scientific freedom and responsibility" in its mission and, in 1981, established the Scientific Freedom and Responsibility Award to "honor scientists and engineers whose exemplary actions have served to foster scientific freedom and responsibility."

Since the founding of the Committee on Scientific Freedom and Responsibility, AAAS ethics activities have focused on human rights and on the ethics associated with scientific research and the impacts of science and technology. The science and human rights activities of AAAS were initially influential in the 1970s and 1980s in defense of scientists, engineers, and health care professionals whose rights were violated by their governments. Collaborating with human rights groups, AAAS has helped to secure the freedom of scientists in the former Soviet Union as well as in Asia, Africa, Latin America, and the Middle East. These efforts have not been without risk, or setbacks. Committee members and staff have been harassed, even in one case arrested, while working on behalf of scientists in their home countries and accused of meddling in countries' sovereign political affairs.

In 1990 the Association established a Science and Human Rights Program that directed resources and expertise to use science to help bring notorious abusers of human rights to justice. AAAS pioneered the application of forensic science, genetics, and statistics to human rights investigations. Its work helped to unite families in Argentina, and identify victims of mass executions in Guatemala; in 2002 results of Program investigations were presented as evidence in the international war crimes trial of former Yugoslavian president, Slobodan Milosevic. The Program's work has made it a frequent technical consultant to *truth commissions* in many countries, including Haiti, Peru, and South Africa.

In 1991 AAAS reorganized its other ethics activities into a Program on Scientific Freedom, Responsibility and Law, which focuses on the ethics associated with the conduct of science as well as on the uses and impacts of advances in science and technology. AAAS has been in the vanguard of scientific societies in developing "a knowledge base to deal intelligently with misconduct" (Johnson 1999, p. 51) in science, in providing educational resources for scientists and administrators responsible for preserving the integrity of research, and in advocating a prominent role for scientific societies in promoting research integrity. Through a series of practicums begun in 1992, AAAS has helped prepare institutional officials for investigating allegations of research misconduct under federal regulations. A set of videos, produced by AAAS in 1996 and used to educate students and researchers in the ethics of conducting and reporting research, is a popular resource in hundreds of colleges and universities.

Engaging the Larger Public

To complement its work in human rights and ethics, in 1995 AAAS established the program of dialogue on science, ethics, and religion to promote scholarship on the religious implications of advances in science and technology and to facilitate communication between the scientific and religious communities. Through its programs, AAAS has recognized that the consequences of science and technology often challenge public and expert sensibilities about what is ethically acceptable,

Forensic anthropologist Clyde Snow on assignment for AAAS in Argentina, excavating a mass grave. AAAS pioneered the application of forensic science to investigations of human rights abuses. *(From the records of the Science and Human Rights Program, AAAS Archives.)*

and has highlighted the issues that may cause tension between the freedom of scientists and their social responsibilities. AAAS works to provide timely, credible, and balanced information to policy debates by bringing multidisciplinary analysis to bear on complex issues, and by brokering among a wide range of stakeholders to promote broad public dialogue on such matters as stem cell research, genetic modification, and human cloning. AAAS has used the knowledge and insights gained through these studies to brief the media, to provide testimony at legislative and administrative hearings, and to develop educational materials. It has also taken public positions on highly controversial issues, including the use of animals in research, the conduct of stem cell research, the prospects of human cloning, and post-9/11 debates over the impact of national security policies on the freedom of scientific inquiry. Although it is difficult to trace the precise influence that these efforts have had, it is testimony to AAAS's credibility that other scientific organizations, public interest groups, and government officials call on the organization for assistance (Teich 2002).

In 2002 under new executive leadership, AAAS revisited its historic mission and reinforced its commitment to "advance science and innovation throughout the world for the benefit of all people," and the priority to be accorded to the "responsible conduct and use of science and technology" (AAAS Mission 2002). As ethical issues associated with scientific research and technology continue to challenge public beliefs and attitudes, the professional responsibilities of scientists, and the capacity of public and private institutions to anticipate and respond effectively, AAAS has repositioned itself to be a more visible voice in science policy and reaffirmed its commitment to advancing science and serving society.

MARK S. FRANKEL

SEE ALSO *Federation of American Scientists; Nongovernmental Organizations; Profession and Professionalism; Royal Society.*

BIBLIOGRAPHY

American Association for the Advancement of Science. Committee on Science in the Promotion of Human Welfare. (1960). "Science and Human Welfare." *Science* 132: 68–73.

Benson, Keith, and Jane Maienschein. (1999). "Introduction: AAAS Narrative History." In *The Establishment of Science in America,* eds. Sally Gregory Kohlstedt; Michael M. Sokol; and Bruce V. Lewenstein. New Brunswick, NJ: Rutgers University Press. This well-documented history covers AAAS's first 150 years, and in the process connects the actions of the association with significant events related to the role of scientists in the United States and the changing relationship between science and American society.

Chalk, Rosemary, ed. (1988). *Science, Technology, and Society: Emerging Relationships*. Washington, DC: American Association for the Advancement of Science. This anthology includes eighty-five articles, editorials, and letters published in the journal *Science,* from 1949 until early 1988. Among the topics covered are science and responsibility, science and freedom, scientists and citizens, science and risk, and science and national security.

Edsall, John, ed. (1975). *Scientific Freedom and Responsibility*. (A Report of the AAAS Committee on Scientific Freedom and Responsibility.) Washington, DC: American Association for the Advancement of Science. This foundational document led AAAS to establish the committee on scientific freedom and responsibility. It maps the boundaries of scientific freedom and responsibility, prescribes criteria and procedures for the study of those boundaries, and recommends a role for AAAS in preserving the freedom of scientists and in encouraging scientists to address the broad social implications of their work.

Johnson, David. (1999). "From Denial to Action: Academic and Scientific Societies Grapple with Misconduct." In *Perspectives on Scholarly Misconduct in the Sciences*, ed. John M. Braxton. Columbus: Ohio State University Press.

Teich, Albert H. (2002). "AAAS and Public Policy: Speaking Softly and Carrying a Medium-Sized Stick." *Technology in Society* 24: 167–178.

INTERNET RESOURCES

American Association for the Advancement of Science. (1946). *AAAS Constitution*. Available from http://archives.aaas.org/docs/documents.php?doc_id=406.

American Association for the Advancement of Science. (2002). *Mission*. Available from http://www.aaas.org/about.

American Association for the Advancement of Science Archives. Available from http://archives.aaas.org.

American Association for the Advancement of Science. Committee on Scientific Freedom and Responsibility. Available from http://www.aaas.org/spp/sfrl/committees/csfr.

American Association for the Advancement of Science. Program of Dialogue on Science, Ethics, and Religion. Available from http://www.aaas.org/spp/dser.

American Association for the Advancement of Science. Science and Human Rights Program. Available from http://shr.aaas.org.

American Association for the Advancement of Science. Scientific Freedom and Responsibility Award. Available from http://www.aaas.org/about/awards/Freedom.shtml.

American Association for the Advancement of Science. Scientific Freedom, Responsibility and Law Program. Available from http://www.aaas.org/spp/sfrl.

ANDERS, GÜNTHER

Philosopher of technology Günther Anders (1902–1992), who was born in the city of Breslau (then a part of Germany) on July 12, developed a unique moral critique of modern technology. He studied psychology, history of art, and philosophy at the universities of Hamburg and Berlin, and, as a student of Edmund Husserl, received his Ph.D. from the university of Freiburg in 1923. Anders's escape from Nazi Germany in 1933, his exile in North America, and, most importantly, the events of Auschwitz and Hiroshima, formed the experiential background to his thought. He returned to Europe in 1950 and lived in Vienna until his death on December 17.

Anders's philosophy exemplifies that tradition of critical and enlightened thought that engages with the world and the concrete problems of its time, seeking to ground human actions and the necessity of morality and ethics from within actual historical conditions. Anders's extensive body of work analyzes the changes to which human beings, both individually and collectively, are subject in a technological world. In the early period of his development, he undertook socio-political analyses of human practice (e.g., studies on fascism and unemployment), while writing poems, philosophical novels, and other books on philosophy, literature, and art.

Concern with the world is such a strong feature of Anders's philosophical identity that, for him, theoretical analysis and practical engagement are inextricably linked. He was one of the first intellectuals who warned against the Nazis and he took part in the resistance against Hitler and fascism. Later he was an active anti-Vietnam War protester, and an initiator of the anti-nuclear and environmental movements. But as much as he was a political activist, he nonetheless recognized the vital role of theory in an increasingly scientific and technological world, and, in reversing Karl Marx's famous formulation, he emphasized: "It is not enough to change the world, we do this anyway. And it mostly happens without our efforts, regardless. What we have to do is to interpret these changes so we in turn can change the changes, so that the world doesn't go on changing without us—and does not ultimately become a world without us" (Anders 2002b [1980], p. 5).

Anders regarded the destruction of Hiroshima as year one of a new era, and as the event that crystallized a newly acquired human capacity for self-destruction. This step into a future continually threatened with its own finality represented for him a radically new context for human action, demanding a new ethics. Anders confronted this changed global reality, and from this point on concentrated his efforts on thinking through the new moral situation and elucidating the relationship between human beings and technology.

Human activity, through its development of technology, had begun to overreach itself in a fatal way. Because human faculties such as emotion, perception, or even the ability to assume responsibility, are relatively circumscribed when compared to the capacity to create new things, human beings are now faced, he says, with a *Promethean discrepancy* between the world of technology and human abilities to visualize it. The divide is primarily attributable both to the accelerated pace of technological development, and to the enormous complexity of the created things and their effects.

In this paradoxical situation, whereby *humans are smaller than themselves*, Anders sees the basic dilemma of the twenty-first century, a dilemma that can only be resolved by a *moral imagination* reconnecting production and visualization, creation and representation.

In his two-volume major work *Die Antiquiertheit des Menschen* (The Obsolescence of Human Beings) (2002a, 2002b), Anders develops the project moral imagination using a specific thing-cognizant approach. Because he realizes that acting has shifted (of course through human action) from the province of humans to the sphere of work and products, and that the created things are not simply neutral means to an end, but in fact represent *incarnated* or *reified actions*, he places the question of morality primarily in the realm of the things themselves. Therefore he is less concerned with listening to the voice of the heart (or examining the social processes of making or use), than with articulating the mute principles of work and the secret maxims of products, and trying to imagine how these embedded precepts are changing human beings and the fabric of daily life. Anders's work constitutes a new form of practical reason that attempts to reconnect modern technology to its human origins. "Have only those things," he formulates as a new categorical imperative, "whose inherent action maxims could become maxims for your own actions" (Anders 2002a [1956], p. 298).

ERNST SCHRAUBE

SEE ALSO *Arendt, Hannah; Atomic Bomb; German Perspectives; Weapons of Mass Destruction.*

BIBLIOGRAPHY

Anders, Günther. (1960). *Franz Kafka*, trans. A. Steer, and A. K. Thorlby. New York: Hillary House. A critical philosophical interpretation of the writings of Franz Kafka; the original German version appeared 1951 under the title "Kafka, pro und contra: die Prozessunterlagen." Munich: Beck.

Anders, Günther. (1962). "Theses for the Atomic Age." *Massachusetts Review* 3: 493–505.

Anders, Günther. (1989 [1962–]). *Burning Conscience: The Case of the Hiroshima Pilot, Claude Eatherly, Told in his Letters to Günther Anders*. New York: Paragon House. An influential dialogue on the moral situation in the atomic age; translated into more than 50 languages. The chapter "Commandments in the Atomic Age" appeared 1972 in *Philosophy and Technology: Readings in the Philosophical Problems of Technology*, eds. Carl Mitchum and Robert Mackey. New York: Free Press.

Anders, Günther. (2002a [1956]). *Die Antiquiertheit des Menschen, Band 1: Über die Seele im Zeitalter der zweiten industriellen Revolution* [The obsolescence of human beings, volume 1: The soul in the age of the second industrial revolution]. Munich: Beck. First volume of Anders's major work. A precise and thoughtful philosophical critique on how modern technologies are changing individual and social life; unfortunately, still not available in English.

Anders, Günther. (2002b [1980]). *Die Antiquiertheit des Menschen, Band 2: Über die Zerstörung des Lebens im Zeitalter der dritten industriellen Revolution* [The obsolescence of human beings, volume 2: The destruction of life in the age of the third industrial revolution]. Munich: Beck. Second volume of Anders's major work; unfortunately, still not available in English.

ANDROIDS

Androids are mechanical, or otherwise artificial, creations in the shape of humans. They have long been a staple of science fiction. From the clockwork persons of myth to Isaac Asimov's humanoid robots, to *Star Wars's* C-3PO, and to Steven Spielberg's *A.I. Artificial Intelligence*, imagined mechanical persons have enabled people to reflect upon what it means to be human.

The real world of androids is substantially more mundane than their appearance in science fiction. Although there exists a long history of clockwork automata and other mechanical imitations of persons, these have never been more than theatrical curiosities. The creation of more ambitious androids has had to await advances in robotics. Until the 1990s, the problems involved in creating a robot that could walk on two legs prevented robots from taking humanoid form. Yet if robotics technology continues to improve, then it seems likely that robots shaped like and perhaps even behaving like human beings will be manufactured within the twenty-first century.

For the purpose of considering the ethical issues they may raise, androids can be divided into three classes: Those that are merely clever imitations of human beings, hypothetical fully-fledged "artificial persons," and—in between—intelligent artifacts whose capacities are insufficient to qualify them as moral persons.

Existing androids are at most clever imitations of people, incapable of thought or independent behavior, and consequently raise a limited range of ethical questions. The use of animatronics in educational and recreational contexts raises questions about the ethics of representation and communication akin to those treated in media ethics. A more interesting set of questions concerns the ethics of human/android relations. Even clever imitations of human beings may be capable of a sufficient range of

Android SDR-3X. Sensory cells beneath its "feet," a camera, and a microphone enable it to walk, talk, and dance. (*© Hashimoto Noboru/Corbis Sygma.*)

responses for people to form relationships with them, which may then be subject to ethical evaluation. That is, people's behavior and attitudes towards such androids may say something important about them. Moreover, the replacement of genuine ethical relations with ersatz relations may be considered ethically problematic. This suggests that some uses of androids—for instance, as substitute friends, caregivers, or lovers—are probably unethical.

Any discussion of the ethical issues surrounding "intelligent" androids is necessarily speculative, as the technology is so far from realization. Yet obvious issues would arise should androids come to possess any degree of sentience. The questions about the ethics of android/human relationships outlined above arise with renewed urgency, because the fact of intelligence on the part of the android widens the scope for these relationships. If androids are capable of suffering, then the question of the moral significance of their pain must be addressed. Once one admits that androids have internal states that are properly described as pain, then it would seem that one should accord this pain the same moral significance as one does the pain of other sentient creatures.

There is also a set of important questions concerning the design and manufacture of such entities. What capacities should they be designed with? What inhibitions should be placed on their behavior? What social and economic roles should they be allowed to play? If androids were to move out of the research laboratory, a set of legal issues would also need to be addressed. Who should be liable for damage caused by an android? What rights, if any, should be possessed by androids? What penalties should be imposed for cruelty to, or for "killing," an android? Ideally, these questions would need to be resolved before such entities are created.

However, the major ethical issue posed by sentient androids concerns the point at which they move from being intelligent artifacts to "artificial persons." That is, when they become worthy of the same moral regard that individuals extend to other (human) people around them. If it is possible to manufacture self-conscious and intelligent androids, then presumably at some point it will be possible to make them as intelligent, or indeed more intelligent, than humans are. It would seem morally arbitrary to deny such entities the same legal and political rights granted human beings.

Importantly, any claim that this point has been reached necessitates a particular set of answers to the questions outlined above. If androids become moral persons then it is not only morally appropriate but required that humans should respond to the death of an android with the same set of moral responses as they do a human person; for instance, with horror, grief, and remorse. This observation alone is enough to suggest that the creation of artificial persons is likely to be more difficult than is sometimes supposed.

ROBERT SPARROW

SEE ALSO *Cyborgs; Robots and Robotics.*

BIBLIOGRAPHY

Brooks, Rodney Allen. (2003). *Robot: The Future of Flesh and Machines*. London: Allen Lane. A popular account of the history and probable future of robots and robotics by a leading robotics researcher.

Menzel, Peter, and Faith D'Aluisio. (2000). *Robo Sapiens: Evolution of a New Species*. Cambridge, MA: The MIT Press. A survey of the state of robotics research at the

beginning of the twenty first century in the form of a photoessay and set of interviews with researchers around the world.

ANGLO-CATHOLIC CULTURAL CRITICISM

The terms *Anglo-Catholic* and *Anglo-Catholicism* are broad descriptions of people, groups, ideas, and practices that emphasize those dogmatic and sacramental aspects of the Church of England that promote continuity with Catholic tradition. Anglo-Catholicism formally began in 1833 with the *Oxford Movement* reaction to extreme liberal and conservative innovations of the Church of England, as argued most prominently in *Tracts for the Times,* eighty-eight pamphlets issued in five bound volumes (1834–1840), written by John Henry Newman, Edward B. Pusey, John Keble, and several others. Following is a brief discussion of several selected forerunners and heirs of Anglo-Catholicism, all who were and are important critics and interpreters of the culture of science in their time.

Jonathan Swift (1667–1745) was one of the keenest satirists and greatest masters of prose style that English literature has produced. His most famous work, *Gulliver's Travels* (1726), was a bitter satire of the politics and social attitudes of his day, and in Part One, "A Voyage to Lilliput," he satirized abstract science or technology. He was not opposed to science and scientific experimentation if it was benevolent, but he warned about putting too much faith in science, as he lived in an age when much that passed for science was pseudoscience, perpetrated by impostors. He was before his time in realizing that science could be put to evil as well as good use. Swift often painted science in a good light in *Gulliver's Travels,* as when Gulliver studies "Physick" at a renowned medical school, when he enthusiastically reports the scientific discoveries he encounters, and when he gives word of the discovery of the two moons of Mars by Laputan observers, 150 years before they were actually discovered in 1877. His attitude was in contrast to many critics of his day, who saw science as promoting intellectual arrogance which could lead a person away from God, and as a philosophy which would likely end in pure materialism.

John Henry Newman (1801–1890) was the Anglican, later Roman Catholic, theologian and churchman who was one of the chief founders of the Oxford Movement. Newman's views about the science of his day were decidedly pessimistic. He avoided the meeting of the British Academy for the Advancement of Science in 1832 because of its interests in theology, and also shunned later meetings of the British Association. He suggested that a person with simple faith had an advantage over an academic or scientist, particularly if the latter did not temper their empirical observations with proper moral quality and regard for faith. In *An Essay in Aid of a Grammar of Assent* (1870), Newman called attention to the faulty psychological presumptions of many scientific claims, with a specific reference to the search for extra-terrestrial intelligence. In *Letters and Diaries* (published posthumously in 1961), he voiced his indignation toward scientists who gave public talks on subjects other than their own.

Gilbert Keith Chesterton (1874–1936) was a convert to Roman Catholicism, social critic, Christian apologist, novelist, and popular speaker. As an apologist for the Catholic Church, Chesterton believed the Church to be a living institution, a meeting place for all truth, including science. But he was opposed to *scientism,* naturalistic science that left no room for metaphysical truth. The popularizers of science in his day (Thomas H. Huxley, H. G. Wells, and others) attacked religion openly, and statements about science as a new religion had become common in intellectual circles. Chesterton pointed out in such works as *All Things Considered* (1908) that scientists, in claiming to have no room for ultimate authority, violated their own rational-empirical methods by making dogmatic pronouncements about religion and God based solely on their own authority. He was critical of evolutionary theory in works like *Orthodoxy* (1908), and *The Everlasting Man* (1925), and reserved some of his harshest words for eugenics (*What's Wrong With the World* [1910]), declaring it would primarily be used to oppress the poor.

Dorothy L. Sayers (1893–1957) was a noted Christian apologist, Dantean scholar, playwright, and detective novelist. Her most original work was *The Mind of the Maker* (1941), in which she examined the creative instinct in human beings and speculated that the capacity to create was a human quality that mirrored the character of God. In that work and in *Begin Here* (1940), Sayers used Trinitarian analogy in describing the human soul. Theology interprets God in nature, humanity, and Christ; philosophy strives to understand humanity and its place in the universe; and science attempts to understand nature and how it should function. She saw science primarily as the study of means and instruments, and believed it could not deal with ultimate values. For Sayers, a Christian humanist, science was one part of the human soul, and it was God who created its possibility. Her creative thought was a synthesis of empiricism, reason, and revelation, all placed in the human spirit by God.

E. F. Schumacher (1911–1977) was born in Germany and was a Rhodes scholar at Oxford in the 1930s. From 1950 to 1970 he was an advisor to the British Coal Board, and his foresighted planning (he predicted the rise of the Organization of the Petroleum Exporting Countries [OPEC] and the problems of nuclear power) assisted Britain in its economic recovery from the war. A Roman Catholic convert, Schumacher's most famous work was *Small is Beautiful: Economics as if People Mattered* (1973), a blending of Christian principles and eastern belief systems (including those of Gandhi and Buddhism) that suggested for him an alternative to rampant accumulation and technology. He had the rare gift of being able to combine sound thinking with pragmatic common sense, and recognized that commitment to technology needed ethics to help give it balance in human affairs, as it had no natural controls or self-limitations. He understood the problem of expensive technology for underdeveloped nations, and proposed for them *intermediate* technology that was less efficient but employed more people and could be incorporated more easily into a poor culture. *A Guide for the Perplexed* (1977) extended his argument. Schumacher spent most of the latter part of his life teaching intermediacy and urging wealthy nations to share scientific advances and new technologies with less fortunate countries. His vision of intermediate technology and economics influenced the alternative technology movement in the developed countries and flourishes in the early twenty-first century in several countries in Africa and Asia.

E. L. Mascall (1905–1993) was a mathematically trained Anglican priest and for many years Lecturer at Christ Church, Oxford, and Professor of Historical Theology at King's College, London. Mascall argued in his *The Openness of Being* (1971) that the natural world reveals the presence of God, who is creator and sustainer. In this and other works such as *Christian Theology and Natural Science* (1956), he contended that the scientist should consider the idea that one does not start with the world and end up with God, but that God and the world can be perceived together in reality. In *The Secularization of Christianity* (1966), he praised those who argued that Christianity and science are compatible, and that scientific achievement only made sense when combined with a study of Christian doctrine. In *The Christian Universe* (1966), he deplored the decay of belief in God in his time, and urged his readers to see their vast world in light of the great creeds of Christendom.

John Polkinghorne (b. 1930) was Professor of Mathematical Physics at Cambridge and President of Queen's College, Cambridge until his retirement in 1997. A significant contributor in the dialogue between science and religion, his autobiography, *The Faith of a Physicist* (1994), was a best-seller. Polkinghorne is a rare combination of a working scientist and Christian apologist. In several of his works, including *The Way the World Is* (1983), and *Belief in God in an Age of Science* (1998), he initiates a place for natural theology (knowing God through reason and experience alone) in apologetics and theology. For Polkinghorne, natural theology is perhaps the crucial connection between the world of science and religion, and he asserts that one of the most important achievements of modern science has been its demonstration of a natural balance and ordering of the world. This leads him to ask in several of his works, where the balance and ordering of the world comes from.

PERRY C. BRAMLETT

SEE ALSO *Christian Perspectives: Historical Traditions; Lewis, C. S.; Tolkien, J. R. R.*

BIBLIOGRAPHY

Allitt, Patrick. (1997). *Catholic Converts: British and American Intellectuals Turn to Rome*. Ithaca, NY: Cornell University Press.

Barbour, Ian G. (2000). *When Science Meets Religion*. San Francisco: HarperSanFrancisco.

Chesterton, G. K. (1908). *All Things Considered*. London: Meuthen.

Chesterton, G. K. (1908). *Orthodoxy*. London: John Lane, the Bodley Head.

Chesterton, G. K. (1910). *What's Wrong with the World*. London: Cassell.

Chesterton, G. K. (1925). *The Everlasting Man*. London: Hodder & Stoughton.

Ferngren, Gary B., ed. (2002). *Science and Religion: A Historical Perspective*. Baltimore, MD: Johns Hopkins University Press.

Fox, Nichols. (2002). *Against the Machine: The Hidden Luddite Tradition in Literature, Art, and Individual Lives*. Washington, DC: Island Press.

Jaki, Stanley L. (1986). *Chesterton, A Seer of Science*. Urbana: University of Illinois Press.

Jaki, Stanley L. (2000). *Newman's Challenge*. Grand Rapids, MI: Eerdmans.

Lindberg, David C., and Ronald L. Numbers, eds. (1986). *God & Nature: Historical Essays on the Encounter between Christianity and Science*. Berkeley: University of California Press.

Mascall, E. L. (1956). *Christian Theology and Natural Science*. London: Longmans, Green & Co.

Mascall, E. L. (1966). *The Christian Universe*. New York: Morehouse-Barlow.

Mascall, E. L. (1966). *The Secularization of Christianity*. New York: Holt, Rinehart & Winston.

Mascall, E. L. (1971). *The Openness of Being: Natural Theology Today*. Philadelphia: Westminster Press.

McGrath, Alister E. (1999). *Science & Religion: An Introduction*. Oxford, England: Blackwell.

Newman, John Henry. (1870). *An Essay in Aid of a Grammar of Assent*. London: Burns, Oates.

Newman, John Henry. (1975). *The Letters and Diaries of John Henry Newman, Volume XXXVIII*. Oxford: Oxford University Press.

Newman, John Henry, et al. (1840). *Tracts for the Times*. Oxford: J. H. Parker.

Pearce, Joseph. (1999). *Literary Converts: Spiritual Inspiration in an Age of Unbelief*. San Francisco: Ignatius Press.

Polkinghorne, John. (1983). *The Way the World Is*. Grand Rapids, MI: Eerdmans.

Polkinghorne, John. (1998). *Belief in God in an Age of Science*. New Haven: Yale University Press.

Sayers, Dorothy L. (1940). *Begin Here*. London: Victor Gollancz.

Sayers, Dorothy L. (1941). *The Mind of the Maker*. New York: Harcourt, Brace, and Co.

Schumacher, E. F. (1973). *Small Is Beautiful: Economics As If People Mattered*. New York: Harper & Row.

Schumacher, E. F. (1977). *A Guide for the Perplexed*. New York: Harper & Row.

Swift, Jonathan. (1984). *Gulliver's Travels and Other Writings*. New York: Bantam.

Westfall, Richard S. (1973). *Science and Religion in Seventeenth-Century England*. Ann Arbor: The University Of Michigan Press.

ANIMAL EXPERIMENTATION

The use of animals in medical and other research has been a staple of modern scientific progress. In the early twenty-first century, biomedical research in the United States involves the use of several million animal subjects (mostly rodents) each year. With the rise of biotechnology and the techniques of genetic modification, the scientific use of animals will continue in novel forms. There are questions, however, about the reliability of information gained from animal experimentation, and whether it is morally defensible to exploit animals for the sake of scientific knowledge.

History

While animal experimentation might be thought of as a thoroughly modern practice, humans have been learning from animals since prehistory. Early human hunters' knowledge of the natural world was likely formed by their awareness of the life cycles and migration patterns of prey species. Prehistoric understanding of anatomy and physiology was no doubt the by-product of butchering animals for food. In classical antiquity, scientifically sophisticated knowledge of animal physiology emerged, indicating that the dissection of animals for the purpose of gaining such knowledge had begun. By the Roman era, dissection and vivisection (the dissection of live animals) were established scientific practices. Like much empirical science, these practices were squelched during the Middle Ages, only to reappear during the Renaissance.

By the seventeenth century, when William Harvey (1578–1657) revolutionized physiology, he and his colleagues relied almost exclusively on knowledge gathered from experiments on animals. Throughout the modern era, each subsequent advance in medical knowledge—the germ theory of disease, vaccinations, nutritional chemistry, surgery performed with anesthesia—was made possible by using animal subjects. In the early twenty-first century, virtually all medical therapies—drugs, vaccines, surgical techniques, prosthetics—are developed with the aid of animal subjects, and animal models play a significant role in psychological research. In the United States, the Food and Drug Administration (FDA) requires that all new medicines undergo animal testing to demonstrate safety before they are tested on humans. Other governmental agencies require that the safety and environmental impact of various consumer products be assayed, and, while not a legal requirement, manufacturers frequently rely on animal subjects to do so.

Given the omnipresence of medical and other technological goods to which animal experimentation has contributed, it is questionable whether moral objections to the practice can be consistently maintained in the modern world. For example, the animal rights theorist Tom Regan, in a paper delivered in May 2005, has raised the issue of whether respect for animals requires that one refuse all medical treatments that have been tested on animals, and thus whether animal advocates who continue to avail themselves of modern medicine are guilty of hypocrisy. Nonetheless, modern animal experimentation has been dogged by moral opposition throughout its history. Beginning in 1824, when the Royal Society for the Prevention of Cruelty to Animals was formed in England, many organizations rose to resist vivisection and other practices that inflict pain and take animal lives. This type of animal advocacy is continued in the early twenty-first century by People for the Ethical Treatment of Animals (PETA) and other international associations. Founded in 1980, PETA's early efforts in the United States led to the first successful criminal prosecution (later reversed on appeal) of a medical researcher on charges of animal cruelty.

The moral core of the opposition to animal experimentation is often overshadowed by the aggressive actions of extremist groups such as the Animal Liberation Front (formed during the 1970s in England by hunt saboteurs), whose members have been responsible for vandalizing animal research facilities and threatening violence against researchers who use animals. Nevertheless, moral concern for animals has also inspired the body of law under which animal experimentation is currently conducted. In the United States, the legal control of animal experimentation began in 1966 with the Animal Welfare Act. Animal research is regulated by the U.S. Department of Agriculture and the Department of Health and Human Services. These agencies require that research facilities establish institutional animal care and use committees (IACUCs) to evaluate the merits of research involving animals and monitor the treatment of experimental subjects.

Challenges

While most opposition to animal experimentation is based on moral considerations, some have also raised epistemological objections. Chief among these is the problem of species extrapolation. Because the relationship between an organism's higher functions and their underlying biology is very complex, it is impossible to predict with certainty how an agent will affect humans based on experiments done with other species. Detractors need only point to headlines from the early 2000s for examples of medicines that fared well during animal studies, but then produced problematic results when used widely on human patients. Proponents of animal testing acknowledge that identifying the animal species whose biology is most appropriate to a specific experiment is a daunting task, but it is not impossible. The number of instances in which failed species extrapolation led to significant harm to human patients is small when compared to the successes, proving that many biological analogies between humans and animals are sound.

This defense of the epistemological foundations of animal research has nevertheless provided the theoretical foundation for much of its moral criticism: If animals are sufficiently similar to humans to justify experimenting on them, it is likely that they also possess a degree of morally relevant attributes sufficient to render the experiments problematic. The point is especially significant for research involving primates. Opponents argue that if primates or other animals possess pain perception, emotional complexity, intelligence, or subjectivity comparable to that of humans, then at a minimum researchers are morally obligated to limit the impact their experiments have on animal subjects. Those who advocate the strong animal rights position argue for the abolition of animal research, even when the pains experienced by the subjects might reasonably be outweighed by gains in human well-being. Others stop short of rejecting all animal experiments, but rather draw attention to research that is redundant, poorly designed, or of dubious merit, or that inflicts a great deal of suffering.

In addition to the treatment that individual animals receive during the course of research, some have raised concerns about the commodification of life-forms that the acquisition of experimental subjects entails. Almost all laboratory animals are now "purpose bred" to make them compliant with the experimental conditions to which they will be subjected, and to ensure consistent data; thus, these living beings are essentially technological products, brought into existence for the purpose of their scientific use. The point is inarguable in the case of experimental subjects produced by means of genetic modification. In the most famous example, researchers at Harvard University developed through genetic modification a breed of mouse (dubbed the "OncoMouse™") with a disposition to develop cancer. Not only did the case raise the question of whether it is ethical to intentionally bring such genetically defective beings into existence, fundamental moral and legal issues were also raised by the researchers' efforts to patent the mice produced through their technique.

While the traditional defense against moral objections to animal research was to deny that animals possess the capacity for morally relevant experiences, that is a position seldom heard anymore. Indeed, many researchers speak in solemn terms about the sacrifices their animal subjects are forced to make; some Western research facilities have adopted a custom developed by Japanese scientists, who hold memorial observances for the animals they have used. Others admit to struggling with their natural inclination to empathize with the creatures they use (a fact that makes distancing techniques—such as limiting personal contact with animal subjects and assigning them numbers rather than names—part of standard laboratory practice). Nonetheless, some proponents make the argument that it is simply a misnomer to apply humankind's strongest moral categories (such as rights) to animals, which lack the capacities of rational self-awareness and moral autonomy that make human life so valuable. This point is buttressed by the clear benefits animal experimentation has brought: It is difficult to appreciate how much progress has been made in the treatment of human disease and the alleviation of human suffering, and how necessary the use of animals has been to this rate of progress. While opponents cite the availability of alternatives to animal research—such as tissue tests, computer models, epidemiological studies, and research involving human volunteers—proponents respond that they are not viable for all research situations, and that relying on them might lead to significant delays in gaining valuable medical knowledge. Given the health crises humankind still faces and the potentially great benefits to human well-being, many proponents argue that animal experimentation is not only defensible, but morally obligatory.

Despite the often heated controversy, a consensus ethic for animal research (the 3Rs approach) is beginning to emerge, with support among both animal advocates and proponents of scientific progress. It holds that researchers have a duty to *refine* experiments that use animals to ensure that the impact on them is proportionate to the potential benefits of the research; to *reduce* the number of animals sacrificed to the minimum that is statistically necessary to obtain the desired data; and, when possible, to *replace* research that uses mammals with nonmammalian or nonanimal alternatives.

MARC R. FELLENZ

SEE ALSO *Animal Rights; Animal Welfare.*

BIBLIOGRAPHY

Haraway, Donna J. (1997). *Modest_Witness@Second_Millennium.FemaleMan©Meets_OncoMouse™*. New York: Routledge. Explores the broad ramifications of the melding of technology and science embodied in the genetically modified laboratory animal.

LaFollette, Hugh, and Niall Shanks. (1996). *Brute Science: Dilemmas of Animal Experimentation*. London: Routledge. An analysis of the epistemological difficulties of animal experimentation, and their link to the moral case against using animals.

Langley, Gill, ed. (1989). *Animal Experimentation: The Consensus Changes*. New York: Chapman and Hall. Collection of essays by scientists and philosophers exploring the epistemological and moral objections to animal experimentation.

Paul, Elizabeth S. (1995). "Us and Them: Scientists' and Animal Rights Campaigners' Views of the Animal Experimentation Debate." *Society and Animals: Journal of Human–Animal Studies* 3(1): 1–21. An analysis of the human psychology of animal experimentation, involving a survey of attitudes on the part of both animal rights advocates and researchers who experiment on animals.

Paul, Ellen Frankel, and Jeffrey Paul. (2001). *Why Animal Experimentation Matters: The Use of Animals in Medical Research*. New Brunswick, NJ: Transaction Publishers. Collection of essays by biomedical researchers, social scientists, and philosophers responding to the strong animal rights objection to animal experimentation.

Regan, Tom. (2004). *The Case for Animal Rights*, 2nd edition. Berkeley and Los Angeles: University of California Press. The clearest articulation of the strong animal rights position.

ANIMAL RIGHTS

It is only recently, and in response to their perceived mistreatment by humans, especially in processes of industrial agricultural production and scientific research, that rights have been ascribed to animals. The concept remains contentious, especially insofar as in radical forms it would severely restrict the use of animals in scientific research and elsewhere, but has been defended on a number of grounds.

Historical Developments

The debate over whether animals possess rights must be viewed against the background of the ubiquitous use of animals to meet human needs and desires throughout history. Although interpreted in various ways, the status of animals is a significant economic and cultural category in every human society. Because the human connection to animals runs so deep, our shared history may amount to a form of coevolution: The selective breeding of domestic species has rendered them substantially different from their wild counterparts, and the effects of domestication on human social evolution have been profound, perhaps defining. At a minimum, because the benefits of this relationship are mutual (although rarely equal), domestication invites comparison to symbiosis.

However, because of the uniquely powerful effect of this symbiotic relationship, technological models contribute to the understanding of domestication. The environmental ethicist J. Baird Callicott (1980) argues that domesticated animals are essentially human inventions and should be viewed as technologies in their own right, to be evaluated in terms of their environmental impact. To a very different effect, the critic Donna J. Haraway (2003) uses the image of the cyborg to capture the complex layers of culture, nature, and technology that define both human and animal reality. This complexity is not limited to the special cases of genetically modified lab mice and artificial heart recipients: Haraway argues that humans and the "companion species" they have bred to work and live with them are equally significant others in an ecosystem that straddles the technological and the biological.

This multilayered, ambiguous relationship between humans and animals has both insulated animal exploitation from moral assessment, and made the assessment maddeningly complex. Any complacency over the possible rights of animals has been shaken over the last three centuries in light of some of the troubling effects of industrialization, including the physical and psychological pressures placed on domesticated animals in technologically intensive economies, and threats to the very survival of wild animal species. It is no coincidence that arguments on behalf of the moral claims of animals have risen in proportion to the distance that industrialization has placed between humans and the natural world.

The idea that animals deserve moral attention is not exclusively modern, however, but has been explored throughout European intellectual history; Pythagoras and Porphyry provided early philosophical arguments that using animals for food is morally problematic. Nonetheless, much of the tradition followed Aristotle in rejecting such arguments. His contention that nonhuman animals categorically lack reason and intellect was used for centuries to justify a moral divide between humans and animals: Irrational animals are natural slaves, and no positive human moral or political categories can govern humankind's relations with them.

Because it harmonized with the Judeo-Christian contention that God gave humans dominion over animals, this model of human/animal relations held sway through much of medieval Christendom. Despite the force of this tradition, a vocal minority argued that Western monotheism can and should accommodate moral concern for animals. (A contemporary example is Andrew Linzey (1994), who argues that animals possess *theos-rights*, and are owed justice simply in virtue of being creatures of the Creator.) This is noteworthy because the roots of the modern analysis of animal rights precede the Industrial Revolution, beginning in England with a sixteenth-century theological debate over whether animals are restored through the Incarnation. This debate expanded over the centuries that followed, inducing various English theologians, literary figures, political scholars, and philosophers to offer new analyses of the moral status of animals.

The result of these efforts was a sustained attempt to rethink the traditional Aristotelian position, and an intellectual climate ripe for the concept of animal rights. By the nineteenth century, the first animal advocacy groups were formed to speak out against the abuse of draft animals and to oppose vivisection, and the first modern legal protections of animals were established.

Basic Theories

The philosophical development in this period that had the greatest influence on subsequent discussion of animal rights is the advent of utilitarianism. Unlike other ethical theories that argue moral goods are the exclusive products of humans' rational nature, the early utilitarians held that the highest moral good is the happiness that results from maximizing pleasure and minimizing pain. Given the legacy of Aristotle, the claim that nonhumans possess anything comparable to the higher cognitive faculties of humans is unavoidably controversial; in comparison, the claim that animals seek comfort and shun suffering is an easy sell. Thus animal advocates found in utilitarianism a fitting ethical theory to make their case. As Jeremy Bentham (1748–1832), the father of utilitarianism, famously asserted, "The day *may* come, when the rest of the animal creation may acquire those rights which never could have been withholden from them but by the hand of tyranny. . . . [T]he question is not, Can they *reason?* nor, Can they *talk?* but, Can they *suffer?*"(Principles of Morals and Legislation, Chapter 17 1789).

Despite these bold words, Bentham was unopposed to using animals in science and agriculture. It would fall to later thinkers to argue that utilitarianism should force us to rethink these institutions. The most important figure to do so is the Australian philosopher Peter Singer, whose *Animal Liberation*, originally published in 1975, inspired much of the subsequent attention the issue has received. Making use of graphic depictions of how livestock are treated in intensive feeding operations, and the painful effects of product testing and medical and psychological research on primates and other mammals, Singer argues that the equal consideration of a sentient animal's interest in avoiding suffering renders these common practices seriously immoral. To defend this conclusion, he offers the following analogy: Racism and sexism are immoral positions because they give undue importance to the morally irrelevant properties of race and gender; likewise, those who fail to extend moral consideration to other animals simply because of their species membership are guilty of a heretofore unrecognized offense: *speciesism*. Because modern science and industry routinely exploit animals in ways we would be loath to treat humans of comparable sentience (such as those with severe mental impairment), there are few citizens of modern industrialized societies whose lives are unaffected by speciesist practices.

While Singer's argument is the most famous in the contemporary debates, he makes clear that his conclusions do not hinge on the concept of animal rights per se, of which he is dubious. Those who try to make the explicit case for rights have generally followed Singer's lead by attempting to extend moral concepts traditionally reserved for humans to cover our treatment of animals as well. Callicott has termed this general approach *extensionism*. For example, Aristotelian ethics holds that the moral good for humans (virtue) is related to our *final cause*, the natural end or function that defines us (rationality). Bernard E. Rollin (1992) argues that this model can be extended to provide the basis for a theory of animal rights: He claims that moral concepts apply to our treatment of animals not simply because they can experience pleasure and pain, but because they, like us, have natural ends or functions that they have an interest in fulfilling. He concludes the most effective way of solidifying this concern is the establishment of legal and political rights for animals. Mark Rowlands (1998) forms an analogous argument to those of Singer and Rollin by extending social contract theory to articulate the rights of animals.

Some extensionists and many laypersons use the term *animal rights* as shorthand for the moral consideration humans owe animals, but they do not all envision the moral claims of animals as fully comparable to the natural rights that modern liberalism has ascribed to humans. Such a vision has been articulated by Tom Regan (2004). Rejecting the utilitarianism of Singer, Regan's argument extends the deontological theory of Immanuel Kant (1724–1804), which holds that all humans have an inherent right to moral respect in virtue of their rational nature. Regan argues that it is arbitrary to limit such respect to those who possess rationality; many humans cannot be described as fully rational, yet we do not therefore subject them to painful experiments or use them for food. Regan argues that all animals to which we can ascribe preferences qualify as *subjects of a life;* he claims this will include most mature mammals. All such beings, he concludes, have an *inherent* value that grounds natural rights to life and autonomy comparable to those of humans.

Critical Assessment

If any of these extensionist arguments are sound, it will require serious reappraisal of the place of domestic animals in society, and of human behavior toward wild animals. In its strongest forms, the claim that animals have rights implies that all forms of animal exploitation are seriously immoral: Vegetarianism is morally obligatory, all animal testing should be proscribed, and wild animals have a right to be left free of all human interference. At a minimum, granting that animals have some claim to direct moral attention would not only allow us to condemn overt acts of animal cruelty, but also raise serious doubts about the use of intensive industrial techniques in animal husbandry (factory farming), the use of animals to test medical technologies from which they will not benefit, and the genetic modification of animals to enhance their usefulness to humans. Although it is not clear where the moral limits to animal exploitation lie, there is a growing consensus that such limits do exist and that it is important that they be clarified.

But is the case for animal rights sound? Critics fall into two camps. First, those who uphold the traditional position argue that extending rights theory to animals goes too far. The category of rights emerged for the kinds of beings that only humans are: free, rational, autonomous agents who can form agreements, respect each other's interests, and operate politically. These critics argue that to apply the concept of rights to animals that do not have these attributes is to extend it beyond coherence. For some in this camp, the ground of their objections is metaethical: Their concern is the nature of moral language and whether it can have any meaning when extended to nonhumans. Others dispute the empirical bases of extensionist arguments, namely that animals possess psychological attributes—consciousness, capacity to suffer, subjectivity, personhood—that are morally relevant. Because the sciences of ethology, animal psychology, and animal welfare are relatively young, there is at present no consensus on which animals possess such attributes, or whether any nonhumans possess them to a degree that is morally significant. Thus, the status of debate on this point is ambiguous: Extensionists can muster enough empirical evidence to give their conclusions some rational support, but not enough to prove that the traditional position is unsustainable.

Second, other critics have argued that the concept of animal rights does not go far enough in expressing the value that animals possess and the challenge that it poses to humans. Some environmental ethicists (including deep ecologists and ecofeminists) have argued that because our moral categories are purely human creations, products of the same cultural tradition that sanctioned animal exploitation for millennia, they cannot simply be *extended* to cover animals, but must be radically rethought. Extensionism implies that animals are valuable to the extent that they can be assimilated to human moral reasoning, but there is another, more radical possibility: that animals should be valued for their differences from humans, and for those aspects of animal reality that lie beyond the reach of the traditional moral and political categories of humankind. Perhaps respecting animals is not simply a matter of protecting them from the effects of humankind's dependence on technology; by inviting us to appreciate the type of reality they occupy, a space where both technological and moral devices are unnecessary, animals may help us develop a critical perspective on the ends of human civilization.

MARC R. FELLENZ

SEE ALSO *Agricultural Ethics; Animal Experimentation; Animal Welfare; Consequentialism; Deontology; Pets.*

BIBLIOGRAPHY

Callicott, J. Baird. (1980). "Animal Liberation: A Triangular Affair." *Environmental Ethics* 2(4). Offers a criticism of animal rights arguments from the perspective of environmental ethics.

Cohen, Carl, and Tom Regan. (2001). *The Animal Rights Debate.* Lanham, MD: Rowman and Littlefield. A clear synopsis of the core arguments on both sides of the animal rights debate.

Fellenz, Marc R. (2006). *The Moral Menagerie: Philosophy and Animal Rights.* Urbana: University of Illinois Press. Surveys and assesses major arguments in the contemporary debate, and analyzes the importance of the debate for philosophy.

Haraway, Donna J. (2003). *The Companion Species Manifesto: Dogs, People and Significant Otherness.* Chicago: Prickly Paradigm Press.

Linzey, Andrew. (1994). *Animal Theology.* Champaign: University of Illinois Press. Develops the case for animal rights in the context of Christian theology.

Linzey, Andrew, and Dorothy Yamamoto, eds. (1998). *Animals on the Agenda: Questions about Animals for Theology and Ethics.* Urbana: University of Illinois Press. Essays by various authors exploring the implications of animal rights for ethics, theology, and human culture.

Miller, Harlan B., and William H. Williams, eds. (1983). *Ethics and Animals.* Clifton, NJ: Humana Press. A valuable selection of philosophically sophisticated essays on the possible rights of animals, the meaning of human/animal relations, and various forms of animal exploitation.

Regan, Tom. (2004). *The Case for Animal Rights,* 2nd edition. Berkeley and Los Angeles: University of California Press. The clearest articulation of the strong animal rights position.

Rollin, Bernard E. (1992). *Animal Rights and Human Morality,* rev. edition. Buffalo, NY: Prometheus Books. Argues that the telic nature of animals requires any adequate moral theory to address their interests, and makes the case for the legal rights of animals.

Rowland, Mark. (1998). *Animal Rights: A Philosophical Defence.* St. Martin's Press. Uses contract theory as the basis for understanding the rights of animals.

Singer, Peter. (1990). *Animal Liberation,* 2nd edition. New York: Random House. The foundational work of the recent debate (originally published in 1975), provides details on the nature of modern animal exploitation, and argues that the failure to give equal consideration to the interests of animals is as morally suspect as racism and sexism.

ANIMAL TOOLS

"Tools maketh man," so said Kenneth Oakley, the prehistorian. He meant that only human beings make tools of flaked stone. More generally, many species of animals make and use tools, both in nature and in natural captivity, from wasps to finches to apes, but many more do not. Few species have *tool kits* (repertoires of different types of tool for different purposes) or *tool sets* (two or more kinds of tools used in series to perform a task). Making sense of such behavioral variation is a challenge to scientists.

Tools

Definitions of tools vary (Beck 1980). In this entry, the following is used: a detached inanimate object used by a living creature to achieve a goal, typically to alter the state or position of another object. This includes constructing a nest, but not reclining on a bough, and cracking a snail with a stone but not with the teeth. It excludes glaciers moving stones across landscapes, but includes sea otters retrieving stones from the seabed. If these actions entail modifying the object so that is it more effective, then tool using becomes toolmaking. Tools can also be classed by function: subsistence (digging stick), social life (weapon), or self maintenance (napkin), or by mode of action: percussion (nut cracking), probe (termite fishing), barrier (leaf umbrella), and more.

For as long as scientists have paid attention to animal tool use, two vertebrate classes, birds and mammals, have predominated. Some examples are classic. California sea otters crack open mollusks on anvil stones balanced on their chests as they float on their backs (but their Alaskan cousins do not). Beavers fell trees and shrubs to construct dams and lodges that transform landscapes and watersheds. Woodpecker finches of the Galapagos Islands detach twigs or spines and use them to probe and to extract insects from cavities in woody vegetation. More magnificently, bowerbirds in Australia and New Guinea build and decorate complex structures and arenas. These edifices, which range from walls to spires, are not nests for residence or rearing young, but instead serve as advertisements by males to court females.

All of these examples of tool use vary across populations within a species or across individuals within populations. In many cases, they are *one-trick ponies*, that is, single, specialized adaptations: Sea otters in Monterey Bay that use anvil stones do not engage in any other type of tool use. The prize toolmaker among birds is probably the Caledonian crow of the south Pacific island of New Caledonia, which uses three types of tool in extractions foraging. By comparing twenty-one populations, scientists determined that tools have diversified over time and across space.

Some creatures with large brains (and so presumed high intelligence) even manage tool use without grasping appendages. The bottle-nosed dolphins of Shark Bay in western Australia carry sponges on their noses. Apparently they use these to root out prey from the sea floor, with the sponge serving as a *glove* to protect the rostra from abrasion.

Of the orders of mammals, the primates are the main tool users, especially the great apes (McGrew 1992). Apart from them, it is the capuchin monkeys of Central and South America that are best known for their tool behavior. Their use of wood or stone anvils to smash open hard-shelled fruits is widespread in rainforests. In harsher habitats, capuchin monkeys are even more enterprising: In the dry open country scrublands of Brazil, they use stones as hammers to crack nuts on anvils, and even as trowels to dig up tubers.

Of the four species of great apes (bonobo, chimpanzee, gorilla, and orangutan), there is surprising variety in nature despite the fact that in captivity, all show similar levels of intelligence. Wild gorillas, whether in lowland forest or on alpine slopes, exhibit no tool use. Similarly bonobos show little, apart from occasional use of leaves as rain shelters or felled saplings in branch-dragging displays; notably absent in these apes from the Democratic Republic of Congo is any tool use in foraging. Orangutans, in some high-density wild populations in Sumatra, are accomplished arboreal tool users, but their special feature is oral tool use, presumably because their hands are needed for support in the forest canopy. Using skillful movements of lips and teeth, tools of vegetation are used to process fruits with stinging hairs and to extract insects from rotten wood.

The champion tool user and maker of the animal kingdom is the chimpanzee, seen in captivity for more than eighty years from the experiments of Wolfgang Köhler and for more than forty years from the field observations of Jane Goodall. More than fifty populations of these wild apes across eastern, central, and western Africa are known to use tools (McGrew 2004). These include flexible probes made of vegetation to fish out termites from underground nests or ants from the cavities in trees, hammers of stone or wood to crack open nuts on anvils of root or stone, pestles of palm frond to smash the mortared heart of palm, crumpled leaves to sponge out water from tree holes, and leaves to wipe off bodily fluids in personal hygiene. Tools are transported from worksite to worksite, and sometimes are made in advance of use or kept to be used again. Termite fishing has been followed through four generations of chimpanzees at Gombe National Park in Tanzania. There are limits, however: No wild chimpanzee has yet been shown to purposefully modify stone for use as a tool, nor to use one tool to make another.

Technology

When the use of tools increases efficiency or convenience, or reduces risk, or opens up new ways to exploit resources, old or new, this knowledge is termed technology. As such, when time or energy is saved, or tasks are made easier or more comfortable, or danger to life or limb is lessened, or innovations yield new payoffs, however elementary, these may be thought of as the basis of material culture. When such techniques are invented and passed on by socially mediated processes of transmission, they come to approximate what in humans is called culture. Transmission within a generation is called horizontal; transmission passed down from one generation to the next is called vertical. The latter is termed tradition. This requires some form of social exposure or interaction between knowledgeable and naïve individuals, which may range from passive observational learning to active teaching. It takes careful experimentation to establish which mechanisms of transmission of knowledge are present, but in the end, what matters most is what technological transfer occurs, not how it gets done.

All known examples of technology in animals, as defined here, come from great apes. Often the first clue comes from observed behavioral diversity in wild populations (Whiten et al. 1999). The chimpanzees of Mahale ignore the fruits of the oil palm; those at Gombe eat the outer husk only and without tools; those at Tai crack open the nuts to extract the kernel; and those at Bossou sometimes modify the orientation of the anvil to make their nut cracking more efficient. The predator (ape) and prey (nut) are the same in all four places; what differs is technical knowledge. Similar cross-cultural differences have been reported for orangutans in Borneo and Sumatra (van Shaik et al. 2003), and bonobos in the Democratic Republic of the Congo (Hohmann and Fruth 2003). Recently studies of technology in animals have extended into the past, with archaeological excavations of chimpanzee nut cracking sites in Ivory Coast. These have yielded fragments of stone, and so give enduring time-depth to nonhuman technology (Mercader et al. 2002).

Are the differences between the elementary technology of nonhuman species and the more complex technology of human ones of degree or kind? This depends on the feature chosen for comparison: Some textbooks state that a key difference is that only humans depend on technology, while for other animals it is somehow optional. The logic is that because all human societies show technology, there must be dependence, but all known wild chimpanzee populations studied in the long term also show technology, so by the same yardstick they too depend on it. On other grounds, there seem to be differences: No known animal technology seems to be imbued with religious or supernatural significance, though it is hard to infer meaning from behavior.

These findings have not only scientific implications for the understanding of humans but ethical implications for the treatment of animals. Animals kept in captivity, but deprived of appropriate objects to manipulate (explore, play, and construct), may lead incomplete or distorted lives. Impoverished of raw materials, they may fail to show species-typical behavior, such as shelter making, or worse, develop abnormal patterns, such as coprophagy. Ecologically valid environmental enrichment means using the findings of field research to provide species-specific contexts for tool use and social settings for technology if animals are confined. This can be done through emulation (seeking to recreate nature, e.g., bamboo plantings) or simulation (seeking to mimic key features of nature, e.g., artificial termite mounds).

WILLIAM C. MCGREW

SEE ALSO *Evolutionary Ethics; Ethology; Sociobiology.*

BIBLIOGRAPHY

Beck, Benjamin B. (1980). *Animal Tool Behavior*. New York: Garland STPM Press. Twenty-five years after publication, this remains the "bible" on animal technology, as a comprehensive review of the literature and theoretical treatise on tool use from insects to apes.

Hohmann, Gottfried, and Barbara Fruth. (2003). "Culture in Bonobos?: Between-Species and Within-Species Variation in Behavior." *Current Anthropology* 44: 563–571.

McGrew, William C. (1992). *Chimpanzee Material Culture: Implications for Human Evolution*. Cambridge, UK: Cambridge University Press. Chimpanzee tool use reviewed and explained in terms of cultural processes as these might shed light on the evolutionary origins of human technology.

McGrew, William C. (2004). *The Cultured Chimpanzee: Reflections on Cultural Primatology*. Updates *Chimpanzee Material Culture* (1992) and expands discussion into related aspects of non-material culture; written in opinionated and accessible style. Cambridge, UK: Cambridge University Press.

Mercader, Julio; Panger, Melissa; and Christophe Boesch. (2002). "Excavation of a Chimpanzee Stone Tool Site in the African Rainforest." *Science* 296: 1452–1455. First attempt to practice archaeology on apes, by excavating stone artifacts from West African chimpanzees' nut-cracking sites.

van Schaik, Carel P.; Ancrenaz, Marc; Borgen, Gwendolyn; et al. (2003). "Orangutan Cultures and the Evolution of Material Culture." *Science* 299: 102–105. Following Whiten et al. (1999), researchers on wild orangutans find behavioral variation across populations of these apes in Borneo and Sumatra.

Whiten, Andrew; Goodall, Jane; McGrew, William C., et al. (1999). "Cultures in Chimpanzees." *Nature* 399: 682–685. Trail-blazing synthesis comparing behavioral diversity in seven populations of wild chimpanzees across Africa.

ANIMAL WELFARE

The concept of animal welfare was essentially unexamined until the 1970s. This is the case because, historically, the major use of animals in society was agriculture—that is, for food, fiber, locomotion, and power. The key to success in animal agriculture, in turn, was good husbandry (Rollin 1995).

The Husbandry Ideal

Husbandry involved putting animals into the best possible environment fitting their biological natures and needs, and then augmenting that environment with the provision by the agriculturalist of food during famine, water during drought, protection from predation, help in birthing, and medical attention. The resulting symbiotic relationships between farmers and their animals represented what has been called "a fair and ancient contract," with both animals and humans better off in the relationship than they would be outside it. Animals benefited from the care provided by humans; humans benefited from the animals' toil, products, and sometimes their lives. Proper animal treatment was assured by human self-interest; if the animals were made to suffer, their productivity was diminished. The only social ethic regarding animal treatment for most of human history was the prohibition of deliberate, sadistic, overt, willful, intentional cruelty, as encoded in anti-cruelty laws, to sanction sadists, psychopaths, and others not motivated by self-interest and likely to abuse humans as well as animals.

Thus animal welfare was not a conceptually problematic notion occasioning much reflection. If the animal was growing, reproducing, giving milk or eggs, or pulling the plow, it was surely enjoying good welfare. So powerful was the husbandry notion, in fact, that when the Psalmist looks for a metaphor for God's ideal relationship to humans, he chooses the shepherd in the Twenty-third Psalm: "The Lord is my shepherd, I shall not want. He leadeth me to green pastures; he maketh me to lie down beside still water; he restoreth my soul." Humans want no more from God than what the good husbandman provides to animals.

From Husbandry to Industrialized Agriculture

Beginning in the 1940s, changes in animal use were catastrophic for animal husbandry. In agriculture, this period saw the rise of the application of industrial methods to the production of animals to greatly increase efficiency and productivity, and academic departments of Animal Husbandry symbolically changed their names to Animal Science. In the industrialized confinement of "factory farming," technoscientific developments such as antibiotics, vaccines, hormones, and air-handling systems allowed human beings to force animals into environments not fitting their natures; these animals continued to be economically productive while their well-being was impaired. Animals thus suffered in four major ways (Rollin 2004).

First, probably the major new source of suffering in confinement agriculture resulted from physical and psychological deprivation for animals in confinement: lack of space, lack of companionship for social animals, inability to move freely, boredom, austerity of environments. Breeding sows, for example, spend their entire productive lives in stalls measuring seven feet by two feet by three feet, so small that the animals cannot turn around or sometimes even stretch out. Because the animals evolved for adaptation to extensive environments but are now placed in truncated environments, such deprivation is inevitably abusive.

Second, in confinement systems, workers may not be "animal smart"; the "intelligence," such as it is, is the mechanized system. Instead of husbandmen, workers in swine factories are minimum wage, often illegal immigrant labor. These workers often have no empathy with, or concern for, the animals. The Biblical shepherds have become detached (and often themselves oppressed) factory assembly-line workers.

Third, the huge scale of industrialized agricultural operations—and the small profit margin per animal—militate against the sort of individual attention that typified much of traditional agriculture. In traditional dairies as late as 1950, one could make a living with a herd of fifty cows. By 2000, one needed literally thousands. In the United States, dairies may have 6,000 cows. In swine operations, sick piglets are sometimes killed, not treated. Agricultural veterinary medicine is far more concerned with "herd health" than with treating sick individuals.

Finally, "production diseases" arise from the new ways animals are produced. For example, liver abscesses in cattle are a function of certain animals' responses to the high-concentrate, low-roughage diet that characterizes feedlot production. Although a certain percentage of the animals get sick and die, the overall economic efficiency of feedlots is maximized by the provision of such a diet. The idea of a method of production creating diseases that were "acceptable" would be anathema to a husbandry agriculturalist.

Thus, in industrialized agriculture, the tie between productivity and welfare was broken. The agriculture community nevertheless continued to insist that if animals were productive, they were well off, despite the fact that welfare applies to individual animals and productivity is an economic measure of an operation as a whole.

The same historical moment also saw the rise of large amounts of animal research and animal testing. This again differed from husbandry in that the animals did not benefit from being in research. Indeed, research deliberately hurt animals, gave them diseases, burns, fractures, and so on, with no compensatory benefit to the animals—although there was undeniable benefit to humans and other animals from the knowledge and therapies produced.

Criticizing Animal Treatment

Since the 1960s, beginning in Great Britain, Western society has become increasingly concerned about animal treatment in agriculture that is industrial, not husbandry-based, and in research and testing. Initially, such uses were seen as "cruel." Yet, as mentioned, the anti-cruelty ethic and laws were designed for deviant behavior, not common uses. In order to rationally capture concern about animal treatment that results from putatively decent motives, such as increasing productivity or studying disease, new conceptual tools were needed. First of all, a new ethic for animal treatment was needed to address suffering not resulting from intentional cruelty. Second, some notion of animal welfare or well-being was needed, given that productivity no longer assured welfare. In both cases, preserving or restoring the fairness inherent in husbandry served as an implicit standard.

Animal-using industries, however, continued to define animal welfare in terms of human goals for the animal. For example, the official agricultural industry response to burgeoning social concern for animal treatment, the Council for Agricultural Science and Technology (CAST) Report of 1981, defined farm animal welfare as follows: "The principle [sic] criteria used thus far as indexes of the welfare of animals in production systems have been rate of growth or production, efficiency of feed use, efficiency of reproduction, mortality and morbidity" (Council for Agricultural Science and Technology 1981).

When dealing with adults and ethics, one does better to remind than teach. New ethical challenges are likely to be answered only by appeal to unnoticed implications of extant ethical principles, rather than by creation of a new ethic *ex nihilo*. Thus the civil rights movement did not invent a new ethic; it rather reminded society that segregation violated basic ethical principles American society took as axiomatic. In the same way, society has looked to the ethic for the treatment of humans to derive an ethic for animals (Rollin 1981).

Specifically, every society faces a conflict between the good of the group and the good of individuals, as when a wealthy person is taxed to support social welfare. In totalitarian societies, the good of the individual is subordinated to the group. Democratic societies, however, build "protective fences" around individuals to protect basic aspects of human nature from being submerged for the general good. These fences protect freedom of speech, freedom of religion, property ownership, privacy, and so on. These are called *rights*, and are a morally-based legal notion. Society has reasoned that if animal use for human benefit is no longer naturally constrained by the need for good husbandry, such proper treatment must be legally imposed. This concept is well-illustrated by the proliferation of laws in Western society to protect animal welfare in research, agriculture, zoos, shows, and elsewhere.

Thus the notion that animals should have rights or legal protections for basic elements of their natures—a notion embraced by more than 80 percent of the U.S. public (*Parents Magazine* 1989)—represents a rational ethical response to the end of husbandry as well as to other factors that have focused social concern on animal treatment. These factors include the urbanization of society and correlative shrinkage in numbers of people making a living from animals; the emergence of companion animals as a paradigm for all animals; the mass media focusing on animal issues as a way of garnering audiences; the shining of a moral searchlight on the traditionally-disenfranchised—minorities, women, the handicapped—out of which movements many of the leaders of animal activism emerged.

Thus animal rights as a mainstream phenomenon captures the social demand for legal codified animal protection and assurance of welfare. In this sense, *animal rights is simply the form concern for animal welfare has taken when animal use is no longer constrained by husbandry*. This sense should not be confused with the vernacular use of "animal rights" as referring to the view of some activists that no animals should ever be used by humans, a view better termed "animal liberation." The two views are clearly distinguished by the fact that most people in society wish to see animals protected while used for human benefit, but do not wish such uses eliminated.

The Good of Animals

Any attempt to protect animals and their interests depends on some socially accepted view of animal welfare, some account of the good of animals themselves and what they are owed by humans to reach an acceptable quality of life. Providing an account of welfare, therefore, is going to involve both factual and value judgments. The factual part involves empirical studies of animal natures—what has been called their *telos*—nutritional needs, social needs, health needs, psychological needs, exercise needs, and needs arising from species-specific behavior (Fraser and Broom 1990). This is the purview of an emerging field known as *animal welfare science*. The value judgment component in addressing animal welfare comes from the moral decision entailed by deciding which of these multiple needs will be met, and to what extent. For example, in zoos during the 1970s, tigers were typically kept in austere cell-like cages and fed horse meat. At the beginning of the twenty-first century, they may have ten acres to prowl. But the natural tiger range is miles, and tigers kill their food. Clearly the situation now is better than the previous one, but major needs are still unmet, because the tigers are not allowed predation and their range has been truncated. Similarly, health is obviously fundamental to welfare, but analysis reveals that the concept of health includes significant value judgments (Rollin 1979). Indeed, the CAST Report definition of welfare as equating to productivity bespeaks a set of quite controversial value judgments.

One additional crucial component is essential to understanding animal welfare. In the early 1980s, a number of philosophers and scientists (Rollin 1981, Duncan 1981, Dawkins 1980) pointed out that, ultimately, animal welfare is most crucially a matter of the animal's subjective experience—how the animal feels, whether it is in pain or suffering in any way, a point that is obvious to ordinary people but which conflicted with the scientific ideology that dominated twentieth century science (Rollin 1998). This ideology affirmed that all legitimate scientific judgments had to be empirically testable. Value judgments and statements about human or animal subjective awareness, thoughts, or feelings were ruled out by fiat. Because most scientists were indoctrinated with this ideology, the scientific community was ill-equipped to deal with ethical issues occasioned in the public mind by scientific activity, the first historically being the ethics of animal research. In any case, the failure to recognize the need for value judgments in general and ethical judgments in particular, as well as judgments about animal feelings, helps explain why the scientific community has not been a major contributor to public understanding of animal welfare.

Assessment

There is no reason to believe that animal welfare issues will not continue to dominate the public imagination. Public fascination with animals, animal treatment, animal thought and feeling, is manifest in the many television programs, newspaper and magazine articles, books, and films devoted to these issues. Every area of human-animal interaction, be it agriculture, research, hunting, trapping, circuses, rodeos, zoos, horse and dog racing, product extraction, and even companion animals, is fraught with ethical and welfare issues. (Currently, a major social concern is elevating the monetary value of companion animals above mere market value.) As these issues are engaged, it is likely that human understanding of animal welfare will be deepened, as it must be to provide rational legislated protection for these fellow creatures.

BERNARD E. ROLLIN

SEE ALSO *Agricultural Ethics; Animal Experimentation; Animal Rights; Pets.*

BIBLIOGRAPHY

Benson, G. John, and Bernard E. Rollin. (2004). *The Well-Being of Farm Animals: Problems and Solutions*. Ames, IA: Blackwell. An anthology with major experts addressing animal welfare issues in agriculture.

Council for Agricultural Science and Technology. (1981). *Scientific Aspects of the Welfare of Food Animals*. Ames, IA: Council for Agricultural Science and Technology.

Dawkins, Marian Stamp. (1980). *Animal Suffering: The Science of Animal Welfare*. London: Chapman and Hall. Classic work defending the notion that animals can suffer and how this can be determined.

Duncan, Ian. J. H. (1981). "Animal Rights—Animal Welfare: A Scientist's Assessment." *Poultry Science* 60: 489–499. Classic paper defending the view that welfare is a function of animal consciousness.

Fraser, Andrew Ferguson, and Donald Broom. (1990). *Farm Animal Behaviour and Welfare*, 3rd edition. London: Bailliere Tindall. Standard textbook of welfare and behavior.

"Parents Poll on Animal Rights, Attractiveness, Television, and Abortion." (1989). *Parents Magazine* (Sept–Oct).

Rollin, Bernard E. (1979). "On the Nature of Illness." *Man and Medicine* 4 (3): 157–172.

Rollin, Bernard E. (1981). *Animal Rights and Human Morality*. Buffalo, NY: Prometheus Books. Account of the emerging social ethic for animals.

Rollin, Bernard E. (1983). "The Concept of Illness in Veterinary Medicine." *Journal of the American Veterinary Medical Association* 182: 122–125.

Rollin, Bernard E. (1995). *Farm Animal Welfare*. Ames: Iowa State University Press. A survey of issues in farm animal welfare.

Rollin, Bernard E. (1998). *The Unheeded Cry: Animal Consciousness, Animal Pain, and Science,* expanded edition. Ames: Iowa State University Press. Exhaustive defense of the legitimacy of talking about animal consciousness and animal pain.

Rollin, Bernard E. (2004). "Animal Agriculture and Emerging Social Ethics for Animals." *Journal of Animal Science* 82: 955–964.

ANSCOMBE, G. E. M.

Gertrude Elizabeth Margaret (G. E. M.) Anscombe (1919–2001), arguably England's greatest female philosopher and one of the great philosophers of the twentieth century, was born on March 18 in South London and died on January 5 in Cambridge, England. Trained at Cambridge and Oxford universities in the classics, ancient history, and philosophy, Anscombe converted to Catholicism while at college. She married Peter Geach, also a philosopher and converted Catholic, with whom she had seven children.

A student and friend of Ludwig Wittgenstein, Anscombe was one of his three literary executors (along with Georg von Wright and Rush Rhees) and was tasked with translating much of Wittgenstein's work. Her *An Introduction to Wittgenstein's Tractactus* (1959) is considered the basic analysis of that work. The recipient of many honors and awards, Anscombe eventually succeeded to Wittgenstein's chair of philosophy at Cambridge. A renowned debater, she was reputably responsible for C. S. Lewis's decision to give up theology and turn to writing children's literature.

While steeped in all aspects of philosophy, Anscombe was well aware of progress in the sciences and humanities, discussing the implications of modern physics on causality (referencing works by Erwin Schrödinger, Albert Einstein, Richard Feynman, and Max Born), noting that there was no point in continuing to work on moral philosophy until psychology was better understood, as well as delving deeply into medical ethics in areas such as abortion, euthanasia, and contraception. A moderately prolific writer, Anscombe wrote for two distinct audiences, her professional colleagues and the Catholic community. Throughout her life she showed no hesitation in publicly acting on her beliefs.

In 1939, while still an undergraduate, she and Norman Daniel coauthored a pamphlet examining British participation in World War II. They concluded that, despite the injustices perpetrated by Nazi Germany, the role of the United Kingdom in the war was immoral. Anscombe argued that U.K. intentions in terms of means, ends, and net probable effects were unjust. In particular, Anscombe predicted, correctly as it turns out, that attacks on civilian targets were likely (blockades were already in effect) and that such actions would constitute murder.

Years later, Anscombe opposed an Oxford University plan to confer an honorary degree on U.S. President Harry S. Truman on similar grounds. The basis of her objection was that Truman was ultimately responsible for what she considered to be the murder of thousands of civilians during the bombings of Hiroshima and Nagasaki. This principle, the immunity of innocents, carried forward in the early-twenty-first century in the international law of war, is the basis for discussions of *collateral damage* and is one driver for the development of more precise munitions.

When the birth control pill and other devices became generally accessible, Anscombe supported Pope Paul VI's pronouncement that contraceptive measures other than the rhythm method were immoral. She wrote a series of articles aimed at the Catholic laity logically justifying the pope's conclusion. Catholics who support liberalization of the Church's policy on contraception have not successfully countered Anscombe's arguments. Interestingly non-Catholics contend that once the religious precepts of Catholicism are removed from Anscombe's arguments, she makes a persuasive case that nearly any sexual act or form of relationship should be permissible.

To Anscombe, abortion also represented an unjust killing of the innocent. In typical fashion, this motivated her in later years to participate in the British pro-life movement, eventually causing Anscombe and her daughters to be arrested for blocking an abortion clinic. In her life and work, Anscombe represents the possibility of an analytic philosopher taking substantive positions on a variety of issues related to science, technology, and ethics.

RUTH DUERR

SEE ALSO *Consequentialism; Just War.*

BIBLIOGRAPHY

Anscombe, Gertrude Elizabeth Margaret. (1959). *An Introduction to Wittgenstein's Tractactus.* London: Hutchinson.

Anscombe, Gertrude Elizabeth Margaret. (1981). *Collected Papers: 1. Parmenides to Wittgenstein. 2. Metaphysics and the*

Philosophy of Mind. 3. Ethics, Religion and Politics. Minneapolis: University of Minnesota Press.

Teichmann, Roger, ed. (2000). *Logic, Cause & Action: Essays in Honour of Elizabeth Anscombe*. Cambridge, UK: Cambridge University Press.

ANTIBIOTICS

The search for antibiotics began with general acceptance of the germ (bacteria) theory of disease. The first antibiotics were developed in the late 1800s, with Louis Pasteur (1822–1895) commonly given credit for discovering that the bacterial disease anthrax could be cured in animals with an injection of soil bacteria. But it was not until Alexander Fleming (1881–1955) discovered penicillin in 1928 that the great potential of antibiotics was recognized. Especially during World War II penicillin revolutionized medical practice, but the subsequent heavy reliance on penicillin and other antibiotic agents as general technological fixes for numerous diseases has led to problems that have distinctly ethical aspects.

Historical Development

Fleming's serendipitous discovery of penicillin came when he examined an old gelatin plate he had forgotten to submerge in detergent solution. Staphylococci, common skin bacteria, were growing on the plate, along with a mold. A product of the mold had seemingly killed some bacteria. Fleming was not the first person to observe the phenomenon of bacterial destruction by mold, but he had the foresight to recognize its potential medical importance. He named the mold product penicillin after the *penicillium* mold that had produced it. By extracting this substance from a culture of the mold, he was able to directly show its antibacterial properties.

An event in the 1930s also helped establish that chemicals taken internally can cure infectious diseases without harming the host. This was the discovery, made by Gerhard Domagk (1895–1964), that a newly patented chemical dye, Prontosil, could cure disease caused by streptococcus bacteria when injected into diseased mice. Interestingly Prontosil only worked when used internally and could not inhibit bacterial growth in a test tube. It was later shown that it was not the dye but a chemical attached to it, the sulfonamide portion, that was responsible for killing the bacteria. The sulfonamide portion was released during metabolism and was free to fight bacterial infections. The discovery of sulfonamides and penicillin as potent antibacterial agents created a strong motivation for developing other antibiotic agents.

The twenty-five years following the introduction of penicillin in 1942 was the heyday of antibiotic development. Developed antibiotics were either natural substances isolated from an organism, or synthetic agents, exemplified by penicillin and the sulfonamides respectively. Antibiotics also typically have a limited scope of effectiveness, often restricted to either *gram-positive* or *gram-negative* bacteria. This distinction in bacteria is named after Hans Christian Gram (1853–1938) who discovered that some bacteria stained with specific dyes kept their color following washing whereas other bacteria lost their color. Those that keep their color are gram-positive and those that lose color are gram-negative. Gram-positive and gram-negative bacteria differ in the composition of their cell walls, the outermost structure of bacteria. So-called broad-spectrum agents are effective against both gram-negative and gram-positive bacteria and include the antibiotics chloramphenicol and tetracycline, first isolated from soil bacteria in the late 1940s. Cephalosporins, first introduced in 1964, were other natural, broad-spectrum agents similar to penicillin. Modification of the cephalosporins and penicillin led to a number of semisynthetic agents with properties varying in adsorption, residence time in the body, spectrum of activity, and insensitivity to degradation by bacterial enzymes. A number of synthetic antibiotics were also introduced, mainly in the 1970s, following the introduction of natural ones. While some antibiotics have been introduced since the 1990s, the pace of discovery and introduction of new antibiotics has slowed markedly from its heyday.

Antibiotic Resistance

Initially seen as *miracle drugs*, antibiotics, once they became widely available, were used not only for bacterial infections, but for everything from the common cold to headaches. Indeed antibiotics were a godsend, drastically improving medicine and contributing significantly to the increase in life expectancy achieved during the twentieth century. Like many technological fixes, along with the positive benefits of antibiotics came negative side effects. Antibiotics can kill the many beneficial bacteria in the human body, for instance those that promote digestion, along with invasive bacteria. Another, unexpected, consequence is the ability of bacteria to overcome the mechanisms that give antibiotics their efficacy, rendering them useless. Antibiotic resistance, first a curiosity seen in the laboratory, became common among populations of bacteria exposed to antibiotics. In a matter of years following the introduction of penicillin, penicillin-destroying staphylococci appeared in hospitals where much of the early use of penicillin had taken place.

A similar response has occurred in various strains of bacteria in response to vastly different antibiotics. Resistance traits exist for every antibiotic available in the marketplace. In addition, bacteria are often resistant to multiple antibiotic agents, leaving only expensive and potentially toxic antibiotics to fight bacterial infection, assuming a patient is fortunate enough to have access to such medicines.

Mechanisms of antibiotic resistance vary markedly but have the same effect of increasing tolerance until the bacteria are resistant. These mechanisms first appear in a few bacteria as a result of random mutations that naturally occur in the DNA that defines the genetic makeup of the bacterium. In the presence of antibiotics the bacteria having these mutations are selected for survival over those that are susceptible. With increased exposure to antibiotics, eventually only those bacteria with the resistance trait will survive. Furthering the propagation of resistances is the presence of transferable elements that readily exchange genetic material between bacteria. These elements exist either as plasmids, circular rings of DNA outside the core genetic material (chromosomes) of the bacterium, or as transposons, regions of DNA that can *jump* between chromosomes. Transferable elements allow susceptible bacteria to acquire resistances from other bacteria, either alive or dead. In order to limit the rise and spread of resistant bacterial strains, measures have been developed to encourage the proper use of antibiotics.

Ethical Use of Antibiotics

Ironically antibiotics have become a victim of their own success. The ability of antibiotics to effectively kill bacteria has also created an environment that selects for resistant strains and allows them to propagate. Antibiotics stand alone as the only therapeutic that is detrimental to society through their usage by an individual. Aside from the individual risks of side effects and allergies, widespread use of antibiotics has a much greater societal effect. Any antibiotic use, regardless of need, will hasten the selection for and propagation of resistant bacteria. Despite this drawback, antibiotics continue to play an invaluable role in healthcare. For them to remain efficacious, the misuse and overuse of antibiotics must be curbed.

In most industrialized countries antibiotics are obtained only through prescriptions. Despite this control on availability many people acquire antibiotics by coercing doctors or hoarding leftover medicine. In some instances people will use antibiotics obtainable from pet stores without prescription. These actions may seem frivolous but in the quick-fix world of medicine many patients demand some form of treatment for every ailment. Additionally many still hold the outdated view of antibiotics as a panacea. Not only does improper use of antibiotics have the danger of side effects, anything short of a full treatment will not rid the patient's system of the entire infection. Because the surviving bacteria are often the ones with a greater tolerance to the antibiotic, the potential exists for the reemergence of an infection resistant to the antibiotic. Though potentially dire outcomes resulting from resistances occur in industrialized nations, such as the emergence of *staphylococcus aureus*, which is resistant to almost all antibiotics, developing countries face even greater hazards.

The overuse and misuse of antibiotics in the developing world far eclipses the abuses present in developed countries. The frequency of infections in the developing world is greater due to poor public sanitation. Infections normally treatable for patients in developed countries often prove fatal when acquired in less developed nations. The uneven distribution of wealth does not allow poorer countries to afford newer antibiotics to overcome infections resistant to the ones readily available. Even if proper medicines are available, they are often misused, encouraging the propagation of drug resistant bacteria. Where one day of treatment can equal the daily wage, many are forced to choose the savings over a full treatment. Medical usage of antibiotics is a huge concern to both developing and developed nations but is not the only use that results in antibiotic resistances.

Use of antibiotics in agriculture, aquaculture, and food animals has been a tenacious issue. Humans are not the only species affected by infectious diseases. Antibiotics can protect the food supply by limiting loss to disease and have frequently been administered as a preventive measure, though use on crops has been banned in many countries. Antibiotics have also been found to promote growth in food animals when given in low doses. The mechanism responsible for this action is not known, but it is speculated that low dose antibiotics reduce competition for nutrients from bacteria living in the guts of these animals. Antibiotics used for treating animals and crops have the same ability to select for resistance traits in bacteria. Even antibiotics not used in human medicine can help to create bacteria resistant to medicinally important antibiotics. Clearly measures for the proper use of antibiotics in food production and medicine need to be advocated.

The Future of Antibiotics

The introduction of antibiotics into medicine has improved the quality and longevity of people's lives. Infections that were once a death sentence are easily controllable in the early twenty-first century. But the misuse and overuse of antibiotics has threatened their ability to control disease. With few new antibiotics being introduced and little incentive for pharmaceutical companies to invest in their research and development, measures are being taken to protect the efficacy of already existing antibiotics. To address this problem more efforts at the local level are needed to ensure their proper use. To this end, an international group, the Alliance for the Prudent Use of Antibiotics (APUA), was established in 1981. The organization, with a presence in more than 100 countries, aims to promote the proper use of antibiotics and to protect their long-term efficacy through communication and education. Although APUA is a start, doctors, pharmaceutical companies, governments, and individual users must continue efforts to improve current usage of antibiotics in order to ensure that such drugs remain effective for future generations.

ANDREW PRICE

SEE ALSO *Bioethics; Clinical Trials; Emergent Infectious Diseases; Medical Ethics; Vaccines and Vaccination.*

BIBLIOGRAPHY

Ferber, Dan. (2000). "Superbugs on the Hoof?" *Science* 5: 792–794. Discusses findings connecting antibiotics used on livestock with outbreaks of disease caused by antibiotic-resistant bacteria.

Hadley, Caroline. (2004). "Overcoming Resistance." *EMBO Reports* 5(6): 550–552.

Levy, Stuart B. (2002). *The Antibiotic Paradox: How the Misuse of Antibiotics Destroys Their Curative Powers*. Cambridge, MA: Perseus Publishing. Classic primer on the misuse of antibiotics.

INTERNET RESOURCES

Alliance for the Prudent Use of Antibiotics (APUA). Available from http://www.antibiotic.org. Internet site of the organization.

U.S. Food and Drug Administration. Antibiotic Resistance page. Available from http://www.fda.gov/oc/opacom/hottopics/anti_resist.html. A comprehensive resource containing background articles and current news.

APOLLO PROGRAM

In the early twenty-first century, the Apollo program still is invoked as the ultimate technological achievement. In terms of percentage of the national budget, that effort to land astronauts on the moon was the largest single scientific program ever undertaken by the United States. Six successful lunar landings were accomplished from 1969 to 1972. The twelve astronauts who walked on the surface of the moon collected samples, set up equipment, and conducted scientific experiments. The scientific return from those missions revolutionized people's understanding not only of the moon, but of the earth and the rest of the Solar System. The program also raised many ethical concerns, notably its motivation, the safety of the astronauts, and its cost at the possible expense of other national needs.

The Origins of Apollo

In a speech to Congress on May 25, 1961, President John F. Kennedy stated, "I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to the earth." This marked the official genesis of the Apollo program, although the rationale had been building steadily since October 4, 1957, when the Soviet Union launched the first satellite, *Sputnik*, into space. A series of successful Soviet space missions followed, culminating with Yuri Gagarin becoming the first human in space during the voyage of *Vostok 1* on April 12, 1961. The United States countered with Alan Shepard's suborbital flight on May 5, 1961, but it was clear that the Soviet Union was the preeminent spacefaring nation and that the United States was losing international prestige.

Many people saw the *space race* as another front in the long-standing rivalry between capitalism and communism. Politicians and the general public also feared that the Soviet Union might use a dominant position in space to gain military advantage. In that climate, Kennedy decided that nothing short of becoming the first nation to put an astronaut on the moon would allow the United States to *win* the space race and regain its technological leadership in the eyes of the world. The National Aeronautics and Space Administration (NASA) was charged with developing a program to achieve that task before 1970. Clearly, the primary goals of the program were political rather than scientific.

Early Apollo Program

The Apollo program proceeded through a series of tests, each building on the one before it. The lunar missions were designed to launch on a *Saturn V* rocket. The first two stages of the *Saturn V* would boost the craft into space, and the third stage would put Apollo into an earth parking orbit and then fire a second time to send Apollo toward the moon. The Apollo spacecraft consisted of a command module that carried the three astronauts; a service module that held much of the water, oxygen, and fuel; and the lunar module, which was designed to bring two astronauts to the surface of the moon. The first Saturn rocket, a *Saturn I,* was launched on October 27, 1961. Through 1966 over a dozen uncrewed orbital and suborbital flights were completed. The components of Apollo were tested and determined to be ready to fly with a human crew.

APOLLO 1. The first crewed Apollo test flight was scheduled for early 1967 to carry the astronauts Virgil Grissom, Ed White, and Roger Chaffee. However, in a preflight test on January 27, 1967, fire broke out in the sealed command module. It grew explosively in the pure oxygen atmosphere and killed all three men. Intense public scrutiny was focused on the first U.S. spacecraft casualties, and a reexamination of NASA procedures resulted in new safety protocols. The public had been awakened to the dangers of space travel and to questions regarding the wisdom of using astronaut versus robots in space exploration.

APOLLO 11. Much testing and three more uncrewed flights followed the *Apollo 1* tragedy. *Apollo 4,* the first launch of a full *Saturn V,* took place on November 9, 1967. Confidence in the Saturn rocket and the Apollo spacecraft was so high that the first astronaut flight, *Apollo 7,* was launched on October 11, 1968. That was an earth-orbiting mission during which the Apollo command and service modules were tested thoroughly. On December 24, 1968, *Apollo 8* became the first crewed mission to reach and orbit the moon. *Apollo 9* and *Apollo 10* followed in early 1969, completing the testing of all the aspects of a lunar landing mission.

Apollo 11 launched on July 16, 1969, carrying the astronauts Neil Armstrong, Edwin "Buzz" Aldrin, and Michael Collins. It reached lunar orbit on July 19, and on July 20 Armstrong and Aldrin landed on the moon in the lunar module. Armstrong stepped onto the lunar surface at 10:56 P.M. Eastern Daylight Time, stating, "That's one small step for man, one giant leap for mankind," to an audience estimated to include half the world's population. The astronauts spent just over two hours on the lunar surface, collecting samples, taking pictures, and setting up experiments. They returned to earth on July 24, completing Kennedy's challenge. *Apollo 12,* launched on November 14, 1969, demonstrated the ability of Apollo to make a targeted landing on the moon and recovered pieces of the 1967 *Surveyor 3* lunar lander.

View of the earth from space. Thanks to the accomplishments of the Apollo program, images like this have a permanent place in the public consciousness. *(U. S. National Aeronautics and Space Administration [NASA].)*

APOLLO 13. The *Apollo 13* mission was the only Apollo mission failure. The explosion of an oxygen tank on April 14, 1970, on the way to the moon, forced the mission to be aborted. The spacecraft circled the moon and headed directly back to earth, overcoming a number of life-threatening problems through the coordinated work of the ground crew and the astronauts. The crew made it back to earth safely, but as had happened after the *Apollo 1* tragedy, the wisdom of risking astronauts' lives was questioned.

Later that year the Soviet Union launched the robotic probes *Luna 16* and *Luna 17* to the moon. *Luna 16* brought back a small sample from the moon, and *Luna 17* carried a rover, *Lunokhod 1,* that traveled across the lunar surface, remotely controlled from the earth, and sent back television images. Over the next six years the Soviets launched two more successful sample return missions and another lunar rover. Those missions demonstrated the capacity of uncrewed vehicles to do scientific work on the moon at a far lower cost and without the risk of astronaut missions. The Apollo missions had a far

Neil Armstrong on the surface of the moon. Armstrong, one of the three members of the crew of Apollo 11, became the first human to set foot on the surface of the moon on July 20, 1969. *(U. S. National Aeronautics and Space Administration [NASA].)*

greater scientific return, but as technology improves, the abilities of robotic probes will come closer to those of astronaut missions. Meanwhile, the dangers inherent in the astronaut program became even more apparent after the space shuttle *Challenger* and *Columbia* accidents.

End of the Apollo Program

The four missions that followed *Apollo 13* were increasingly ambitious, with each spending more time on the moon, setting up more scientific experiments, and returning with more samples, culminating in the *Apollo 17* mission. Three more missions originally had been planned. After *Apollo 11*, the prime motivation for the program had been achieved, and public and political support began to wane. Additionally, the argument was made that money going to Apollo could be spent better elsewhere. The total cost of the Apollo program was over $20 billion and accounted for more than 2 percent of U.S. budget appropriations in the middle to late 1960s. The country was still fighting an expensive war in Vietnam, and it was pointed out that many social programs were underfunded. The final three missions were canceled as a cost-cutting measure. Apollo spacecraft were used in 1973 to launch and bring three crews to Skylab and in 1975 for the Apollo-Soyuz earth orbiting mission, in which the United States and the Soviet Union cooperated in a joint rendezvous mission.

Was the Expense of the Apollo Program Justified?

One of the arguments routinely used to defend the cost of the Apollo program is the value of *spin-offs*, technological developments made in the course of building the spacecraft. Although this would be hard to quantify, many technological advances were made during the Apollo program that later had commercial applications. However, it also can be argued that the economic return would have been even greater if the Apollo budget had been spent directly on technological innovation.

The scientific return from Apollo is unquestioned, but the economic value of those achievements is difficult to quantify. Much current knowledge of the moon, the earth, and the solar system is a direct result of the data returned from the Apollo missions.

Another unmeasurable aspect of the Apollo program is the effect on the public of the moon landings and pictures of earth from space. Apollo represented a cultural as well as a scientific milestone. The pictures of earth and of the astronauts on the moon are among the most famous photographs ever taken.

Arguably, Apollo also gave an impetus to science programs in schools and inspired many young people to go into science and engineering. Although science was not the primary motivation behind the Apollo program, the scientific benefits derived from it are of inestimable value and could not have been garnered during that period in any other way.

DAVID R. WILLIAMS

SEE ALSO *National Aeronautics and Space Administration; Space Exploration; Space Shuttle* Challenger *and* Columbia *Accidents*.

BIBLIOGRAPHY

Chaikin, Andrew. (1994). *A Man on the Moon*. New York: Penguin. An account based on interviews with the Apollo astronauts.

Cortright, Edgar M., ed. (1975). *Apollo Expeditions to the Moon*. Washington, DC: National Aeronautics and Space Administration. A collection of chapters written by astronauts and Apollo managers and flight directors on all aspects of the Apollo program.

Holman, Mary A. (1974). *The Political Economy of the Space Program*. Palo Alto, CA: Pacific Press. A survey of the economic impacts of the Apollo program.

McDougal, Walter. (1985). *The Heaven and the Earth: A Political History of the Space Age*. New York: Basic Books.

Siddiqi, Asif A. (2000). *Challenge to Apollo: The Soviet Union and the Space Race, 1945–1974*. Washington, DC: National Aeronautics and Space Administration. A history of the Soviet Union's part in the space race.

Spudis, Paul. (1996). *The Once and Future Moon*. Washington, DC: Smithsonian Institution Press. A scientific view of the moon largely based on samples and data returned by the Apollo program.

Van Nimmen, Jane; Leonard C. Bruno; and Robert Rosholt. (1988). *NASA Historical Data Book*. Vol. 1: *NASA Resources 1958–1968*. Washington, DC: National Aeronautics and Space Administration. A collection of information and statistics on NASA programs.

APPLIED ETHICS

While applied ethics may appear to be a relatively recent development, serious philosophy has always had its applications. Since the time of Plato (fourth century B.C.E.), philosophers have been concerned with problems of living in the real world. Plato's *Republic*, for instance, concerned as it was with the nature of justice, discussed inescapable questions relevant to how one should live.

What is now known as applied ethics, however, came to prominence in the last third of the twentieth century, after a period in which the prevailing view, among Anglo-American philosophers at least, was that philosophy could not usefully be applied to practical problems. Instead, ethics had often been rejected as emotive and noncognitive in character or, in an effort to contribute to progressive clarity in moral discussions, philosophy devoted itself to metaethics or the analysis of ethical language. Applied ethics initially came to the fore in a medical context, where expanding commitments to human rights and developments in technology gave rise to challenging ethical issues related, for example, to the allocation of scarce resources such as kidney dialysis machines, the use of heart–lung devices, and organ transplantation protocols. Questions such as the extent to which health care professionals should intervene to extend life, along with the definitions of life and death themselves, became extensively debated in a new field called bioethics, defined as the study of the ethical, legal, social, and philosophical issues arising from advances in medicine and the life sciences.

Scope

Applied ethics, is, however, by no means confined to bioethics. Indeed, in its many iterations since the mid-1970s applied ethics has included the discussion of such diverse non-biomedical issues as capital punishment, economic development, free speech, human rights, pornography, poverty, social discrimination, and war. Applied ethical issues arise in any area of life in which the interests of individual or groups conflict, including not just national groups but even different species. Prominent branches of applied ethics include business ethics, environmental ethics, biomedical ethics, legal ethics, military ethics, and professional ethics.

Some of these branches are more directly involved with science and technology than others. Bioethics, which is obviously influenced by biomedical science and technology, has already been mentioned. Nuclear ethics, which deals with nuclear weapons and deterrence strategies, is also closely tied to developments in nuclear science and engineering. Another example is environmental ethics, which has acquired increasing importance as a reflection on the moral limits of industrial development and pollution. Environmental ethics is also pertinent to research on animals, the crossing of species boundaries by means of genetic engineering, and the impact of genetically modified crops on nature.

Agricultural ethics, computer ethics, and media ethics might be cited as still other examples. Agricultural and food ethics are two expanding fields concerned with the production and distribution of food as well as its genetic modification (thus overlapping with environmental ethics while at the same time opening up new perspectives on the issues). Ethics in relation to computing and information technology (IT) has raised the issue of whether there are new ethical questions to be answered, or just new versions of old questions. Arguably the creation of new entities such as web sites, along with new forms of human interaction, give rise to a unique set of issues, although there are also issues of scale relating for example to the power of IT to transform social institutions. Media ethics, as various forms of communications media technologies become digitalized, further overlaps with and extends computer ethics questions and concerns.

Professional ethics is also pertinent with respect to scientists and engineers. Questions arise about the professional responsibilities of scientists with regard to the setting of research agendas, the conduct of research, the use of results, and communication with the public and potential users. The move from programs of promoting the public understanding of science toward enhancing public engagement with science and technology has led to debates about how upstream in the research and development process such engagement should be. Is there a role for public involvement in deciding what research is carried out, or should the role of the public be limited to discussing the impact of research on society? The increasing commercialization of science and the changing social context in which scientists operate are areas that overlap with business ethics, which concerns itself with questions about conflicts of interest, the pressures of commercialization on the setting of research priorities, the sharing of the benefits of the outcomes of research, and whether there are some things (e.g., living organisms) that should not be commercialized and that should therefore be outside the patenting system.

Even more than scientists, however, professional engineers have developed explicit codes of ethics to guide their technical conduct. These now generally emphasize responsibilities to protect public safety, health, and welfare, as well as to promote the profession, protect confidentiality, and avoid conflicts of interest. Engineers may be confronted with situations of conflict, for example, in which one safety concern has to be traded off against another, or concern for public safety is in tension with protection of confidentiality or corporate interests. There may also be international engineering projects in which different standards are applicable in different countries.

Models

There are different models concerning what is involved in applied ethics. In addition to those areas in which particular issues arise, it is essential to reflect on what if anything is being applied. It is tempting to think that in order for ethics to be applied, there must be something such as a theory to apply, which is indeed one possible model. According to James M. Brown (1987), conceiving applied ethics as the application of theory may be described as a "fruits of theory" approach. Although it depends on the view that in applied ethics *some* theory is applied, it admits the application of a variety of possible theories. This is to be distinguished from what might be termed an "engineering approach" (cf. Caplan 1983), which holds that there is one particular theory that is to be drawn upon to address practical problems as and when they occur, and that will produce answers as a result. Because agreement is lacking on any *one* theory, the engineering approach has relatively few adherents, but the fruits of theory approach—that applied ethics must involve the application of *some* ethical theory—remains a popular conception of applied ethics.

Contemporary applied ethics, insofar as it *is* an application of theory, relies to a large extent on ethical theories that date from the eighteenth and nineteenth centuries: deontology and utilitarianism. Deontological ethics draws on the thought of Immanuel Kant (1724–1804) in a tradition that stresses respect for persons and notions of human rights and dignity, without necessarily being a strict application of Kant's own philosophy. Similarly, utilitarian ethics as it is employed today rarely attempts to reproduce the thought of its original authors, Jeremy Bentham (1748–1832) and John Stuart Mill (1806–1873).

An alternative to applying high-level theory is the appeal to mid-level principles as found in Tom L. Beauchamp and James F. Childress's influential text, *Principles of Biomedical Ethics* (2001). Mid-level principles are said both to be in accordance with the "common morality" and to be reconcilable with different underlying theories. This in part explains their appeal. The notion of the common morality on which the approach depends has nevertheless been questioned: Common to whom? The "four principles" in Beauchamp and Childress include autonomy, beneficence, nonmaleficence, and justice. Thus autonomy, for example, can be supported both from a Kantian and a utilitarian point of view, although the interpretation of autonomy will be different in either case. Utilitarian ethics portrays the agent as choosing to maximize his or her utility, while the Kantian moral agent's exercise of autonomy is in accordance with what is right, rather than a pursuit of the good.

The four principles have been regarded by some of their advocates as forming the basis of a "global bioethics" in that they represent values that can be supported by anyone, although they may be so for different reasons. Thus people from very different cultures might support autonomy and justice, even when they disagree about their meanings.

The transferability of the four principles to different cultural contexts has nevertheless been challenged, as has the priority commonly accorded to the principle of autonomy. Furthermore, it is important to note that the application of the four principles does not represent the application of a theory as such. The principles simply represent a useful framework for highlighting the moral dimensions of a situation, but a great deal of work is required in thinking about prioritizing, balancing, and specifying them.

Because the fruits of theory approach involves appeal to a level of abstraction in either theories or principles, other models for the practice of applied ethics have attempted a more contextual and relational approach (Alderson 1991). Feminist ethics, for example, critically examines issues of power, assessing them from the perspective of the more vulnerable party. In discussions of the abortion issue or of reproductive technology, feminist ethics will not in an abstract way discuss the status of the fetus or the right to life, nor does it operate with the ideal of the abstract autonomous individual (which might be regarded as prominent in several other approaches); rather it will look at the position of the woman who has to carry the fetus or who has to undergo assisted reproductive techniques, and at the ways in which power relations in society have an impact on options and decision-making.

Feminist ethics has some characteristics in common with virtue ethics, which, rather than trying to apply principles, asks what traits of character should be developed, and what a person who has the virtues would do in particular situations. The virtuous person is one who, because he or she has the virtues, can *see* what is appropriate in particular cases (cf. Statman 1997).

A problem with the fruits of theory approach, over and above the fact that there is considerable and apparently irresolvable disagreement about the theories themselves and the issue of abstraction, is that the model presupposes there is a clear understanding or agreed-upon description of what the theory in question should be applied *to*. Arguably a prior task of applied ethics is to elucidate what the ethical issues *are*—and there is concern, especially in ethics as applied to the professions, that those working in the field uncritically accept problems defined in a particular way (see, e.g., O'Neill 1986). Contemporary debates about ethical aspects of developments in science and technology frequently focus on issues such as informed consent, safety and risk, privacy and security, conflict of interest, and professional responsibility. It is important to ask if significant matters of ethical concern are overlooked, such as the factors that influence the choice of areas of research.

In the light of such various considerations, antitheorists argue the desirability of doing applied ethics without theory. One way this finds expression is in judgment about particular cases. Specific developments and particular cases may affect the development of appropriate theory, and some argue that there is room for a bottom-up rather than a top-down approach. The approach of casuistry, for instance, starts from cases (analogous to case law) and has principles emerge from these, rather than being developed in the abstract and applied from above (Jonsen and Toulmin 1988).

One may thus distinguish at least five general models for doing applied ethics: theory application, mid-level principle application, feminist contextualism, virtue contextualism, and case-based casuistry. The first two apply some form of theory and may be described as top-down models. The second two are more concerned to apply traditions of reflection that emphasize context. The last is a very bottom-up model that applies one case to another. In regard to issues related to science and technology, top-down models are perhaps more common, with much of the literature in biomedical or computer ethics tending to illustrate such an approach. Context models exercise a stronger role in discussions of the professional responsibilities of scientists and engineers. Casuistry is no doubt the least-common approach to doing applied ethics in science and technology, in part because many of the ethical problems associated with science and technology are so unprecedented that argument by case analogy is often a stretch.

Challenges

Against all models of applied ethics certain challenges remain. One focus of concern is the notion of the ethical "expert." What might be meant by ethical expertise is problematic, and this issue has become a high-profile one as applied ethics has become increasingly involved or even institutionalized in public policy. There is skepticism regarding whether any one group of people has privileged access to the truth about what ought to be done—although insofar as applied ethics admits a plurality of legitimate approaches this criticism can be moderated.

This issue is not, therefore, unconnected with that of the models of applied ethics being practiced. On the fruits of theory model, one concern is that principles developed in one field of expertise, such as philosophy, are applied to another area of activity, such as the health care professions (e.g., MacIntyre 1984). There are questions here about whether it is possible or desirable for principles to be developed externally rather than internally to the profession in question.

Are there alternative notions of expertise that might be available (Parker 1994)? One possibility is that expertise in ethics involves familiarity with a range of views, skills in reasoning and argumentation, and an ability to facilitate debate. Insofar as this is the case, applied ethics expertise could be committed to a kind of ethical pluralism. In applying ethics to particular issues, discussions from more than one perspective are to be preferred to discussions from only one perspective. For some, however, this liberal approach constitutes a kind of relativism.

There remain questions about the identification of the ethical problems for which such reasoning is required. Is this a matter for particular professional groups, or can they be identified from outside by ethical experts? It may be the case that this is not a situation in which an either/or approach is desirable, but that it should be a collaborative venture. Thus policymaking on science needs to include the perspectives of both science and ethics so that greater insight can be achieved through dialogue. It is essential that ethics in this area be scientifically informed, but it is also the task of ethics to question assumptions about aspects of science that may have been overlooked because they appear so unproblematic within the scientific community.

A more radical objection to the notion of expertise comes from those who see applied ethics, and in particular bioethics, as an assertion of power on the part of a certain group. Bioethicists themselves, from this perspective, arguably form a powerful professional group. Bioethics then becomes not a field of study, but a site of struggle between different groups, where philosophers, for example, claim to have a special role. In addition to these challenges to applied ethics in general, however, there are particular issues about the relationship between ethics, on the one hand, and developments in science and technology, on the other.

Science and Technology

The assessment of science and technologies is made more problematic by the ways they extend the reach of human power across ever-wider spatial and temporal scales (Jonas 1982). Nuclear weapons systems are the most dramatic example. Because science and technology were traditionally limited in the extent to which they could know the world and transform it, issues of scientific and technological ethics seemed marginal in relation to ethical reflection on politics and economics, in which contexts human behavior could have much larger impacts on other human beings. But in the contemporary world politics and economics have themselves been transformed by science and technology—while science and technology themselves directly challenge ethics as well. These considerations lend weight to the view that over and above the assessment of individual technologies, there is a need for attention to the overall impact of technology on the human condition. This is more apparent in Continental philosophy than in Anglo-American applied ethics (Mitcham and Nissenbaum 1998).

Even within the Anglo-American tradition, however, applied ethics is called to respond both to rapid developments in science and technology and expanding opportunities and potential for use. The speed of change requires a similarly swift response on the part of society in terms of ethics, policy, and legislation. It is frequently argued that ethical deliberation comes too late—although in the case of the Human Genome Project ethical research was funded alongside the science. The difficulties posed by the speed of change are further complicated by perceptions that in some instances the development of technologies may pose challenges to traditional ethical frameworks themselves. In other words, humankind can no longer continue to think in ways that were once comfortable.

This is not just a point about how attitudes *do* change: Certain ways of thinking turn out to be no longer *thinkable*. As Albert Einstein remarked with regard to how nuclear weapons had altered warfare, "a new type of thinking is essential if mankind is to survive and move toward higher levels" (Einstein 1960, p. 376). New technologies sometimes push ethical frameworks, such as just war, to their limits of applicability. Insofar as this is the case, even those who subscribe to a fruits of theory approach may find it necessary to rethink theories and concepts. Ethical theories emerge in particular social and historical contexts, so why should they be presumed to apply in all other contexts?

To cite one other example, there has been discussion about "genetic exceptionalism" or the extent to which genetics requires rethinking of ethical doctrines such as the importance of confidentiality, because blood relatives have an interest in genetic information about those to whom they are related. Should the principle of medical information privacy always apply? Is it to be broken only in the case of life-threatening communicable diseases? The thesis of genetic exceptionalism is, however, hotly contested by arguments that genetic information is no different in kind, only in degree, from other kinds of information. Whether and to what extent this implies a need to rethink the principles of information privacy in general becomes an issue for any applied ethical engagement with the information explosion that is associated with new scientific and technological transformations.

Whatever model of applied ethics is preferred, science and technology thus appear to give rise to basic questions for applied ethics. One of the most general concerns how to address the presentation of new possibilities for human action, such as whether or not the normal human lifespan should be extended by, say, fifty years. Should the burden of proof be on those who want to make the extension or on those who oppose it? That is, should new technological possibilities be guilty until proven innocent or innocent until proven guilty?

As new developments occur, even among those in favor, they easily give rise to anxieties about possible consequences, and these anxieties find expression in some commonly used arguments that are not tied to any particular theory. In part, such anxieties may arise from previous experiences of things going badly wrong. But anxiety may also arise precisely because there is no experience on which to draw. With regard to certain developments, the worry of crossing limits or boundaries that should not be crossed is one expression of such an anxiety. The related objections to "playing God" or going "against nature" are others. Advocates of caution sometimes deploy the precautionary principle, which has been used by a number of policymaking bodies. Slippery slope arguments are also frequently invoked. It is in the effort to think through such arguments that applied ethics in the Anglo-American analytic tradition may be called upon to make its most general contributions to assessing science and technology.

Tools

In light of the multiplicity of approaches to applied ethics (see Chadwick and Schroeder 2002), some of those working in the field have tried to identify ethical "tools" to assist in identifying the ethical dimensions of a variety of situations. One example is the ethical matrix developed by Ben Mepham (1996) in the context of food ethics. The matrix does not apply a theory as such, although it borrows from the Beauchamp and Childress principles of biomedical ethics. In so doing it provides a structured way of identifying interest groups affected by a given new development and assesses the ways in which they will be affected across a number of dimensions: autonomy and rights, well-being, and justice or fairness. It does not purport to be a decision procedure that will produce answers (as in the engineering model), but a useful tool to assist deliberation.

Although the debates about the relative merits of theory and antitheory continue, along with arguments about the nature of expertise, if such exists, what cannot be doubted is that there are questions to be addressed, and they are not ones that can be settled by opinion polls. Even when the majority agree that x ought to be done, it does not follow that x is right. At the same time ethical reflection cannot be undertaken independent of some empirical input from the social sciences. Insofar as applied ethics involves interactions among science, technology, ethics, and the social sciences it may thus also be described as a new form of interdisciplinarity. Applied ethics requires collaboration, not only between philosophers and professionals but also between different academic disciplines.

RUTH CHADWICK

SEE ALSO *Consequentialism; Deontology; Dutch Perspectives.*

BIBLIOGRAPHY

Alderson, Priscilla. (1991). "Abstract Bioethics Ignores Human Emotions." *Bulletin of Medical Ethics,* no. 68: 13–21.

Almond, Brenda, ed. (1995). *Introducing Applied Ethics.* Oxford: Blackwell. An introduction including more than twenty texts on family life, professional ethics, law, economics, and international relations.

Beauchamp, Tom L., and James F. Childress. (2001). *Principles of Biomedical Ethics,* 5th edition. New York: Oxford University Press. First edition published in 1979.

Brown, James M. (1987). "On Applying Ethics." In "Moral Philosophy and Contemporary Problems," ed. J. D. G. Evans. *Philosophy: The Journal of the Royal Institute of Philosophy.* Suppl., vol. 22: 81–93.

Caplan, Arthur L. (1983). "Can Applied Ethics Be Effective in Health Care and Should It Strive to Be?" *Ethics* 93(2): 311–319.

Chadwick, Ruth, ed. (1998). *Encyclopedia of Applied Ethics.* 4 vols. San Diego: Academic Press. A standard work in the field.

Chadwick, Ruth, and Doris Schroeder, eds. (2002). *Applied Ethics: Critical Concepts in Philosophy.* 6 vols. London: Routledge.

Davis, Michael. (1991). "Thinking Like an Engineer: The Place of a Code of Ethics in the Practice of a Profession." *Philosophy and Public Affairs* 20(2): 150–167.

Edel, Abraham; Elizabeth Flower; and Finbarr W. O'Connor. (1994). *Critique of Applied Ethics: Reflections and Recommendations.* Philadelphia: Temple University Press.

Einstein, Albert. (1960). *Einstein on Peace,* ed. Otto Nathan and Heinz Norden. New York: Simon and Schuster.

Jonas, Hans. (1982). "Technology as a Subject for Ethics." *Social Research* 49(4): 891–898.

Jonsen, Albert R., and Stephen Toulmin. (1988). *The Abuse of Casuistry: A History of Moral Reasoning.* Berkeley: University of California Press.

MacIntyre, Alasdair. (1984). "Does Applied Ethics Rest on a Mistake?" *Monist* 67(4): 498–513.

Mepham, Ben. (1996). *Food Ethics.* London: Routledge.

Mitcham, Carl, and Helen Nissenbaum. (1998). "Technology and Ethics." In *Routledge Encyclopedia of Philosophy,* ed. Edward Craig. London: Routledge.

O'Neill, Onora. (1986). "The Power of Example." *Philosophy* 61(235): 5–29.

Parker, Jenneth. (1994). "Moral Philosophy—Another 'Disabling Profession'?" In *Ethics and the Professions*, ed. Ruth Chadwick. Aldershot, UK: Avebury.

Statman, Daniel, ed. (1997). *Virtue Ethics*. Edinburgh: Edinburgh University Press.

Wilcox, Diane Michelfelder, and William H. Wilcox, eds. (1997). *Applied Ethics in American Society*. Fort Worth, TX: Harcourt Brace. More than sixty texts on abortion, euthanasia, the death penalty, welfare, discrimination, animals, freedom of expression, sexual rights, and privacy.

AQUINAS, THOMAS

SEE *Thomas Aquinas*.

ARCHAEOLOGICAL ETHICS

When the public thinks of archaeology, it may have mental images of the fictional character Indiana Jones, who travels to exotic places, overcomes numerous challenges to capture precious antiquities, and brings them back to the United States for display. Life as an archaeologist must be full of adventure. Although images such as these are based loosely on some events in archaeological history, archaeologists more typically "seek knowledge rather than objects that are intrinsically valuable . . . to help us understand vanished peoples and cultures" (Stiebing 1993, p. 22).

Anthropology, history, and other fields all attempt to understand the past, but what sets archaeology apart from the other disciplines is the way it achieves understanding, particularly through discovering the physical objects and human remains left behind by ancient and not so ancient peoples. The emergence of archaeology as a science has enhanced the understanding of human history but in the process has given rise to important ethical questions relating to ownership of artifacts and the disturbance of gravesites, among other issues.

History and Development

Archaeological activity of one type or another has existed for millennia, whether in the form of treasure hunting, looting, or appreciating and seeking understanding of the past. The sixth-century B.C.E. kings of Babylon Nebuchadrezzar and Nabonidus excavated and even restored parts of the ancient city of Ur, and local antiquities were collected by a Babylonian princess (Daniel 1981). Many of the tombs of Egyptian pharaohs were looted by treasure hunters despite the elaborate methods employed by the tomb builders to thwart such breaches.

Some of the earlier accounts of archaeological exploration as it is understood in the early twenty-first century began in Europe during the sixteenth century when Henry VIII appointed the King's Antiquary, whose duties were to travel the land "describing things of antiquarian interest" (Daniel 1981, p. 25). Sweden led the rest of Europe in the study, teaching, and collecting of antiquities with an Antiquities College and Museum and an official proclamation protecting "ancient monuments . . . and portable antiquities" (Daniel 1981, p. 32). During that time archaeological scholars carried on robust debates about the age of the world; some held to the biblical age of the earth (dating back to about 4000 B.C.E.), and others claimed that it had to be older in light of the types of artifacts being discovered throughout Europe, such as stone axes and knives.

The notion of the technological stages of human cultural evolution—the age of stone, characterized by weapons and tools constructed of wood and stone; the age of bronze, in which tools and weapons were constructed of copper and later bronze; and the age of iron, in which tools and weapons that had been constructed of bronze were replaced by those made of iron—was proposed as early as 1738. The Danish National Museum curator Christian Jurgensen Thomsen (1788–1865), however, is credited with systematizing the three technological stages in archaeology (Daniel 1981).

The ancient Roman cities of Herculaneum and Pompeii, which were destroyed in 79 B.C.E. by the eruption of Mount Vesuvius, were the subject of the first large-scale excavations in the modern era. The suddenness of the eruption, coupled with rapid burial from ash, mud flows, and lava, preserved both cities until their discovery sixteen centuries later. Initially the purpose of the excavations was not to understand the past but to extract valuables from the ruins, resulting in haphazard and destructive extraction methods. It was not uncommon for small and seemingly worthless artifacts to be destroyed, and systematic identification of the location and position in which the artifacts were found was not practiced.

Partly as a result of the discoveries of Herculaneum and Pompeii European interest in classical antiquity exploded. However, much of the activity was centered on the acquisition of antiquities for collectors and museums (Lynott 2003), not on the production of historical knowledge. To satisfy the desires of collectors, most antiquities were collected hastily without proper cataloging and recording of the context in which they were found, causing the loss of valuable historical information forever. Even though many of those antiquities have been preserved in European museums, the debate over the ownership of the antiquities and the unscientific methods of excavation continues, constituting one of the earliest ethical conflicts in the field (Lynott 2003).

Archaeologists' interests grew spatially during the late eighteenth and nineteenth centuries, with excavations occurring in Asia, India, the Near East, and the Americas. After Napoleon Bonaparte arrived in Egypt in 1798, his scholars conducted excavations and recorded a substantial amount of information. Most impressive was the 1799 discovery of the Rosetta Stone, which, after it was deciphered in 1822, provided the key to understanding Egyptian hieroglyphics. Other activities in that century included the founding of the American Antiquarian Society in 1812, extensive explorations and recording of Central American civilizations in the 1830s and 1840s, the first excavations of Mesopotamia in 1843 at Nineveh, and excavations in India throughout the first half of the nineteenth century (Daniel 1981).

Emergence as a Science

Early archaeological method was mostly descriptive, based on the objects that were found. Basic mapping and drawing of the artifacts was the common practice. Thomas Jefferson, who excavated burial mounds in Virginia, "became the first person . . . to have used the principles of stratigraphy to interpret archaeological finds" (Stiebing 1993, p. 173). Stratigraphy, or the study of sedimentary distribution, age, and strata, enables archaeologists to estimate the ages of artifacts. In 1860 Giuseppe Fiorelli (1823–1896) took over the excavations in Pompeii and developed several new methodological approaches. Fiorelli pioneered the approach of using plaster to cast the remains of humans and animals, initiated a top-down approach to excavating buildings to reduce the frequency of their collapse, and left large objects "in situ" (Stiebing 1993, Daniel 1981). General Augustus Pitt Rivers (1827–1900) is credited with systematizing modern excavation methods, including the careful recording of the site and location of all objects found, the reproduction of all notes and drawings in publications, and the practice of recording even small and seemingly worthless artifacts (Stiebing 1993, Daniel 1981).

One of the most important contributions to the field of archaeology was the discovery of carbon-14 by Willard Libby (1908–1980) in 1949. Carbon-14, a radioactive isotope of carbon, is used to date living and formerly living things (Stiebing 1993, Daniel 1981). Progress in the field of geology and dating rocks through a similar process also expanded methods to establish the archaeological record. Other ways to date artifacts include dendrochronology (counting tree rings) and paleomagnetic dating, which compares the magnetic orientation of earthenware with the past orientation of the magnetic poles. Other technologies in use to locate, describe, and record artifacts include x-ray technology, aerial photography, geographical information systems (GISs), computer software programs, ground-penetrating radar, and miniature cameras (Stiebing 1993, Daniel 1981).

The invention of the Aqua-Lung and scuba (self-contained underwater breathing apparatus) technology revolutionized maritime archaeology and allowed the exploration of thousands of previously untouched archaeological sites around the world. More recently the development of deep-sea submersibles, both manned and unmanned, extended exploratory reach further. In 1985 one of the most famous shipwrecks was discovered through the use of such technology: the SS *Titanic*, which sank in 12,500 feet of water on its maiden voyage in 1912, killing about 1,500 people (Ballard and McConnell 1995).

The contemporary archaeological process includes more than just anthropologists and archaeologists. The study of ancient peoples and cultures requires scientists from diverse fields such as botany, geology, medicine, computer science, and art, among others.

Legal Activities

The first national law in the modern era to address concerns about preserving archaeological sites was the Antiquities Act of 1906, which protected sites on government lands (Messenger 1999). The National Historical Preservation Act of 1966 established various institutions for dealing with historical preservation. Although those laws provided needed protection to valuable archaeological sites, they did not address the concerns of the Native Americans whose ancestors and their gravesites were the focus of research and excavation. In 1990 Congress passed the Native American Graves Protection and Repatriation Act (NAGPRA). That law clearly delegates ownership of artifacts to the Native American tribes that descend from the ancient people who are the subject of archaeological studies (Messenger

1999). Some archaeologists were surprised by passage of NAGPRA and "viewed the new law as antiscience and a threat to their access to the archaeological record" (Lynott 2003, p. 23).

The debate over "Kennewick Man" illustrates the ongoing ethical issues with regard to the ownership of artifacts and remains. In 1996 skeletal remains were discovered near Kennewick, Washington, and through the use of radio carbon dating were estimated to be about 9,000 years old (Smith and Burke 2003). Five local Native American Indian tribes claimed the remains under the provisions of NAGPRA, seeking to rebury the artifacts after proving their "cultural affiliation" with the remains, thus removing Kennewick Man from scientific investigation.

A group of scientists challenged the claim on two grounds. First, they argued that the characteristics of Kennewick Man's skull indicated that he may have been white and not Native American. Second, they argued that it was unlikely that the present-day Native Americans actually were descended from Kennewick Man in light of the passage of 9,000 years and the likelihood that there was much movement of the tribes in the intervening years. In 2002 a U.S. district court ruled in favor of the scientists, although the tribal coalition appealed the ruling. The findings of the court raise important questions about Native American connections to ancient remains and the conflict between Native American values and the desire to conduct scientific research (Smith and Burke 2003).

Archaeological discoveries also spur debates centered on economic issues, as in the case of Ötzi, also known as the Iceman, who was discovered by a hiker in the Alps in 1991. Ötzi's body, clothing, and tools were particularly well preserved after having been encased in ice for almost 5,300 years. Both Austria and Italy claimed ownership of Ötzi in a bitter custody battled until it was determined that Ötzi had been found in Italian territory. With the expectation that tourists would flock to see Ötzi, Italy constructed a museum to display him and expected to earn millions of dollars in museum entrance fees. The hiker who discovered Ötzi also demanded compensation, but it took twelve years before he was legally declared Ötzi's discoverer. The hiker is entitled to 25 percent of Ötzi's value, but determining that value is a difficult endeavor.

One of the more famous cases of ownership disputes centered on the Elgin Marbles, so called because Thomas Bruce, the seventh earl of Elgin, was responsible for transporting the marbles from Greece to England in 1806. Also called the Parthenon Marbles, the collection includes much of the surviving frieze and sculptures from the Parthenon and other Greek sites. Bruce later sold the marbles to the British government, which put them on display. Many people and organizations, particularly the Greek government, have called for the return of the marbles to Greece, but as of 2005 none has been returned.

Ethical Issues

Ethical standards in archaeology developed simultaneously with the maturation of the field. With the exception of the seventeenth-century decree to protect antiquities in Sweden, little was done with regard to ethics until the second half of the nineteenth century. During that period many of those who called themselves archaeologists and conducted excavations were not formally trained in the field. Poor excavation practices damaged and occasionally destroyed artifacts. According to Lynott (2003), ethical concerns in archaeology originally were focused on the need to preserve sites from destruction through vandalism, looting, and poor excavation practices. In the early twenty-first century many archaeologists view ruins as nonrenewable resources that should be protected accordingly (Warren 1999).

Professionalization of the field began in earnest in 1879 with the creation of the Archaeological Institute of America (AIA), followed by the Society for American Archaeology (SAA) in 1934. Concerns about professionalism and technique continued, resulting in the creation in 1976 of the Society of Professional Archaeologists (SOPA), which established a professional registry.

The first major effort to codify professional practices occurred in 1960 with the SAA's "Four Statements for Archaeology" (Lynott 2003), which defined the field, established guidelines for record keeping, suggested standards for training, and established ethical standards that focused primarily on professional practices related to the larger archaeological community. SOPA also established a grievance procedure and enforced its ethical standards (Lynott 2003).

Attitudes toward cultural artifacts changed during the 1980s, when indigenous people worldwide developed greater concern over the treatment and ownership of their ancestors' remains and artifacts (Lynott 2003). Ethical codes changed in response to those concerns, but there still is no single set of ethical standards that defines the field of archaeology. For example, the World Archaeological Congress (WAC) developed "eight principles to abide by and seven rules to adhere to"

(Lynott 2003, p. 23). The AIA established its "Code of Ethics" in 1990, and the SAA developed its new "Eight Principles of Archaeological Ethics," which it approved in 1996 (Messenger 1999). The SAA's principles address archaeologists' responsibility to affected peoples, stewardship and accountability to society, rejection of the commercialization of archaeology, public education and outreach, intellectual property, public reporting and publication standards, records and preservation of collections and artifacts, and training standards for archaeological professionals (Messenger 1999, Society for American Archaeology 2004).

Other ethical concerns in archaeology relate to occasional incidents of fraud or unscientific analyses. In 2000 Shinichi Fujimura, one of Japan's most respected archaeologists, was photographed planting stone tools at a site he claimed to be 600,000 years old. He later admitted to having planted dozens of items at several sites, raising questions of legitimacy with most of his work. Both the Tohoku Institute and the Japanese Archaeological Association expelled Fujimura, although the institute's reputation was "irreparably damaged" by the event (Romey 2001).

As in any field, establishing codes of ethics and practicing them are two different issues. However, the archaeological community seems to understand the important responsibility it has not only to further the understanding of the past but to do so in cooperation with and with respect for people who have vested cultural and ancestral interests in archaeological research. Not only is there a healthy and lively discussion within the community regarding ethics, modern students of archaeology are likely to take a course on ethics as part of their preparation to become professional archaeologists.

ELIZABETH C. MCNIE

SEE ALSO *Misconduct in Science; Museums of Science and Technology.*

BIBLIOGRAPHY

Ballard, Robert D., with Malcolm McConnell. (1995). *Explorations: My Quest for Adventure and Discovery under the Sea.* New York: Hyperion.

Daniel, Glyn. (1981). *A Short History of Archaeology*. London: Thames and Hudson. This book, although somewhat dated, provides an excellent overview of the history of archaeology and the people behind the story.

Delgado, James. (2001). *Lost Warships*. Vancouver: Douglas & McIntyre.

Lynott, Mark. (2003). "The Development of Ethics in Archaeology." In *Ethical Issues in Archaeology*, ed. Larry J. Zimmerman, Karen D. Vitelli, and Julie Hollowell-Zimmer. Walnut Creek, CA: AltaMira.

Messenger, Phyllis Mautch, ed. (1999). *The Ethics of Collecting Cultural Property*, 2nd edition. Albuquerque: University of New Mexico Press.

Smith, Clarie, and Heather Burke. (2003). "In the Spirit of the Code." In *Ethical Issues in Archaeology*, ed. Larry J. Zimmerman, Karen D. Vitelli, and Julie Hollowell-Zimmer. Walnut Creek, CA: AltaMira.

Stiebing Jr., William H. (1993). *Uncovering the Past: A History of Archaeology*. Buffalo NY: Prometheus Press. An excellent historical account of archeology.

Vitelli, Karen D., ed. (1996). *Archaeological Ethics*. Walnut Creek, CA: AltaMira.

Warren, Karen J. (1999). "A Philosophical Perspective on the Ethics and Resolution of Cultural Property Issues." In *The Ethics of Collecting Cultural Property*, 2nd edition, ed. Phyllis Mautch Messenger. Albuquerque: University of New Mexico Press.

Zimmerman, Larry J.; Karen D. Vitelli; and Julie Hollowell-Zimmer, eds. (2003). *Ethical Issues in Archaeology*. Walnut Creek, CA: AltaMira. Excellent resource on current ethical issues in archaeology.

INTERNET RESOURCES

Romey, Kristin M. (2001)."'God's Hands' Did the Devil's Work." *Archaeology: A Publication of the Archaeological Institute of America*, vol. 54, no. 1. Available at http://www.archaeology.org/0101/newsbriefs/godshands.html.

Society for American Archaeology. (2004). Available at http://www.saa.org. Provides a complete list of the ethical standards required of all members.

ARCHITECTURAL ETHICS

It is estimated that 90 percent of contemporary human existence takes place within built environments. It is also well known that the onset of illness and death is more rapid and often more prevalent as a result of inadequate shelter than of inadequate food supply. As economies shift to urban centers throughout the world with little or no civic infrastructure to receive their bulging populations, homelessness has become a global pandemic—and yet buildings alone are now considered responsible for at least 50 percent of all environmental waste. It is therefore surprising that a comprehensive ethical discourse, compared to other disciplines or professions, is relatively nonexistent within contemporary architectural, graphic, interior, industrial, landscape, urban, and regional design practices. This, according to scholars, was not always the case. In most premodern societies, and in many traditional or non-Western societies in the early twenty-first century, making and ethics were, and are, intertwined if not inseparable. Whenever eighteenth-century Enlightenment principles were uncritically adopted or imposed by force around the world, architects and designers—often in tandem with their clients and communities of users—rapidly abandoned their traditional discourse and practice of ethics, bowing to the demands of utilitarian market forces.

The Central Issues

The recovery of an architecture and design ethics within this postindustrial context begins with four key questions: What is (and is not) architecture and environmental design? Who is ethically responsible for the built environment? What are they ethically responsible for? And, how is ethics manifest through architecture and environmental design?

WHAT IS (AND IS NOT) ARCHITECTURE AND ENVIRONMENTAL DESIGN? This question attempts to define the boundaries and scope of the terms within which an ethics can be discussed. The way in which these terms are defined, however, is an ethical task of the first order. Without clarity in language, slippages in moral reasoning follow. While some scholars believe the terminological division between built and natural environments is largely self-evident, upon closer examination the boundary becomes less clear. If the built environment includes all that is made by humans, what of those places or objects found by humans and inhabited or used in an unaltered state, such as a cave for dwelling or a stick for digging? Is the cave or stick no longer "natural" once a human perceives it as useful? Furthermore, what "natural" environment or object has not already been altered by pollution, acid rain, global warming, or, say, overharvesting in neighboring environments—all effects caused by humans—long before any human "discovers" it? Alternatively, many nonhuman sentient beings—from bacteria through to mammals—may be said to design and/or build their habitats with a care and complexity that often rivals human ability. Could these not be considered built environments? If one considers the effects of human-initiated training, husbandry, breeding, or genetic engineering to generate places or products more useful to humans, would these effects be considered "natural"? Conversely, if a human-built artifact is abandoned and thus deteriorates until it is entirely reinhabited, reshaped, and subsumed by flora and fauna, is this still considered a designed environment?

One response to such questions is to shift the focus from built products to human intentionality. The degree to which human interest and imagination has shaped a given place or thing over time is the degree to which it could be considered "designed." The inherent problem with this, however, is the equality with which imaginary works—from the very influential futuristic cities of "paper architects" to the use of architectural metaphor in poetic verse—may be considered an essential part of the human-built environment and thus answerable to an ethics. If one adds in the inevitable misunderstandings between languages and cultures in an ethical discourse that hopes to be anything but local, then careful attention to terminology must be an essential responsibility of all participants.

WHO IS ETHICALLY RESPONSIBLE FOR THE BUILT ENVIRONMENT? It is estimated that more than 95 percent of the built environment is vernacular, that is, "not designed by professionals" but designed "by the people for the people." The shapes of these places and objects are determined as much by needs, available materials, and traditional building techniques as by regional or local production codes. Ethical responsibility may be considered shared among the owner who determines the need; the builders and craftspeople involved in the project; the communal representatives who determine site selection, safety considerations, zoning, water supply, and local material production; and the users of the building or object, for their involvement in future renovations and maintenance. In many traditional societies this responsibility extends to the ancestors, gods, or spirits who may be seen as the main inspiration for, producers of, or maintainers of the artifact, as long as the community performs the proper rituals. In some societies, responsibility may be laid upon the building or object itself for its good or bad actions. In these cases a tool, building, or city wall may be ritually fed or killed depending on its perceived benefit to the community.

In modern economies, where an architect or designer is involved in a project, this professional would often collaborate with or oversee an enormous diversity of professionals such as engineers, lawyers, design professionals, consultants, researchers, sociologists, archaeologists, technicians, contractors, realtors, manufacturers, restorers, and artists, as well as clients, user groups, neighbors, and/or political representatives. Designers themselves are typically answerable to their peers and society for obtaining their educational requirements and upholding ethical guidelines, technical codes, and bylaws. The problem with accepting, let alone determining, precise ethical responsibility for a particular decision is thus often complex. The matter is further complicated by an often nonexistent or faulty ethical education among most of the participants in a given project, the absence or ineffective presence of professional disciplinary bodies, and the enormous costs of initiating fair legal proceedings or protecting whistleblowers. As a result of this unique and extraordinarily complex network of relationships compared to most professions, ethical responsibility or blame in the design world is often more difficult to designate.

WHAT ARE THEY ETHICALLY RESPONSIBLE FOR? Designers, unlike scientists or technicians, are essentially midwives for a "total artifact" in search of its status—at its highest vocation—as a living being. As such, the designer is responsible for the same development a parent would most want for a child: a life of health, truth, beauty, and meaning. In terms of health, the designer seeks to ensure that the artifact poses no safety risks such as dangerous misuse, collapse, toxicity, or disorientation. It also needs to be secure from intentional criminal activity such as vandalism, theft of its contents, or easy transformation into a weapon. Typically it must perform the tasks it was designed for with relative efficiency, longevity, flexibility, and low maintenance. But in the wake of the 1948 Universal Declaration of Human Rights, the 1992 Rio Declaration on Environment and Development (along with Agenda 21, also from 1992), and the 2000 Earth Charter, professional design bodies have been asked to go well beyond this prescriptive minimum. As a result, the International Union of Architects and the American Institute of Architects now encourage all their members to observe "the rights and well being of the Earth and its peoples, the integrity and diversity of the cultural heritage, monuments and sites, and the biodiversity, integrity and sustainability of the global ecosystem" (World Congress, Principle 9). In practice this involves a holistic approach to the life of any conceived artifact in the ecosystem—from lowering energy use and toxic emissions to using reusable/recyclable materials. These declarations demand the integration of rigorous research science, citizen participation, and interdisciplinary cooperation into the building process, with legislative and legal protection accompanying these efforts. They also state that women, youth, indigenous peoples, and other voiceless groups must be heard and addressed throughout the entire planning and implementation process.

Although health aspects are desirable, many designers claim that their primary drive is to make a beautiful object. Here the use of narrative or poetic reference to history aims to create emotional resonance among the artifact, its context, and human experience. For many of these designers and the communities for which they design, to create a kitsch object or ugly city is a profound breach of ethical practice. In a similar way, quite a few designers see their creations as vehicles for communicating if not bringing about the context for an experience of truth. Here the idea of health at the expense of meaning, the idea of safety or security at the expense of liberty or free expression, or the idea of biodiversity at the expense of fostering traditional craft techniques is critically addressed. As such, the artifact demonstrates its vocation as a rational being seeking understanding, balance, equality, and logical harmony. Within the upper echelons of the design world, it is often on this basis that architectural or design critics evaluate certain works as primarily ethical or unethical. Finally, some objects or sites have a uniquely spiritual, mystical, or imaginative characteristic that the architect or designer seeks to respect if not prioritize over other considerations. In this case the architect becomes less a fabricator or technician than someone in relationship with a special object or site to whom the object or site reveals its living self and true spirit. Ethical interventions, therefore, must be consonant with the needs and character of the spirit, god, or mystical religious tradition present in that place.

These are but some of the possible ethical priorities with which designers approach their commissions. As these priorities come into conflict, so begins the need for ethical discernment.

HOW IS ETHICS MANIFEST THROUGH ARCHITECTURE AND ENVIRONMENTAL DESIGN? There are many ways to understand architectural ethics and how it should be brought about. Within this diverse space, philosophers have identified three of the most common approaches operating in post-Enlightenment societies and influencing their built environments: (1) outcome ethics (otherwise known as consequentialism or utilitarianism), (2) principle ethics (otherwise known as deontology or Kantianism), and (3) character ethics (otherwise known as virtue ethics or Aristolelianism).

Outcome ethics aims to create a state of affairs utilizing any actions necessary to bring about maximum happiness, or the "good." Outcome-directed designers may focus their efforts entirely on bringing about the "good" product by the most efficient means necessary: The best modern tools for research, development, implementation, and maintenance of a product are employed to engineer the longest lasting ease, comfort, and social health. The belief here is that general happiness in society, or the "good," is proportional to the abundance of "good" products circulating in that society. This approach is clearly the most dominant within market-driven economies of the early twenty-first century.

Indeed, one cannot ignore the plethora of excellent tools, appliances, buildings, cities, and ecosystems that have truly made the world an easier if not happier place in which to live. Criticism of this approach, however, is twofold. First, because the means is subordinated to the end, an enormous amount of damage to the environment and/or human rights might be perpetrated in order to bring about the "good" product. Second, despite using the best research methods or real-world modeling available at the outset of a project, the guarantee of producing a lasting good, or any good at all, through this particular product always remains a conjecture.

A principle ethics approach to design focuses less on the "good" product, and more on "right" actions. The process must have logical, rational consistency with universal moral precepts or imperatives, unswayed by inordinate desires or "false promises" of happy outcomes. Principle-based designers are conspicuous for their production and upholding of the laws, codes, and guidelines within which architects and designers have traditionally operated. Their hope is that by training the will to follow reason based on moral duty, a calm, rational civility will then pervade society, regardless of its products, because acting right itself is the ultimate good. Criticism of this approach centers on its tendency toward rigidity in the face of changing ethical situations, as well as a devaluing of human experience, memories, and imagination.

Finally, character ethics steps outside the means/ends debate to focus on developing the best habits or character for the architect or designer. Proponents of this approach hope that through a humanities-based education with history and the arts at its core, designers will be better able to respond with compassion, virtue, and reason to the often unprecedented moral dilemmas the future world will surely present. Detractors question what would compel a designer who follows character ethics to consider the real facts of an ethical dilemma, rational operating procedures to solve it, or solutions to bring about the good if their analysis is primarily historical/poetic, their solutions experimental/creative, and their outcomes primarily evaluated on the presence of beauty or deep interpersonal harmony.

As with the need for clear terminology, determining responsibility, and clarifying design priorities, so is it critical that an ethical methodology is carefully negotiated among all involved in a conflict of values.

The Relation and Impact of Science and Technology on Ethics in the Built Environment

Because architecture and design have both technological and poetic components, any development in science or technology could become a physical element or methodology adopted by a built or fabricated work, as well as a potential subject about which the work might "speak." Thus, no ethical issue arising within science and technology can be completely outside the making and discourse of architecture and environmental design. For instance, a skyscraper adopting the braided form of a DNA molecule as it reaches the sky might be seen to take an outcome ethics stance on the wonderful benefits of genetic science. An urban garden in the adjoining lot designed using principle ethics, meanwhile, might be filled only with non–genetically modified plants. Advances in computing, engineering, environmental, and material research along with the ethical issues they raise concerning security, health, safety, and just distribution of resources would be likely to have an obvious and immediate impact on the physical shape, use, and placement in society of newly designed goods. Of course this does not mean that pure sciences could not have a similar impact on design; such an impact would depend on the ethical dimensions of a problem that are given new shape by a finding in one of its fields.

A holistic critique raised by many post-Enlightenment philosophers, including Friedrich Nietzsche (1844–1900), Edmund Husserl (1859–1938), Martin Heidegger (1889–1976), Michel Foucault (1926–1984), and Jacques Derrida (b. 1930), is the alienation or "loss of meaning" in society brought about by each new technology introduced into the built environment. According to this argument, modern technology and science begin with a daringly original transformation: the reduction of the mysterious complexity of the given world to distinct quantifiables, categories, or simple binary digits. Human community and activity are likewise reduced by technology to distinct quantifiable tasks and ever-smaller specializations. Once reduced, these units can be traded, discarded, calculated, or multiplied with ever-greater speed, acceleration, and automation. The degree to which this self-generation mimics natural growth is the degree to which an uncritical enthusiasm for its technology is assured. Once the domain of the ancient magician, technology self-generates its own awe, propaganda, and docile adherents awaiting the promise of a better and better world. Whereas humans were once communally and ecologically integrated, modern technology demands isolated consumers, globalized uniformity, communication as monologue, and being without death. Perhaps the most disturbing aspect of unchecked technology is its inherent irreversibility; once the automobile, the nuclear bomb, clear-cut forestry, or human cloning become possible, they then become necessary.

Technology, according to these thinkers, is the primary cause of the dominant characteristics of the modern city: ugliness, alienation, toxicity, danger, waste, and constant expansion. While in the current geopolitical environment, this harmful growth is unlikely to stop anytime soon, warnings based on the results of research science of an imminent worldwide ecological crisis through ozone depletion and global climate change are beginning to be heard. As well, a number of contemporary academics and policymakers are advocating a less polarized position. They contend that technology, although inherently unsafe, dehumanizing, and accelerating, is still controllable and able to be harmonized with the biosphere through the promotion of slower, appropriate, or "medium" technologies (the latter in contrast to high technologies), as well as lifestyle change, political action, poverty eradication, demilitarization, and worldwide consensus on tough global policies representing a diversity of voices.

History of Ethics in the Built Environment

Myth and origin cycles, guidelines, or commentaries on what constitutes right action concerning building, boundary determination, and ritual object or place making can be found throughout the earliest known examples of writing in almost every culture. According to archaeologists, writing developed independently in Egypt, Mesopotamia, and Harappa between 3500 and 3100 B.C.E. But the human ancestor *Homo erectus* had campsites, fire, and tools, conducted burials, and began erecting megaliths and dolmens (a type of monument) as early as 3,000,000 B.C.E.; the earliest known shelters date from 2,000,000 B.C.E.; and the first cities came into existence around 7500 B.C.E. in the Indus Valley (present-day Pakistan). While the configuration, orientation, material selection, and care or destruction of early objects, buildings, and settlements might in themselves communicate proper ethical action to its community, only in the relatively late appearance of writing can one find specific ethical statements relating to building, orientation, calendars, ritual, and myth that could be used to guide appropriate procedures of making in harmony with that of the gods. For instance, a Sumerian inscription from Lagash, circa 2500 B.C.E., lists the actions of a corrupt ruler, Urlumma, that should not be imitated because he "drained the boundary canal of Ningirsu, the boundary canal of Nina; those steles he threw into the fire, he broke [them] in pieces; he destroyed the sanctuaries, the dwellings of the gods, the protecting shrines, the buildings that had been made. He was as puffed up as the mountains" (Barton 1929, p. 63) The Egyptian *Proverbs of Ptahhotep* of circa 2400 B.C.E. suggest the best mind-set for establishing a dwelling: "When a man has established his just equilibrium and walks in this path, there where he makes his dwelling, there is no room for bad humor" (Horne 1917, p. 62). And the Indian *Rig Veda* of circa 1500 B.C.E. records how making and orientation itself must be attributed, and thus be in alignment with the goddess Aditi because "The earth was born from her who crouched with legs spread, and from the earth the quarters of the sky were born" (10.72.3-4).

Eventually entire texts emerged whose subject matter was building practice alone—none of which, until the nineteenth century C.E., separated ethics or poetics from making and technique. The Indian *Manasara* of circa 800 C.E., for instance, integrates ritual activity at every step of its guidelines for building in order to ensure the most auspicious blessings upon the construction. Not only are lotus, water lily, and corn offerings essential for constructing foundations, so must the architect be bathed, clothed, and purified in order to perform the rituals and meditate on the creator-god such that the building will stay strong. Deviation from these prescriptions constitutes the most serious ethical breach (Manasara 1994, 109–129). In the classical West, *De architectura* (translated as *The Ten Books on Architecture*), written by Vitruvius circa 25 B.C.E., details how architectural making seeks to preserve the traditional symbolic order handed down through the Greeks in order to set the conditions for virtuous, civic, and ethical behavior of inhabitants and visitors (Vitruvius 1999). Much the same can be said for the writings of Abbot Suger (1081–1151), Guillaume Durandus (c. 1230–1296), Leon Battista Alberti (1404–1472), Giacomo da Vignola (1507–1573), and Andrea Palladio (1508–1580)—all of whom, in their given context, sought to preserve the civic, religious, and ethical order of the dominant classes they served through architectural making (Suger 1979, Durandus 1843, Alberti 1988, and Palladio 1997).

There is, however, an equally long and eloquent tradition of anti-architectural writing in which the techniques and products of craftsmen are said to deeply offend the gods, disgrace the ancestors, and corrupt the people. This, for instance, is one of the most important themes from the Hebrew Bible through to the Christian New Testament. In Genesis, Cain, the city builder, slays out of jealousy his brother Abel, the wandering pastoralist, because God told Cain he prefers the nomadic life over a settled existence for his chosen people (*Gen.* 4:1–16). Moses was prohibited by god the use of tools in building altar stones because instrumental manipulation of holy objects profanes them (*Ex.* 20:25). According to the prophet Isaiah, even though cities were constructed out of human goodwill, all are cursed by God. The city is the agent of war, financial greed, sexual abandon, idols, and injustice, where humans become merchandise. Once built, Isaiah says, they can never be reformed but can only self-destruct, Like Sodom, Gomorrah, Nineveh, and Jericho, as well as Jerusalem and its temple mount (*Is*. 13:19, 22:1–4, 66:1). Isaiah's call for a return to desert simplicity that would permit an undistracted contemplation on the mysteries if not the architecture of heaven, is cited by Saint Stephen before his death in the New Testament's *Acts of the Apostles* (7:44–50), and was carried out by tens of thousands of Christian desert monks and wilderness hermits from Egypt to Italy since the second century C.E. In this tradition, one of the most notable critiques of dominant building and craft practices comes from the thirteenth-century poet, saint, and builder Francis of Assisi. In the rules he wrote for his order and in his final testaments, Francis insists that his followers refuse the ownership, size, and expense of the neighboring cathedrals and more powerful monasteries, preferring that they live instead "as pilgrims and strangers" renovating small, abandoned, and dilapidated churches and dwelling in mud and stick huts surrounded by walls made of hedges (Francis 1999, p. 126).

Architectural writings produced by the dominant world powers after this time eventually reduced and eliminated ethical precepts or discourse in favor of describing practical techniques to bring about the most efficient, cost-effective, and comfortable cities. Claude Perrault (1613–1688) was one of the first to promote architecture as a vehicle for the principles of modern science, declaring that "man has no proportion or relation with the heavenly bodies" (1692–96: Vol. 4, pp. 46–59), thus severing the traditional natural and religious orders from architectural making. By the late eighteenth century, architecture students at the École Polytechique studied Gaspard Monge's (1746–1818) *Géométrie descriptive* (1795; Descriptive geometry), which applied to the totality of human action a synthetic system of mathematics, measurement, and geometry, stripped of all previous symbolic content. One of the most influential nineteenth-century textbooks on architecture, the *Précis des Leçons d'Architecture* (1819; Précis of the lectures on architecture), was composed by Monge's follower, Jean-Nicolas-Louis Durand (1760–1834). Durand's philosophical foundation was triumphantly materialistic. Humans, he declared, exist for two reasons only: to increase their well-being and to avert pain. Such a harsh positivist viewpoint accrued wide acceptance. The only sustained critique of this reduction of architecture to engineering came from Charles-François Viel (1745–1819). Reminding his readers that the two foundational principles of architecture, according to the ancients, were proportion and eurythmy (or "rhythmic pattern"), Viel strove to bring nature, human experience, and the traditional symbolic order back into harmony with making. To Viel, applied geometry masquerading as architecture without care for character, beauty, or metaphysics was harmful and decadent if not evil.

Viel's critique, the first of its kind in architecture, did little to stem the tide of new civic works such as bridges, railway stations, factories, and city plans that were now problems best resolved by engineers. Ornament, once the existential infrastructure of making, was now reduced to mere decoration (Viel 1812, pp. 51–52). As a result, an ethical debate raged in Germany and England concerning which "style" would be most appropriate to decorate certain building types. The point quickly became moot once twentieth-century modernists such as Walter Gropius (1883–1969), Ludwig Mies van der Rohe (1886–1969), and the early Le Corbusier (1887–1965) entirely abandoned ornament for the power, height, and awe available through the bold "expression" of modern materiality: iron, steel, glass, and ferroconcrete. This ideology, now intricately tied to corporate-driven market economies, continued to dominate architecture and design throughout the world into the early twenty-first century.

Following in the footsteps of other professional fields, architecture and design are beginning to develop their own "ethical culture" appropriate to their unique problems and challenges. Only now are the champions of environmental sustainability in the construction and manufacturing sectors beginning to see the deeper implications necessary to have it take hold: slower, reusable, "medium" technologies; community-based participation; global–local integration; historical/poetic awareness; and the fostering of a diverse, intergenerational culture of care. Many of these same conclusions have already been reached by social and environmental scientists who were among the first to critique, along with Werner Heisenberg (1901–1976) and Thomas S. Kuhn (1922–1996), their own historical roots and research agendas. Scientists and designers each have a lot to gain from widening their present specializations, exchanging research independent of corporate sponsorship or private gain, and coming to the table as global citizens with the responsibility to speak for the voiceless: the dead, the yet to be born, the poor, the marginalized, and nature itself.

GREGORY CAICCO

SEE ALSO *Building Codes; Building Destruction and Collapse; Design Ethics; Engineering Design Ethics; Engineering Ethics.*

BIBLIOGRAPHY

Alberti, Leon Battista. (1988 [1450]). *On the Art of Building in Ten Books,* trans. Joseph Rykwert, Neil Leach, and Robert Tavernor. Cambridge, MA: MIT Press.

Barton, George A. (1929). "Inscription of Entemena #7." In his *The Royal Inscriptions of Sumer and Akkad.* New Haven, CT: Yale University Press.

Casey, Edward S. (1997). *The Fate of Place: A Philosophical History.* Berkeley and Los Angeles: University of California Press.

Durand, Jean-Nicolas-Louis. (1809). *Précis des leçons d'architecture données à l'École polytechnique.* 2 vols. Paris: Author.

Durandus, Gulielmus. (1973 [1843]). "Rationale Divinorum Officiorum." In *The Symbolism of Churches and Church Ornaments,* trans. John Mason Neale and Benjamin Webb. Leeds, UK: T.W. Green. Original work published c. 1286.

Fox, Warwick, ed. (2000). *Ethics and the Built Environment.* London: Routledge.

Francis of Assisi, Saint. (1999). "A Rule for the Hermitages, the earlier Rule, the Later Rule and Testament." In *Francis of Assisi: Early Documents,* vol. 1, *The Saint,* ed. Regis J. Armstrong, J. A. Wayne Hellmann, and William J. Short. Hyde Park, NY: New City Press.

Glowacka, Dorota, and Stephen Boos, eds. (2002). *Between Ethics and Aesthetics: Crossing the Boundaries.* Albany: State University of New York Press.

Harries, Karsten. (1997). *The Ethical Function of Architecture.* Cambridge, MA: MIT Press.

Horne, Charles F., trans. (1917). *The Sacred Books and Early Literature of the East,* Vol. II.: *Egypt.* New York: Parke, Austin, and Lipscomb.

Manasara. (1994). *Architecture of Manasara, Translated from Original Sanskrit,* trans. Prasanna Kumar Acharya. Manasara Series, Vol. 4. New Delhi: Low Price Publications. Original work published c. 800 C.E.

McDonough, William, and Michael Braungart. (2002). *Cradle to Cradle: Remaking the Way We Make Things.* New York: North Point Press.

Monge, Gaspard. (1811–1812). *Géométrie Descriptive.* Paris: J. Klostermann fils.

Palladio, Andrea. (1997 [1570]). *The Four Books on Architecture,* trans. Robert Tavernor and Richard Schofield. Cambridge, MA: MIT Press.

Pelletier, Louise, and Alberto Pérez-Gómez, eds. (1994). *Architecture, Ethics, and Technology.* Montreal: McGill-Queen's University Press.

Perrault, Claude (1964 [1693]). *Parallèle des anciens et des modernes en ce qui regarde les arts et les science.* Munich: Eidos.

Rig Veda. (1981). In *The Rig Veda: An Anthology,* trans. Wendy Doniger O'Flaherty. London: Penguin Books. Original work first appeared c. 1750–900 B.C.E.

Suger, Abbot of Saint Denis. (1979 [1144–1148]). "On What Was Done under His Administration." In *Abbot Suger on the Abbey Church of St-Denis and Its Art Treasures,* ed. and trans. Erwin Panofsky. Princeton, NJ: Princeton University Press.

University of Pennsylvania, Graduate School of Fine Arts Staff, eds. (1990). "Architecture and Ethics." *Via* no. 10 (special issue).

Viel de Saint-Marx, Charles-François. (1812). *Principes De L'ordonnance Et De La Construction Des Bâtiments.* 4 Vols. Paris: Author.

Vitruvius Pollio. (1999 [c. 25 B.C.E.]). "De Architectura." In *The Ten Books on Architecture,* trans. Ingrid D. Rowland; commentary and illustrations by Thomas Noble Howe. New York: Cambridge University Press.

World Congress of the International Union of Architects and the American Institute of Architects. (1993). *Declaration of Interdependence for a Sustainable Future.* Paris: International Union of Architects; Chicago: American Institute of Architects.

ARENDT, HANNAH

Hannah Arendt (1906–1975) was born in Hannover, Germany on October 14 to a Jewish family of Königsberg, East Prussia, Germany. She studied philosophy at Marburg, Freiberg, and Heidelberg. At Marburg she was a pupil of the philosopher Martin Heidegger (1889–1976), with whom she had an affair, and at Heidelberg she did her doctoral dissertation on love in Saint Augustine with the philosopher Karl Jaspers (1883–1969). When Hitler came to power in 1933, Arendt left Germany and for eighteen years was a "stateless person," first in Paris, where she worked with Jewish refugee groups, and then, after the outbreak of war, in the United States. From 1929 to 1937 she was married to Günther Anders (1902–1992), a journalist, philosopher, and essayist. Arendt became an American citizen in 1951 and for the rest of her life lived in New York with her second husband, the historian Heinrich Blücher (1899–1970). She died on December 14.

The Human Condition

Arendt's major work with implications for science and technology was *The Human Condition* (1958). It is an inquiry into the *vita activa,* that is, "human life in so far as it is actively engaged in doing something" (p. 22). Within the *vita activa* Arendt distinguishes between three fundamental human activities, labor, work and action, each of which corresponds to a different condition of human existence.

Hannah Arendt, 1906–1975. Arendt was a historian and philosopher of Jewish descent whose scholarly work is devoted to the study of the origins of totalitarianism and anti-semitism. *(© Bettmann/Corbis.)*

Labor includes all the repeated tasks of daily life—growing food, cooking, washing up, cleaning—to which there is no beginning or end. If labor "produces" anything at all, it is something, such as food, that is consumed almost as soon as it is produced. People labor because they are living, embodied beings; thus, life is the condition of labor.

Work is the activity through which people produce durable things—tables, chairs, buildings, but also institutions—that together form the world they inhabit. Humans may use the things of the world made by work and that use may wear those things out, but unlike the food that people consume, this destruction is incidental; it is not an inherent feature of that use. The durability of what work produces means that work has a definite end in the thing made as well as a clear beginning. People work to build a world, and so the world, or "worldliness," is the condition of work.

Action is the capacity to do something new, something that could not have been expected from what has happened before, that reveals who the actor is, and that cannot be undone once it has been accomplished. It derives from the fact of a person's uniqueness as an individual. Action is beginning a boundless unpredictable process of action and reaction. The condition of action is human plurality: a person can labor or work alone as well as with others, but action always requires the presence of others, who, like the actor, are unique human beings. Politics arises out of people acting together, so action constitutes the political realm.

Since the industrial revolution, new technology has transformed work in two ways. First, "automatic" machines and the assembly line transformed work into labor by transforming it into a process without beginning or end, done merely to "earn a living." This means that it is done for the sake of life rather than to build a world. Second, technologies such as nuclear power, synthetic chemicals, and genetic engineering all start new, unprecedented processes that would not exist on earth in the absence of those technologies. Because they are starting something new, the human capacity they make use of must be that of action. In the sphere of human affairs the boundlessness and unpredictability of action can be limited by promising and forgiveness, options that are not available with actions into nature. The inability to limit boundlessness and unpredictability has resulted in uncertainty becoming the defining characteristic of the human situation.

Arendt stresses that humans are "conditioned beings," although the conditions of human existence—the earth, birth and death as well as life, the world and plurality—never condition people absolutely. The earth is the natural environment in which people live, as other animals do, and is characterized by constant cyclical movement: Each new generation replaces the previous one in a process that is indifferent to the uniqueness of individuals.

The world is the condition of human existence that people have made themselves. Biological life is sustained by the earth, but life as a unique, human individual can be lived only in a durable, stable world in which that individual has a place—an identity. The world is always to some extent public in that unlike private thoughts and sensations, it can be perceived by others as well as by oneself. The presence of these others with different perspectives on a world that retains its identity when seen from different locations is what assures the individual of the reality of the world and of themselves (*Human Condition*, p. 50).

The world is related to action in that action always takes place in the world and is often about the world. Political action attempts to change the world. The deeds and words of action constitute an intangible but still real in-between, the web of human relationships that overlies the tangible objective reality of the world. Because it overlies the world, the forms that can be taken by the web of human relationships must depend on, although they are not determined by, what the world is like. To be a home for men and women during their lives on earth the world "must be a place fit for action and speech" (*Human Condition*, p. 173).

Implications

Arendt's most important work, *The Human Condition*, was only part of a lifelong effort to understand what happened to her world during the first half of the twentieth century. For instance, her first major work, *The Origins of Totalitarianism* (1951), analyzed the political systems of Nazi Germany and Stalinist Russia, with their historical roots in anti-Semitism and imperialism. Totalitarianism, Arendt concluded, required atomized, individualized masses: people who had lost any sense of living in a common world for which they shared responsibility. Totalitarianism made life subject to "inevitable" natural or historical processes and thus destroyed the possibility for human action.

Arendt's most controversial work was a report on the trail of the Nazi war criminal Adolf Eichmann (1906–1962). Her conclusion contained the phrase "the banality of evil," which encapsulated her view that the evil done by Eichmann was not a result of base motives, but of his inability to think. The evil resulting from modern technology could also be described as banal. It is not the result of extraordinary actions by people of ill intent, but of unthinking "normal" behaviour, using the technology that has become integral to everyday life in the western world.

In the posthumously published *The Life of the Mind* (1981) Arendt attempted to complement her interpretation of the *vita activa* with one of the *vita contemplativa*. This contains an account of thought that has important implications for thought and knowledge in science and for the relationship between science and technology.

In an approach clearly influenced by Arendt, Langdon Winner has suggested that the most important question to ask of technology is, "What kind of world are we making?" (Winner 1986). The clear implication of Arendt's argument is that questions concerning the nature of the world, and therefore of technology, are political questions. They cannot be decided simply by reference to science, or by technical decision procedures, but only through political debate: the exchange of opinions among people who share, but have different perspectives on, a common world. This position continues to animate many discussions of science, technology, and ethics in ways that can be deepened by dialogue with Arendt's thought.

ANNE CHAPMAN

SEE ALSO *Anders, Günther; Fascism; Heidegger, Martin; Holocaust; Socialism; Totalitarianism.*

BIBLIOGRAPHY

Arendt, Hannah. (1958). *The Human Condition*. Chicago: University of Chicago Press.

Arendt, Hannah. (1964). *Eichmann in Jerusalem: A Report on the Banality of Evil*. New York: Viking.

Arendt, Hannah. (1968). *Between Past and Future*. New York: Viking Compass Edition with additional text. This collection of essays contains further discussion of some of the concepts relevant to science and technology developed in the human condition.

Arendt, Hannah. (1973). *The Origins of Totalitarianism*. New York: Harcourt Brace Jovanovich.

Arendt, Hannah. (1981). *The Life of the Mind*. New York: Harcourt Brace Jovanovich.

Canovan, Margaret. (1992). *Hannah Arendt: A Reinterpretation of Her Political Thought*. Cambridge, UK, and New York: Cambridge University Press. A good general introduction to Arendt's work that emphasizes its origins in her thoughts on totalitarianism.

Young-Bruehl, E. (1982). *Hannah Arendt: For the Love of the World*. New Haven, CT, and London: Yale University Press. The main biography of Arendt.

Winner, Langdon. (1986). *The Whale and the Reactor: A Search for Limits in an Age of High Technology*. Cambridge, MA: MIT Press.

ARISTOTLE AND ARISTOTELIANISM

Aristotle (384–322 B.C.E.), born at Stagira, in northern Greece, was a philosopher and scientist, and a student of Plato (c. 428–c. 348 B.C.E.). The range and depth of Aristotle's thought is unsurpassed. He wrote on logic, physics and metaphysics, astronomy, politics and ethics, and literary criticism. His work formed the backbone of much Islamic and late medieval philosophy. In the early 2000s he is taken seriously as a social scientist and philosopher of biology. On a number of levels his thought is significant for science, technology, and ethics.

Basic Concepts

The root of Aristotle's thought lies in his response to the central puzzle of ancient Greek philosophy. For something to come to be, it must come either from what it is or from what it is not. But it cannot come from what it is, for what already exists cannot come to be; nor can it come from what it is not, because there would

Aristotle, 384–322 B.C.E. This Greek philosopher and scientist organized all knowledge of his time into a coherent whole which served as the basis for much of the science and philosophy of Hellenistic and Roman times and even affected medieval science and philosophy. *(NYPL Picture Collection.)*

not be anything for it to come to be from. Aristotle offered a commonsense solution to this conundrum: A kettle comes to be from and remains what it is, iron; but at the same time it comes to be from what it is not, not yet a kettle.

The confusion arises, Aristotle observes, because such concepts as "being" and "generation" are ambiguous; and this is because the objects to which they apply are not simple, but are compounds of *hule,* or matter, and *morphe,* or form. This view is known as *hulomorphism.* Matter is *potentiality.* The deer eats the corn and the hunter eats the deer: Thus the same materials are potentially herb, herbivore, and carnivore. The form is the *actuality:* This collection of matter at my feet is actually a dog.

Aristotle's primary interest was in the development of living things. He observed that an individual organism, say, Socrates, can change in a variety of formal ways: It can grow old or blush, but it remains the same thing—a human being and Socrates—all the while. Aristotle thus distinguished between accidents, such as Socrates' complexion, and his *substance,* which persists through many changes. Living organisms are clearly substances.

Aristotle's emphasis on substance reflects the general Greek view that what is most real is what persists through changes. But by this standard the species is more real than the individual, which dies. He thus felt compelled to distinguish between the primary substance, species, and secondary substances, individual organisms. This has its parallel in contemporary Darwinian thought: Some hold that it is the species form contained in the genes that is persistent and primary, and so is the real thing in evolution; others insist that the individual is the primary target of selection.

Perhaps Aristotle's most famous conceptual apparatus was his doctrine of causation, which he sometimes employed in analyzing technology but more often applied to living phenomena. The term for *cause* in Greek, *aitia,* indicates whatever is responsible for something being as it is or doing what it does. Aristotle distinguished four basic causes. Consider the growth of an animal from birth to adulthood. In part this happens because the organism is composed of certain materials, and these it may add to or subtract from itself (material causation). Second, it grows as it does because it is one kind of thing: Kittens become cats and never catfish (formal causation). Third, the form of the animal is more than a static arrangement; it is a complex dynamic process by means of which it is constantly recreating itself (efficient causation). Finally, this process does not proceed randomly but aims at some goal or *telos,* in this case the adult form (final causation).

Aristotle's insistence on teleological explanations (explaining something by explaining *what it is for*) became controversial in the modern period. But it amounts to two claims: First, many structural and behavioral features of organisms are clearly functional in design. Teeth are *for* biting and chewing. Second, organic processes are clearly self-correcting toward certain ends. The acorn grows toward an oak, its roots reaching down for water and minerals. The wolf weaves this way and that *in order to* bring down the fawn. Both of these claims are largely confirmed by modern biology.

From Biology to Politics

Aristotle's biology includes a distinctly nondualistic account of *psyche,* or soul, which in Greek refers to the principle of life. Rather than some separable substance, "soul" comprises all the processes by which the organism maintains itself and responds to its environment. In *On the Soul,* Aristotle distinguishes three types. Nutritive soul includes the capacity for self-nourishment, and so the possibility of growth and decay. All organisms possess this type of soul. Plants possess nutritive soul alone, but animal soul also includes perception and mobility. Finally, whereas animals are capable of pain and pleasure, human beings are capable of distinguishing what is really good and bad from what is merely attractive or unattractive, and so what is just from what is unjust. In addition to nutritive and animal soul, human beings possess *logos*, the power responsible for reason and speech. Aristotle's biology thus proceeds in a way similar to modern evolutionary accounts: Complex organisms are built by adding new levels of organization on top of existing ones.

Although Aristotle flirts only briefly with evolutionary explanations in biology, such an explanation is conspicuous at the beginning of his political science. Starting from political life as he knew it, he observed that the most elementary human partnerships were male and female (for the sake of procreation) and master and slave (for the sake of leisure). These comprise the household, which serves everyday needs. A union of households into a village serves more occasional needs, such as a barn raising. In turn, a union of villages makes up a polis, the independent city that was the foundation of classical political life. The polis is comprehensive: It incorporates all the elementary associations into a new, functional whole. Moreover the polis is self-sufficient, needing nothing more to complete it; and while it evolves for the sake of survival and comfort, it exists for the sake of the good life.

Aristotle's political science preserves the standard Greek classification of governments according to whether there is one ruler, a few, or many, as well as the argument that the primary tension in politics is between the few rich and the many poor. But it is not reductionist. What drives politics most of the time is not economic necessity but the desire for honor and wealth. Moreover, he recognizes a broad spectrum of regimes in place of simple kinds: Some monarchies are closer to aristocracies than others. In the body of the *Politics* Aristotle considers, from the point of view of various regimes, which institutions will tend to preserve that form and which will destabilize it. Because he includes even tyrants in this analysis, some have seen his approach as an example of a value-free social science. He also insists, however, that the authority of the ruling part of any partnership—father, king, or congress—is justified only to the degree that it serves the common good rather than the interest of the rulers. Aristotle's advice for more extreme regimes is also to move them in the direction of moderation, by broadening the base of citizens who benefit from the regime's rule. The goal of political action is the common good; authority should therefore be apportioned according to the contribution that each person or group can make toward that goal.

It is interesting to consider what Aristotle would have thought of modern technological and scientific expertise as a claim to rule. Unlike Plato, he does not explicitly consider the possibility of rule by trained elites. He does observe, however, that the best judge of a house is not the architect but the occupant, and similarly that the people collectively are better judges of policy outcomes than the best trained policymakers. Rule by experts would be safest in a regime with a substantial democratic element.

Aristotle's Ethics

The *Ethics*, like the *Politics*, begins with the observation that all human actions aim at some apparent good. But Aristotle distinguishes goods that are merely instrumental from those that are good in themselves. A person swallows a bitter medicine only for the sake of something else, health; but people seek out simple pleasures for their own sake. Aristotle argued that all the various good things can contribute to or be part of one comprehensive good, which he called *eudaemonia*, or blessedness. This term signifies a life that is complete and satisfying as a whole.

Eudaemonia requires certain basic conditions—such as freedom, economic self-sufficiency, and security—and it can be destroyed by personal tragedies. It is to this degree dependent on good fortune. Most important, however, are those goods of the soul that are largely resistant to fortune. The body of the *Ethics* is accordingly devoted to a treatment of virtues such as bravery, temperance, generosity, and justice. Perhaps Aristotle's greatest achievement was to have reconciled the concept of a virtuous action with that of a virtuous human being. Aristotle usually defines a virtuous action as a mean between two extremes. For example, a brave action is a mean between doing what is cowardly and what is foolhardy, in a given set of circumstances. But it is not enough merely to perform the appropriate action; virtue is also a matter of the appropriate emotional reactions, neither excessively fearful nor insensitive to genuine dangers. A virtue, then, is the power of acting and reacting in a measured way.

Virtues are different, however, from those powers that come directly from nature. In the case of sight, for example, one must first possess the power before one can begin to use it. By contrast, it is only by first doing brave things that one then becomes brave. Thus, a virtue requires cultivation. A virtuous person is someone who is habituated to acting properly in each situation, without hesitation, and who does so because it is the virtuous thing to do. The most important requirement of *eudaemonia* is the possession of a complete set of virtues.

Aristotle draws a clear distinction between moral and intellectual virtues. The former are acquired by habituation and produce right action in changing circumstances. The latter are acquired by learning and are oriented toward an understanding of the nature of things. Modern scientific and technological expertise certainly involves intellectual virtues as Aristotle understood them. But the one sort of virtue does not imply the other: A good ruler might be illiterate, or a scientist greedy and a coward. This is another Aristotelian reason why expertise alone cannot be a sufficient title to rule.

Aristotelianism

For well more than a thousand years after his death, and across several great traditions, Aristotle's works guided research in natural science, logic, and ethics. In Greek philosophy his own school, the Peripatos or Lyceum, long survived him; the first of many revivals of Aristotelianism occurred in the first century B.C.E., when Andronicus of Rhodes edited and published his major works. Aristotelianism thrived in centers of Hellenistic civilization and was revived again as part of a Byzantine scholarly renaissance in the ninth century C.E. By that time Aristotle's works had been translated into Syriac and Arabic, and in these languages became available both to Islamic and Jewish scholars. During the twelfth and thirteenth centuries the Aristotelian corpus was gradually translated into Latin and introduced to Western Christendom.

In all these traditions, his work served as a stimulus to scientific, ethical, and even technological progress. His natural science inspired his successor at the Lyceum, Theophrastus (c. 372–c. 287 B.C.E.), who produced an impressive botany. His logic, his empiricism, and his interest in nature inspired the stoics. Aristotle's work was instrumental to the medical researches of Galen (129–c. 199 C.E.) and the optics of Alhazen (965–1039 C.E.). Perhaps most importantly, the Jewish thinker Moses Maimonides (1135–1204) and the Christian Thomas Aquinas (1225–1274) wedded a modified Aristotelianism to existing theologies in attempts to create comprehensive systems of thought. Even his early modern critics such as Francis Bacon (1561–1626) and Thomas Hobbes (1588–1679) employed methods and concepts that were Aristotelian in origin.

Aristotle's reputation went into decline with the rise of early modern science and has only recently recovered. This is sometimes attributed to his scientific errors, which were many. He believed for example in spontaneous generation, the view that organisms can be produced by the action of heat and moisture on natural materials. He believed that in sexually reproducing species, the male provides all the form while the female provides only the matter. He believed that the function of the brain is to cool the blood. But such mistakes, amusing as they are, were due to the poverty of his experimental technologies and not to errors in his basic theories.

Nor do the flaws in his methods of investigation explain the modern decline of Aristotelianism. His logic was sound and is mostly preserved in contemporary philosophy. Moreover, contrary to a common prejudice, he and his students aimed at a rigorous empiricism. They gathered as much data as possible given the available technologies. It is true that Aristotle lacked a modern scientific method by which a hypothesis might be built and tested. But such a method could have as easily been employed to build on the Aristotelian foundation of premodern thought as to undermine it.

The reason for Aristotle's dismissal had more to do with the status of physics as the paradigmatic science. Confining itself to the mechanics of matter and energy, modern physics achieved a rigor previously matched only by abstract mathematics. On the topic of physics, Aristotle is embarrassingly weak, in part because he tried to extend biological reasoning to inorganic nature. Modern biologists, who might have defended him, suffered from their own inferiority complex. They were particularly embarrassed by the occasional flirtation of biologists with occult concepts, such as a mysterious "vital force" in living things. They accordingly pursued a rigorously reductionist view of organisms and tried to avoid any hint of purpose in their descriptive language. They could not afford to be seen in public with Aristotle, who was famous for teleological explanations.

Since the mid-twentieth century, the center of gravity in modern science has begun to shift from physics toward biology. This is marked by the quite literal drift of talented physicists into the laboratories of the biologists. One reason for this shift is the recognition that biology is in some ways a broader science than physics. No biologist is much surprised by the findings of chemists; but no physical scientist could remotely expect the existence of a cell from the principles of chemistry. As biology has become increasingly confident, it finds itself speaking in a language that is reminiscent of Aristotle. It is now safe to recognize him, in the words of the American zoologist Ernst Mayr

(b. 1904), as the greatest contributor to current knowledge of life before Charles Darwin (1809–1882).

In recent decades a number of thinkers have taken Aristotelian approaches to the philosophy of biology, bioethics, and political philosophy. The philosopher Hans Jonas (1903–1993) adopted a hulomorphism, teleology, and concept of life derived largely from Aristotle's *On the Soul.* Jonas (1966) argued that the greatest error of modern thought was dualism, in particular the isolation of the concept of mind from that of the living body. For Jonas, mind, and perhaps even some germ of consciousness, is present even in the simplest organisms. As in Aristotle, the natural history of mind and that of organic life are in fact the same study.

This rejection of dualism has important ethical as well as philosophical consequences. Modern ecological thought has largely discredited the early modern view of nature as a storehouse of materials to be manipulated by human will. If humans are as much a part of nature as any organic or inorganic process, then nature should be approached with respect, and cultivated rather than merely manipulated. Deeply influenced by Jonas, the philosopher Leon Kass (1985) puts special emphasis on the dignity of *human* life. As Aristotle argued, human beings share the capacities of soul that demarcate plants and animals but enjoy other capacities (such as speech and intelligence) that are found nowhere else in nature. Precisely if human nature is the result of an unrepeatable evolutionary process, we ought to take a cautiously ecological approach to biotechnology.

KENNETH C. BLANCHARD JR.

SEE ALSO *Natural Law; Plato; Scientific Ethics; Thomas Aquinas; Virtue Ethics.*

BIBLIOGRAPHY

Arnhart, Larry. (1998). *Darwinian Natural Right: The Biological Ethics of Human Nature.* Albany: State University of New York Press. An attempt at reconciling Aristotle with contemporary Darwinian social and political thought.

Barnes, Jonathan, ed. (1984).*The Complete Works of Aristotle,* 2 vols. Princeton, NJ: Princeton University Press. A good collection of Aristotle's major works.

Charlton, William, ed. (1984). *Aristotle's "Physics," Book One and Two.* Oxford: Clarendon Press. An excellent translation with notes of one of the most important passages in Aristotle's work. Includes discussions of hulomorphism, the doctrine of four causes, and teleology.

Gotthelf, Allan, and James G. Lennox, eds. (1987). *Philosophical Issues in Aristotle's Biology.* Cambridge, UK: Cambridge University Press. A collection of important essays by different scholars concerning Aristotle's philosophy of biology. All take Aristotle seriously from the point of view of modern biology.

Jaffa, Harry V. (1963). "Aristotle." In *History of Political Philosophy,* ed. Leo Strauss and Joseph Cropsey. Chicago: University of Chicago Press. Not included in later editions of the Strauss-Cropsey collection, this is possibly the best essay on Aristotle's politics in English.

Jonas, Hans. (1966). *The Phenomenon of Life: Toward a Philosophical Biology.* New York: Delta. A sustained attempt to reconstruct an Aristotelian philosophy of life out of the insights and evidence provided by modern biology.

Kass, Leon. (1985). *Toward a More Natural Science: Biology and Human Affairs.* New York: Free Press. A series of essays taking a mostly Aristotelian approach to contemporary bioethical questions.

Lennox, James G. (2001). *Aristotle's Philosophy of Biology.* Cambridge, UK: Cambridge University Press. A collection of essays by one of the foremost authorities on Aristotelian biology.

Nussbaum, Martha C., and Amélie Oksenberg Rorty, eds. (1992). *Essays on Aristotle's "De anima."* Oxford: Clarendon Press. A number of diverse essays organized around the question whether Aristotle's biological thought can be commensurate with modern biology.

ARSENIC

Arsenic has long been regarded as a dangerous poison and an environmental contaminant. But in the 1980s the focus on arsenic changed dramatically when approximately 3 million tube wells in Bangladesh and West Bengal, India, were found to be contaminated with that highly reactive chemical agent. By 2003 public health authorities estimated that as much as 40 million persons were being exposed to varying concentrations of the chemical in Bangladesh, plus another 3 million in West Bengal. The source of the arsenic came as a surprise to the toxic substance community in that the contamination was so widespread and came not from any industrial source but from rocks and sediment in the region's natural geological formations.

Arsenic is one of the most ubiquitous and paradoxical substances on Earth. In very small amounts, it is essential to life. In large amounts it is poisonous. While its inorganic forms are toxic, its organic forms are benign. Industrial arsenic is used for leather tanning, in pigments, glassmaking, fireworks, and medicinals, and as an additive that gives strength to metals. It is also a poison gas agent.

Arsenic's toxic effects vary according to exposure. Moderate levels (roughly 100 parts per billion and higher) can cause nausea and vomiting, decreased production of red and white blood cells, abnormal heart rhythm, and tingling in the hands and feet. Chronic exposure over time causes dark sores on hands, feet, and torso plus overall debilitation from damage to the cardiovascular, immune, neurological, and endocrine systems. Cancer can also occur after years of arsenic exposure at moderate to high levels.

After years of controversy over compliance costs, the U.S. Environmental Protection Agency in 2001 established a drinking water standard of 10 parts per billion, that was scheduled to go into effect in January 2006. The new rule supplanted the 50 ppb standard that had been in effect since 1975. The World Health Organization's has likewise adopted a 10ppb guideline. Arsenic readings in the Bangladesh/West Bengal groundwater frequently run from 200 ppb to 1,000 ppb. Deep wells, however, are not believed to be a problem.

Arsenic as both an industrial and natural pollutant is hardly a new phenomenon worldwide. High arsenic levels in air and water from mining and manufacturing operations from China to Peru have been well recognized though sporadically regulated for decades. Moreover, arsenic leached into waterways and aquifers from naturally occurring geological formations has been recorded in several regions. But because most of those areas are geographically remote, only the environmental toxicology community has taken much notice.

The ethics of arsenic control are vastly complex. The moment an environmental problem rises to crisis proportions in the industrial democracies of Europe and North America, the response is to assemble all possible mitigation techniques and human resources to attack the problem quickly. Nothing of the sort had happened in response to the disaster in South Asia, owing mainly to political graft, bureaucratic bloat, and the conflicting and poorly coordinated maze of national and international institutions whose involvement is required. The World Bank in 1998 issued a $32.4 million loan for the planning and execution of mitigation projects, but not until 2004 were the funds released for the project to begin.

As of 2005, the problem remained so widespread and Bangladesh was so lacking in resources that villagers themselves had to be taught to self-police and improve their water supplies by marking contaminated wells and using cheap and simple filtration techniques. For that to happen, inexpensive, mobile testing kits were needed and alternative sources of water had to be developed.

WIL LEPKOWSKI

SEE ALSO *Heavy Metals.*

BIBLIOGRAPHY

National Academy of Sciences. (2001). *Arsenic in Drinking Water: 2001 Update*. Washington, DC: National Academy of Sciences Press.

Patel, Priya Harish. (2001). "The Crisis of Capacity: A Case Study of Arsenic Contamination in Bangladesh and West Bengal." Cambridge, MA: Harvard University, Department of Environmental Science and Public Policy. Honors thesis.

INTERNET RESOURCES

Arsenic Crisis Information Center. Available at http://bicn.com/acic/.

Harvard University Environmental Science Group. Available at http://phys4.harvard.edu/~wilson/arsenic. Provides valuable information on the Bangladesh crisis.

Jadavpur University Department of Environmental Studies. Available at http://www.sos-arsenic.net.

ARTIFICIAL INTELLIGENCE

Artificial Intelligence (AI) is the science and technology that seeks to create intelligent computational systems. Researchers in AI use advanced techniques in computer science, logic, and mathematics to build computers and robots that can mimic or duplicate the intelligent behavior found in humans and other thinking things. The desire to construct thinking artifacts is very old and is reflected in myths and legends as well as in the creation of lifelike art and clockwork automatons during the Renaissance. But it was not until the invention of programmable computers in the mid-twentieth century that serious work in this field could begin.

AI Research Programs

The computer scientist John McCarthy organized a conference at Dartmouth College in 1956 where the field of AI was first defined as a research program. Since that time a large number of successful AI programs and robots have been built. Robots routinely explore the depths of the ocean and distant planets, and the AI program built by International Business Machines (IBM) called Deep Blue was able to defeat the grand master chess champion Garry Kasparov after a series of highly publicized matches. As impressive as these accomplishments are, critics still maintain that AI has yet to achieve the goal of creating a program or robot that can truly operate on its own (autonomously) for any significant length of time.

AI programs and autonomous robots are not yet advanced enough to survive on their own, or interact with the world in the same way that a natural creature might. So far AI programs have not been able to succeed in solving problems outside of narrowly defined domains. For instance, Deep Blue can play chess with the greatest players on the planet but it cannot do anything else. The dream of AI is to create programs that not only play world-class chess but also hold conversations with people, interact with the outside world, plan and coordinate goals and projects, have independent personalities, and perhaps exhibit some form of consciousness.

Critics claim that AI will not achieve these latter goals. One major criticism is that traditional AI focused too much on intelligence as a process that can be completely replicated in software, and ignored the role played by the lived body that all natural intelligent beings possess (Dreyfus 1994). Alternative fields such as Embodied Cognition and Dynamic Systems Theory have been formed as a reply to this criticism (Winograd and Flores 1987). Yet researchers in traditional AI maintain that the only thing needed for traditional AI to succeed is simply more time and increased computing power.

While AI researchers have not yet created machines with human intelligence, there are many lesser AI applications in daily use in industry, the military, and even in home electronics. In this entry, the use of AI to replicate human intelligence in a machine will be called *strong AI*, and any other use of AI will be referred to as *weak AI*.

Ethical Issues of Strong AI

AI has and will continue to pose a number of ethical issues that researchers in the field and society at large must confront. The word *computer* predates computer technology and originally referred to a person employed to do routine mathematical calculations. People no longer do these jobs because computing technology is so much better at routine calculations both in speed and accuracy (Moravec 1999). Over time this trend continued and automation by robotic and AI technologies has caused more and more jobs to disappear. One might argue, however, that many other important jobs have been created by AI technology, and that those jobs lost were not fulfilling to the workers who had them.

This is true enough, but assuming strong AI is possible, not only would manufacturing and assembly line jobs become fully automated, but upper management and strategic planning positions may be computerized as well. Just as the greatest human chess masters cannot compete with AI, so too might it become impossible for human CEOs to compete with their AI counterparts. If AI becomes sufficiently advanced, it might then radically alter the kinds of jobs available, with the potential to permanently remove a large segment of the population from the job market. In a fully automated world people would have to make decisions about the elimination of entire categories of human work and find ways of supporting the people who were employed in those industries.

Other ethical implications of AI technology also exist. From the beginning AI raised questions about what it means to be human. In 1950 the mathematician and cryptographer Alan Turing (1912–1954) proposed a test to determine whether an intelligent machine had indeed been created. If a person can have a normal conversation with a machine, without the person being able to identify the interlocutor as a machine, according to the Turing test the machine is intelligent (Boden 1990). In the early twenty-first century people regularly communicate with machines over the phone, and Turing tests are regularly held with successful results—as long as the topic of discussion is limited. In the past special status as expert thinkers has been proposed as the quality that distinguishes humans from other creatures, but with robust AI that would no longer be the case. One positive effect might be that this technology could help to better explain the place of humans in nature and what it means for something to be considered a person (Foerst 1999).

The ethical responsibility that people have toward any strong AI application is a matter that must be taken into consideration. It does not seem moral to create thinking minds and then force them to do work humans do not want to do themselves.

Finally because AI technology deals directly with human operators, people must make decisions regarding what kind of ethics and morality are going to be programmed into these thinking machines. The scientist and fiction writer Isaac Asimov proposed in his writings three moral imperatives that should be programmed into robots and other AI creations:

- A robot may not injure a human being or, through inaction, allow a human being to come to harm.
- A robot must obey the orders given it by human beings except where such orders conflict with the first law.
- A robot must protect its own existence as long as such protection does not conflict with the first or second law.

These imperatives make for good reading but are sadly lacking as a solution to the problems presented by fully autonomous robotic technologies. Asimov wrote many stories and novels (The *Robot Series* [1940–1976] and *I,* *Robot* [1950]) that used the unforeseen loopholes in the logic of these laws, which occasionally allowed for fatal encounters between humans and robots. For instance, what should a robot do if, in order to protect a large number of people, it must harm one human who is threatening others? It can also be argued that AI technologies have already begun to harm people in various ways and that these laws are hopelessly naïve (Idier 2000). Other researchers in the field nevertheless argue that Asimov's laws are actually relevant and at least suggest a direction to explore while designing a computational morality (Thompson 1999).

This problem is more pressing than it may seem, because many industrial countries are working to create autonomous fighting vehicles to augment the capabilities of their armed forces. Such machines will have to be programmed so that they make appropriate life and death choices. More subtle and nuanced solutions are needed, and this topic remains wide-open—widely discussed in fiction but not adequately addressed by AI and robotics researchers.

Ethical Issues of Weak AI

Even if robust AI is not possible, or the technology turns out to be a long way off, there remain a number of vexing ethical problems to be confronted by researchers and technologists in the weak AI field. Instead of trying to create a machine that mimics or replicates exactly human-like intelligence, scientists may instead try to imbed smaller, subtler levels of intelligence and automation into all day-to-day technologies. In 1991 Mark Weiser (1952–1999) coined the term *ubiquitous computing* to refer to this form of AI, but it is also sometimes called the *digital revolution* (Gershenfeld 1999).

Ubiquitous computing and the digital revolution involve adding computational power to everyday objects that, when working together with other semismart objects, help to automate human surroundings and hopefully make life easier (Gershenfeld 1999). For instance, scientists could imbed very small computers into the packaging of food items that would network with a computer in the house and, through the Internet perhaps, remind people that they need to restock the refrigerator even when they are away from home. The system could be further automated so that it might even order the items so that one was never without them. In this way the world would be literally at the service of human beings, and the everyday items with which they interact would react intelligently to assist in their endeavors. Some form of this more modest style of AI is very likely to come into existence. Technologies are already moving in these directions through the merger of such things as mobile phones and personal data assistants.

Again this trend is not without ethical implications. In order for everyday technologies to operate in an intelligent manner they must take note of the behaviors, wants, and desires of their owners. This means they will collect a large amount of data about each individual who interacts with them. This data might include sensitive or embarrassing information about the user that could become known to anyone with the skill to access such information. Additionally these smart technologies will help increase the trend in direct marketing that is already taking over much of the bandwidth of the Internet. Aggressive advertisement software, spying software, and computer viruses would almost certainly find their way to this new network. These issues must be thoroughly considered and public policy enacted before such technology becomes widespread.

In addition, Weiser (1999) argues that in the design of ubiquitous computing people should work with a sense of humility and reverence to make sure these devices enhance the humanness of the world, advancing fundamental values and even spirituality, rather then just focusing on efficiency. Simply put, people should make their machines more human rather then letting the technology transform human beings into something more machine-like.

A last ethical consideration is the possibility that AI may strengthen some forms of gender bias. Women in general, and women's ways of knowing in particular, have not played a large role in the development of AI technology, and it has been argued that AI is the fruit of a number of social and philosophical movements that have not been friendly to the interests of women (Adam 1998). Women are not equally represented as researchers in the field of AI, and finding a way to reverse this trend is a pressing concern. The claim that AI advances the interests of males over those of females is a more radical, yet intriguing claim that deserves further study.

AI continues to grow in importance. Even though researchers have not yet been able to create a mechanical intelligence rivaling or exceeding that of human beings, AI has provided an impressive array of technologies in the fields of robotics and automation. Computers are becoming more powerful in both the speed and number of operations they can achieve in any given amount of time. If humans can solve the problem of how to program machines and other devices to display advanced levels of intelligence, as well as address the many ethical issues raised by this technology, then AI may yet expand in astonishing new directions.

JOHN P. SULLINS III

SEE ALSO *Artificial Morality; Artificiality; Asimov, Isaac; Automation; Computer Ethics; Robots and Robotics; Turing, Alan; Turing Tests.*

BIBLIOGRAPHY

Adam, Alison. (1998). *Artificial Knowing: Gender and the Thinking Machine*. New York: Routledge. Adam is an AI researcher who writes from experience about the difficulties encountered by women working in AI. She also argues that if women were more involved in AI it would significantly alter and improve the results of this science. Accessible, informative, and includes a select bibliography.

Asimov, Isaac. (2004). *I, Robot*. New York: Bantam Books. Classic science fiction account of the social impact of robotics. The stories are very entertaining while at the same time exploring deeply philosophical and ethical questions.

Boden, Margret A., ed. (1990). *The Philosophy of Artificial Intelligence*. New York: Oxford University Press. A collection of the best papers written on the philosophical debate regarding the possibility of creating AI. The research included stops at the early 1990s but this is a good place to start one's study of the subject. Includes a select bibliography.

Dreyfus, Hubert L. (1994). *What Computers Still Can't Do*. Cambridge MA: MIT Press. This is a famous counter argument to the very possibility of achieving any results in strong AI. Largely dismissed by the AI community, it is still useful as an example of how one might argue that AI misses the important insights into human intelligence and consciousness that phenomenological psychology and Heideggerian philosophy might add.

Dreyfus, Hubert L., and Stuart E Dreyfus. (1986). *Mind over Machine: The Power of Human Intuition and Expertise in the Era of the Computer*. New York: Free Press. This book was written with the author's brother who worked with the AI technology questioned in the book. They claim that human intelligence is not completely captured by AI technology and give numerous examples to illustrate their claims. Many of their claims, such as the inability of AI to program a computer to beat a chess master, seem to have been incorrect but this book is an important first step in Dreyfus's critique of AI.

Foerst, Anne. (1999). "Artificial Sociability: from Embodied AI toward New Understandings of Personhood." *Technology in Society* 21(4): 373–386. Good discussion of the impact AI and robotics has on complicating the notion of *personhood*, or what are the conditions under which something is understood to be a person.

Gershenfeld, Neil. (1999). *When Things Start to Think*. New York: Henry Holt. Good general overview of the attempt to add intelligence to everyday technology. Gershenfeld is involved in this research and speaks with authority on the subject without being overly technical.

Idier, Dominic. (2000). "Science Fiction and Technology Scenarios: Comparing Asimov's Robots and Gibson's Cyberspace." *Technology in Society* 22: 255–272. A more up-to-date analysis of Asimov's prognostications about robotics in light of the more dystopian ideas of the science fiction author William Gibson.

Luger, George F., ed. (1995). *Computation and Intelligence*. Cambridge, MA: AAAI Press/ MIT Press. A collection of many of the best early papers written on AI by the pioneers of the field. These papers have shaped the field of AI and continue to be important. Includes an extensive bibliography.

Moravec, Hans. (1999). *Robot: Mere Machine to Transcendent Mind*. New York: Oxford University Press. One of the most successful AI researchers unabashedly predicts the future of humanity and the emergence of its robotic "mind children." Deftly presents very technical arguments for the general reader.

Nilsson, Nils J. (1986). *Principles of Artificial Intelligence*. Los Altos, CA: Morgan Kaufmann. Good introduction to the more technical issues of AI as a science.

Searle, John R. (1992). *The Rediscovery of the Mind*. Cambridge, MA: MIT Press. The American philosopher John Searle argues for the inability of AI to capture semantics (the meaning of words), with machines that can only manipulate syntax (the grammar and symbols of a language). If there is no mechanical way to create semantic understanding then there is no way to create thinking machines. This argument has not gone unchallenged by AI researchers and many of the entries in this bibliography attempt to refute Searle.

Thompson, Henry S. (1999). "Computational Systems, Responsibility, and Moral Sensibility." *Technology in Society* 21(4): 409–415. A discussion of how humans should be more sensitive to the moral implications of the computational systems they build.

Weiser, Mark. (1993). "Hot Topics: Ubiquitous Computing." *IEEE Computer* 26(10): 71–72. Also available from http://www.ubiq.com/hypertext/weiser/UbiCompHotTopics.html. Weiser introduces the concept of ubiquitous computing. This remains a very important defining moment for the field.

Weiser, Mark. (1999). "The Spirit of the Engineering Quest." *Technology in Society* 21: 355–361. Weiser argues that those who engineer devices that mediate the human-to-world interface should be especially careful that their work enhances human life rather than detracts from it.

Winograd, Terry, and Fernando Flores. (1987). *Understanding Computers and Cognition: A New Foundation for Design*. Boston: Addison-Wesley Publishing. Winograd and Flores argue for a form of AI that takes into account the important counterarguments to traditional AI, and instead of ignoring them, incorporates them into a better science that takes the embodiment of cognitive agents seriously.

ARTIFICIALITY

In the European and North American tradition, a thing is natural insofar as its existence does not depend on human intervention, while something is artificial if its existence depends on human activity. From this per-

English conjuror John Neville Maskelyne with two "musical automata" playing a trumpet and a tuba, c. 1890. These lifelike objects are an example of early forms of artifciality. *(Hulton Archive/ Getty Images.)*

spective, artificiality extends not just to some physical objects but also to intellectual phenomena such as science, art, and technology—to the extent that they are characteristic of human life. With regard to strictly physical artifice, Aristotle, in *Physics*, further notes that unlike natural objects, artifacts do not have internal sources of motion and rest. If a bed were to sprout, what would come up would not be another bed, but an oak tree (Book 2.1). In relation to both these extrinsic and intrinsic features, it has also been common to assess artifice, in comparison with nature, as a diminished level of reality, and sometimes as less valuable. The ethics of artifacts has usually been to argue their lesser intrinsic value but their greater extrinsic or instrumental value insofar as they benefit humans and moderate a sometimes harsh experience of nature.

From Nature to Technology and Back

Nevertheless it is necessary to distinguish at least two types of artificiality. For instance, Aristotle again distinguishes those technics that help nature do more effectively or abundantly what it already does to some extent on its own and those that construct objects that would not be found at all in nature if it were not for human ingenuity. The former or what might be called type A artifacts are associated with the techniques of agriculture, medicine, and education. The latter or type B artifacts are associated with architecture and more modern technologies. But type B artifacts need not always create things not found in nature such as right-angle buildings. Using technology it is also possible to create replacements or substitutes for natural objects in the form, for example, of artificial grass, artificial kidneys, and even artificial intelligence. The term *synthetics* is also sometimes applied to this class of artifacts, as with synthetic oil or synthetic wood. It is thus necessary to distinguish type B(1) and type B(2) artifice, and because of the special features of type B(2) artifacts it is useful to coin the term *naturoids*. Naturoids may include a variety of artifacts, from automatons, robots, and androids to humanoids, bionic humans, and more.

The field of naturoids is greatly advanced in the early twenty-first century thanks to developments in physics, chemistry, biology, materials science and technology, electronics, and computer science. Nevertheless its roots are quite ancient because, as Derek de Solla Price emphasizes, human history "begins with the deep-rooted urge of man to simulate the world about him through the graphic and plastic arts" (de Solla Price 1964, p. 8). Well-known are the efforts of eighteenth-century mechanics to build machines that would often mimic certain living systems, as in the cases of Jacques de Vaucanson, Julien Offray de Lamettrie, and Pierre Jacquet-Droz, as well as Karel Capek's image of a robot in the early twentieth century. Twenty-first century naturoids cover a wide range of machines, including artificial body parts and organs, advanced robots, and reproductions of other physical objects or processes—such as stone, grass, smell, and speech—and, on a software level, artificial intelligence or life.

Genetic engineering offers even more dramatic prospects, but in a different direction from naturoids' tradition. In fact, humans are able to change the architecture of DNA, but the final result is a quite natural system, though possibly unusual. At the contrary, a naturoid, even if built by means of nanotechnology, comes always from an analyical design within which all the components are replacements of the corresponding natural parts. Nevertheless, a new reality could come from mixed systems such as bionic ones, where natural subsystems are put at work along with artificial devices giving birth to fascinating and unexperienced problems even from an ethical point of view.

Embodied Ethics

Artificiality has often been criticized as opposed to the natural and the naturally human, and also for its unintended social, legal, and ethical consequences. Such attitude, which recalls the suspicion of sorcery directed at the mechanicians of the Renaissance, takes on a new form in the present. As Edward Tenner (1996) has argued, artifacts have a tendency, not unlike ill-behaved pets, to *bite back* through what he calls "the revenge of unintended consequences" (Tenner 1996).

However in discussions of unintended consequences—which is often taken as a fundamental ethical problem of artifacts—little effort has been made to distinguish among the types of artificiality already mentioned. In fact, while type I artifacts (such as pencils, rifles, cars, and cathode-ray tubes) return to human beings responsibility for their uses, type B artifacts, especially type B(2) artifacts or naturoids, as forms of objects and processes in nature, tend to embody ethical models in their own architecture.

The famous *Three Laws of Robotics*, proposed by Isaac Asimov, illustrate this phenomenon. Yet in fact every naturoid includes at its core not only some image of the natural exemplar it aims to recreate, but also its ideal function. For instance, an artificial organ embodies both the current knowledge of the natural organ and the views regarding its correct functioning in human physiology and even within human society. The same may be said for artificial intelligence programs, artificial life simulations, *virtual reality* devices, and other attempts to give birth to the entities of posthumanism.

Once some implicit or explicit ethical model is assigned to a naturoid, it will appear to be an actor itself, and people will interact with it as if they were interacting with something natural or social. This explains why some scholars such as Latour have begun to think that machines "challenge our morality" (quoted in Margolin 2002, p. 117) while others predict that they will soon be considered responsible actors.

The Third Reality

Unlike technologies that do not aim to produce anything immediately present in nature—that is, type B(1) artifacts—naturoid or type B(2) technologies emerge from a design process that begins with an idea not only of what a machine has to be and to do, but also of what the natural exemplar actually is and does. Nevertheless constructing a model of a natural exemplar requires some reduction in its complexity. This reductive process includes: (a) the selection or the construction of an observation level; (b) the simplification of the exemplar structure according to the selected observation level; (c) its isolation from the context in which it exists; and (d) the selection or the attribution of some performance function that designers judge essential in its behavior.

The adoption of materials that differ from those used by nature—and their interplay in a machine—makes the naturoid an alternative realization (Rosen 1993) when compared to the natural exemplar. All this, in turn, implies that the appearance and behavior of a naturoid will unavoidably overlap with only a limited set of properties from the natural exemplar, and thus importantly, give them a transfigured character in many respects and to various degrees (power, sensitivity, flexibility, side-effects, and so forth).

As a consequence, even the ethical models implicit in all naturoids will tend to work according to styles that are rather unusual in human behavior. This explains why, for example, automatic or artificial devices often appear too rigid in applying their rules. The same may be said for so-called *enhanced reality* devices—for example, deliberate transfigurations of some natural exemplar through its artificialization—because it is not possible to resort to any known or sufficiently established *artificial morality* model.

What must be emphasized is that naturoids are not simply devices humans *use;* rather, humans expect them to be self-adaptive and transparent *replacements* of natural objects. Therefore their way of being and acting is intrinsically presumed to be compatible with human ethics. Nevertheless naturoids are setting up a third reality, part natural and part artificial, whose ethical significance remains to be determined.

MASSIMO NEGROTTI

SEE ALSO *Artificial Intelligence; Artificial Morality; Plastics; Posthumanism.*

BIBLIOGRAPHY

Cordeschi, Roberto. (2002). *The Discovery of the Artificial: Behavior, Mind and Machines Before and Beyond Cybernetics*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

de Solla Price, Derek. (1964). "Automata and the Origin of Mechanism." *Technology and Culture* 5(1): 24–42.

Latour, Bruno. (1992). "Where Are the Missing Masses: The Sociology of a Few Mundane Artifacts." In *Shaping Technology/Building Society: Studies in Sociotechnical Change*, ed. Wiebe E. Bijker and John Law. Cambridge, MA: MIT Press.

Margolin, Victor. (2002). "Human And Machine: Issues Of Collaborative Action." In *Yearbook of the Artificial, Nature, Culture and Technology*, ed. Massimo Negrotti. Bern, Switzerland: Peter Lang.

Negrotti, Massimo. (2002). *Naturoids: On The Nature of the Artificial.* River Edge, NJ: World Scientific Publishing.

Rosen, Robert. (1993). "Bionics Revisited." In *The Machine as Metaphor and Tool,* eds. Hermann Haken, Anders Karlqvist, and Svedin Uno. Berlin: Springer Verlag.

Simon, Herbert A. (1996). *The Sciences of the Artificial,* 3rd edition. Cambridge, MA: MIT Press. Earlier editions published in 1969 and 1981.

Tenner, Edward. (1996). *Why Things Bite Back: Technology and the Revenge of Unintended Consequences.* New York: Knopf.

ARTIFICIAL MORALITY

Artificial morality is a research program for the construction of moral machines that is intended to advance the study of computational ethical mechanisms. The name is an intentional analogy to artificial intelligence (AI). Cognitive science has benefited from the attempt to implement intelligence in computational systems; it is hoped that moral science can be informed by building computational models of ethical mechanisms, agents, and environments. As in the case of AI, project goals range from the theoretical aim of using computer models to understand morality mechanistically to the practical aim of building better programs. Also in parallel with AI, artificial morality can adopt either an engineering or a scientific approach.

History

Modern philosophical speculation about moral mechanisms has roots in the work of the philosopher Thomas Hobbes (1588–1679). More recently, speculation about ways to implement moral behavior in *computers* extends back to Isaac Asimov's influential three laws of robotics (1950) and pioneer cyberneticist Warren McCulloch's 1965 sketch of levels of motivation in games. On the lighter side, Michael Frayn's *The Tin Men* (1965) is a parody of artificial morality that features an experimental test of altruism involving robots in life rafts. Although there has been fairly extensive work in this field broadly considered, it is an immature research area; a recent article calls itself a "Prolegomena" (Allen, Varner, and Zinser 2000). The following survey will help explain some of the goals and methods in this young field.

Ethics in the Abstract

Consider first the easiest goal: to understand ethics in the abstract context provided by computer programs. Robert Axelrod (1984) made a breakthrough in the field when he organized tournaments by asking experts in decision and game theory to submit programmed agents to play a well-known game: the iterated prisoner's dilemma. That challenge entailed the basic computational assumption that everything relevant to such a player could be specified in a computer program. Although games-playing programs figured in the early history of artificial intelligence (for example, A. L. Samuel's [1959] checkers program), the prisoner's dilemma is a mixed motive game that models morally significant social dilemmas such as the tragedy of the commons. In such situations one alternative—overfishing or creating more greenhouse gas—is rational yet morally defective because it is worse for all.

These models have generated considerable interest in the question of the ways rational choice relates to ethics. By focusing on an abstract game Axelrod was able to avoid trying to model full human moral decision making. Nonetheless, the iterated prisoner's dilemma is a hard problem. There is a large strategy set, and good strategies must take account of the other players' strategies. Thus, unlike AI, which for much of its first generation focused on single agents, artificial morality began by focusing on a plurality of agents.

Ethics and Game Theory

One result of Axelrod's initiative was to unite ethics and game theory. On the one hand, game theory provides simple models of hard problems for ethics, such as the prisoner's dilemma. First, game theory forces expectations for ethics to be made explicit. Early work in this field (Danielson 1992) expected ethics to solve problems—such as cooperation in a one-play prisoner's dilemma—that game theory considers impossible. More recent work (Binmore 1994, Skyrms 1996) lower the expectations for ethics. Consider Axelrod's recommendation of the strategy tit-for-tat as a result of its relative success in his tournament. Because the game is iterated, tit-for-tat is not irrationally cooperative. However, its success shows only that tit-for-tat is an equilibrium for this game; it is rational to play tit-for-tat if enough others do. But game theory specifies that many—indeed infinitely many—strategies are equilibria for the iterated prisoner's dilemma. Thus game theory shifts the ground of ethical discussion, from a search for the best principle or strategy, to the more difficult task of selecting among many strategies, each of which is an equilibrium, that is to say, a feasible moral norm.

Artificial Evolution

Another result of Axelrod's work was to link ethics and the evolutionary branch of game theory and modeling.

Axelrod established equilibriums by means of an evolutionary simulation (a form of the standard replicator dynamics) of the initial results. His later work introduced agents whose strategies could be modified by mutation. Classic game theory and modern ethics share many assumptions that focus on a normative question: What should hyperrational, fully informed agents do, taking their own or everyone's interests into account, respectively? However, it sometimes is easier to discover which of many simpler, less well-informed agents will be selected for solving a problem, and generally evolution selects what rationality prescribes (Skyrms 1996). This change from attempting to discover the perfect agent to experimenting with a variety of agents is especially helpful for ethics, which for a long time has been divided among partisans of different ethical paradigms. Evolutionary artificial morality promises to make it possible to test some of these differences. One benefit of combining evolution and simple programmed agents is that one can construct, for example, all possible agents as finite state machines of a given complexity, and use evolutionary techniques to test them (Binmore 1994). Another example is provided by Skyrms (1996), who ran evolutionary simulations where agents bargain in different ways, characteristic of different approaches to ethics.

A third effect of this research program is more directly ethical. A common result of experiments and simulations in artificial morality is to heighten the role of reciprocity and fairness at the expense of altruism. This shift is supported by human experiments as well as by theory. Experiments show that most subjects will carry out irrational threats to punish unfair actions. The theory that supports these results shows that altruism alone will not solve common social dilemmas.

Moral Engineering

The previous examples illustrate the simplest cases of what more properly might be called artificial moral engineering. In this area theorists are happy to study simple agents in simple games that model social settings to establish proofs of the basic concepts of the field: that moral behavior can be programmed and that ethically interesting situations can be modeled computationally.

At the other end of the engineering spectrum are those who try to build moral agents to act in more realistic situations of real artificial agents on the Internet and in programs more generally (Coleman 2001). This highlights the most immediate importance of artificial morality: "The risks posed by autonomous machines ignorantly or deliberately harming people and other sentient beings are great. The development of machines with enough intelligence to assess the effects of their actions on sentient beings and act accordingly may ultimately be the most important task faced by the designers of artificially intelligent automata" (Allen, Varner, and Zinser 2000, p. 251).

However, this survey of artificial moral engineering would be misleading if it did not note that there is a well-developed sub-field of AI—multiagent systems—that includes aims that fall just short of this. In a successful multiagent system computational agents without a common controller coordinate activity and cooperate rather than conflict. No current multiagent system is ethically sophisticated enough to understand harm to humans, but the aims of these fields clearly are convergent.

Moral Science

All this is engineering, not science. Artificial moral science adds the goal of realism. An effective ethical program might work in ways that shed no light on human ethics. (Consider the analogy between cognitive engineering and science, in which the Deep Blue chess program would be the analogous example of cognitive engineering. The clearest cases of artificial moral science are computational social scientists who test their models of social interaction with human experiments. For example, Peter Kollock (1998) tests a model in which moral agents achieve cooperation by perceiving social dilemmas in the more benign form of assurance games by running experiments on human subjects.

Finally, one benefit of the computational turn in ethics is the ability to embed theories in programs that provide other researchers with the tools needed to do further work. Again there is an analogy with artificial intelligence, many early discoveries in which have been built into standard programming languages. In the case of artificial morality academic computational tools such as Ascape and RePast allow researchers to construct experiments in "artificial societies" (Epstein and Axtell 1996). A related benefit of the computational approach to ethics is the development of a common language for problems and techniques that encourage researchers from a range of disciplines, including philosophy, biology, computing science, and the social sciences, to share their results.

Computer Games

While the work discussed so far is academic research some of the issues of artificial morality have already come up in the real world. Consider computer games. First, some of the most popular games are closely related to the artificial society research platforms discussed above. The bestselling SimCity computer game series is a popularized urban planning simulator. The user can select policies favoring cars or transit, high or low taxes, police or education expenditures, but, crucially, cannot control directly what the simulated citizens do. Their response is uncontrolled by the player, determined by the user's policies and values and dynamics programmed into the simulation. This serves as a reminder that artificial morality is subject to the main methodological criticism of all simulation: Assumptions are imbedded in a form that can make their identification and criticism difficult (Turkle 1995, Chapter 2).

Second, as computer games make use of AI to control opponents and other agents not controlled by humans, so too they raise issues of artificial morality. Consider the controversial case of the popular grand theft auto series of games, in which the player can run over pedestrians or attack and kill prostitutes. The victims and bystanders barely react to these horrible acts. These games illustrate what one might call "artificial amorality" and connect to criticisms that video and computer games "create a decontextualized microworld" (Provenzo 1991, p. 124) where harmful acts do not have their normal social consequences.

Third, games and programmed agents on the internet raise questions about what features of artificial characters lead to their classification in morally relevant ways. Turkle (1995) shows how people adjust their category schemes to make a place for artificial agents they encounter that are "alive" or "real" in some but not all respects.

PETER DANIELSON

SEE ALSO *Altruism; Artificial Intelligence; Artificiality; Game Theory; Robots and Robotics.*

BIBLIOGRAPHY

Allen, Colin; Gary Varner; and Jason Zinser. (2000). "Prolegomena to Any Future Artificial Moral Agent." *Journal of Experimental and Theoretical Artificial Intelligence* 12: 251–261. A survey of problems to which artificial morality might apply.

Asimov, Isaac. (1950). *I, Robot*. New York: Fawcett. Classic science fiction source of the three laws of robotics.

Axelrod, Robert. (1984). *The Evolution of Cooperation*. New York: Basic Books. Accessible introduction to some game theory and evolution methods for studying moral problem of cooperation.

Binmore, Ken. (1994). *Game Theory and the Social Contract: Playing Fair*. Cambridge, MA: MIT Press. A sophisticated use of game theory to criticize and extend artificial morality

Coleman, Kari. (2001). "Android Arete: Toward a Virtue Ethic for Computational Agents." *Ethics and Information Technology* 3(4): 247–265.

Danielson, Peter. (1992). *Artificial Morality: Virtuous Robots for Virtual Games*. London: Routledge.

Danielson, Peter. (1998). *Modeling Rationality, Morality, and Evolution*. New York: Oxford University Press.

Danielson, Peter. (2002). "Competition among Cooperators: Altruism and Reciprocity." *Proceedings of the National Academy of Sciences* 99: 7237–7242.

Epstein, Joshua M., and Robert Axtell. (1996). *Growing Artificial Societies: Social Science from the Bottom Up*. Cambridge, MA: MIT Press. Introduction to agent based modeling in the social sciences.

Frayn, Michael. (1965). *The Tin Men*. New York: Ace. A parody of artificial intelligence and artificial morality.

Kollock, Peter. (1998). "Transforming Social Dilemmas: Group Identity and Co-operation." In *Modeling Rationality, Morality, and Evolution*, ed. Peter Danielson. New York: Oxford University Press. Illustrates how experiments and game theory can be used together.

McCulloch, Warren Sturgis. (1965). "Toward Some Circuitry of Ethical Robots or an Observational Science of the Genesis of Social Evaluation in the Mind-Like Behavior of Artifacts." In his *Embodiments of Mind*. Cambridge, MA: MIT Press. Early speculation of the ethical potential of simple machines and game-like situations.

Provenzo, Eugene F. (1991). *Video Kids: Making Sense of Nintendo*. Cambridge, MA: Harvard University Press.

Samuel, A. L. (1959). "Some Studies in Machine Learning Using the Game of Checkers." *IBM Journal of Research and Development* 3: 210–229. Classic article on machine chess.

Skyrms, Brian. (1996). *Evolution of the Social Contract*. Cambridge, UK, and New York: Cambridge University Press. Accessible introduction to evolutionary game theory and ethics.

Turkle, Sherry. (1995). *Life on the Screen: Identity in the Age of the Internet*. New York: Simon & Schuster.

ASILOMAR CONFERENCE

In February 1975 an international group of scientists met at the Asilomar Conference Grounds in Pacific Grove, California, to discuss the potential biohazards posed by recombinant DNA (rDNA) technology. The official title of the meeting was the International Conference on Recombinant DNA Molecules, but it is remembered simply as the Asilomar Conference. It established guidelines concerning the physical and biological containment of rDNA organisms that served as the model for the current guidelines used by the National Institutes of Health (NIH). Although the Asilomar Conference marks a watershed moment in the regulation of rDNA technology, its broader implications remain controversial (Barinaga 2000, Davatelis 2000). Some claim that it was an example of self-promotion by a small but powerful interest group. Others argue that the process was too alarmist and generated unfounded fears in the public. Still others contend that it was an instance of scientists successfully regulating their own work.

The Events Preceding Asilomar

The first successful trial of rDNA technology (a type of genetic engineering that involves splicing genes into organisms) was performed by Paul Berg and other researchers at Stanford University in the early 1970s. It quickly raised concerns about "playing God" and the potential biohazards posed by recombinant microorganisms. In an unprecedented call for self-restraint, prominent scientists sent letters to the journal *Science* calling for a temporary moratorium on rDNA research (Singer and Söll 1973, Berg et al. 1974). Concerns included the development of biological weapons and the potential for genetically engineered organisms to develop resistance to antibiotics or to escape control.

Singer and Söll's letter was the result of a June 1973 meeting of the Gordon Conference on Nucleic Acids. In response, Berg led a committee of the National Academy of Sciences (NAS) in April 1974 to formulate policy recommendations for the use of rDNA technologies. The Berg committee, which met at the Massachusetts Institute of Technology, was composed of leading molecular biologists and biochemists involved in the emerging rDNA field.

This committee produced three recommendations addressed at the scientific community and the NIH: (1) instituting a temporary moratorium on the most dangerous experiments; (2) establishing an NIH advisory committee to develop procedures for minimizing hazards and to draft guidelines for research (which became the Recombinant DNA Advisory Committee [RAC]); and (3) convening the Asilomar Conference. All three recommendations were implemented.

The Conference Itself

Participation in the NIH-sponsored Asilomar Conference was by invitation only. It was attended by 153 participants. Outside of sixteen members of the press and four lawyers, it was composed entirely of scientists, mostly molecular biologists from the United States. There were no representatives from ethics, social science, ecology, epidemiology, or public-interest organizations.

The formal task of the conference was to identify the potential biohazard risks involved with rDNA technology and design measures to minimize them. Yet there was also a more important informal task faced by the participants. The emerging rDNA technology presented novel problems of regulation characterized by vast uncertainties concerning potential environmental and public health threats. The conference was set within a cultural and political context marked by a growing awareness of these threats and an increasing suspicion of new technologies. Therefore, the informal task faced by the scientists was to regulate rDNA technology in such a way that satisfied the public and, most importantly, allowed the science to be self-governing.

A comment made by Berg, cochair of the conference, illustrates this mind-set:

> If our recommendations look self-serving, we will run the risk of having standards imposed. We must start high and work down. We can't say that 150 scientists spent four days at Asilomar and all of them agreed that there was a hazard—and they still couldn't come up with a single suggestion. That's telling the government to do it for us. (Wright 2001 [Internet source])

In order to achieve the goal of self-governance, the participating scientists narrowed the agenda such that the issue was defined as a technical problem. The organizers decided not to address ethical concerns but to focus on biohazard issues (Wright 1994). Defining the problem in technical terms legitimated the model of self-government by scientists, because they were the only group that could solve such problems.

The conference organizers shaped a consensus around this technical problem definition. There were, however, threats to consensus from both sides. Some participants were opposed to any type of regulation, because it would compromise their freedom of inquiry. Others wanted a broader agenda that included public input on ethical considerations and explicit bans on the development of biological weapons.

In the end, guidelines with respect to physical and biological containment of rDNA organisms were drafted that allowed the scientific community to police itself under the auspices of the NIH-RAC mechanism. The guidelines involved working with disabled bacteria that could not survive outside the lab and classifying experiments according to the level of containment necessary. They also called for an end to experimentation using known carcinogens, genes that produce toxins, and genes that determine antibiotic resistance. The Asilomar Conference established a general sense that the burden of proof rested with scientists and that they must proceed cautiously until they can show that their research is safe.

The laboratory guidelines also became the international standard for rDNA research (see Löw 1985, Wright 1994). In the United States, the system of self-policing avoided both the chaotic patchwork of local legislation established by community decision-making forums and the legal rigidity, yet political changeability, of federal legislation.

Conference Legacy

There have been changes to the guidelines drafted at Asilomar. The membership and role of the NIH-RAC have been expanded, and containment levels have been lowered for many experiments. More public involvement has been incorporated into decision-making processes, and subsequent Food and Drug Administration (FDA) and Environmental Protection Agency (EPA) rules have ensured that the private sector complies with rDNA guidelines as biotechnology has experienced an increasing corporatization. Despite such developments, the Asilomar Conference established the fundamental institutional mechanisms for decisions about rDNA technologies in the United States. It also heavily influenced rDNA research guidelines developed by other countries. In this sense, the legacy of Asilomar is unequivocal.

Yet in another sense its legacy remains controversial. Participants at Asilomar wrestled with two basic questions: How should the protection of scientific freedom of inquiry be balanced with the protection of the public good? How should decisions about scientific research and its technological applications in society be made, especially in climates of uncertainty? Evaluating the legacy in light of these questions points toward three possible conclusions.

First, it has been argued that the conference represented the use of covert power by special interest groups (Oei 1997). According to this claim, scientists marginalized social and ethical questions in order to legitimize the new rDNA technology and persuade the public that control of this technology is best left to scientists (Wright 1994). The Asilomar Conference is portrayed by external critics as an elitist process with a narrow agenda designed to justify the self-government of science.

Second, there is an internal criticism voiced by some within the scientific community. According to this conclusion, the process of the Asilomar Conference and the controversies over regulation were too alarmist. The conference set the precedent for debates that focus on worst-case scenarios and largely ignore a growing scientific consensus about the safety of many rDNA applications. Increasing public opposition to many types of genetic engineering may prevent beneficial uses of these technologies in agriculture and medicine.

The third conclusion is that, despite its shortcomings, the Asilomar Conference represents an unprecedented exercise of the social conscience of science. For the first time, scientists voluntarily halted their own work until the potential hazards could be assessed (Mitcham 1987). This made it one of the first instances of what came to be known as the "precautionary principle." The Asilomar Conference was a novel attempt to balance scientific self-interest with self-restraint. It has left a legacy that transcends rDNA technology by taking an important step in the process of integrating scientific progress into its environmental and social contexts.

ADAM BRIGGLE

SEE ALSO *Genetic Research and Technology; Governance of Science.*

BIBLIOGRAPHY

Barinaga, Marcia. (2000). "Asilomar Revisited: Lessons for Today?" *Science* 287: 1584–1585. Covers a meeting that examined the Asilomar Process twenty-five years later and its implications for contemporary societal issues surrounding rDNA and other technologies.

Berg, Paul; David Baltimore; Herbert Boyer, et al. (1974). "Potential Biohazards of Recombinant DNA Molecules." *Science* 185: 303. One of the letters that sparked the temporary moratorium.

Davatelis, George N. (2000). "The Asilomar Process: Is It Valid?" *Scientist* 14(7): 51. Examines a meeting held on the twenty-fifth anniversary of the Asilomar Conference and interprets the usefulness of the Asilomar process for the social regulation of current and future scientific research.

Grobstein, Clifford. (1979). *A Double Image of the Double Helix: The Recombinant DNA Debate*. San Francisco: Freeman. Surveys the main political and social issues surrounding rDNA science in its infancy.

Löw, Reinhard. (1985). *Leben aus dem Labor: Gentechnologie und Verantwortung—Biologie und Moral* [Life from the laboratory: Gene technology and responsibility, biology and morality]. Munich: C. Bertelsmann. An introduction to the German discussion on recombinant DNA technology.

Mitcham, Carl. (1987). "Responsibility and Technology: The Expanding Relationship." In *Technology and Responsibility*, ed. Paul T. Durbin. Dordrecht, Netherlands: Reidel Publishing. A broad treatment of the ethics of science and technology, which covers rDNA and Asilomar on pp. 11–13.

Oei, Hong Lim. (1997). *Genes and Politics: The Recombinant DNA Debate*. Burke, VA: Chatelaine Press. Explores policy-making processes in the early years of rDNA debates. Outlines three alternative policy processes: technocratic, democratic, and legislative. Offers recommendations for emerging controversies.

Richards, John, ed. (1978). *Recombinant DNA: Science, Ethics, and Politics*. New York: Academic Press. Contains a good annotated bibliography of primary, first-hand accounts of the Asilomar Conference.

Rogers, Michael. (1977). *Biohazard*. New York: Knopf. Explores the moral and ethical confrontations over rDNA research. Includes three full sections on the Asilomar Conference with detailed quotations from many top participants.

Singer, Maxine, and Dieter Söll. (1973). "Guidelines for DNA Hybrid Molecules." *Science* 181: 1114. Outlines the potential benefits and hazards of rDNA technology and propose an NAS committee to study the issue and "recommend specific actions or guidelines should that seem appropriate."

Wade, Nicholas. (1975). "Genetics: Conference Sets Strict Controls to Replace Moratorium." *Science* 187: 931–935. An eyewitness account of the Asilomar Conference.

Wright, Susan. (1994). *Molecular Politics: Developing American and British Regulatory Policy for Genetic Engineering, 1972–1982*. Chicago: University of Chicago Press. Chronicles the response of various groups in the United States and Britain to the emerging genetic engineering technologies, traces the evolution of policies and discourses, and includes a section on the Asilomar Conference and its legacy.

INTERNET RESOURCE

Wright, Susan. (2001). "Legitimating Genetic Engineering," *Foundation for the Study of Independent Social Ideas*. Available from http://www.biotech-info.net/legitimating.html. Examines the problem definition and the consensus forged at Asilomar and the process of persuading the public. A somewhat cynical interpretation of the self-governance of science.

ASIMOV, ISAAC

Author of more than 500 books on a multitude of subjects, Isaac Asimov (1920–1992) was born in Petrovichi, Russia on January 2. He emigrated to the United States in 1923, sold his first science fiction story at the age of eighteen, and went on to become one of the most prolific and well-known popularizers of science for the public in the post-Sputnik era. He died in New York City on April 6.

Asimov was a child prodigy who graduated from high school at the age of fifteen and earned his bachelor's degree at nineteen. His studies were delayed by World War II, after which he received a Ph.D. in Chemistry from Columbia University in 1948. He became an assistant professor of biochemistry at Boston University's School of Medicine in 1951. Asimov left the School of Medicine in 1958, but retained the title of associate professor, and was promoted to professor of biochemistry in 1979.

Asimov sold his first science fiction story at the age of eighteen. By 1950 he had become a well-known science fiction writer and by the end of that decade, published fifteen novels.

Asimov's best known science fiction includes his *Foundation* series of stories, which dealt with the decline and rebirth of a future galactic empire, and his positronic robot stories, in which he formulated the Three Laws of Robotics:

1. A robot may not injure a human being, or through inaction, allow a human to come to harm.
2. A robot must obey the orders given it by human beings except where those orders would conflict with the First Law.
3. A robot must protect its own existence except where such protection would conflict with the First or Second Law.

The Three Laws were designed as safeguards so that robots could be treated sympathetically, rather than be objects of fear as they were in many earlier science fiction stories. Asimov coined the word *robotics*, which later came to be the standard term used for the technology of robots. Many robotics researchers acknowledged that Asimov influenced their interest in their field of study, and almost universally have tried to design robots with the equivalent of his three laws, which required them to be safe, effective, and durable.

Asimov exploited ambiguities in the Three Laws to explore a variety of ethical issues associated with technology. His robot characters often faced difficult decisions in predicaments where they had to choose between alternatives in order to do the least harm to humans. Asimov's later robot novels featured self-aware robots that considered the consequences of obeying the Three Laws, and then formulated a Zeroth Law that applied not merely to individuals, but to all of humankind, which stated that a robot may not harm humanity, or through inaction, allow humanity to come to harm. The Zeroth Law considered humanity as a single entity, where the needs of the many outweighed the needs of the individual.

During the 1950s, Asimov had two careers, as an author and a biochemist. His scientific career was rather unremarkable, and he published only a small number of papers in scientific journals. However in one of them, he pointed out that the breakdown of carbon-14 in human genes always resulted in a mutation. Nobel Prize winning chemist Linus Pauling (1901–1994) later acknowledged that Asimov's notion of the dangers of carbon-14 was in his mind when he successfully campaigned for an end to atmospheric testing of nuclear weapons.

Asimov's career took a major turn after the launch of Sputnik I in October 1957. At that time he had published twenty-three books, most of them science fiction, but he immediately turned to concentrating on writing about science for the general public. In addition he began lecturing on the significance of space exploration and other science matters.

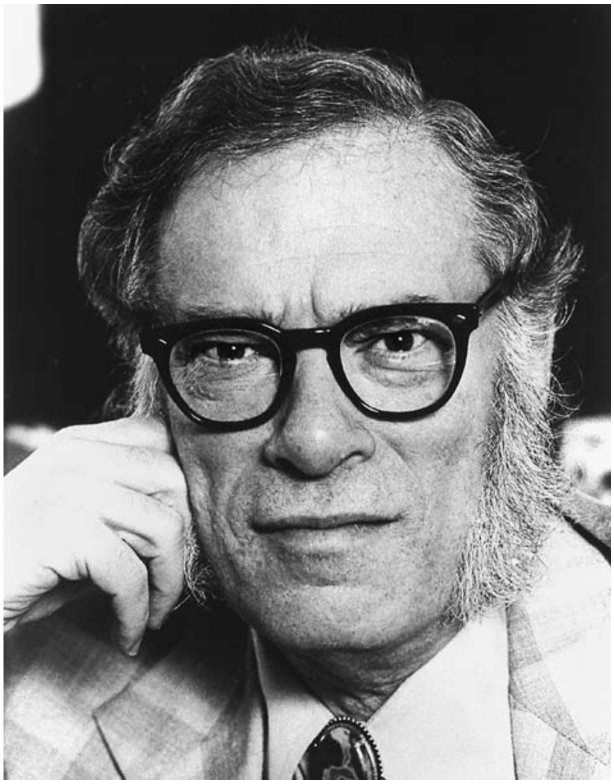
Asimov prided himself on his ability to write clearly rather than poetically, in both his fiction and nonfiction. He felt it was important to educate the public about science, so that people could make informed decisions in a world both dependent upon and vulnerable to advances in technology, mindful of the fact that poor decisions could potentially have catastrophic consequences.

Asimov wrote often about the dangers of overpopulation, and the importance of changing attitudes so that population could be held in check by a decrease in the birth rate rather than an increase in the death rate. He routinely spoke out against the dangers of the nuclear arms race, and believed that the exploration of space provided an opportunity for nations to put aside their differences and cooperate to achieve a common goal. Asimov argued that the most serious problems threatening humanity—such as overpopulation, nuclear war, the destruction of the environment, and shortages of resources—do not recognize international boundaries. Consequently he called for the establishment of a unified world government as the most sensible way to solve such global problems.

Asimov was a crusader against irrationality and superstition, and he believed strongly that the problems caused by science and technology could only be solved by further advances in science and technology.

EDWARD J. SEILER

SEE ALSO *Artificial Intelligence; Robots and Robotics; Science Fiction; Science, Technology, and Literature.*



Isaac Asimov, 1920–1992. As one of the world's leading and most prolific science writers, explaining everything from nuclear fusion to the theory of numbers, Asimov illuminated for many the mysteries of science and technology. *(AP/Wide World Photos.)*

BIBLIOGRAPHY

Asimov, Isaac. (1950). *I, Robot.* New York: Gnome Press. Asimov's earliest positronic robot stories, in which he introduced the three laws of robotics.

Asimov, Isaac. (1951, 1952, 1953). *Foundation; Foundation and Empire; Second Foundation.* New York: Gnome Press. The "foundation trilogy" of science fiction novels about the fall of a galactic civilization, and the efforts of two factions to minimize the duration of the dark age that follows.

Asimov, Isaac. (1962). *Fact and Fancy.* New York: Doubleday. The first collection of Asimov's science articles from the *Magazine of Fantasy and Science Fiction.*

Asimov, Isaac. (1979). *In Memory Yet Green.* New York: Doubleday. The first volume of Asimov's autobiography, detailing his life and career from 1920 to 1954.

Asimov, Isaac. (1980). *In Joy Still Felt.* New York: Doubleday. The second volume of Asimov's autobiography, covering the years 1954 to 1978.

Asimov, Isaac. (1985). *Robots and Empire.* New York: Doubleday. A science fiction novel in which Asimov introduced the Zeroth Law of robotics, and unified the fictional universes of his positronic robot and foundation stories.

Asimov, Isaac. (1991). *The Secret of the Universe.* New York: Doubleday. The twenty-third collection of Asimov's science articles from the *Magazine of Fantasy and Science Fiction.*

Asimov, Isaac. (1994). *I. Asimov: A Memoir.* New York: Doubleday. Asimov's third autobiographical volume, in which he uses recollections from throughout his life to present his thoughts and philosophy.

Gunn, James E. (1996). *Isaac Asimov: The Foundations of Science Fiction*. Lanham, MD: Scarecrow Press. A critical analysis of Asimov's science fiction. The author is a retired professor of English at the University of Kansas and has written twelve science fiction novels and five short story collections.

Olander, Joseph D., and Martin Harry Greenberg, eds. (1977). *Isaac Asimov*. New York: Taplinger. Part of the book series *Writers of the 21st Century*. Nine authors provide their literary perspectives of Asimov's science fiction.

ASSISTED REPRODUCTION TECHNOLOGY

On July 25, 1978, the work of Robert Edwards and Patrick Steptoe led to the birth of the first "test-tube baby," Louise Brown, in England. Since then, thousands of babies throughout the world have been born with the help of assisted reproduction technologies (ARTs). ARTs such as artificial insemination have been in use since the nineteenth century and, as with the technology that helped bring Louise Brown into existence, they still raise ethical concerns. Although ARTs are a common therapy to treat infertility, such treatments continue to provoke questions about safety and efficacy. Many of the ethical issues that appeared with the advent of these technologies continue to be relevant in the early twenty-first century.

Technologies

ARTs refer to a group of procedures, often used in combination, that are designed to establish a viable pregnancy for individuals diagnosed with infertility. The degree of sophistication of these techniques is highly variable. Artificial insemination (AI) requires the least technological complexity and is the oldest of such technologies. It consists of the mechanical introduction of sperm, from the husband or a donor, into a woman's reproductive tract. AI with the husband's sperm is indicated in cases where there are anatomical abnormalities of the penis, psychological or organic conditions that prevent normal erection and ejaculation, or female or male psychosexual problems that prevent normal intercourse. AI by donor is employed in cases of low sperm count or abnormal sperm function. It is also used by single women and by lesbian couples.

In vitro fertilization (IVF) is the quintessential type of ART. Approximately 1 million babies have been born worldwide through this procedure. In its most basic form (that is, the woman undergoing IVF provides her own eggs, and her husband or partner supplies the sperm), IVF consists of several stages. First doctors stimulate the woman's ovaries with different hormones to produce multiple oocytes. Next they remove the eggs from her ovaries through procedures such as laparoscopy or ultrasound-guided oocyte retrieval. After preparation of semen, specialists fertilize the mature eggs in a laboratory dish with the partner's sperm. If one or more normal looking embryos result, specialists place them (normally between three and five) in the woman's womb to enable implantation and possible pregnancy. The sperm and the eggs can also come from donors. Also the embryos might be cryopreserved for later use and transferred into the woman who supplied the eggs or into a surrogate. Similarly examination of sperm, eggs, and embryos for chromosomal and genetic abnormalities can be performed through preimplantation diagnosis. Although IVF was originally developed to use in cases of infertility when the woman's fallopian tubes were damaged, it soon became common treatment for other reproductive problems such as inability to produce eggs, poor sperm quality, endometriosis, or unexplained infertility.

Several modifications and variations from the basic IVF procedure exist. In the gamete intrafallopian transfer (GIFT), the specialists transfer both eggs and sperm to the woman's tubes. Thus conception occurs inside the woman's body. With the zygote intrafallopian transfer (ZIFT), fertilization, as with IVF, occurs in a petri dish. The difference here is that the fertilized egg is transferred to the fallopian tube eighteen hours after fertilization occurs. The newest of these procedures is intracytoplasmatic sperm injection (ICSI), which consists of the direct injection of one sperm into a harvested egg. Since the birth of Dolly the sheep in 1997, somatic cell nuclear transfer (SCNT) has been cited as another possible ART. In SCNT or reproductive cloning, the nucleus of a somatic cell is transferred into an egg cell from which the nucleus has been removed. Most countries have implemented bans or moratoriums on research directed to cloning human beings.

Although there are some ethical questions that are specific to particular reproductive technologies (for instance, manipulation of human embryos), many concerns are common to all. This entry will focus on ethical issues shared by all ARTs.

Procreation, Families, and Children's Well Being

Many of those who support the use and development of ARTs argue that people have a fundamental right to procreate. Thus the state should not interfere with the rights of infertile married couples to have offspring, unless compelling evidence of tangible harms is presented. Proponents claim that critics of ARTs have not offered such evidence (Robertson 1994). An emphasis on individual rights, however, might neglect the fact that reproduction is an act that clearly involves the community by bringing new persons into the world and by using societal resources.

From some religious perspectives, ARTs sever the natural link between sexual intercourse and procreation and, therefore, are impermissible. Many Christian theologians call the use of ARTs immoral because these technologies allow for the separation of procreation and sexual love between married partners (Ramsey 1970). Others contend that, within limits, ARTs can help infertile couples to reproduce and thus should not be completely rejected.

Some also argue that the use of ARTs challenges the traditional conception of the family by separating genetic, gestational, and rearing components of parenthood. Such criticisms assume that by *family* one can only mean a nuclear family composed of a male, a female, and their genetic offspring. They also ignore historical and anthropological evidence according to which humans have successfully adopted many kinds of family arrangements. Moreover such criticisms often fail to offer any compelling normative arguments that show that societies built of nuclear families, as generally understood, are better off than societies with other kinds of family arrangements (Coontz 1992).

The physical well being of children born through these technologies is another concern common to all the ARTs. Although initial assessments indicated that children born as a result of the use of ARTs did not suffer from more problems than did children born through conventional intercourse, such assessments are being questioned. Studies indicate that such children, especially those born through IVF and related techniques, are at increased risk of being premature, having low or extreme low birth weight, and suffering congenital malformations. It is still unclear, however, whether these risks are linked to the technologies themselves or to parental factors (Ludwig and Diedrich 2002).

Women's Well Being

Feminist criticisms have tended to focus on the effect of these technologies on the lives of women. They emphasize the risks that ARTs pose to women's health as well as their impacts on women's status in society. Some feminist groups argue that the new procedures are not designed to give women more choices but are based on the capitalist and patriarchal ideology of abusing, exploiting, and failing to respect women. They call attention to the dismemberment of women's bodies, the medicalization of the reproductive experience that puts pregnancy and birth in the hands of the medical profession, the commercialization of motherhood, and the eugenic and racist biases that the new technologies promote (Arditti et al. 1984.).

Other feminist authors have been less eager to completely reject ARTs. They maintain that assisted-conception techniques could be used to the advantage of women. Although they recognize that no technology is neutral, they reject the social and technological determinism that permeated initial feminist objections. These feminist critics acknowledge that the social policies surrounding ARTs harmed women's interests. However they oppose the image of women as brainwashed individuals, immersed in a world of constructed needs and unable to decide by themselves. They urge widespread public discussion and eventual political and legislative action to improve women's reproductive autonomy instead of a complete rejection of the new procedures (Callahan 1995).

Conception of Infertility

Another criticism common to all ARTs is that they reinforce a particular understanding of infertility as an individual medical failure to have children who are genetically related. Whether one views infertility mainly as a medical condition or also as a social one has important implications. Defining infertility as an individual medical difficulty suggests that a technological treatment is the appropriate response. Thus one might ignore that the causes of reproductive difficulties and the reasons that make infertility a serious concern are, in part, socially rooted. Analyzing infertility also as a socially generated problem indicates that social, ethical, and political solutions to reproductive difficulties should be considered. In this case there may be an emphasis on solutions such as preventive measures or social changes that might be more effective and less costly. This is especially noteworthy because sexual, contraceptive, and medical practices, occupational health hazards, environmental pollution, inadequate nutrition, and poor health are some of the main causes of infertility. Attention to these issues would require consideration of preventive measures rather than only curative treatments as solutions to the infertility problem.

Similarly the use of ARTs emphasizes the importance of genetic relationships in parenthood. One of the main goals of these technologies is to guarantee that at least one of the members of the couple would have genetically related offspring. Although a genetic link to one's offspring may be important, an emphasis on such a relationship might prevent social policies directed to facilitate and encourage adoption or other forms of parenting.

INMACULADA DE MELO-MARTÍN

SEE ALSO *Bioethics; Feminist Ethics; In Vitro Fertilization and Genetic Screening; Medical Ethics; Rights and Reproduction.*

BIBLIOGRAPHY

Arditti, Rita; Renate Duelli-Klein; and Shelley Minden, eds. (1984). *Test-Tube Woman: What Future for Motherhood?* London: Pandora Press. A collection of articles from a feminist perspective that address the ethical and medical implications of reproductive technologies for women's lives. Most of the authors are skeptical about the ability of these technologies to improve the lives of women.

Callahan, Joan. (1995). *Reproduction, Ethics, and the Law: Feminist Perspectives.* Bloomington: Indiana University Press. A collection of essays that consider moral and legal quandaries related to human reproduction. Without completely rejecting all ARTs, the authors call attention to new complexities brought about by these new technologies, such as the legal definition of parenthood, the status of frozen embryos, and the use of fetal tissue.

Coontz, Stephanie. (1992). *The Way We Never Were: American Families and the Nostalgia Trap.* New York: Basic Books. An analysis of some of the myths related to the so-called traditional two-parent nuclear family.

Ludwig, Michael, and Klaus Diedrich. (2002). "Follow-Up of Children Born after Assisted Reproductive Technologies." *Reproductive Biomedicine Online* 5(3): 317–322. Discusses the possibility that risks to the health of children born through ARTs might be related to the techniques themselves and not only to infertility related problems.

Ramsey, Paul. (1970). *Fabricated Man: The Ethics of Genetic Control.* New Haven, CT: Yale University Press. An evaluation of the implications of ARTs from a Christian perspective. The author rejects the use of these technologies for severing the sacred tie between procreation and married love.

Robertson, John. (1994). *Children of Choice: Freedom and the New Reproductive Technologies.* Princeton, NJ: Princeton University Press. A defense that the principle of procreative liberty should be used to resolve the ethical and legal controversies surrounding ARTs.

ASSOCIATION FOR COMPUTING MACHINERY

Founded in 1947, the Association for Computing Machinery (ACM) is a nonprofit scientific and educational organization devoted to advancing knowledge and practice in computing and information technology. The ACM comprises professionals, students, practitioners, academics, and researchers—a total of 75,000 members around the world. The ACM sponsors more than one hundred annual conferences and publishes magazines and journals in both print and electronic form. It provides expertise on social concerns and public policies related to computing and information technology, including ethical issues such as privacy, security, intellectual property, and equitable access to computing resources.

Major Activities

Within the ACM are several special interest groups. The Special Interest Group on Computers and Society (SIGCAS) sponsors activities in ethics. SIGCAS manages the quarterly online magazine *Computers and Society,* which publishes articles, book reviews, educational materials, and news reports related to the ethical and social impacts of computers. SIGCAS organizes occasional conferences and presents the annual Making a Difference Award to an individual who has contributed to understanding the ethical and social impacts of computers. The award has honored Deborah G. Johnson and James H. Moor for scholarly work on the philosophical foundations of computer ethics, and Ben Shneiderman for championing universal access to computing resources.

For many years, the ACM has promoted education in social and ethical issues in computing. The Special Interest Group on Computer Science Education (SIGCSE) usually schedules sessions on teaching computer ethics at the annual Technical Symposium on Computer Science Education. Two of the ACM's series of self-assessments focused on ethics in computing and information science (Weiss 1982, Weiss 1990). In 2001 a joint task force of the ACM and the Computer Society of the Institute of Electrical and Electronics Engineers (IEEE) produced recommendations for undergraduate curricula in computer science that require instruction in ethics in the context of professional practice. Unlike accreditation standards, these curricular recommendations are not mandatory, but they have influenced the development of undergraduate curricula.

The ACM Office of Public Policy and the U.S. Public Policy Committee of the ACM assist policymakers and the public in understanding social issues in information technology, with particular attention to legislation and regulations. For example, since publishing the report *Codes, Keys, and Conflicts: Issues in U.S.*

Crypto Policy in 1994, the ACM has advocated effectively against restrictions on the use of strong encryption. Although these restrictions were intended to thwart criminals and terrorists, they might instead reduce information security and harm electronic commerce. Recognizing ACM's concerns, the U.S. federal government relaxed export controls on encryption products. Since 1999, the ACM has criticized deficiencies in the Uniform Computer Information Transactions Act (UCITA), a proposed uniform state law that creates new rules for computerized transactions. The ACM believes that UCITA would threaten public safety and product quality, because the act would prevent software users from publicizing information about insecure products, and it would allow vendors to disable software remotely. Initially enacted by two states, UCITA has not been adopted by other states because of ACM's efforts.

Codes of Ethics

Like many professional organizations, the ACM has developed its own codes of ethics and professional conduct. In 1966 the ACM adopted its first codes, Guidelines for Professional Conduct in Information Processing (Parker 1968). These guidelines were expanded in 1972 into the ACM Code of Professional Conduct. In 1992 the ACM adopted the current Code of Ethics and Professional Conduct (Anderson et al. 1993).

The 1992 ACM code strives to educate computing professionals about professional responsibilities, rather than to regulate ACM members. In contrast with other professional codes of ethics, the ACM code has three notable features. First, each statement in the ACM code is supplemented by interpretive guidelines. For example, the guideline for the statement on confidentiality indicates that other ethical imperatives may take precedence:

> **1.8 Honor confidentiality** The principle of honesty extends to issues of confidentiality of information whenever one has made an explicit promise to honor confidentiality or, implicitly, when private information not directly related to the performance of one's duties becomes available. The ethical concern is to respect all obligations of confidentiality to employers, clients, and users unless discharged from such obligations by requirements of the law or other principles of this Code.

Second, a large section of the ACM code applies specifically to "organizational leaders"—typically technical managers. According to the code, organizational leaders must encourage subordinates to accept professional responsibilities, provide opportunities for subordinates to pursue continuing education, support policies that mandate appropriate uses of computing resources, and ensure that computing systems are designed to enhance the quality of life and protect the dignity of users. Third, the ACM code obligates members to "improve public understanding of computing and its consequences." It is unclear, however, whether this obligation applies to each member individually or to the computing community collectively.

Beginning in 1994 the ACM collaborated with the Computer Society of the IEEE to create the Software Engineering Code of Ethics and Professional Practices, drafted in 1997 and finalized in 1999 (Gotterbarn, Miller, and Rogerson 1999). Like the 1992 ACM code, the Software Engineering Code includes a section on the obligations of technical managers. Although the ACM participated in the development of the Software Engineering Code, the ACM opposes the licensing of software engineers (White and Simons 2002). (Both the 1992 ACM code and the Software Engineering Code appear in the appendix of this encyclopedia.)

Throughout its history, the ACM has dedicated attention to ethical issues in computing and information technology, both the impacts of computers on society and the responsibilities of individuals as professionals. The ACM will continue to emphasize these issues through conferences and publications, codes of professional conduct, educational activities, and public advocacy, particularly in the United States.

MICHAEL C. LOUI

SEE ALSO *Institution of Electrical and Electronics Engineers; Professional Engineering Organizations*.

BIBLIOGRAPHY

Anderson, Ronald E.; Deborah G. Johnson; Donald Gotterbarn; and Judith Perrolle. (1993). "Using the New ACM Code of Ethics in Decision Making." *Communications of the ACM* 36(2): 98–107. The current (1992) ACM code of ethics, with short fictional cases that illustrate uses of the code.

Gotterbarn, Don; Keith Miller; and Simon Rogerson. (1999). "Software Engineering Code of Ethics Is Approved." *Communications of the ACM* 42(10): 102–107. The full text of the software engineering code of ethics, developed by the ACN and IEEE Computer Society.

Landau, Susan; Stephen Kent; Clint Brooks, et al. (1994). *Codes, Keys, and Conflicts: Issues in U.S. Crypto Policy*. New York: Association for Computing Machinery. Raises questions and concerns about standards, laws, and policies for cryptography in the United States.

Parker, Donn B. (1968). "Rules of Ethics in Information Processing." *Communications of the ACM* 11(3): 198–201. Details the background and explains the motivation for the first ACM Code of Ethics.

Weiss, Eric A., ed. (1982). "Self-Assessment Procedure IX." *Communications of the ACM* 23(3): 181–195.

Weiss, Eric A., ed. (1990). "Self-Assessment Procedure XXII." *Communications of the ACM* 33(11): 110–132. Two self-tests on computer ethics; readers analyze several scenarios and compare their opinions with experts' opinions.

White, John, and Barbara Simons. (2002). "ACM's Position on the Licensing of Software Engineers." *Communications of the ACM* 45(11): 91. Justifies ACM's opposition to the licensing of software engineers.

INTERNET RESOURCES

Association for Computing Machinery. 2004. Available from http://www.acm.org.

Association for Computing Machinery. 2004. Special Interest Group on Computers and Society. *Computers and Society* online magazine. Available from http://www.computersandsociety.org.

Computer Society of the Institute for Electrical and Electronic Engineers and the Association for Computing Machinery. "Computing Curricula." Available from http://www.computer.org/education/cc2001/. Recommendations for undergraduate curricula in computer science, computer engineering, software engineering, and information systems.

ASTRONOMY

Astronomy, from the Greek *astron,* star, plus *nomos,* law—thus the laws or regular patterns of the stars—is now defined as the science of objects beyond the Earth's atmosphere, including their physical and chemical properties. This science of what is beyond the Earth paradoxically served as the model for the early modern effort to create a science of terrestrial phenomena. Because of their apparently more simple and necessary order, astral phenomena were the first to be subject to explanations in the form of "laws," the methods of which were then extended in modern physics to explain the dynamics of falling bodies at or near the Earth. Yet just as modern physics emerged to give human beings greater powers over material affairs than ever before, and thus pose a challenge to ethics, so subsequent developments in astronomy deprived humans of an order that could be perceived as a transcendent and normative guide for human conduct. Immanuel Kant (1724–1804) could still wonder at the correspondence between the "starry heavens above and the moral law within" (*Critique of Practical Reason,* p. 288), but the achievements of modern astronomy have left the moral law within to fend for itself.

Pre-Modern Astronomy

Astronomy has been called the world's second oldest profession. Notations found on artifacts scattered over Africa, Asia, and Europe dating from 30,000 B.C.E. appear to be rudimentary calendars based on the phases of the moon (Hartmann and Impey 1994). The transition from hunter-gatherers to life in stable villages, occurring around 10,000 B.C.E. with the rise of agriculture, required a refined estimation of the timing of seasonal changes. The sky, although no doubt deeply mysterious to these ancient cultures, was also reassuringly deterministic. By 4000 B.C.E., for instance, Egyptian astronomers knew that the first appearance of the brightest star in the dawn sky, Sirius, marked the beginning of the Nile's annual flooding. Many, probably most, cultures timed their agricultural activities based on similar annual celestial events.

The stars of course were also used for navigation. The Minoans of the island of Crete employed the stars to navigate the Mediterranean and to forge relationships with the Greeks as long ago as 2600 B.C.E. In developing this technology, they grouped the stars into pictures that gave rise to some of the constellations that we still know today (Hartmann and Impey 1994). The navigational prowess of the Polynesians is legend. The courage and faith these seafarers had in the heavens' ability to guide their way is astonishing. Crossing vast expanses of the Pacific, Polynesians discovered that if they sailed north until the Southern Cross dropped to a hand's length above the horizon, they would be at the latitude of Hawaii. To return, they would point their outriggers south until two stars, Sirius and Pollux, set together.

The megalithic monument Stonehenge on the Salisbury Plain in Great Britain had a utilitarian as well as spiritual design. On the longest day of summer, at solstice, the sun rose over a huge, notched boulder, the "Heel Stone," as seen from the center of concentric rings of massive boulders. Some weighed thirty to fifty tons (Hawkins and White 1965). The accompanying midsummer ritual 4000 years ago would have been an annual part of the cultural weaving of astronomy, beliefs, and values for the participants. Enormously demanding achievements such as the construction of Stonehenge and of the Egyptian pyramids are testament to the power the heavens exerted on the societies that built them.

Possibly the most extraordinary early example of institutional astronomy was that of the Mayans. The priest-astronomers that observed the heavens and performed the calculations to produce their calendars were publicly supported for at least 200 years around 400 C.E. The Mayan calendar did not only chart the seasons for agriculture. It also predicted eclipses, experienced by the Mayans as traumatic and darkly mysterious. Mayan astronomers computed the complex motions of Venus, believing it to be one god in the evening, and another when it reappeared in the morning. Venus's quasi-periodic disappearance and reemergence on the other side of the world was seen as a journey and transformation in the underworld (Aveni and Hotaling 1994). It appears that in all early cultures, astronomy and religion were deeply interconnected. Astronomy, by giving an accurate description of the motions of heavenly bodies, was at the same time a very powerful tool for sustaining civilization and exploring the world.

However it goes about it, religion seeks to provide guidance for living in harmony with the Earth, with other people, and with the universe. But peace, it could be argued, is only possible for human beings if they have in some way accepted what their lives mean. Religion addressed the human question of meaning, by defining our relationship with the cosmos. So astronomical questions, such as what brought forth the universe, how old it is, and what our place in it is, were religious questions. It has been suggested that the starkly hierarchical medieval (Aristotelian) cosmology, with the universe consisting of ten concentric spheres around the Earth (the outermost being heaven), was reflected in the rigidly hierarchical society that oppressed the vast majority of people (Abrams and Primack 2001).

The astronomical observations of Galileo Galilei (1564–1642), using the new technology of the telescope, began the fracture of science and religion that is today a deep chasm. As is well known, Galileo kept his head because he recanted his conclusions that the sun was at the center of the solar system and that the celestial bodies were not flawless. With improving technologies and the bold modern project begun by René Descartes (1596–1650), Francis Bacon (1561–1626), and John Locke (1632–1704), however, science and religion diverged under the auspices of an uneasy truce. As the quest for truth in the universe became a scientific endeavor, it was no longer part of the institution that spoke directly to meaning in human lives, to guidance for living in harmony, and for rules that guide human behavior.

Modern Astronomy and the Rise of Scientific Cosmology

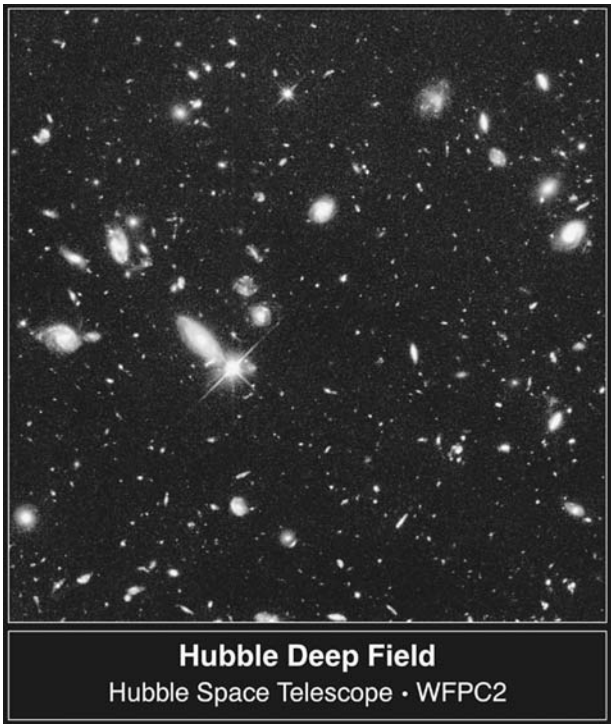
Modern astronomy can be described in terms of its institutional structures, its intellectual debates, and its scientific discoveries.

NATIONAL, PRIVATE, AND UNIVERSITY OBSERVATORIES. Astronomy may have grown from a fundamental desire to understand the universe, but the use of heavenly motions as a powerful *technology* for navigation grew with it. Systematic observations of the heavens for centuries allowed us to chart the limits of our world, and to navigate confidently within it.

By the end of the nineteenth century, large national observatories existed in the United Kingdom, France, the United States, and Russia. Although originally designed to survey the heavens for applications in geodetics and navigation, these institutions also began to branch out and address more fundamental questions (Struve and Zebergs 1962). Especially as instrumentation improved, astronomers were increasingly making observations in attempts to understand the structure, history, and origin of the universe. Larger and larger telescopes would enable astronomers to see further into the universe and with ever greater sharpness. The excitement of this quest was felt keenly by a number of American philanthropists, and the late nineteenth century saw the rise of large, privately funded observatories such as the Lick (1888), the Lowell (1894), and the Yerkes (1897). Following these, construction of the last of the giant, privately funded observatories was completed with the McDonald Observatory in 1939 and the Palomar Observatory in 1947. The flagship of Palomar is the 200"-diameter Hale telescope, which reigned supreme as the largest and most capable telescope in the world until the launch of the Hubble Space Telescope into Earth orbit in 1990.

Hubble was born of the dreams of astronomer Lyman Spitzer (1914–1997), who, in the heady days of the postwar technology boom, first advocated a telescope in space to explore the universe with unprecedented clarity. Above the veil of obscuring atmosphere and luminous clamor of the Earth, a moderate telescope in space would see the universe 100 times clearer than the behemoths on Earth. This meant that it could see 100 times further away and 100 times further back in time. This it has done, and the images of the universe that it has returned have astonished us and enriched our lives.

Light is the only form of electromagnetic energy that is directly perceived by human beings. Electromag-



View of space from the Hubble Space Telescope. *(Courtesy NASA STScl.)*

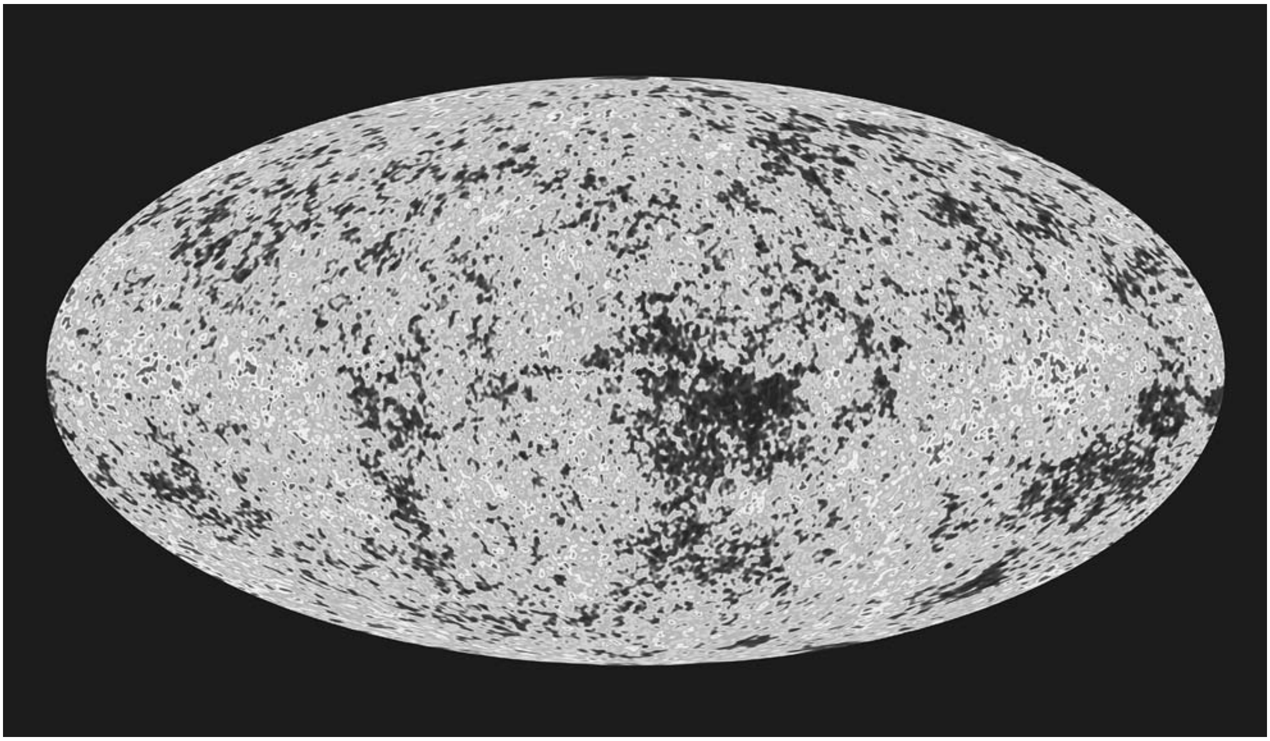
netic waves are produced by a vast array of physical phenomena in the universe, including stars, planets, galaxies, supernovae remnants, black holes, and almost everything in between. Many of these emissions have wavelengths that are much longer than those of light; these are radio waves. Because they are absorbed by dust and gas less readily than is light, radio waves traveling through space allow a glimpse of parts of the Milky Way that cannot be seen by optical telescopes. In addition, radio waves are produced by different processes than those that create light, giving scientists insights into the physical processes and compositions of many objects in space.

Primitive radio receivers were first pointed at the sky in the early 1930s. It became clear soon thereafter that radio waves can be detected from all parts of the sky, but most especially from the center of the Milky Way. The rapid advances in electronics due to the technological efforts in waging World War II paved the way for vast improvements in radio telescope sensitivity. Serious construction of large astronomical radio telescopes began in 1947. Some are steerable, such as the 250-foot wire-mesh dish at Jodrell Bank in Great Britain. The largest is Arecibo, the immovable 1,000-foot dish carved into a limestone sinkhole in Puerto Rico. Today, enormous arrays of radio dishes are icons of modern astronomy, probing the universe's mysteries and listening for signs of alien minds.

THE ISLAND UNIVERSE DEBATE. On a clear night away from city lights, a ghostly swath cuts through the sky. It is thickest in the constellations of Sagittarius and Scorpio, and thins as its path is traced northeast through Cassiopeia or southwest through the summer constellations of Cygnus and Aquila. One of the great conceptual leaps of humanity was the realization that this apparition was our view of a great island universe, a galaxy, from the inside. The peculiar smudgy swirls seen in early telescopes, such as Galileo's, were vast communities of stars, comparable to ours but unimaginably far away. The close ones, such as Andromeda, can be seen to be in the shape of a pinwheel with a bright central bulge. As we look to Sagittarius, we look into the core of our galaxy from the inside of the disk. On the other side of the sky where the Milky Way is more diffuse, we can see dark lanes of dust obscuring stars, and the outline of spiral arms. Our sun is one dot in the multitudes that blend together with such promiscuity that they form the milk of the Milky Way.

By the end of the nineteenth century, astronomers knew that the Milky Way was a vast field of stars in which the sun and solar system were embedded. Systematic star counts led to estimates of the size and shape of our galaxy, but also to the erroneous conclusion that the sun was at the center of it. In spite of the Copernican revolution, subtle assumptions on the centrality and primacy of humans in the universe remained, skewing scientific interpretations of the observational data.

Our view of the Milky Way galaxy from within was sharpened considerably by the observations of Harlow Shapley (1885–1972). Shapley noticed that globular clusters—beautiful, tightly packed spherical aggregates of stars—tended to form a vast spherical halo around the nucleus of the Milky Way. His observations successfully set the stage for the twentieth-century view: that the sun exists in an enormous, flattened disk of stars, about two-thirds of the way from the center to edge. This final dethroning of the role of humans in the cosmos played out during the 1910s and 1920s and was one of the great classic scientific debates of the century. The new picture did little at first to illuminate what the universe was, or its extent. Was our disk, 100,000 light years wide and 10,000 light years thick, with a central bulge and 100 billion stars, *the* universe? What was outside of it, and how did it come to be? These questions could only be answered with improvements in telescope and photographic technology, which followed rapidly.



The afterglow of the Big Bang. This image is a map of the very edge of the Universe—looking so far back in time and space that all we see is the heat from the creation cataclysm. *(NASA/WMAP Science Team.)*

Kant proposed, in the eighteenth century, that the Milky Way we are inside of was a disk-shaped spiral, similar to the far-away spiral nebulae seen in telescopes at the time. He called these spirals "island universes." Kant's famous intuition turned out to be largely correct, although the scientific path to this conclusion did not end until the middle 1920s. During that decade, the shape of our galaxy's spiral arms came into focus, and the correspondence to the shapes of the far-off spiral nebulae became scientifically accepted. Until then, it was generally thought that the Milky Way was all that there was, and the large variety of spiral nebulae were smaller aggregates of stars within or just outside of it. As telescopic and photographic technology progressed in the twentieth century, and ever more detailed images of the deep heavens were acquired, this view began to change.

It was Edwin Powell Hubble (1889–1953) who eventually solved the mystery of the celestial spirals. It had long been known that a special class of variable stars, known as Cepheid variables, exhibited a well-determined relationship between periodicity and intrinsic brightness. Distance determinations to celestial objects were bootstrapped to ever more distant objects by noting the parallax shifts of nearby stars (including Cepheids) due to the earth's orbit around the sun. This technique was used to calibrate Cepheid variables at far more distant locales. Using the 100" telescope at Mt. Wilson observatory above Pasadena, then the largest instrument in existence, Hubble was able to resolve individual Cepheid variables in the Andromeda galaxy. Extrapolating from the period-luminosity relation for these variables in our own galaxy, in 1923 Hubble conclusively showed that the Andromeda galaxy was far, far away, about ten times further than the diameter of our own galaxy. So spiral galaxies are indeed island universes, vast collections of stars very much like our Milky Way, many with 100 billion stars or more. The press for larger, more powerful instruments in the early part of the twentieth century was on, driven almost entirely by a thirst for understanding the depth and breadth of all existence. This thirst was very much felt by society in general, and was part of the great scientific excitement of the time, which included the development of quantum mechanics and the deeper understanding of space and time worked out by Albert Einstein (1879–1955).

We now know that the Andromeda galaxy is only one of more than 100 billion such whirlpools of stars, making the observable universe an inconceivably large place, containing 100 billion times 100 billion stars, and perhaps almost as many solar systems. On a cloudless night in autumn, the Andromeda galaxy is clearly visible to the unaided eye. It is the farthest thing we humans can perceive directly. Light reaching us today left the galaxy 2.2 million years ago, traveling 10,000,000,000,000,000,000 miles before leaving its impression on our retinas and minds.

In his famous book *The Realm of the Nebula,* Hubble classified the vast diversity of extragalactic forms into a more-or-less coherent taxonomy (1926). The realization that spiral nebulae and their brethren, giant elliptical galaxies, were island universes, coequal with our own vast Milky Way, paved the way for one of the most extraordinary scientific discoveries of all time and gave birth to modern cosmology. In 1929, Hubble announced his discovery that the recessional velocities of galaxies were proportional to how far away they were. The furthest galaxies were receding the fastest, as measured by the Doppler shifts of their emitted light. The constant of proportionality became known as the Hubble constant. The implications of this relationship are profound. The simplest way to explain it is that at some time in the very distant past, all the galaxies were packed together. If we reverse the movie of the universe, all the galaxies speed in toward each other until—what? Georges-Henri Lemaitre (1894–1966) hypothesized that the movie takes us back to the primeval egg, a cosmology that poetically phrased the juxtaposition of myth and science. But how far one can extend the movie and continue to rely on the laws of physics as we know them is at the heart of modern cosmology. At the beginning of time and space, the galaxies or their precursors were propelled somehow from the egg. In this picture, the reciprocal of the Hubble constant is the age of the universe, and its extent is approximately the distance that light travels in this time. This theory became known as the Big Bang. Science has thus looked directly at *the* question: What is the origin of everything? We cannot go back: The countless and varied myths, societies' identification with the infinite, have been supplanted by the power of scientific truth.

THE MORALITY OF SUPERNOVAE. One of the great natural wonders of the universe is the supernova. In schoolchildren, descriptions of the great power of these exploding stars excite a keen intellectual wonder in the natural world. Stars are a great balance between gravity trying to squeeze them small, and nuclear-generated heat trying to pull them apart. The story of the supernova is awesome and kinetic, its wonders easily readable in the faces of children who listen to it. A single, supergiant star approaches the end of its life. As its final generation of fuel is exhausted, the giant radiation engine that supports the star shuts down. Massive collapse ensues, on a scale that is well beyond human comprehension. The implosion rebounds ferociously, spewing the alchemy of the old star into the cosmos. The transmuted elements are made nowhere else but here, the hellish belly of the most powerful beast of the universe. And these elements disperse through the cosmos—and become us.

Supernovae are so rare that one occurs in our galaxy, with 100 billion stars, only about once a century. For about a month, though, the maelstrom from that single, dying star is brighter than all of its 100 billion siblings combined. Overall, in the 100 billion galaxies that we can see from our vantage point, that means we have seen and measured and analyzed many hundreds of supernovae.

It isn't hard to see how a driving scientific curiosity could be drawn to trying to understand this thing. Indeed, supercomputer models of unimaginable explosions are quite refined, and scientific models of how stars explode have been highly successful. What is curious is that they are aided by a rather keen interest in an entirely different field: the nature and yield of human-made nuclear explosions. As declassification of the fundamental nuclear science of the 1940s and 1950s proceeded during the last decades of the twentieth century, there was a highly successful synergy between the study of the most fantastic, wondrous, violent explosions in our universe and the efficiency and effectiveness of nuclear weapons.

Conclusion

For 200,000 years, human beings have had an intense, powerful relationship with the skies above them. We all evolved within societies for which the sky was a pervasive source of magic, awe, religion, and art. For *every* human being, for 99.9 percent of the history of humankind, there was a personal relationship with the sky. For 10,000 generations, the sky had personal meaning to people, figuring in much of what they did and how they behaved, how they moralized, and how they loved. We were born with humanity's relationship to the sky in our genes. The scientific study of astronomy doesn't change this, although it has changed the feelings we have about our place in the universe. As humanity explores and understands the natural world, the ever-growing power it wields over nature demands clarity and wisdom. Shortly before his death in 1695, the eminent Danish astronomer Christiaan Huygens (1625–1695) wrote in *Kosmotheoros,* for his time and ours:

> This shows us how vast those Orbs must be, and how inconsiderable the Earth, the Theater upon which all our mighty Designs, all our Navigations, and all our Wars are transacted, is when compared to them. A very fit Consideration, and matter of Reflection, for those Kings and Princes who sacrifice the Lives of so many People, only to flatter their Ambition in being Masters of some pitiful corner of this small Spot.

MARK A. BULLOCK

SEE ALSO *Cosmology.*

BIBLIOGRAPHY

Abrams, N. E., and J.R. Primack. (2001). "Cosmology and 21st-Century Culture." *Science* 293: 1769–1770. One of the few works that investigates the impact cosmology has had on culture.

Aveni, A.F., and L.D. Hotaling. (1994). "Monumental inscriptions and the observational basis of Maya planetary astronomy." *Archaeoastronomy* 19: S21–S54. The definitive popular work on Mayan astronomy by a leading expert in the field of archeoastronomy.

Hartmann, William K., and Chris Impey. (1994). *Astronomy: The Cosmic Journey,* 5th edition. Belmont, CA: Wadsworth. A standard undergraduate astronomy text book.

Hawkins, Gerald S., with John B. White. (1965). *Stonehenge Decoded.* Garden City, NY: Doubleday. A fascinating popular book on the mysteries of Stonehenge.

Hubble, Edwin P. (1936). *The Realm of the Nebula.* New Haven, CT: Yale University Press. The classic work on the taxonomy of galaxies.

Huygens, Christiaan. (1698). *Kosmotheoros.* London: Timothy Childe. A philosophical treatise addressed to Huygen's brother Constantijn on the construction of the universe and the habitability of planets.

Kant, Immanuel. (1956). *Critique of Practical Reason,* translated by Louis White Beck. New York: Liberal Arts Press. The second of Immanuel Kant's three critiques, dealing with moral philosophy.

Struve, Otto, and Velda Zebergs. (1962). *Astronomy of the 20th Century.* New York: Macmillan. A comprehensive text on the history of modern astronomy up to the early 1960s.

ATLANTIS, OLD AND NEW

The story of Atlantis was invented by Plato in an unfinished sequel to the *Republic* constituted by the *Timaeus* and the *Critias*. These two dialogues attempt to relate the political philosophy of the *Republic,* the argument of which is reviewed at the beginning to the *Timaeus,* to natural philosophy. The *Timaeus* describes a prehistorically virtuous Athens, embodying the natural harmonies argued in the *Republic,* that defeats attack from the unlawful empire of Atlantis, once located in the Atlantic Ocean beyond the Iberian peninsula and the North African coast. In defeat it sinks into the ocean. As Critias describes Atlantis, it was rich in both natural resources and technical developments—indeed, its technological works are described as "incredible" (*Critias* 118c) canals, fortifications, and palaces—but lacking in wisdom. With this story Plato raises questions about relationships between science and technology as well as technological and other forms of power.

Plato himself describes Atlantis as being recovered from the Egyptians, and the imagined island empire has exercised a continuing fascination in European literature. In the classical period, Aristotle, Herodotus, Proclus, Plutarch, Pliny, and others mention it. During the Middle Ages, interest languishes. With Francis Bacon's *New Atlantis* (1627), however, the story is critically revived to address precisely the issues raised by Plato but in a distinctly non-Platonic manner.

The New Atlantis: Salomon House

Bacon's imaginary story is of a society ruled by scientists dedicated to the technological conquest of nature. For those who share Bacon's vision of scientific progress, it is an inspiring vision of how modern science and technology could promote a good society. For those who disagree with Bacon, it is a disturbing depiction of how a scientific elite could use manipulation and secrecy to rule over a docile people.

The story is about European sailors who discover an island in the South Pacific inhabited by the people of Bensalem. These people live by laws and customs that secure a life that is free, healthy, and peaceful. They are Christians, although Jews and other religious believers are free to live there without persecution. Marital unions and family life are regulated to promote fertility, monogamous fidelity, and respect for the authority of fathers. Economic life is prosperous; political life is organized around a structure of offices with a king at the top, although the king's rule is cloaked in secrecy.

The most important institution in Bensalem is Salomon's House. Bacon's description of Salomon's House is remarkable, because it is the first account of a modern scientific research institution supported by public authority to promote progress in science and technology to conquer nature for human benefit. Salomon's House is said to have two purposes—"the knowledge of causes, and secret motions of things; and the enlarging of the bounds of human empire, to the effecting of all things possible" (Bacon 1989, p. 71). The first purpose is knowledge for its own sake. The second purpose is power over the world. The aim is to unite human knowledge and human power.

Salomon's House has facilities and tools for studying every realm of nature, including soil, minerals, air, light, wind, water, plants, animals, and human beings. Scientists work to produce new kinds of drugs, foods, and machines. They produce flying machines, boats that move under water, robotic devices that move like animals and human beings, powerful military weapons, and artificially created plants and animals. The scientists search for ways to preserve human health and prolong human life.

The scientists in Salomon's House are assigned various duties. Some travel throughout the world secretly gathering whatever experimental knowledge human beings have developed. Others draw out general conclusions from these experiments. Others apply these experiments to develop new inventions. Still others build on this knowledge to develop a comprehensive knowledge of nature. The scientists consult together to decide which inventions and experiments should be made public and which should be kept secret. They all take an oath of secrecy to conceal whatever should not be publicized. Inventions are particularly important in Salomon's House, and for every new invention, the inventor is honored with the erection of a statue. The scientists visit the major cities of Bensalem to announce useful inventions and to help people explain and protect themselves against natural dangers such as diseases, threatening animals, earthquakes, floods, comets, and scarcity of resources. Salomon's House conducts daily religious ceremonies to praise God for his works and to ask his aid in applying knowledge of his works to good and holy uses.

Heritage

Throughout his life, Bacon had tried unsuccessfully to persuade the British monarch to sponsor scientific research just as Bensalem supports the work of Salomon's House. After his death, many people were inspired by *New Atlantis* to devise plans to set up publicly supported scientific institutions for promoting experimental studies of nature and useful inventions. The establishment of the Royal Society of London in 1682, with a royal charter from Charles II, was one of the most successful outcomes. Contemporary institutions for collaborative scientific research dedicated to new discoveries and inventions such as the U.S. National Science Foundation also seem to follow the model first depicted in *New Atlantis*.

The careful reader of *New Atlantis* may wonder about the ethical problems that arise from possible conflicts between science, politics, and religion. The religious faith of Bensalem depends on a belief in a biblical God who performs miracles, and yet the scientists in Salomon's House are responsible for judging whether apparent miracles are true or fraudulent, which implies the rule of scientific reason over religious faith. Indeed it seems that the scientists rule Bensalem through a new religion of scientific technology that secures earthly life, which replaces the old religion of pious hope in heavenly redemption. The scientific research on prolonging life suggests that the new religion might even provide immortality through the scientific conquest of death. But one must wonder whether the abolition of death through scientific technology is possible or desirable.

The oath of secrecy in Salomon's House suggests that Bensalem cannot be a completely free and open society based on universal enlightenment. The scientific philosophers must hide from the general public those experiments, inventions, and discoveries that would be harmful if they were open to full public view. This implies that scientific and technological innovation can be dangerous for society, and therefore it needs to be regulated by those with the wisdom to understand the ethical problems of such innovation. The critics of Baconian science see this as confirming their fear that modern science and technology shape social life without the free and informed consent of ordinary citizens.

Yet defenders of Baconian science point out the theoretical understanding and practical usefulness that this science has produced. By executing Bacon's project, human beings have both a greater knowledge of nature and a greater power over nature than ever before. Some economic historians argue that economic growth in the Western world since the eighteenth century has been driven largely by a Baconian view of knowledge that connects science, technology, and industrial production. Since the late-twentieth century, Baconian principles are evident in biotechnological research for enhancing physical and mental health and perhaps prolonging life. People are moving toward "the enlarging of the bounds of human empire, to the effecting of all things possible" (Bacon 1989, p. 71). In many respects, human beings are now living in Bensalem.

Shadow

Indeed the effectiveness of Bacon's vision may even be reflected in the way the whole discussion of Atlantis, old and new, has turned away from philosophy and toward fiction and science. Ever since Captain Nemo's visit to Atlantis in Jules Verne's *Twenty-Thousand Leagues Under the Sea* (1870), the lost continent has been a persistent theme in contemporary entertainments. From the time Ignatius Donnelly, a congressman from Minnesota, published *Atlantis: The Antediluvian World* (1882), persistent interest has also focused on such historical and geographical issues such as whether Atlantis might have really existed and where. The journal *New Atlantis* (founded 2003) nevertheless seeks to return to that cluster of issues regarding science, technology, and philosophy that were at the heart of both the Platonic and the Baconian uses of the story of Atlantis.

LARRY ARNHART

SEE ALSO *Bacon, Francis; Governance of Science; Plato; Utopia and Dystopia.*

BIBLIOGRAPHY

Bacon, Francis. (1989). *New Atlantis and The Great Instauration*, ed. Jerry Weinberger. Wheeling, IL: Harlan Davidson.

Jones, Richard Foster. (1982). *Ancients and Moderns: A Study of the Rise of the Scientific Movement in Seventeenth-Century England*. New York: Dover Publications. History of Bacon's influence on early modern science.

Lampert, Laurence. (1993). *Nietzsche and Modern Times: A Study of Bacon, Descartes, and Nietzsche*. New Haven, CT: Yale University Press. Account of Bacon's philosophic vision for modern world.

Leiss, William. (1994). *The Domination of Nature*. Montreal: McGill-Queen's University Press. Critical history of the Baconian idea of mastering nature.

Merchant, Carolyn. (1980). *The Death of Nature: Women, Ecology, and the Scientific Revolution*. San Francisco: Harper & Row. Feminist historian's critical account of Baconian science.

ATOMIC BOMB

The mushroom-shaped cloud associated with the above-ground detonation of an atomic bomb is one of the most defining images and represents one of the most challenging moral imperatives to arise from the mid-twentieth century. The scientific, technological, political, sociological, psychological, religious, and ethical ramifications of humankind's ability to harness and release in a fraction of a second fundamental forces of nature make the atomic bomb one of the preeminent issues of modern society and human existence.

Bomb Engineering

An atomic bomb is a weapon that derives its energy from a nuclear reaction in which a heavy nucleus of an atom such as uranium or plutonium splits into two parts and subsequently releases two or three neutrons along with a vast quantity of energy. These nuclear reactions, if they can be induced rapidly and in quick succession across a critical mass of material, produce a cataclysmic release of energy of prodigious dimensions from a very small quantity of initial material.

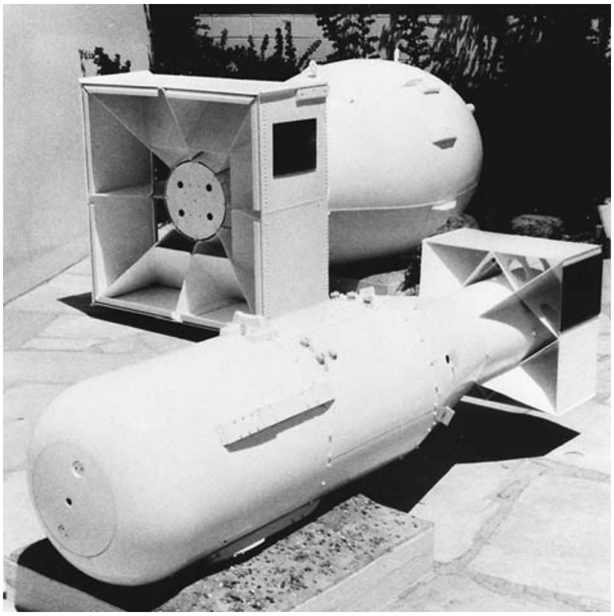
Advances in the design of these weapons have focused on efficiency and effectiveness, including ways to produce purer initial materials, induce and sustain more rapid reactions, and produce similar effects with smaller amounts of material. As a result, nuclear devices now available to the armed forces can yield effects from a small warhead on a missile that compare favorably to those generated in the 1950s by weapons so large that bombers had to be specially adapted to haul and drop them. Advances in weapons construction techniques further allow experts to assemble even relatively impure materials into "dirty" bombs with limited yield but severe environmental effects.

Developments since the mid-1980s have posed new threats to world security as an ever-expanding set of nations gained access to suitable raw materials for constructing these devices. Global monitoring of these materials has become increasingly more difficult and nongovernmental organizations have sought, and probably have obtained, previously unavailable raw materials to construct small-scale nuclear devices to advance sinister purposes.

The technology behind atomic bombs dates to work in physics including the theoretical work of Albert Einstein at the beginning of the twentieth century and experimental work by Otto Hahn, Fritz Strassmann, Lise Meitner, Otto Robert Frisch, and others in Germany and Sweden in the late 1930s. Scientists in Germany, France, the United Kingdom, the Soviet Union, Japan, and the United States all realized that it might be possible to produce weapons of mass destruction as an extension of the work of the experimental physicists, but it was only in the United States that these efforts were organized and funded to achieve success.

State Construction

The Hungarian refugee physicist Leo Szilard organized his physics colleagues in the United States to petition President Franklin Delano Roosevelt to sponsor work to build an atomic bomb out of fear that the Germans were already well advanced in their efforts. (This claim was



"Fat Man" (left) and "Little Boy" (right), the only two nuclear weapons that have ever been used in warfare. The Little Boy was dropped on Hiroshima, Japan on August 6, 1945. The Fat Man was detonated over Nagasaki three days later. *(The Library of Congress.)*

later shown to be completely erroneous.) He enlisted the aid of Einstein in this cause, and Roosevelt responded in the fall of 1939 by devoting $6,000 in discretionary money to preliminary investigations by scientists. This sum had grown to $300,000 per year by 1941 with funds channeled through the National Bureau of Standards to hide the scientists' true intent. By 1941 Vannevar Bush, president of the Carnegie Institute of Washington, DC, had formed and chaired an Office of Scientific Research and Development to better harness the abilities of scientists in the United States to contribute substantially to the war effort. A series of experiments at the University of California at Berkeley, the University of Chicago, and a remote location in Oak Ridge, Tennessee, during the period of 1940 to 1941 established that a fission reaction could be created and controlled, that new elements were created in such reactions that could also be useful as sources for bomb materials, and that uranium-235 could be separated from the much more abundant but non-useful for bombs uranium-238 via a number of different means. Several of these separation techniques involved the use of highly reactive and corrosive materials, especially uranium-hexafluoride, in addition to a whole series of radioactive and dangerous by-products from the various processes associated with production of the basic materials needed for atomic bombs—by-products that continue to create problems of waste disposal and health impacts to this day.

Bush appointed a secret National Academy of Sciences (NAS) committee in 1941 to recommend whether it was feasible to build an atomic bomb. The committee, chaired by the Nobel Prize–winning physicist Arthur Holly Compton of the University of Chicago, concluded in May 1941 that an expanded six months of intensive research was needed before a decision could be rendered. Bush was dissatisfied with this report and responded by appointing more engineers to the committee and asking them to reconsider and produce a new report. This report, delivered on July 18, reached the same general conclusions as the prior one. By this point, Bush had a secret report from British scientists concluding that an atomic bomb could conceivably be built within the next few years.

Bush used this report and his own persuasive powers to convince President Roosevelt to give his full backing to proceeding with a large-scale effort to build the bomb. Roosevelt decreed that only four other people were to know: James B. Conant (Bush's deputy and president of Harvard University), Vice President Henry Wallace, Secretary of War Henry Stimson, and U.S. Army Chief of Staff George Marshall. Members of Congress were explicitly excluded from knowledge of the project and remained so throughout the war. The third and final NAS committee report completed in November 1941 provided a cost estimate of $133 million (in 1940 dollars)—a vast underestimate for a project whose final cost of $2 billion was about two-fifths of the entire military cost of World War II to the United States.

The U.S. Army Corps of Engineers (ACE) became the vehicle by which this massive endeavor would be hidden in the federal war budget because construction contracts were large and difficult to understand. The project was turned over to ACE in June 1942 and codenamed the Manhattan Engineer District (MED) for its proposed base of administrative operations in New York City. MED became known colloquially as the "Manhattan Project," even though building the atomic bomb had little to do with the city of New York. Colonel Leslie Groves, the civil engineer who supervised the building of the Pentagon in record time, was promoted to brigadier general and given command of the Manhattan Project.

General Groves swiftly commandeered equipment, supplies, human resources, and the best scientists who could be assembled, and created a series of centers in remote locations in Hanford, Washington; Oak Ridge; and Los Alamos, New Mexico in addition to maintaining work at many universities and over 200 corporations including Stone and Webster, Dupont, Eastman Kodak, and Union Carbide. At its peak in 1944 there were more than 160,000 employees working on the project. This workforce overcame tremendous scientific and technical problems in the push to build "the device," and the first atomic bomb performed superbly at Alamogordo, New Mexico, on July 16, 1945. Three weeks later the first atomic bomb was used in war as the *Enola Gay* bomber dropped a single 90-kilogram device over Hiroshima, Japan, on August 6, 1945. Two days later the Soviets declared war on Japan and invaded Manchuria, and on August 9 a second atomic bomb weighing only 6.1 kilograms fell from the sky over Nagasaki, Japan, which created equally widespread destruction (because of its smaller size, the second bomb was considerably more powerful per kilogram). The emperor of Japan announced his intent to accept the Potsdam Proclamation and surrender to the Allied forces on August 14, 1945, with a formal surrender occurring on the 2nd of September.

Assessments

These first atomic bombs affected earth, water, air, and all living organisms in the targeted area. The Hiroshima bomb delivered the equivalent energy of 13.5 kilotons of TNT, while the much smaller but technically superior Nagasaki device yielded 22 kilotons of TNT. The fireball radius was 150 yards with a peak heat close to that of the center of the sun. These bombs leveled the core of these cities with a huge shock wave moving at the speed of sound and heat radiation moving at the speed of light that, while sustained for only a few seconds, vaporized entire structures and human beings, seriously burned thousands of others, and sowed radiation poisoning in human and animal tissue, water supplies, building remains, and the very earth itself, which would affect generations to come. J. Robert Oppenheimer, the scientific leader of the Manhattan Project, when viewing the test site explosion at Alamogordo was reminded of the words of Shiva from the Bhagavad Gita, a Vedic text of India, "I am become death, the destroyer of worlds."

Many scientists associated with the Manhattan Project went on to take leading roles in organizations such as the American Nuclear Society, Federation of Atomic (later American) Scientists, Union of Concerned Scientists, and International Pugwash that sought to stop the spread of nuclear weapons and better educate the public about the brave new world humanity entered with the creation and use of these devices. Einstein expressed deep regret at his own key role in getting the ear of President Roosevelt for Szilard. Einstein would later write, "the unleashed power of the atom has changed everything save our modes of thinking, and thus we drift toward unparalleled catastrophe . . . [A] new type of thinking is essential if mankind is to survive and move toward higher levels." Szilard was appalled to learn that America had used the atomic bomb against Hiroshima and devoted himself to the post-war effort to restrict and control the development and use of nuclear weapons. Most nuclear scientists, however, went on to further government contract work on the construction of thermonuclear weapons that were more than one thousand times more powerful than those developed during the project or to work on peaceful uses of nuclear energy. Many scientists, joined by other scholars such as Pitirim Sorokin, Ruth Sivard, Alex Roland, Bruce Mazlish, Kenneth Waltz, and John Mearsheimer, agreed with the assessment of the nuclear scientist Donald York that providing these types of implements rendered war on a large scale too horrific to contemplate and consequently saved hundreds of millions of lives in the standoff between the United States and the Soviet Union known as the Cold War (1945–1989).

Karl Jaspers, a noted German philosopher, argued in *Atombombe und die Zunkunft des Menschen* (1958), that an entirely new way of thinking was required after the creation of the atomic bomb. The philosopher and mathematician, Bertrand Russell, argued in 1946 in "The Atomic Bomb and the Prevention of War" (*Bulletin of the Atomic Scientists* 2(5): p. 19), that the only way to prevent war was through an international government that possessed atomic weapons and was prepared to use them if nations would not heed its directives and settle their disputes amicably with one another.

In the years following the development and deployment of the atomic bomb, the United States and other nations went on to develop more powerful weapons and to repeatedly test them above and below ground. Tens of thousands of civilians and military personnel were exposed to increased amounts of radiation, many unwittingly and unknowingly. The balance of evidence and the opinion of the majority of scientists with expertise who have studied this issue, suggest that for the most part the effects were quite minimal, although whether these low levels of exposure have long-term detrimental health effects can neither be demonstrated nor conclusively denied. The government of the United States, throughout this period, consistently assured the American public that there were *no* risks, despite voluminous information from scientists and classified studies they had commissioned that showed such a claim to be preposterous.

Various ethical arguments have been advanced against nuclear weapons. For example, some have argued that atomic weapons are "unnatural" and on this basis alone should be banned. But all armaments beyond sticks and stones fall under the same charge. Massive fire bombings in World War II of British, German, and Japanese cities killed far more civilians and in ways every bit as horrendous. While an atomic weapon is more than the "beautiful physics" that Enrico Fermi declared when asked about any moral qualms he had about working on the bomb, it must be viewed on a long continuum of the technological evolution of warfare. Whether nations holding nuclear technologies can, and should be able to, prohibit others from acquiring such devices remains an open question to be decided in sociopolitical processes that will include but not be wholly determined by ethical criticism. There is little question that human thought as expressed in writings across a wide range of other subject areas has also been profoundly influenced by the genesis and spread of nuclear weapons. The future of the world is literally increasingly in the hands of a very small number of individuals.

DENNIS W. CHEEK

SEE ALSO *Baruch Plan; Einstein, Albert; Hiroshima and Nagasaki; International Relations; Limited Nuclear Test Ban Treaty; Oppenheimer, J. Robert; Rotblat, Joseph; Weapons of Mass Destruction.*

BIBLIOGRAPHY

Badash, Lawrence. (1995). *Scientists and the Development of Nuclear Weapons: From Fission to the Limited Test Ban Treaty, 1939–1963.* Atlantic Highlands, NJ: Humanities Press. This study portrays the scientific work, ethical and human dimensions, and societal interactions of scientists who worked on nuclear weapons over this period of time.

Bauckham, Richard J., and R. John Elford, eds. (1989). *The Nuclear Weapons Debate: Theological and Ethical Issues.* London: SCM Press. Series of essays by theologians and philosophers who take up central issues concerning nuclear weapons.

Bergeron, Kenneth D. (2002). *Tritium on Ice: The Dangerous New Alliance of Nuclear Weapons and Nuclear Power.* Cambridge, MA: MIT Press. Examines ramifications of a U.S. decision in 2003 to allow conventional nuclear power plants to produce tritium, a radioactive form of hydrogen used to convert atomic bombs into hydrogen bombs.

Canaday, John. (2000). *The Nuclear Muse: Literature, Physics and the First Atomic Bomb.* Madison, WI: University of Wisconsin Press. A detailed analysis of a variety of texts produced by physicists before, during and after World War II.

Einstein, Albert. (1960). *Einstein on Peace*, ed. Otto Nathan and Heinz Norden. New York: Simon and Schuster. A series of writings on peace by one of the most famous physicists of all time, including many reflections on the nuclear age.

Gusterson, Hugh. (2004). *People of the Bomb: Portraits of America's Nuclear Complex.* Minneapolis: University of Minnesota Press. A portrait based on fifteen years of research at weapons laboratories that shows how the military-industrial complex built consent for its programs and transformed public culture and personal psychology since the beginning of the nuclear age.

Hacker, Barton C. (1994). *Elements of Controversy: The Atomic Energy Commission and Radiation Safety in Nuclear Weapons Testing, 1947–1974.* Berkeley: University of California Press. A balanced portrait of weapons testing programs in the United States and their effects, including documentary evidence, clinical, and epidemiological studies. Contains an extensive bibliography.

Hashmi, Sohail, and Steven Lee, eds. (2004). *Ethics and Weapons of Mass Destruction: Religious and Secular Perspectives.* New York: Cambridge University Press. Structured dialogues among representatives of various religious and secular traditions along with essays on weapons of mass destruction and an analysis of existing agreements among nations.

Palmer-Fernandez, Gabriel. (1996). *Deterrence and the Crisis in Moral Theory: An Analysis of the Moral Literature on the Nuclear Arms Debate.* New York: Peter Lang. A systematic comparative study of the dominant views on nuclear arms. It suggests the weapons and the plans that accompany them challenge traditional moral reasoning and understandings of the relationship between intentions and actions.

Rhodes, Richard. (1986). *The Making of the Atomic Bomb.* New York: Simon and Schuster. The author won a Pulitzer Prize for this massive study that is rich in the human, political, and scientific dimensions of the making and use of the atomic bomb.

Smith, Alice Kimball. (1970). *A Peril and a Hope: The Scientists' Movement in America, 1945–47.* Cambridge, MA: MIT Press. Explores the political influence of scientists on arms control in the period just after the dropping of the atomic bomb.

ATOMS FOR PEACE PROGRAM

The Atoms for Peace program, announced by President Dwight Eisenhower at the United Nations in December 1953, constituted a new international effort to regulate the uses of nuclear energy. With its ethical and political justifications, it thus provides an important case study in the control of one specific form of science and technology.

Background

Following the Soviet Union's rejection of the 1945 Baruch Plan for the international control of atomic energy, passage of the Atomic Energy Act of 1946 established a U.S. policy to prevent the spread of nuclear technology by secrecy and denial. Even exchanges of information with U.S. allies who had cooperated in the development of the atomic bomb were prohibited.

By the end of 1953, however, it was apparent that the policy of restriction had failed. The Soviet Union had joined the United States as an atomic weapons state, and both the United States and the USSR had tested hydrogen bombs. In addition to the development of more sophisticated nuclear weapons, research also had progressed on the peaceful uses of nuclear power, especially in commercial applications. As Secretary of State John Foster Dulles noted during testimony before the Joint Committee on Atomic Energy, knowledge about atomic energy was growing in so much of the world that it was impossible for the United States to "effectively dam . . . the flow of information." If the United States continued to try to do so, he observed, "we [would] only dam our influence and others [would] move into the field with the bargaining power that that involves" (Guhin 1976, p. 10).

The transition from a policy of secrecy and denial to active promotion of the peaceful applications of atomic energy was first clearly articulated in President Eisenhower's famous "Atoms for Peace" speech before the United Nations. There, Eisenhower acknowledged that the secret of the atom eventually would be acquired by other states, and he emphasized the need to exploit those properties in the atom that were good rather than evil. More specifically, he proposed that the governments principally involved in nuclear research and development make joint contributions from their stockpiles of fissionable materials to an International Atomic Energy Agency (IAEA).

The IAEA was to be set up under the jurisdiction of the United Nations and would be responsible for the storage and protection of contributed fissionable materials. It also was to have the important task of devising methods to distribute nuclear material for peaceful purposes, especially the production of electrical power. Eisenhower hoped that the contribution of fissionable products to the IAEA would assist arms control by diverting the stockpile of nuclear material from military to peaceful purposes. The contributing powers would, in Eisenhower's words, "be dedicating some of their strength to serve the needs rather than the fears of mankind" (*Papers of the Presidents of the United States: Dwight D. Eisenhower 1953*, pp. 813–822).

Implementation

It was not until 1957 that Eisenhower's Atoms for Peace proposals found fruition in the establishment of the IAEA. Not only did the Soviet Union's initial opposition need to be overcome, but substantial revisions had to be made in the very restrictive U.S. Atomic Energy Act of 1946. These changes, incorporated in the Atomic Energy Act of 1954, included removing most controls on the classifications of information regarding nuclear research, approving ownership of nuclear facilities and fissionable material by private industry, and authorizing the government to enter into agreements for cooperation with other nations on the peaceful uses of nuclear energy.

President Eisenhower's Atoms for Peace program ushered in a period of relaxed control over nuclear information, which, ironically, facilitated the development of a race between the United States and the Soviet Union for peaceful nuclear energy and prestige, in tandem with the superpower arms race. One aspect of the former competition was the rush by both the United States and the Soviet Union to declassify and disseminate a large volume of technical information. By 1958 this competition resulted in the adoption of new guidelines for information declassification in the United States that made it possible for any nation to gain access to almost all basic scientific information on the research, development, and operation of plants and equipment in the field of nuclear fission.

More than fifty years after president Eisenhower's "Atoms for Peace" speech, it is apparent that his initiative was a double-edged sword. Predicated on the belief—or at least the hope—that peaceful nuclear energy might be as beneficial to humanity as nuclear weapons were destructive, one indeed can observe many benefits derived from nuclear activities in the realms of medicine, agriculture, and industry. In addition, Eisenhower's initiative gave rise to a number of the most important components of the contemporary nonproliferation regime, including the IAEA and its international system of safeguards. However, one cannot ignore the fact that the Atoms for Peace program also accelerated nuclear proliferation by making it easier for some states to pursue their nuclear weapons ambitions. Although it may be more obvious today than in 1953, the fundamental dilemma remains unchanged—how can a policy prevent the proliferation of nuclear weapons capabilities while at the same time promoting the benefits of nuclear energy if the basic raw materials and technology for both are essentially the same?

WILLIAM C. POTTER

SEE ALSO *Baruch Plan; International Relations.*

BIBLIOGRAPHY

Guhin, Michael A. (1976). *Nuclear Paradox: Security Risks of the Peaceful Atom*. Washington, DC: American Enterprise Institute.

Lavoy, Peter R. (2003). "The Enduring Effects of Atoms for Peace." *Arms Control Today* 33(10): 26–30.

Papers of the Presidents of the United States: Dwight D. Eisenhower, 1953. (1960). Washington, DC: U.S. Government Printing Office.

Sokolski, Henry D. (2001). *Best of Intentions: America's Campaign against Strategic Weapons Proliferation*. Westport, CT: Praeger.

Weiss, Leonard. (2003). "Atoms for Peace." *Bulletin of the Atomic Scientists* 59(6): 34–41, 44.

INTERNET RESOURCE

Center for Global Security Research, Lawrence Livermore National Laboratory. (2003). "Atoms for Peace after 50 Years: The New Challenges and Opportunities" Available from http://www.eisenhowerinstitute.org/programs/globalpartnerships/safeguarding/AtomsPeace_Dec2003_whole.pdf.

AUGUSTINE

Augustine (354–430), born in Thagaste, North Africa, November 13, synthesized Platonism with Christian theology, and is considered a doctor of the European church. He taught rhetoric in Carthage, Rome, and Milan, until his conversion (386) and entry into monastic life; he became a presbyter (391) and bishop of Hippo (396), now Annaba, Algeria. Representative of the implications of his thought for science, technology, and ethics is the fact that in his early years he took an interest in one of the sciences of his day, astrology, and may even have practiced it himself; later he argued decisively against it. Augustine died in Hippo on August 28.

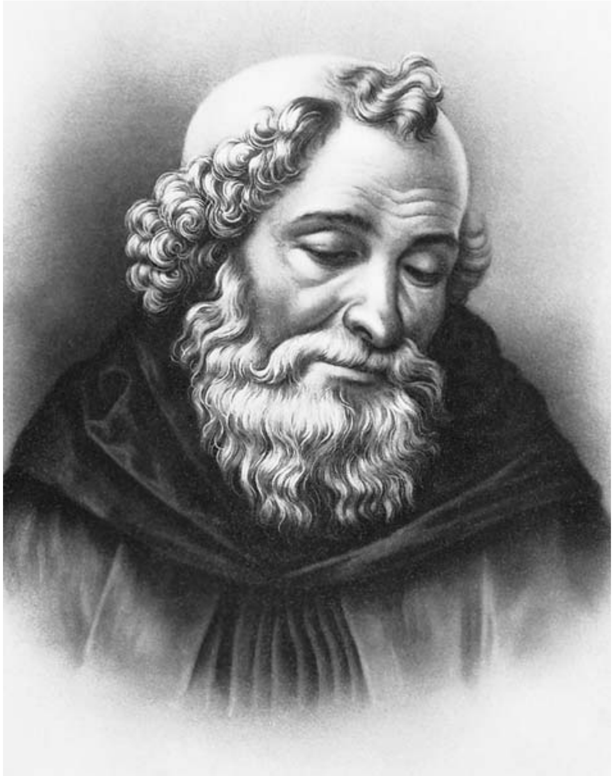
For Augustine, the chief concern of human beings ought to be God and the soul. This did not imply indifference to the material world and its events. When human beings perceive order in nature, he said, it points toward the realm of true happiness, the *intelligible realm* of divine ideas, which not only gives the world its form but enables the mind to discover both regularities in the world and rules for ethical behavior (*De ver. rel.* 29,52–36,67; 39,72–45,83). His general principle was that the mind judges things that are *inferior* to it, according to norms that are *above* it (*De ver. rel.* 31,58; 52,101). In the world presented by modern natural science, in which the order of the physical world appears to be the result of impersonal forces if not chance, the decisive question becomes to what extent the human mind can connect with realities superior to it.

In this journey from the outward to the inward and then upward, his most impressive venture was an analysis of music. In the sixth book of *De musica* (389), he traces the crucial role of proportions or *numbers*, starting with the physical sounds and moving inward to hearing, memory, speech, the spontaneous judgments that arouse *delight* at these proportions, and finally to the intelligible principles by which such judgments are made. His approach foreshadows modern interests in acoustics, the psychological effects of music, and the importance of music to the human spirit (for example, Arthur Schopenhauer).

Similarly he was aware of optics. When viewing a structure or a painting, humans spontaneously make judgments of harmony, he stated (*De lib. arb.* 30,54; 32,59). But there are complexities. An oar in water appears bent, but the light waves are not being *deceptive*; they act according to their nature as they are propagated through media of different densities, and what is fallacious is the premature judgment that the oar is really bent (*De ver. rel.* 33,62; 36,67).

Truth, he said, is God's wherever it is found; just as the Israelites were justified in appropriating the Egyptian's gold and silver because it belonged to God (*Ex.* 3:22, 11:2, 12:35), so Christians can appropriate all truth. The glory of the Gentiles, he said, is their science and philosophy (*Conf.* VII,9,15), though it must be transformed by the insights gained from revelation, which is the tradition of Israel. This early Christian attitude is continued by many modern Christians in dealing with secular science.

One of the major scientific disputes in which Augustine took part concerned the *antipodes*: Are there people living on the other side of a round earth, standing upside down? He regarded it as a matter of scientific conjecture rather than direct experience, but on the basis of Scripture he decided against it; he even thought that, if there should be people there, they could not be descendants of Adam and Eve (*De civ.*



Augustine, 354–430. Augustine was a Christian bishop whose vast literary output is an indispensable source for the religious and secular history of the twilight years of the Roman Empire in the West. (© *Bettmann /Corbis.*)

Dei XVI, 9). The eighth-century Irish monk Fergal or Vergilius in Salzburg was notorious for taking the opposite position. Gradually the question was seen as one for scientific inquiry rather than revelation, and Augustine's position was cited by Johannes Kepler, René Descartes, and the Encyclopedists as evidence of theological obscurantism.

Augustine's contributions relevant to science, technology, and ethics may be summarized in three ways. First his *last word,* at the end of *The City of God* (413–426), is an appreciation of human culture—the liberal arts (geometry, grammar, logic, and music); the fine arts, which use material things to convey thoughts and feelings (poetry, theater, painting, and architecture); and, perhaps most basic, the practical arts (domestication of plants and animals, the crafts, architecture and civil engineering, and navigation). These are indispensable, he said, to the life of the earthly city, even though the latter is not the highest end to be sought.

Second, in dealing with the issue of *natural evil,* Augustine acknowledged that humans live in a dangerous world, but saw this as an invitation to scientific inquiry and technological mastery. He argued that people are like visitors to a forge, surrounded by unknown implements; they resent falling against a furnace or a sharp tool, but the smith knows how to use each of these objects to accomplish his work (*De Gen. c. Man.* I,16,25–26). The venom of scorpions is poisonous, but it can also be put to medicinal use (*De mor.* II,8,11–12). The most personal kind of intervention is medicine, in which he finds many metaphors for the healing activity of God through Christ. In the early-twenty-first century, industry and government support both scientific inquiry and technological intervention.

Third, beyond these kinds of intervention in the world, Augustine suggests that human beings should not think solely in terms of their own discomfort or inconvenience; rather they should appreciate the intricate structure of all living forms, knowing that God created them though humans may not know why (*De civ. Dei* XII,4; XXII,24). In this respect he encouraged the later Christian Platonism of the Chartres school and of Kepler, which sought order in nature precisely because of the conviction that God rules intelligently and intelligibly.

EUGENE TESELLE

SEE ALSO *Christian Perspectives: Historical Traditions; Just War.*

BIBLIOGRAPHY

Delhaye, Phillipe. (1951). "La theacytelorie des antipodes et ses incidences théologiques." In *Le Microcosmus de Godefroy de St-Victor: Étude théologique,* ed. Phillipe Delhaye. Lille, France: Facultés Catholiques. History of the "round earth" question.

Ferrari, Leo C. (1996). "Augustine's Cosmography." *Augustinian Studies* 27: 129–177. The most complete account of Augustine's picture of the world.

Fortin, Ernest. (1984). "Augustine, the Arts, and Human Progress." In *Theology and Technology: Essays in Christian Analysis and Exegesis,* eds. Carl Mitcham and Jim Grote. Lanham, MD: University Press of America. Reprinted in *Ernest Fortin: Collected Essays,* Vol. III: *Human Rights, Virtue, and the Common Good: Untimely Meditations on Religion and Politics,* ed. J. Brian Benestad. (Lanham, MD: Rowman and Littlefield [1996]). Survey of Augustine's appreciation of culture and technology.

Martin, Thomas F., O.S.A. (2001). "Paul the Patient: *Christus Medicus* and the *Stimulus Carnis* (2 *Cor.* 12:7): A Consideration of Augustine's Medicinal Christology." *Augustinian Studies*: 219–256. Thorough discussion of the medical metaphor.

Nowak, Adolf. (1975). "Die 'numeri judicales' des Augustinus." *Archiv für Musikwissenschaft* 32: 196–207. A close analysis of Augustine's view of aesthetic judgment.

O'Daly, Gerard. (1987). *Augustine's Philosophy of Mind*. London: Duckworth. Comprehensive survey of Augustine's theory of knowledge.

Pickstock, Catherine. (1998). "Ascending Numbers: Augustine's *De Musica* and the Western Tradition." In *Christian Origins: Theology, Rhetoric and Community*, eds. Lewis Ayres and Gareth Jones. London and New York: Routledge. Defense of Augustinian aesthetics and cosmology by comparison with Indian, modern, and postmodern approaches.

AUSTRALIAN AND NEW ZEALAND PERSPECTIVES

Although they maintain their distinct identities, Australia and New Zealand are linked closely and together are often referred to as Australasia. Both countries claim to be "knowledge societies" and to value science and technology highly (if somewhat uncritically). Yet an apparent lack of understanding in government of the long-term character of scientific and technological development contributes to a perception among scientific and technical professionals that they have little political influence. Extensive corporatization and privatization of publicly-owned infrastructure during the 1990s was aimed largely at retiring government debt, while governments in both countries failed to provide effective support for the development of information- and sustainability-based technologies. However, early in the new century there were encouraging indications in New Zealand of government engagement with sustainability issues (Geddes and Stonyer 2001, Laugesten 2002). In Australia commitment to environmental/sustainability issues varies among and across the three tiers of government (federal, state/territory and local).

Historical Background

Australia and New Zealand had very different traditional cultures. Australian aborigines can demonstrate a continuous hunter-gatherer occupation of 40,000 years; in contrast, the Maori reached New Zealand as recently as 1000 to 1200 C.E., bringing with them a distinctive Polynesian cultural tradition. Australia became a British colony in the late eighteenth century, and New Zealand in the mid-nineteenth century. Invasion and settlement brought European religious and moral doctrines and European technologies designed to dominate the indigenous populations and exploit the natural environment.

Unfortunately, the colonists of both countries disdained indigenous knowledge and technologies. Only in the last quarter of the twentieth century did political activism lead to a broader appreciation of the depth of indigenous cultural and spiritual links with the land. There is increasing recognition that these values enrich the societies as a whole and in particular suggest important approaches to the search for sustainability. However, unresolved questions of reconciliation and compensation still constitute a major fault line in both societies and pose fundamental ethical dilemmas for their governments. This inevitably colors other ethics discussions on a host of issues related to ownership and custodianship of the land, including the use of natural resources and environmental degradation. As its population reached 20 million early in the twenty-first century, Australia became multi-cultural. New Zealand, with a population of 4 million, remains bicultural, with distinct Maori/Anglo (Pakeha) polarization.

As colonies and later as dominions within the British empire, Australia and New Zealand were until about 1950 major suppliers of food and raw materials to Great Britain and were captive markets for British manufactured goods. The colonial governments supplied essential infrastructure and took responsibility for funding science and technology, which tended to be applied and utilitarian, focusing initially on primary industries, particularly agriculture and mining. When multinational corporations set up substantial local operations after World War II, those operations were commonly "branch plants" with minimal research and development capability.

Although Australia and New Zealand have produced individual scientists and technologists who earned international acclaim, the technical culture in both countries was until relatively recently essentially derivative. Despite homegrown inventions and innovations, both countries were largely the recipients of technology transfer. While this tended to encourage a client-state mentality, valued local resources and technologies have been strongly defended, for example through resistance to the introduction of genetically modified crops.

While achieving rigorous academic standards, for many years the universities failed to provide an effective forum for broad ethical debate in science and technology. Higher education was based on British models, and into the second half of the twentieth century universities in Australia and New Zealand commonly looked to Britain for academic leadership. As in the rest of the "Western" world, scientific and technological advances were equated with social progress and the ethical focus was on gaining peer support, maintaining professional standards, and ensuring competent technical performance.

New Voices

Although the science and technology professions in Australia and New Zealand are well integrated into the global community, since the 1970s a distinctively Australasian voice has emerged, asserting that those professions must take a much broader approach to issues of ethical practice. There is growing awareness that science and technology involve social as well as technical practices (Johnston, Gostelow, and Jones 1999). Framing problems and choosing decision-making criteria increasingly are recognized as areas for professional judgment in which ethical choices are deeply embedded. For instance, in New Zealand Roy Geddes and Heather Stonyer (2001) highlight the ethical implications of setting national priorities and of deciding how far professionals should go in challenging government failure to provide adequate education and training in science and technology.

This groundswell of broader ethical awareness draws on worldwide developments in the scientific and technological communities, making the identification of distinctive local inputs and key national figures problematic. One person who stands out in this area is the Melbourne-born utilitarian moral philosopher Peter Singer, recognized for his courageous and challenging work on globalization, medical ethics and bioethics, and human relationships with the rest of the animal kingdom (Singer 2003).

The international partnership between New Zealand ethicist Alastair S. Gunn at the University of Waikato and U.S. civil and environmental engineer P. Aarne Vesilind also needs to be mentioned here. Their first book (Vesilind and Gunn 1986) was an important and timely contribution, not least because it argued that environmental ethics were relevant to the whole profession, and not only to environmental engineers. Two of their three books have been translated into Japanese and one into Chinese. Gunn has also been working with colleagues at the University of Malaya on an Internet site to provide ethics resources for technology professionals in Asia.

In Australia, Sharon Beder at the University of Wollongong is another public champion of ethical concerns, particularly within engineering. She has led a move away from paternalistic views of the public and toward greater transparency of professional action (Beder 1998). Until the 1980s government agencies in Australia that supplied major services and public utilities, including energy, communications, and water, were staffed mainly by engineers who prided themselves on doing the best they could with the resources allocated by the political process. Criticism of either the process or its outcomes was seen as bringing the profession into disrepute, and the profession's code of ethics was used to suppress internal dissent. Beder successfully challenged that limited approach to professional responsibility. By the 1990s the engineering profession in Australasia was looking outward and moving toward a clearly formulated emphasis on sustainability as a key ethical value.

In 1992 the Institution of Professional Engineers New Zealand (IPENZ) decided to revise its code of ethics. Gerry Coates argued that the new code should be values- rather than rules-based, provide high rather than low levels of guidance, and offer real ethical leadership for the profession. A key question was the extent to which technical and scientific professionals should be involved in political decision making. The change process took ten years and included extensive debate on the community-oriented values of *sustainable management* and *care of the environment*. However, respect for nonhuman life forms was considered too radical for inclusion at that time, and the revision did not provide guidance on the hierarchy of the values that were asserted (Coates 2000).

In Australia and New Zealand medical research became an important area of scientific and technical activity during the twentieth century. Since World War II there has been a worldwide strengthening of ethical guidelines and controls for research involving humans and animals and increasing awareness of environmental issues. The Australian National Health and Medical Research Council, a major channel for government funding, has exercised significant ethical leadership (National Health and Medical Research Council 2001). The Royal Society of New Zealand is also important in coordinating scientific and technical activity; its Code of Professional Standards and Ethics underscores legal and other constraints on professional behavior.

In both countries there is a powerful network of broadly based ethics committees in universities and research establishments that have a general commitment to ethical practice. There is frank debate in areas such as human stem-cell research, and ethics committees veto projects that do not satisfy their guidelines. However, globalization of research and pressures for economic returns promote increasing commercialization and public-private collaboration, and the traditional ideal of openness is under challenge.

Ethical issues have been highlighted in Australia since the late 1980s by dramatic business failures. Broad concerns have emerged about accountability and about the inward focus of much of the ethical debate in the professions, and the authority and influence of professional bodies have declined. Statutory anticorruption bodies and mechanisms such as commissions of inquiry appointed to look into specific problems or disasters now provide more effective sanctions against unethical behavior. In the public sector reliance on legislation and regulation remains fundamental.

Advancing Practice

By the 1990s ethics-focused research and guidance centers were emerging. With a focus on leadership rather than enforcement, Sydney's St. James Ethics Centre has an international reputation. Its executive director, Simon Longstaff, presents ethical practice in terms of building relationships, developing a well-informed conscience, being true to oneself, having the courage to explore difficult questions, and accepting the costs of ethical behavior. The center provides a framework for discussions that emphasize the recognition of the interests of stakeholders and the impacts of decisions. Developing involvement and avoiding polarization in ethical decision making require structure, space, and time (Taylor 1998). One facility provided by the center that is believed to be unique is a confidential ethics counseling help line for individuals.

There continue to be problems involving business ethics. In 2003 a royal commissioner reporting on the corporate culture that led to the multi-billion-dollar collapse of a major Australian insurance group, HIH, wondered if anyone had asked the simple question "Is this right?" The HIH demise highlighted problems with professional indemnity insurance. Some Australian states, in association with professional standards councils, have provided methods for limiting indemnity claims for professional groups that take specified steps to improve professional standards and protect consumers. Participating groups develop and adopt acceptable codes of ethics that are based on a model document that explains the nature and role of codes, describes their generic content, and outlines the development processes (Miller 2002). This approach encourages professional groups to acknowledge the non-technical aspects of problems; cross-disciplinary approaches are used to develop socially relevant project design criteria and address broad ethical issues.

One of the most promising developments has been a move toward exploration of the ways practitioners develop their own ethical frameworks. This work has led to programs that encourage and support students in recognizing, reflecting on, and dealing effectively with the ethical issues they encounter in practice (Johnston, McGregor, and Taylor 2000).

Ethical professional practice requires a broad awareness of social context, but this in itself is not sufficient. As Peter Singer pointed out, it is "clarity and consistency in our moral thinking [that] is likely, in the long run, to lead us to hold better views on ethical issues" (Singer 2003).

STEPHEN F. JOHNSTON

SEE ALSO *Engineers for Social Responsibility; Institute of Professional Engineers New Zealand.*

BIBLIOGRAPHY

Beder, Sharon. (1998). *The New Engineer: Management and Professional Responsibility in a Changing World.* South Yarra, Victoria, Australia: Macmillan Education Australia. A widely used text and a good introduction to her work, much of which is available at: http://www.uow.edu.au/arts/sts/sbeder/index.html.

Coates, Gerry. (2000). "Developing a Values-Based Code of Engineering Ethics." *IPENZ Transactions* 27: 11–16. Available from http://www.ipenz.org.nz; includes the IPENZ Code of Professional Ethics.

Johnston, Stephen F.; J. Paul Gostelow; and Evan Jones. (1999). *Engineering and Society: An Australian Perspective.* 2nd edition. Melbourne: Longman. A comprehensive exploration of the history and the social, political and economic context of engineering practice in Australia. A U.S./global version was published by Prentice Hall (2000).

Johnston, Stephen; Helen McGregor; and Elizabeth Taylor. (2000). "Practice-Focussed Ethics in Australian Engineering Education." *European Journal of Engineering Education* 25: 315–324.

Longstaff, Simon. (2003). *Hard Cases: Tough Choices.* Sydney: St James Ethics Centre. Available, with much other material, from http://www.ethics.org.au.

Miller, Seumas. (2002). *Model Code of Ethics Principles.* Sydney: Professional Standards Council.

National Health and Medical Research Council. (2001). *National Statement on Ethical Conduct in Research Involving Humans.* Canberra: Commonwealth of Australia.

Taylor, Elizabeth. (1998). "Peeling the Onion: A Technoprudence for Engineering." *Proceedings of the Tenth Annual Conference and Congress, Australasian Association for Engineering Education.* Gladstone: Central Queensland University: 311–314. Elizabeth Taylor is currently dean of the James Goldston Faculty of Engineering and Physical Systems at the University of Central Queensland.

Vesilind, P. Aarne; and Alastair S. Gunn. (1986). *Environmental Ethics for Engineers*. Chelsea, MI: Lewis. The latest collaboration by these authors, *Hold Paramount: The Engineer's Responsibility to Society* (Stamford, CT: Brooks Cole/ Thomson, 2002), written as a novel, explores ethical dilemmas faced by Chris (gender undefined), a structural engineer, in his/her work.

INTERNET RESOURCES

Abrams, Louise. (2003). "Controlling the Direction of Research in Australia: An Ethical Debate. " Research Office, University of Technology, Sydney. Available from http://www.uts.edu.au/

Geddes, Roy, and Heather Stonyer. (2001). "Science and Technology: Participating in the 'Knowledge' Culture." *Proceedings of the Sixth Annual Conference Australian Institute of Health Law and Ethics*. Melbourne: June/July. Available from http://www.law.unimelb.edu.

Laugesen, Pauline, ed. (2002). "Creating Our Future: Sustainable Development for New Zealand." Wellington, New Zealand: Parliamentary Commissioner for the Environment. Available from http://www.pce.govt.nz/.

Singer, Peter. (2003). "Interview: Peter Singer." *Heilpädagogik Online* 1/03: 53. Available from http://www.petersingerlinks.com.

AUTHORITARIANISM

Along with totalitarianism and democracy, authoritarianism is one of the main types of political regimes or systems. Though different variants exist, all authoritarian systems share certain basic features that have significant implications for science, technology, and ethics. For instance, the easy flow of information that facilitates science and is promoted by communications technology creates both opportunities for and burdens on authoritarian leaders seeking to maintain their control over the political realm.

Prominent scholars of authoritarianism include Juan J. Linz and Guillermo A. O'Donnell. Linz (2000) highlights the differences between authoritarianism and totalitarianism, while also pointing out the possibility for authoritarianism to combine with the other two types of government in a hybrid form of political regime. O'Donnell (1973) emphasizes the importance of a bureaucratic form of authoritarianism, distinct from cases of traditional military regimes or authoritarian systems managed by a dominant political party, while highlighting differences among authoritarian systems based on the degree of modernization in particular countries.

TABLE 1

Comparison of Democracy, Authoritarianism, and Totalitarianism

Democracy	Authoritarianism	Totalitarianism
Political mobilization promoted	Political mobilization generally discouraged	Political mobilization promoted
Competing pro-democratic ideologies	No state ideology	State ideology
Legitimacy based on ideology, rule of law, and performance	Legitimacy based on performance	Legitimacy based on ideology and performance
Official and unofficial limits on government	No official limits on government	No official or unofficial limits on government

SOURCE: Courtesy of Carl Mitcham and Lowell W. Barrington.

Features of Authoritarianism

In its ideal form, authoritarianism exhibits four defining features: a depoliticization or demobilization of the general population, the lack of a central governing ideology, legitimacy based on performance, and the general absence of official limitations on government action. These features distinguish authoritarian systems from democratic and totalitarian ones (see Table 1).

Because authoritarian governments do not seek to remake society in the way totalitarian systems do, there are fewer reasons to mobilize the masses compared to the other types of political systems. When it occurs, mobilization is generally designed to enhance the legitimacy of the system (the belief by the general public in the right to rule of the governmental institutions and individual leaders). As Samuel P. Huntington (1968) has argued, instability in any political system is often the result of political participation that is not channeled into regime-supportive activities. Thus, although authoritarian political systems may hold elections, the campaigns for such elections are devoid of significant discussions of issues in a form critical of the government, and the outcome is not in doubt. If necessary, ballot boxes will be stuffed or results falsified. Likewise, political parties may exist, but they are not used to organize the masses as in a totalitarian system nor to aggregate and articulate issue positions to allow the masses to choose in free and fair elections as in democracies. Opposition political organizations are either tightly controlled or not tolerated at all.

Partly because authoritarian systems do not seek the remaking of society, ideology is less important than in either totalitarian states or democracies. This is not to imply that authoritarian systems lack goals or a vision for change; they tend to focus on a particular vision, what Linz (1975) has called the "mentality" of authoritarian systems. In cases in which an authoritarian system is established through the overthrow of a democracy, the authoritarian leaders may concentrate on the need to institute policy changes to bring economic stability or otherwise restore order to a chaotic situation. This is often welcomed by the masses, who will, in many cases, prefer order to freedom. Thus, an important part of the legitimacy for an authoritarian system is based on its performance. As long as it achieves its goals, the general population may be quite willing to tolerate the absence of freedoms and the lack of a check on government power.

The final central feature of authoritarian political systems—the lack of official limitations on government action—is one that these systems share with totalitarian regimes. As Mark Hagopian (1984) has argued, the lack of legal restraints helps define both totalitarian and authoritarian systems as dictatorships and allows one easily to distinguish them from constitutional democracies. There are differences, however, between authoritarian and totalitarian systems in this regard. One could argue that authoritarian systems have even fewer institutional constraints than do their totalitarian counterparts (because of the comparatively limited role of a ruling political party in most authoritarian regimes). On the other hand, totalitarian regimes lack the informal—or, to use Hagopian's (1984, p. 118) term, "extralegal"—limits on power found in most authoritarian systems. The lack of official constraints does not imply the absence of ruling institutions or an official constitution, nor does it mean that society is completely controlled or powerless. Instead, the official rules of the game are subordinate to the will of the authoritarian ruler or rulers. Checks and balances (including judicial review) and the rule of law, both of which are familiar to citizens of many democratic countries, are unusual in authoritarian states. To the extent that constraints exist, they tend to be informal or based on connections between the government and powerful figures in society such as the wealthy. Such figures, or social institutions such as the church, can have a degree of autonomy from the state—and in some cases even a degree of influence over it.

Types of Authoritarianism

There are as many variations of authoritarianism as there are of democracy. The three main forms, however, are: military, bureaucratic, and party. A military authoritarian system (such as Pinochet's Chile) is one in which the military actually controls the policymaking institutions. Military authoritarian systems can arise for several reasons: an external threat to the security of the country, instability within the country, or threats to the autonomy of the military and/or the degree of military spending by the government. A bureaucratic authoritarian system (for example, Brazil following the military coup in 1964, Argentina in 1966–1974) usually involves an uneasy relationship between the military and the bureaucracy. Experts in their fields hold important political positions, and the bureaucracy becomes a central actor in the creation and implementation of policy. This policy is designed to facilitate internal stability, foster economic development, and maintain a modern society (O'Donnell 1973). The goal of modernization helps justify the power of "technocrats" in this form of authoritarianism.

A party authoritarian system (such as Mexico during much of the twentieth century) uses an existing or newly created political party to organize political activity and enhance the legitimacy of the system. The party is less important than in totalitarian systems, though it can play a role in facilitating elite–mass linkages. During the long period of dominance of the Institutional Revolutionary Party (PRI) in Mexico in the twentieth century, connections between government officials and interests within society were maintained through the party rather than the state. Even the party authoritarian type can be dissected. Huntington (1970), for example, lists three forms of party authoritarianism. If control through a political party is combined with a broader effort to remake society, the result is a hybrid form of government bridging authoritarianism and totalitarianism.

A hybrid between authoritarianism and democracy is also possible. Some call this semi-democracy, while others have termed it semi-authoritarianism (Ottaway 2003). In these systems, certain aspects of democracy exist, though others—most commonly freedoms such as of speech and the press—are curtailed by government control and/or intimidation. Thus, elections may exist without significant fraud, but the range of opinions expressed during the campaign is limited; media coverage of the government leadership is uniformly favorable. Since the election (and reelection) of Vladimir Putin, Russia has moved more and more in this direction. In some countries, this semi-authoritarianism can act as a bridge to democracy. In others, as is arguably the case in Putin's Russia, it may signal a move away from liberal democracy and toward a more classic authoritarian system. But semi-authoritarianism can also be quite persistent and need not be a transition to something else.

Science, Technology, and Ethics

The impact of authoritarianism on science, technology, and ethics is significant. For authoritarian leaders, ethical considerations are usually secondary to the goals of maintaining power, fostering stability, and facilitating economic performance. The concept of the rule of law has no place in the ideal authoritarian system. Human rights violations are common, as those whom the government perceives to be potential political threats are harassed, arrested, or killed. As in totalitarian systems, scientists in authoritarian states face ethical dilemmas working with such governments. On the one hand, cooperation with the state may provide an essential opportunity to conduct research. On the other, such cooperation both sanctions the actions of the government and opens the door to government use of the research in ways scientists may find morally objectionable.

Likewise, science and technology in general are double-edged swords for authoritarian officials. Authoritarian leaders who emphasize economic development as a central goal must foster technological advancements. In addition, science and technology may be put to use in assisting the maintenance of authoritarian power. Though less so than in totalitarian systems, authoritarian governments monitor the actions of individuals who might threaten their political power. In China, leaders have sought to harness the power of new technology to spread regime-supportive propaganda.

But technology can also threaten authoritarian rule. Those leaders who emphasize as their defining goal the protection of national culture rather than economic development often see technology as a transmission belt for "foreign" (especially Western) values. Those leaders who seek to use technology to monitor the actions of individuals also find that the technology allows those individuals to hide from this monitoring. The information-enhancing capacity of the Internet can be harnessed by opponents as well as government officials. The Chinese government works diligently to shut down Internet sites of regime opponents. But as quickly as these sites are removed, others spring up. Simply put, the more advanced and complex the society, the more difficult it is to keep it under surveillance. Thus, some authoritarian leaders may actively discourage certain types of technological advancements in their country.

LOWELL W. BARRINGTON

SEE ALSO *Expertise; Fascism; Technocracy; Totalitarianism.*

BIBLIOGRAPHY

Hagopian, Mark N. (1984). *Regimes, Movements, And Ideologies: A Comparative Introduction To Political Science*, 2nd edition. New York: Longman.

Huntington, Samuel P. (1968). *Political Order in Changing Societies*. New Haven, CT: Yale University Press.

Huntington, Samuel P. (1970). "Social and Institutional Dynamics of One-Party Systems." In *Authoritarian Politics in Modern Society: The Dynamics of Established One-Party Systems*, ed. Samuel P. Huntington and Clement H. Moore. New York: Basic.

Linz, Juan J. (1975). "Totalitarian and Authoritarian Regimes." In *Handbook of Political Science*, Vol. 3: *Macropolitical Theory*, ed. Fred I. Greenstein and Nelson W. Polsby. Reading, MA: Addison-Wesley.

Linz, Juan J. (2000). *Totalitarian and Authoritarian Regimes*. Boulder, CO: Lynne Rienner.

O'Donnell, Guillermo A. (1973). *Modernization and Bureaucratic-Authoritarianism: Studies in South American Politics*. Berkeley: University of California, Institute of International Studies.

Ottaway, Marina. (2003). *Democracy Challenged: The Rise of Semi-authoritarianism*. Washington, DC: Carnegie Endowment for International Peace.

AUTOMATION

The term *automation* was coined by John Diebold (born 1926), a pioneering management consultant and entrepreneur, when he shortened the more correct term *automatization*. His classic book *Automation* (1952) was the first to advocate this process, and to consider the general implications of this process for manufacturing and society. Using what were at that time only emerging concepts of control, communication, and computers, he described the coming industrial world of automated production and predicted the incipient information revolution. In pioneering the automation of production systems, Diebold extended the concepts of materials handling to information handling, to analyzing information flows, and to studying ways to automate office processes.

The Automation Process

In general the term *automation* describes the employment of automatic devices as a substitute for human physical or mental labor. An automatic device is one that performs a specified function without human intervention. Critical in one form of this process is "feedback." For example, when an autopilot is set to fly an airplane along a given course, it will by itself correct any deviation from that course caused by air turbulence. It

Automobile assembly line with welding robots. The automobile industry relies heavily on automation in many parts of its manufacturing process. *(AP/Wide World Photos.)*

does this by sensing the degree of deviation from the course and then actuating the appropriate control surfaces, such as ailerons, elevators, and rudder of the plane in a way that will restore the desired heading.

The sensors of the autopilot measure the amount of deviation from the course and "feed back" the right amount of electrical signal or hydraulic pressure to restore the intended course. A system with these characteristics also is referred to as a servomechanism or control system. Norbert Wiener (1894–1964), a pioneer in developing the theory of control systems, used the word *cybernetics* to describe the science of control and communication in both machines and living organisms.

In automating a manufacturing process, functions once performed by humans are replaced by automatic devices that replicate those functions. Computers are widely used for process control. Manufacturers invest in automation because it increases productivity per worker employed, creates greater uniformity of product, and lowers cost per unit of output.

Economic Implications

The substitution of human and animal effort by machines has been pursued throughout history. Some substitutions have been beneficial in their effect, relieving humans from the need to do heavy physical labor. Automation is a relatively recent development in the long history of technological change and a new issue in long-standing debates about technological unemployment. These debates were particularly fierce during the Industrial Revolution in England, when new machines displaced workers and left many unemployable.

Many economists argue that automation, along with technological change in general, does not add to total unemployment. Total unemployment is not affected by technological innovation because although workers in one industrial sector lose jobs, others gain employment through the creation of new jobs. Frequently cited evidence includes the widespread anxiety in the 1950s that automation would lead to mass unemployment, which never materialized. This anxiety can be chalked up to the "lump of labor fallacy," which holds that there is a constant amount of work to be performed in the world, and therefore any increase in the productivity of workers reduces the number of available jobs.

Ethical Issues

Ethical issues arise when public policies or the strategies of industrial management lead to unemployment and other consequences that harm the life of the individual or lead to social dislocation. Diebold was much concerned with the social effects of automation and predicted that the "age of automation" would transform society as radically as did the Industrial Revolution but that that change would be more profound because the rate of change had become so much more rapid. He acknowledged that automation created some employment problems but stated that the social effects of communications and computer systems will be more insidious because information, its communication, and its use will change people's approach to work, society, and life.

It was Ben B. Seligman who in *Most Notorious Victory* (1966) cataloged the harmful consequences of automation. With a social scientist's broad interest in the human condition he systematically examined the economic, social, psychological, and philosophical implications of automation. His main indictment is implied in the title: The successful diffusion of wave upon wave of new technology threatens to destroy essential human qualities. New technologies render traditional work patterns obsolete, and the mechanization of labor may undermine the significance of work as a source of meaning for many people. Seligman also was concerned that complex technological issues that require the judgment of experts will weaken the democratic process and lead to a situation in which technocrats will chart the future of society.

Ethical issues that derive from automation will continue to confront society. There appears to be no end to technological innovation in the foreseeable future and to the application of automation to new areas. The new frontier for automation is no longer production but the service industries, prominent among them health care, financial services, telecommunications, retail, and transportation.

A. GEORGE SCHILLINGER

SEE ALSO *Artificial Intelligence; Autonomous Technology; Cybernetics; Wiener, Norbert; Work.*

BIBLIOGRAPHY

Diebold, John. (1952). *Automation: Its Impact on Business and Labor*. New York: Van Nostrand. The first comprehensive book on the subject. It is prophetic in its projections of how automation and computers will change production, management, labor and the nature of work in the office.

Quinn, Francis X., ed. (1962). *The Ethical Aftermath of Automation*. Westminster, MD: Newman Press.

Seligman, Ben B. (1966). *Most Notorious Victory: Man in an Age of Automation*. New York: Free Press. A systematic and sensitive analysis of the harm massive rapid technological development and automation in particular can inflict on the individual and society.

Zuboff, Shoshana. (1988). *In the Age of the Smart Machine*. New York: Basic Books.

AUTOMOBILES

One of the distinguishing characteristics of human beings is that they have always been mobile. From its origins on the African continent, the human species has traversed the earth and populated every continent but Antarctica. For most of human existence, land travel was entirely dependent on human and animal muscle power. Radical changes came in the nineteenth century with the invention of steam-powered locomotives, and toward the end of the century the first automobiles powered by internal combustion engines were created in several industrially developed countries. By the first decade of the twentieth century automobile ownership was expanding at a rapid rate in the United States, and this pattern was followed in subsequent decades in many other parts of the world.

Cars gave people an unparalleled ability to go where they wanted, when they wanted, and with whom they wanted. In short, they promised freedom. Early motorists eagerly took advantage of this freedom, embarking on long journeys despite miserable road conditions and the uncertain reliability of their vehicles. By the 1920s automobile ownership had been *democratized* in the United States as manufacturing innovations dramatically lowered purchasing prices, giving rise to an era of mass motorization.

In the early-twenty-first century car ownership has expanded to such an extent that in many industrial nations the ratio of cars to people approaches or even exceeds one to two. Yet universal automobile ownership presents a paradox. Although the great virtue of the automobile lies in the freedom that it confers, the ownership and operation of a car has subjected its users to numerous restrictions. Traffic laws, registration and licensure requirements, vehicle inspections, insurance, and a significant financial burden put a serious crimp on feelings of unrestrained freedom. Individual freedom is also stifled by the sheer proliferation of automobiles; people acquire and use cars to enhance their mobility, but when they do so in large numbers the result is traf-

Safety demonstration on a Volkswagen car. Advances in automotive technology have contributed to the development of devices, such as seat belts and air bags, for the protection of the human occupants of automobiles. *(© Richard Olivier/Corbis.)*

fic-stopping congestion, and everybody's freedom of movement is diminished accordingly. In sum, the automobile is a prime example of how the aggregated pursuit of individual freedom can produce the opposite result—submission to numerous restraints, immobility, and frustration.

Clearing the Air

Many of the ethical quandaries posed by the automobile can be reduced to an overarching issue: achieving a balance between the individual freedom that comes with operating a car and the needs of society as a whole. The difficulty of doing so is exemplified by the forty-year-old campaign to reduce air pollution. A single car has a negligible effect on air quality, but 100,000 in a limited area can be the source of significant pollution. In recent years there have been substantial gains in air quality due to the application of technological fixes such as computerized engine management systems, reformulated fuels, and catalytic converters. But these never would have been developed and used if each motorist followed only his or her self-interest. Emission-control technologies add substantial costs to the purchase and operation of a vehicle, yet they do nothing to improve air quality if no other cars are similarly equipped. It is therefore necessary for an agency working on behalf of the collectivity, in most cases government at some level, to mandate that cars and the fuel they use produce fewer pollution-forming emissions. As long as everyone is required to meet similar regulations there is little cause for complaint. People may grumble about paying higher prices for cars and fuel, and they may resent the time absorbed by periodic smog checks, but few would want to return to the preregulation era when air pollution caused by uncontrolled vehicle emissions severely diminished the quality of life.

It has been relatively easy to mesh individual with collective interests in combating air pollution because the environmental consequences of operating an automobile are all too apparent to anyone who has to live in a gray-brown haze of smog. This in turn substantially increases public receptivity to the governmental actions

Emissions technicians evaluating automobile emissions in a garage. Technological advances in emissions systems, such as reformulated fuels and catalytic converters, have led to improvements in air quality. *(© Martha Tabor/Working Images Photographs.)*

taken to reduce emissions. It also helps that the available technological fixes do not require a massive overhaul of the transportation system; all that is needed are some modifications to automobile engines and the fuel they use. The same does not hold true when addressing another inescapable product of vehicle operation: the generation of carbon dioxide (CO_2). There are no easily applied technological fixes to reduce CO_2 emissions, which are the inevitable product of burning hydrocarbon fuels. The only likely solution entails the abandonment of the internal combustion engine in favor of battery-powered electrics, while hoping that battery performance can eventually be improved. Further in the future lies the possibility that fuel cells will become practical sources of power, but their adoption would necessitate major changes in the infrastructure that supports the automobile and the expenditure of billions of dollars. Moreover obtaining the hydrogen to power the fuels cells is problematic. The most feasible source is petroleum, and the energy costs of the conversion process would require the production and consumption of significantly larger quantities of this diminishing resource.

Even if alternatives to the internal combustion engine become available, the task of getting motorists to accept them remains, because CO_2 emissions do not have the immediate, all too apparent effects of ordinary smog. Because CO_2 is odorless and colorless, most drivers are unaware of the fact that, on average, they are pumping about a pound of it into the atmosphere for every mile they drive, and that vehicles account for about 30 percent of CO_2 emissions in the United States. Yet in the long run these emissions may be more harmful than the smog-forming by-products of internal combustion. If, as many atmospheric scientists believe, CO_2 accumulation in the atmosphere is a major cause of global warming, the long-term results of automobile operation could be disastrous. But global warming is still a controversial issue, and if it occurs will take a long time to manifest itself. Consequently it will be far more difficult to mandate the manufacture and operation of totally different kinds of vehicles, or to do away with the private automobile altogether.

Automotive Safety as an Ethical Issue

Setting aside the problem of controlling CO_2, the case for asserting the primacy of collective needs over individual freedom seems clear-cut in regard to automotive emissions controls. Somewhat more ambiguous is the issue of making safer cars. One may reasonably begin with the assertion that the most important determinants of the safe operation of vehicles are the actions and skills of their operators. When 30 percent of the more than 42,000 fatalities on U.S. roads in 2003 involved drivers whose blood-alcohol level was over the legal standard for driving under the influence, it is not reasonable to demand that cars should provide perfect protection from the consequences of individual irresponsibility. At the same time, however, some accidents may be unavoidable, and even when driver error is involved, death and injury cannot be considered appropriate penalties for momentary lapses.

For decades automobile manufacturers were convinced that *safety features were of scant interest to consumers* and they expended little or no effort to improve the ability of automobiles to protect their occupants in the event of an accident. This situation began to change dramatically in the 1960s, when Ralph Nader and other critics attacked the industry's indifference. Automotive safety became a salient cultural and political issue, and a combination of market demands and government regulations prodded manufacturers into making cars that did a much better job of protecting their occupants when accidents occurred.

Of all the safety improvements that ensued, the most important was the fitting of seat belts as standard equipment. Subsequent advances such as shoulder-and-lap belts made these restraints even more effective, but they were of no value when left unused. During the early 1970s only a small minority of U.S. drivers and passengers regularly used seat belts, so for the 1974 model year an effort was made to encourage their use by fitting cars with interlocks that prevented the vehicle from being started if all occupants had not buckled up. Vociferous protests caused Congress to repeal the requirement in short order.

Convinced that the majority of drivers and passengers could not be convinced to use seat belts, the federal government mandated the fitting of *passive restraints* to new cars. Some of these took the form of motorized harnesses that wound their way over an occupant's upper body, but far more popular was the airbag. By the mid-1990s driver and front-seat passenger airbags were virtually universal fittings on new cars. Airbag technology was predicated on the need to protect an unbelted male weighing 80 kilograms (175 pounds). Providing protection for a person of this size necessitated the design of airbags that inflated in milliseconds and reached speeds of up to 320 kilometers per hour (200 miles per hour), at which point they exerted 500 to 1,180 kilograms (1,100 to 2,600 pounds) of force on the upper body.

It soon became apparent that airbags deploying with this force could be lethal, especially for children and drivers under a certain height who had to sit close to the steering wheel. By mid-2003, 231 people (144 of them infants and children) had been killed by airbag deployments, some of them triggered by collisions occurring at very low speeds. In contrast to these airbag-related fatalities, there was an estimated 14 percent reduction of the risk of being killed in the event of an accident. But this is far less than the 45 percent reduction attributed to the use of seat belts. Used together, airbags and seat belts lower the risk of fatality by 50 percent. It is thus apparent that airbags are a useful supplement to lap-and-shoulder belts, but they are not a substitute. A majority of the driving public seems to have recognized this fact, and approximately 70 percent of drivers now use seat belts, far more than had been deemed possible when passive restraints were first decreed. This has allowed the installation of airbags that inflate with less force. Some cars are being designed with *smart* airbags that vary the force of deployment according to a number of variables, such as the weight of the driver or passenger. These improvements will make airbag deployment less hazardous, but the risk of some airbag-induced casualties still remains.

Assessing whether or not the lives saved by airbags have outweighed the deaths they cause is no easy task. It can be said with certainty, however, that no medicine with the airbag's ratio of deaths caused to lives saved would ever have been approved by government regulators.

Ethical Perspectives

Although the United States, with its long travel distances and individualist social values, has set a dominant pattern for automobile development and utilization, other countries have sometimes adopted public policies at variance with those of the United States. For example, in part because of smaller streets and roadways, cars in Europe are generally smaller in size than those in the United States. And because automobile ownership was for many decades largely restricted to upper-income individuals, European countries also have generally taxed gasoline at higher rates, with some of the revenues used to subsidize public transportation systems.

The issues engendered by automobile emissions and automotive safety hardly exhaust the ethical concerns posed by the automobile wherever it has taken hold. For example, important issues can be raised about the consequences of the automobile's ravenous consumption of energy. In addition to the environmental problems already mentioned, the massive demand for petroleum-based fuels has affected the distribution of wealth at both a national and international level. In many petroleum-producing countries the bulk of oil revenues has gone to a small segment of the population, contributing to a lopsided distribution of income and wealth, and exacerbating social tensions. For the world as a whole, high energy prices due in part to the ever-increasing demand for automotive fuels have made the efforts of poor countries to modernize their economies more difficult.

In the realm of international relations, important questions can be raised in regard to how foreign policies and military operations have been affected by the need to maintain access to, or even control of, oil supplies, especially in the Middle East. Finally the accelerating use of the world's petroleum supplies and their inevitable depletion should provoke questions regarding what, if anything, is owed to future generations by the present one. In sum, as befits an artifact that has shaped the modern world like few others, the automobile has generated a host of ethical issues that need to be addressed if reasonable and effective public policies are to be developed and implemented.

RUDI VOLTI

SEE ALSO *Environmental Ethics; Ford Pinto Case; Pollution; Safety Engineering: Practices; Roads and Highways.*

BIBLIOGRAPHY

Bryner, Gary C. (1995). *Blue Skies, Green Politics: The Clean Air Act of 1990 and Its Implementation.* Washington, DC: CQ Press. A narrative and analysis of the governmental processes that resulted in stiffer emissions regulations.

Flink, James J. (1988). *The Automobile Age.* Cambridge, MA: MIT Press. A comprehensive history of the automobile and its consequences.

Illich, Ivan. (1974). *Energy and Equity.* New York: Harper & Row. A provocative challenge to the dominance of automobile-based transportation and an energy-intensive society in general.

Nader, Ralph. (1972). *Unsafe at Any Speed: The Designed-In Dangers of the American Automobile.* New York: Grossman. The book that launched the crusade for improved automobile safety.

Volti, Rudi. (2003). "Reducing Automotive Emissions in Southern California: The Dance of Public Policies and Technological Fixes." In *Inventing for the Environment,* ed. Arthur Molella and Joyce Bedi. Cambridge, MA: MIT Press. A discussion of the interrelationship of policy initiatives and technological change.

AUTONOMOUS TECHNOLOGY

The term *autonomous technology* is associated with arguments that modern technology has grown out of control or develops independent of any particular human intention or plan. It is usually used to highlight undesirable aspects of technological society undermine human autonomy, thus signaling its ethical relevance. The clear ethical connotation of autonomous technology marks its difference from the notion of technological determinism, with which it is often associated.

Challenging the taken-for-granted notion of technology as simply an instrument or a tool, as well as the belief in human freedom, the concept of autonomous technology has been at the center of various controversies in the philosophy of technology, where it has functioned in three related contexts. First, it has served to articulate an uneasy feeling that has accompanied the mastery of nature and the fast pace of technological change since the Industrial Revolution. As early as the nineteenth century, stories were written about human beings being ruled by "their" mechanical creatures, which had gained autonomy. Mary Shelley's famous novel *Frankenstein* (1994 [1818]) is the best-known example. Second, the concept has been associated with those philosophers who stressed the alienating and dehumanizing aspects of modern technology. Examples include Martin Heidegger (1889–1976), Herbert Marcuse (1898–1979), and Lewis Mumford (1895–1990). Finally, third, are those who have popularized the term and made it a central theme in their analyses of technology. Here the natural reference is to Jacques Ellul and Langdon Winner.

Theories of Autonomous Technology

Ellul (1954) presents characteristics of modern technology such as automatism, self-augmentation, universalism, and autonomy—the last of which summarizes the rest. Ellul claims that modern technology, unlike traditional technology, is not bound by any heteronomous rules or principles, but develops according to its own rules. As its scale and pervasiveness increase, the development of technology (Ellul's term is *la technique*) is influenced neither by sociopolitical and economic changes, nor moral and spiritual values. Rather, technological change itself now defines the context of other aspects of culture such as capitalist competition for survival in the market. The pursuit of human well-being, presumably the purpose of technological development, is replaced by obsessive pursuit of efficiency, even though the exact meaning of efficiency is often unclear. Technological progress is assumed to be always beneficial, while dimensions of sacredness, mystery, and morality are minimized. Autonomous technology reaches fulfillment when people no longer feel uneasy about "mastering nature" that has come to contradict their own human autonomy.

Winner (1977) claims that autonomous technology is revealed most clearly in technological politics. Examples include the political imperative to promote technology, because problems from one technology require another to address it, and the phenomenon of reverse adaptation, in which an end is modified so that it fits the available means. Showing that technological artifacts have political implications (Winner 1980), Winner argues that modern technology should be perceived as legislation that shapes "the basic pattern and content of human activity in our time" (Winner 1977, p. 323) and as forms of life, which have become part of our humanity (Winner 1986). The dilemma of technological society is that decisions on technology are often necessitated by existing technologies (the technological imperative); examples include the nuclear power plant and nuclear waste storage. Furthermore, sometimes, the ends and means of technological enterprises are reversed (reverse adaptation), as one can see in the development of space projects. In this respect, Winner agrees with Ellul that "if one looks at the broader picture of how technique is welcome and incorporated into society, one can hardly be confident that the origins, activities, and results of social choice about technology are firmly in anyone's grasp at all" (Winner 1995, p. 67).

Nevertheless, while appreciating Ellul's analysis, Winner eventually criticizes Ellul for ignoring human agency in his conception of autonomous technology. For Winner, it was humans that have let modern technology grow out of control, by mistakenly ignoring its political dimensions. He argues that although technology is out of control or drifting without fixed direction, it is not fully self-determining, with a life of its own. Technology is only semiautonomous. Thus, the issue raised by autonomous technology is "what humanity as a whole will make of them" (Winner 1995, p. 71).

Criticism and Response

Concepts of autonomous technology have been subject to various criticisms and misunderstandings. First, autonomous technology is often accused of reflecting irrational technophobia. This view relies on the simple assumption that technology is a neutral instrument, and as such under full human control. Accordingly, autonomous technology is regarded as a self-contradicting term.

A second objection is that the history of technology shows that technological development is not autonomous. Social constructivists argue that technological developments are contingent, because they are shaped by various sociopolitical and economic influences. A famous example is how the bicycle came to have its current design (Pinch and Bijker 1987). In the nineteenth century, there was another competing design with a large front wheel. As time went by, the current design became the standard model, not because of any internal drive for efficiency but simply because people began to perceive the bicycle as a means of transportation rather than as something used for sport. Based on this thesis, some social constructivists have developed theories of public participation in technological decision making processes (Feenberg 1999, Bijker 1995).

A more serious challenge to autonomous technology is that the idea leads to technological determinism and pessimism. Technological determinism claims that technological development has a unilateral influence on all aspects of human life and follows a fixed path according to its inner dynamics. Consequently, there cannot be any meaningful effort to avert the situation. The concept of autonomous technology is often considered the most straightforward and pessimistic version of technological determinism that denies any hope for a better future in the technological society.

However, the idea of autonomous technology rests on an understanding of technology that is often overlooked by such criticisms. First, autonomous technology specifically refers to modern technology as opposed to traditional technology. Calling a hammer and a nuclear power plant "technology" in the same sense ignores technology as a *modern experience*. Second, the prime concern of autonomous technology is not individual technologies, such as the bicycle. For Ellul, technology (*la technique*) is the *ensemble* of individual technologies that compose a technological system. The particular development of the bicycle is thus irrelevant. Autonomous technology is not about the next step of individual technological development, but about the movement of the technological system at large, with its unintended socioeconomical, cultural, environmental, and political consequences. It is impossible for anyone to claim full control over technological change in this broad sense, which is always geared toward increased levels of technology or artifice in the human world.

When technology is viewed in this way, it is misleading to quickly identify autonomous technology and technological determinism. Autonomous technology does not claim that the evolution of individual technologies follows a fixed path, nor does it exclude possible sociopolitical interventions. On the contrary, Winner claims, "one can say that all technologies are socially produced and that technical devices reflect a broad range of social needs" (Winner 1995, p. 70). As aforementioned, the concept of autonomous technology should be seen in the broader context of technological society. Technological evolution would function like biological evolution, on its own terms but not in a wholly deterministic manner. Autonomous technology certainly allows superficial variances in technical processes, caused by sociocultural and economic factors, but the efficiency principle remains the driving force directing the all-embracing comprehensive technological enterprise, which human beings are not able to alter or stop. Carl Mitcham (1994) distinguishes Ellul's theory as a form of *qualified determinism*, contrasted with naive determinism.

Autonomous Technology and Human Freedom

Hence, the way in which autonomous technology undermines human autonomy is subtle and indirect. People can freely choose whether they will use this or that computer program, for example, but the decision is made based upon the belief in the inevitability of progress in computer technology, which no one can alter. The conviction that technological progress is inevitable and beneficial is the basis of virtually every political agenda and education system around the globe.

Is an escape possible? Does autonomous technology encourage pessimism by denying human freedom? It is undeniable that this concept is discouraging in the sense that it does not leave much room for a bright future or positive action toward change. Nevertheless, it is important to remember that this concept is proposed in the context of a social critique of the contemporary technological society, rather than being part of theoretical and neutral reflection on technology. Therefore, it is misleading to focus on whether technology is autonomous or not "by nature." The argument for autonomous technology remains strong, as long as people allow technology to increasingly dominate all aspects of their lives without any critical reflection.

Ellul (1988, 1989) sees little hope for reverting the movement of autonomous technology. He argues that the only chance—the only freedom—left for a human being in the face of autonomous technology is to acknowledge one's non-freedom and to practice an ethics of non-power, namely, deciding not to do everything one can do with technology. Because Winner (1977) views technnology as a political phenomenon, he denies the absoluteness of autonomous technology; he proposes new technological forms that can accommodate more public participation and flexibility, thus allowing the possibility of political intervention in the process of technological development. This suggestion was further developed in Richard E. Sclove's "design criteria for democratic technologies" (Sclove 1995). Winner (1977) says that autonomous technology is the question of human autonomy reiterated. This remark succinctly expresses the main concern of the concept, because, paradoxically enough, different theories of autonomous technology all emphasize the importance of human autonomy, whether they are encouraging or discouraging concerning the future of technological society.

WHA-CHUL SON

SEE ALSO *Artificial Intelligence; Automation; Autonomy; Critical Social Theory; Determinism; Ellul, Jacques; Frankenstein; Freedom.*

BIBLIOGRAPHY

Bijker, Wiebe E. (1995). *Of Bicycles, Bakelites and Bulbs: Toward a Theory of Sociotechnical Change*. Cambridge, MA: MIT Press.

Ellul, Jacques. (1954). *La Technique ou l'Enjue du Siècle* [The technological society]. Paris: Armand Colin. This work is the main reference to the notion of autonomous technology.

Ellul, Jacques. (1988). *Le bluff technologique* [The technological bluff]. Paris: Hachette. Ellul argues that discourses on technique since the 1980s make people feel comfortable with dehumanizing technique, completing the autonomy of technique. He also talks about the paradox of non-freedom as the only freedom left for people in technological society.

Ellul, Jacques. (1989). "The Search for Ethics in a Technicist Society." *Research in Philosophy and Technology* 9: 23–36.

Feenberg, Andrew. (1999). *Questioning Technology*. London: Routledge.

Micham, Carl. (1994). *Thinking through Technology: The Path between Engineering and Philosophy*. Chicago: University of Chicago Press.

Pinch, Trevor J., and Wiebe E. Bijker. (1987). "The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other." In *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, ed. Wiebe E. Bijker, Thomas P. Hughes, and Trevor J. Pinch. Cambridge, MA: MIT Press.

Sclove, Richard E. (1995). *Democracy and Technology*. New York: Guilford Press.

Shelley, Mary. (1994 [1818]). *Frankenstein, or the Modern Prometheus, the 1818 Text*, ed. Marilyn Butler. Oxford: Oxford University Press.

Winner, Langdon. (1977). *Autonomous Technology: Technics-Out-of-Control as a Theme in Political Thought*. Cambridge, MA: MIT Press. Winner confronts with different versions of autonomous technology theory, while developing his own.

Winner, Langdon (1980). "Do Artifacts Have Politics?" *Daedalus* 109(1): 121–136. This is one of the most frequently cited work in philosophy of technology concerning the political aspect of technology.

Winner, Langdon. (1986). *The Whale and the Reactor: A Search for Limits in an Age of High Technology*. Chicago: University of Chicago Press.

Winner, Langdon. (1995). "The Enduring Dilemmas of Autonomous Technique." *Bulletin of Science, Technology & Society* 15(2): 67–72. The notion of autonomous technology is defended mainly against social constructivism.

AUTONOMY

Autonomy (from the Greek *autos* for self and *nomos* for rule, governance, or law) is defined as self-determination or self-rule. Its original use in ancient Greece referred to the sovereignty of states, but Immanuel Kant (1724–1804) and others in the modern period applied the term to individuals. For Kant, one is autonomous when one subjects oneself to moral rules recognized by the rational self. In contrast, one whose decisions and actions are shaped by others without critical reflection on the individual's part is heteronomous. Autonomy brings with it moral responsibility, and the autonomous person is open to charges of negligence or recklessness in the uses of science or technology if proper precautions against risk are not taken. Autonomy may also refer to the self-governing nature of professions or groups, such as the scientific community. Furthermore technology that operates without regular instruction from a person is sometimes called autonomous technology.

Conditions of Autonomy

Autonomy has many faces. Joel Feinberg (1989) points out at least four meanings: the capacity to rule oneself; the condition of ruling oneself; the virtuous ideal of ruling oneself; and the authority to rule oneself. Gerald Dworkin (1988) highlights eight common uses. One commonality is the idea that autonomy, like freedom, combines two aspects: the negative condition of freedom from external constraints and the positive condition of a self-determined will. Those barred from acting in accordance with their will, for instance, by physical constraints or coercive threats, are not able to act autonomously despite what they may internally will. Their will is either rendered impotent by force or limited to such an extent that a reasonable person could be said to have no choice. Someone who offers a wallet in response to a threat with a gun (Your money or your life) can be said to will such an action, but not autonomously, given the lack of reasonable alternatives. Yet a person may fail to act autonomously even without the existence of external constraints.

Harry Frankfurt (1989) famously argued that one cannot be said to choose freely unless one's first order desires (what one wants) are themselves chosen or affirmed by one's second order volition. That is, to be autonomous, one must want to want what one wants. Reluctant addicts who desire more heroin may wish that they did not want it, but nonetheless succumb to the strong first order desire for the drug. According to Frankfurt, they do not act autonomously, though they are free from external constraints. In contrast, rational agents who carefully reflect on their first order desires, identify with their preferred desires, and then act accordingly, *are* autonomous due to this vertical alignment of desires.

One problem with this view is that a person could have this vertical alignment of desires only as a result of undue interference from a third party (e.g., a hypnotist), making the identification inauthentic. This problem led Dworkin (1986) to add a procedural independence criterion to the concept of autonomy, meaning that to be autonomous one must identify with one's desires for reasons that are *one's own*. Yet some reasons that appear to be one's own may in fact be part of a larger system of values that has shaped the very person one becomes, and the desires one forms. For instance, a scientist's first order desire may be to receive a grant. The scientist may critically reflect on this desire, and approve of it, recognizing that grants are the way to succeed in science (they support work that leads to progress, publication, and future grants). So it appears that the scientist acts autonomously in applying for the grant. But the kinds of grants that a scientist may submit (or that have any likelihood of being funded), are in large part dependent on broader forces: governmental agendas, money-making prospects, and what counts as a hot issue. Has the scientist autonomously chosen the specific focus of the research? Traditional theories of autonomy do not allow much room for critique of background conditions that may unjustly or unduly shape an individual's desires and identification with those desires.

Relational Autonomy

The difficult question of determining when, if ever, *anyone* is truly free of external constraints that inhibit autonomy has led some feminist theorists to offer a theory of relational autonomy. Relational autonomy is built on the idea that our selves are relational and social, rather than essential and ontologically independent. Marilyn Friedman (1999) proposes an autonomy model that requires integration of first and second order desires, without putting priority on second order desires (sometimes a first order desire may be more authentic than what one has been socially shaped to believe one *ought* to want, especially under conditions of discrimination).

In a complementary manner, Diana Meyers (1999) argues that autonomy requires certain competency skills (e.g., self-definition, self-discovery, self-direction) that allow for sufficient critical reflection on one's desires and choices. If a social context impedes the development of competency skills for certain groups (e.g., women or racial minorities), then such people may never achieve full autonomy.

However Meyers (1999) allows for degrees and spheres of competency, which can result in partial autonomy. In the case of the scientist, investigation of the fairness of background conditions that determine the focus and availability of grants would be part of determining the individual's degree of autonomy (and resultant responsibility for actions). Contemporary life takes place against a large technological system (roads, electrical utilities, water systems, phone service, and others) that inevitably shapes the kinds of choices individuals can make. Relational autonomy theorists insist that the fairness of such background conditions be evaluated as part of our understanding of individual autonomy.

Significance of Autonomy for Moral Practice

Our theoretical understanding of individual autonomy will have significant effects on the use and meaning of autonomy in practical settings in medicine, law, scientific research, education,and more. In medical ethics, for instance, respect for autonomy is often considered the most important moral principle (Beauchamp and Childress 2001). It protects patients from paternalism, respects differences in individual values, and allows patients to refuse unwanted treatment. The principle of respect for autonomy includes rules regarding truth telling, promise keeping, and informed consent. Informed consent, in turn, consists of requirements of patient competency, disclosure of information, patient comprehension, voluntariness, and ongoing consent. Yet such conditions are often not guaranteed by simple informed consent documents, and even when fulfilled, they may "mask the normalizing powers of medicine" (Sherwin 1998, p. 28) that set the standards for competency, relevant information, and voluntariness.

Background conditions may also influence the degree to which one is autonomous in regard to new technologies. Available technologies can increase an individual's autonomy, for instance, when an insulin pump allows a diabetic person to avoid the constraints of dialysis, or a computer message board allows a patient with Lou Gehrig's disease to communicate preferences. Such technologies increase options, enhancing autonomy.

However some medical technologies, offered for the betterment of the individual, may in fact decrease autonomy, in that they override individuals' unpopular preferences. Some deaf individuals reject cochlear implant technology, some amputees refuse prosthetic replacements, and some intersexual people argue against sex-definition surgery. The available technologies, they warn, appear to increase options when in fact they eliminate other, less popular options, forcing individuals to fit the norm.

In the traditional models of autonomy, individual choice takes priority. But with relational autonomy, individual choices are only as valuable as their historical and relational precursors. Thus rather than taking a treatment request at face value, a relational autonomy model recommends the following:

1. lively dialogue, including critical questions regarding competency skills and the context of desire formation (our self-knowledge is in part social, and so engagement in dialogue should be seen as helpful rather than as a sign of disrespect) (McLeod 2002);
2. more respect for people who are only partially autonomous (e.g., children, individuals with mental retardation, mental illness, or senility);

3. recognition that patients may autonomously make decisions based on their familial situations (e.g., requesting assisted suicide because they do not want to be burdens on their families).

Indeed, on the relational autonomy model, making a choice *without* reference to our social context appears inauthentic rather than autonomous (Wolf 1996). Perhaps the most contentious issue of autonomy is determining when one's context undermines rather than engenders one's capacity for self-determination.

Autonomy in Science and Engineering

Professions or groups, as well as individuals, may be autonomous to the extent that they are self-governing. The autonomy of the scientific community has been defended as important for the preservation of free inquiry that results in knowledge production. Preserving that autonomy requires defining the boundaries and norms of the community. Free inquiry, for instance, may be stifled when academic scientists partner with private industry in order to gain grants that support the university as well as their own research. Such partnerships may decrease scientific autonomy by limiting the focus of investigation to what is marketable and/or profitable, and discouraging the sharing of results and methods in order to protect patents and preserve trade secrets. Scientific investigation will always be tied to funding, but must be protected from influences that threaten to corrupt the scientific process.

Yet with autonomy comes responsibility. Scientists who freely choose to develop nuclear weapons, or who experiment on genetically modified foods, retain some responsibility for the societal risks incurred in their work. The idea that science is value-free and that the responsibility for using or misusing scientific data rests with society at large rather than with the scientists who undertake the research is difficult to defend. Value-laden decisions are made throughout the scientific process. Scientists who retain autonomy in their profession must also accept the responsibility to avoid recklessness and negligence in respect to the risks created by their research (Douglas 2003).

Furthermore the value of free inquiry is limited when it threatens to undermine even more fundamental issues, such as access to free inquiry itself (Kitcher 2001). In defending this claim, Kitcher considers the work of sociobiologists and evolutionary psychologists who have attempted to support inegalitarian racial views that themselves threaten the ability of racial minorities to participate in scientific debates. Scientific autonomy, then, may also be limited by background conditions. A move to more democratic regulation of science (involving lay citizens) has been suggested as a possible remedy for these problems, highlighting again the relation between scientists and the broader community (Kleinman 2000).

Professional autonomy among engineers diverges from that of scientists in that engineers tend to have less individual autonomy on the job and more direct public impact in their work. Most engineers, at least in the United States, are employees rather than independent contractors, resulting in less opportunity for self-determination on the job, and setting up potential conflicts between their obligations as employees and their duties to exercise professional judgment. An employer that demands a sacrifice in safety precautions in the interest of profit or timeliness, for instance, may interfere with the autonomy of the engineer (Mitcham and Duvall 2000). Because engineering work often results in public technologies or structures (bridges, transportation, and others), failures of professional judgment can have widespread impact, as in the famous cases of the Challenger disaster, the American Airlines DC-10 crash of 1979, and the Hyatt Regency hotel walkway collapse (Whitbeck 1998). Whistleblowers may be required to sacrifice corporate loyalty (and job security) in the name of protecting the public good.

SARA GOERING

SEE ALSO *Autonomous Technology; Human Subjects Research; Informed Consent; Kant, Immanuel; Medical Ethics*

BIBLIOGRAPHY

Beauchamp, Tom, and James Childress. (2001). *Principles of Biomedical Ethics,* 5th edition. New York: Oxford University Press. Classic text in medical ethics.

Douglas, Heather. (2003). "The Moral Responsibilities of Scientists: Tensions Between Autonomy and Responsibility." *American Philosophical Quarterly* 40(1): 59–68.

Dworkin, Gerald. (1988). *The Theory and Practice of Autonomy.* New York: Cambridge University Press. Excellent discussion of the concept of autonomy and its significance.

Dworkin, Gerald. (1989). "The Concept of Autonomy." In *The Inner Citadel: Essays on Individual Autonomy,* ed. John Christman. New York: Oxford University Press.

Feinberg, Joel. (1989). "Autonomy." In *The Inner Citadel: Essays on Individual Autonomy,* ed. John Christman. New York: Oxford University Press.

Frankfurt, Harry. (1989). "Freedom of the Will and the Concept of a Person." In *The Inner Citadel: Essays on Individual Autonomy,* ed. John Christman. New York: Oxford University Press.

Friedman, Marilyn. (1999). "Autonomy, Social Disruption, and Women." In *Relational Autonomy: Feminist Perspectives on Autonomy, Agency, and the Social Self*, eds. Catriona MacKenzie and Natalie Stoljar. New York: Oxford University Press. The book contains a great collection of works on relational autonomy.

Kleinman, Daniel Lee. (2000). "Democratization of Science and Technology." In *Science, Technology and Democracy*, ed. Daniel Lee Kleinman. Albany: State University of New York Press.

McLeod, Carolyn. (2002). *Self Trust and Reproductive Autonomy*. Cambridge: MIT Press.

Meyers, Diana. (1999). "Intersectional Identity and the Authentic Self: Opposites Attract!" In *Relational Autonomy: Feminist Perspectives on Autonomy, Agency, and the Social Self*, eds. Catriona MacKenzie and Natalie Stoljar. New York: Oxford University Press.

Mitcham, Carl, and R. Shannon Duvall. (2000). *Engineering Ethics*. Upper Saddle River, NJ: Prentice-Hall.

Sherwin, Susan. (1998). "A Relational Approach to Autonomy in Health Care." In *The Politics of Women's Health*, ed. Susan Sherwin. Philadelphia: Temple University Press.

Whitbeck, Carolyn. (1998). *Ethics in Engineering Practices and Research*. Cambridge: Cambridge University Press. Excellent introduction to ethical issues in engineering.

Wolf, Susan. (1996). "Gender, Feminism, and Death: Physician-Assisted Suicide and Euthanasia." In *Feminism & Bioethics: Beyond Reproduction*, ed. Susan Wolf. New York: Oxford University Press.

AVIATION REGULATORY AGENCIES

Aviation regulatory agencies are charged with oversight of the aviation industry. Such agencies are primarily governmental or international organizations. The issue of safety is central to any such agency: Not only must the aviation industry be supervised, passenger aircraft must also be certified safe. How should this supervision and certification be accomplished? Is the most effective regulation done with a centralized system? What are the alternatives? What standards should be used? Aviation regulatory agencies, such as the Federal Aviation Administration (FAA) in the United States, have been established to address these issues.

The United States Federal Aviation Administration (FAA), in its draft Flight Plan 2004–2008, states that it regulates more than half of all air traffic. The FAA also certifies more than seventy percent of all large jet aircraft. Most countries around the world have their own civil aviation authorities to devise and implement regulations within their respective territories, but the FAA provides indirect or direct assistance to 129 countries to help improve their air traffic control systems. The International Civil Aviation Organization (ICAO) represents 188 independent civil aviation authorities, but the FAA is the largest intellectual and financial ICAO contributor.

History of the FAA

During World War I, the U.S. government expanded the aviation manufacturing industry, and Congress funded a postal program that would serve as the model for commercial air operations. In the early 1920s, many argued for federal regulation of the nascent commercial aviation sector to ensure public confidence, but others distrusted the government or wanted states to regulate aviation. Must the aviation industry be regulated? Prior to 1926, flyers of airplanes required no pilot's license, nor a license to carry passengers or materials, and took lessons from unlicensed schools or individuals. They generally took off and landed wherever they pleased (Komons 1978). But that year U. S. President Calvin Coolidge signed the Air Commerce Act (ACA) and federal oversight began under the direction of the Department of Commerce, which established safety standards and certification procedures for pilots and aircraft. The aviation industry was growing quickly and problems were being encountered with safety, aircraft route allocations, and airline formation. But was the public interest being protected or were the interests of the airline industry being served?

The response to this question was the 1938 Civil Aeronautics Act that transferred Federal civil aviation responsibilities to the Civil Aeronautics Authority (CAA), an independent agency. In 1940, the CAA was split into two agencies: One was the Civil Aeronautics Administration, responsible for air traffic control (ATC), airperson and aircraft certification, safety enforcement, and airway development. The other was the Civil Aeronautics Board (CAB), which became the specialized agency to regulate the airline industry. It was charged with assigning routes to air carriers and controlling the fares charged. In 1958 the Federal Aviation Act created the Federal Aviation Agency, which in 1996 was renamed the Federal Aviation Administration. The passage of this act was prompted by the development of jet airliners and a series of midair collisions, suggesting that greater centralization and standardization were necessary to ensure safety. The FAA absorbed the functions of both the CAA and the CAB (although CAB continued to exercise economic regulations of airlines until 1978) and acquired sole responsibility to operate a national ATC system and develop, initiate, and monitor standardized safety requirements for air travel. The FAA is charged with promoting safety and security and developing and maintaining an air traffic management system that is efficient, secure, and safe.

Deregulation

Is the FAA effective in exercising its responsibilities? Some have argued that the FAA is the cause of current problems in the United States because it resists change. Some of these problems are specific, such as runway incursions (critics maintain that the technology for surface navigation and communications has been inadequately developed), whereas others are more systematic, such as management issues that have led to cost overruns, schedule delays, and performance shortfalls. According to a Government Accounting Office Report it takes the FAA five to seven years to implement meaningful and lasting responses to challenges posed by increased capacity, safety, efficiency, and other demands.

In 1978 the Airline Deregulation Act ended the CAB, began the removal of government control, and opened the deregulated passenger air transport industry to market forces. Eventually, deregulation would benefit the consumer with lower ticket prices. By 1988 the number of people working in the industry had increased by thirty-two percent, with air traffic up by fifty-five percent and costs down seventeen percent. In 1998 ticket prices had been reduced by twenty percent and passenger numbers increased from 275 million to 600 million compared to ten years earlier.

Airline deregulation is nevertheless controversial (see Bailey et al. 1985). Deregulation and economic competition directly contributed to the bankruptcy of several major airlines. Prior to September 11, 2001, the projections were for the airline industry to grow 5 to 7 percent per year. Air travel declined over the next few years, putting airlines and aircraft manufacturers on the financial edge. With increasing economic pressures and rising fuel prices, the pressure exists to cut costs and take greater risks. It is the job of the FAA to insure that safety is not compromised.

Technology and Safety Regulations

People look to technology to solve many problems associated with the crowded ATC system. One concept being considered is the free flight system. Currently, major airlines use a hub and spoke model. Small commuter airlines feed into larger airports that allow major airlines to have a higher passenger density and reduce costs. In contrast, a free flight system allows people to fly direct from any nearby, small airport to an airport near their destination. This creates complexity and pushes the limits of technology, as aircraft will no longer use common routes. Only sophisticated navigation equipment and procedures would make this possible. The Global Positioning System (GPS) would allow ATC to track each airplane. Benefits of implementing such a free flight system would include time savings on trips of approximately 400 miles in length (Czajkowski 2002). However, one possible drawback is increased travel costs, which may further restrict air travel to the wealthy. This free flight concept might also include an airplane design such as the Advanced Flying Automobile that would make personal flights accessible to those who could afford the technology.

The FAA often partners with the National Aeronautics and Space Administration (NASA) on issues of technology development, including innovations to improve aging aircraft, prevent accidents caused by weather, and improve air traffic control operations. Collision avoidance is also being researched by the NASA Dryden Research Center. Early twenty-first century technology makes it possible for Unmanned Aerial Vehicles (UAVs) to fly in airspace with piloted aircraft (Degaspari 2003). Whether this will be allowed is up to the FAA. The FAA makes all final decisions concerning airspace, aircraft certification, aircrew certification, and airports. The main goal for these decisions is to ensure safety, but the FAA must also take technological and economic factors into consideration. Many technologies are not mature enough or the expense to the aviation industry is prohibitive. Decisions are made most rapidly when the public demands action due to safety concerns. However, swift decisions sometimes generate more controversy in the long term.

According to the National Transportation Safety Board (NTSB), human error has accounted for the greatest percentage of aviation accidents since the 1950s. Furthermore, increasing capacity and technological complexity at all levels of the aviation industry can exacerbate human error by introducing demands on limited cognitive capacities. Thus, the most important technological improvements to aircraft and ATC systems are those that can minimize human error. This also means that training and human resource management may be the best investment for regulatory agencies to fulfill their goal of improved safety. Regulatory agencies are also faced with a vast safety discrepancy between the top twenty-five airlines with the best safety records and the bottom twenty-five airlines with the worst. This suggests that the technologies and human resource management systems already exist to ensure greater safety. The challenge is in transferring these strategies and capabilities to other airlines and enforcing strict compliance with safety regulations by all airlines.

This raises the issue that not all segments of the aviation industry are regulated by the same set of standard rules. For example, general aviation (flights that are on-demand, that is, not routinely scheduled) accounts for seventy-seven percent of all flights in the United States, including the majority of pilot training flights. The bulk of fatalities occur in the general aviation sector, and the accident rate is many times greater than in the commercial sector. Both the Transportation Security Administration (TSA) and the FAA have different regulations for general aviation. New regulations were put in place after the terrorist attacks of September 11, 2001, because some of the terrorists utilized general aviation flight schools to learn how to steer aircraft. The seventeen general aviation associations comprising the General Aviation Coalition often work closely with regulatory agencies in crafting rules and best practice procedures.

Another sector of the aviation industry is ultralight aircraft, which are light weight (less than 150 lbs if not powered and less than 254 lbs if powered), single occupant, low-speed, recreational aircraft. The ultralight movement formed in the 1970s as operators began to attach small engines to foot launched hang gliders. In 1982, the FAA implemented ultralight regulations, and the Experimental Aircraft Association (EAA) develops and administers ultralight self-regulation programs.

Future Regulation

The FAA draft Flight Plan 2004-2008 outlines four goals. The first is increased safety, a top public-interest priority and economic necessity. People will fly only if they feel safe and are confident in the system. Increased capacity is the second goal: More passengers must be able to move quickly and efficiently through the system. The third goal is improved international partnerships to promote and enhance safety. The FAA works with other regulatory organizations such as the ICAO, the European Aviation Safety Agency, and the North American Aviation Trilateral. Lastly, the FAA seeks organizational excellence in all areas: strong leadership, fiscal responsibility, and performance-based management. The FAA also needs to simplify and clarify technical issues for the general public.

The challenges faced by the FAA and other aviation regulatory agencies may nevertheless inhibit achievement of such goals. Airline and aircraft manufacturing industries are having financial difficulties, and are thus reluctant to equip their aircraft with the latest technology to improve safety. If the technology for improved safety exists, should it be required on aircraft? This is a decision usually left to the FAA. An example illustrating this decision process is the post-2001 reinforcement of cockpit doors. An FAA regulation required the modifications, but the implementation time frame made the request quite reasonable. Most everyone could see the benefit of stronger cockpit doors and airlines agreed to spend the money. Some critics doubted it was enough to deter terrorists. The same is true of the decision to allow pilots to carry weapons in the cockpit. Critics argue that inexperience with handguns makes their use by pilots dangerous. But the FAA has allowed pilots to carry weapons under specific guidelines.

Although safety is a key element of the FAA Flight Plan 2004–2008 there are questions about whether it is doing everything possible. Former FAA Administrator Jane Garvey has stated that flying in a commercial aircraft is forty times safer than driving a car, but that does not clarify whether that level of safety is high enough to secure public trust. Prior to 2001, the FAA had the responsibility to deliver a safe system for passengers, not just a safe aircraft and competent pilot. The terrorist attacks highlighted several errors in airport security. Shortly after the attacks, the Transportation Security Agency (TSA) was formed and given the responsibility of protecting all transportation modes from terrorism and other criminal threats. Much money and effort has been expended to improve security at major airports. One result is increased passenger processing time before takeoff, which has resulted in many new federal security workers being added to the government payroll.

The FAA is also responsible for certification of new aircraft and engines. Airbus and Boeing are proposing the Airbus 380 and the 7E7, respectively, as large aircraft replacements for current civilian airliners. The Airbus 380, first shown to the public on January 18, 2005, will carry 550 people and have wingspans at the maximum allowable specification for current airport terminal requirements. Other designs are capable of achieving supersonic speeds that will require minimizing the shock wave generated by those aircraft. Should such aircraft be allowed to fly over populated areas? The original supersonic airliner, Concorde, was not allowed to fly supersonically over populated areas. Again, the FAA makes the final decision.

The FAA has the oversight of environmental issues concerning aircraft engines. One issue is noise pollution. Another is particulate emissions, which pollute the areas surrounding airports. While at altitude, emissions of NO_x and CO_2 are blamed for depleting the ozone layer and contributing to global climate change. The FAA has the power to regulate the concentrations of these substances found in engine exhaust emissions and is also able to modify the limits when target goals are not reached.

One major question is whether the FAA should be privatized. Canada, Great Britain, and New Zealand have already made this step. The advantages are clear in terms of possible cost savings to the government, but it is less clear if privatization is in the best interest of the customer. Many argue that the costs to the consumer will increase to pay for improvements to the system.

Aviation regulatory agencies are one response to the social and environmental dilemmas posed by aviation technologies. The public has come to rely on organizations such as the FAA to make decisions concerning equipment and cost which directly impact passenger safety. Is the FAA acting in the interests of the passenger and government or are they easily influenced by pressure groups from the aviation industry? Safety is the most important concern for air travel, but the public seems to have a blind trust in these agencies. The public should be more involved in these decisions, especially those concerning safety.

KENNETH W. VAN TREUREN

SEE ALSO *Airplanes; Global Positioning System; Regulation; Safety Engineering Practices; Security; Science, Technology, and Law; Terrorism.*

BIBLIOGRAPHY

Bailey, Elizabeth E., David R. Graham, and Daniel P. Kaplan. (1985). *Deregulating the Airlines (Regulation of Economic Activity)*. Cambridge: MIT Press.

Cleveland, Paul A., and Jared R. Price. (2003). "The Failure of Federal Aviation Administration Regulation." *Independent Review* 8(1): 53–64.

Czajkowski, Mike. (2002). *Benefits of Door-to-Door Travel Time Reduction to US Economy*. San Diego, CA: 2000 World Aviation Congress, October 10–12, 2000.

Degaspari, John. (2003). "Flying Blind." *Mechanical Engineering* 125 (7): 10–12.

Komons, Nick. (1978). *Bonfires to Beacons: Federal Civil Aviation Policy under the Air Commerce Act, 1926–1938*. Washington DC: DOT/FAA.

Oster, Clinton V., Jr.; C. Kurt Zorn; and John S. Strong. (1992). *Why Airplanes Crash: Aviation Safety in a Changing World*. Cambridge, UK: Oxford University Press.

Wells, Alexander T. (2004). *Commercial Aviation Safety*. New York: McGraw-Hill.

INTERNET RESOURCES

Boeing. (2003). "Jetliner Safety: Government's Role in Aviation Safety." Available from http://www.boeing.com/commercial/safety/pf/pf_government_role.html.

Federal Aviation Administration: *Draft Flight Plan 2004–2008*. Available from http://www.faa.gov/AboutFAA/FlightPlan.cfm.

Government Accountability Office (GAO). (2003). "Reform Effort Requires a More Strategic Result." February, GAO-03-156. Available from http://www.gao.gov/new.items/d03156.pdf.

Thierer, Adam D. (1998) "20th Anniversary of Airline Deregulation: Cause for Celebration, Not Re-Regulation." The Heritage Foundation Backgrounder Executive Summary, No. 1173, April 22. Available from http://www.heritage.org/Research/Regulation/BG1173.cfm.

AXIOLOGY

Axiology, according to its Greek etymology, means "theory of values." The term was introduced at the beginning of the twentieth century when it became a recognized part of philosophy. As a discipline distinct from science, axiology was sometimes even equated with the whole of philosophy, especially in Germany. The first books containing this expression are Paul Lapie's *Logique de la volonté* (1902); Eduard von Hartmann's *Grundriss der Axiologie* (1908); and Wilbur Marshal Urban's *Valuation* (1909).

The Concept of Value

This new branch of philosophy emerged as the concept of *value*, after having been treated almost exclusively in a technical sense in economics, began to be used in the plural (*values*) and to be an issue in philosophy. In response to the cultural imperialism of the sciences (including the so-called "human sciences"), philosophers defended their discipline and stressed that the "domain of values" was precisely a field that no science was able or entitled to treat, and was thus the exclusive responsibility of philosophy. Moreover, several philosophers argued that it was in the interest of science not to admit consideration of values into its own discourse. They advocated a neat separation of science and values, one that could be traced back to the famous clear-cut distinction between "being" and "ought to be" (*sein* and *sollen*) of Immanuel Kant: The realm of what is real is described by the sciences and has nothing to do with the realm of what ought to be, of what is worthy, which is determined by ethics. However, unlike Kant, these philosophers did not imply any rejection of a scientific—that is, rigorous and objective—treatment of the domain of values. Indeed, the neologism *axiology* indicated an intention to develop just such a treatment and to promote a more advanced and technically specific approach than the reflections on particular values that had been part of philosophy in the past.

In a very general sense, a *value* is whatever is positively appreciated; the concept usually indicates that positive characteristic for which something is appreciated, as well as the thing that carries this characteristic. Axiology considers only the first sense of value, conceived as an ideal object capable of exact study. The idea of positive appreciation can be made more precise by saying that a certain value attributed to something expresses the desirability of that thing by a certain subject: The value has the nature of a *relation* between an object and a desiring subject. This explains the early psychological trend in the theory of values, although this was soon superseded by those who maintained the *objectivity* of values (Franz Brentano, Max Scheler, Nicolai Hartmann, Wilhelm Windelband, Heinrich Rickert, and others). Therefore, not only does a value subsist independently of the fact of being or not being recognized, but it is possible to propose lists and classifications of values, on the basis of a specific access—typically an emotional intuition, according to Scheler.

However, axiology is nothing emotional; instead it aspires to be a strict *logic*. Edmund Husserl pointed out that it is possible to make a formal treatment of mental acts that are different from theoretical judgments, and "this has great significance, because it opens up the possibility of broadening the idea of formal logic to include a formal axiology and a formal theory of practice. Accordingly there arises what might be called a 'formal logic' of concrete values [der werte] and a formal logic of *practical* goods" (1969, p. 136). This approach allowed for a distinction between axiology and ethics that was not present in Kant. Indeed, as thinkers such as Hartmann and Scheler argued, although a value entails a duty in the moral sphere (i.e., the moral duty of the individual to satisfy the value), in a more general sense it implies *norms* that are not necessarily moral in character. Rickert, for example, argues that truth is also a value, because it imposes norms to be followed by those who are trying to attain it. The logic of values therefore includes only as a part the logic of truth, because there are not just epistemic and moral values, but also others such as aesthetic and religious values. Along this path it was natural to argue, with Scheler, that axiology is a logic and, as such, distinct from ethics, which is a theory of action. As a consequence, Scheler elaborated a formal theory of values, distinct from a formal theory of value-attitudes, and proposed an axiomatic treatment according to principles already outlined by Brentano. Axiology thus presented itself as a kind of rigorous discipline capable of meeting the requirements of exactness and even of formal rigor advanced by the sciences, though remaining within the realm of philosophy.

Axiology and the Social Sciences

Reference to values appeared as a specific characteristic of the epistemological structure of the historical and social sciences during the late-nineteenth- and early-twentieth-century debates that opposed them to the natural sciences. Values were seen as indispensable to *understanding* human actions in the social sciences, and as a necessary framework for historical and social scientific *explanations*. The most influential proponent of this view was Max Weber, who argued that although "reference to values" is indispensable in the social sciences, the social sciences must also be "value-free" (*wertfrei*), not only because values cannot be objectively affirmed, but also because there is a fundamental difference between ascertaining facts and evaluating how they "ought to be" according to a normative criterion:

> What is important from the methodological point of view is that the validity of a practical imperative as a norm, on the one hand, and the truth claims of a statement of empirical fact, on the other, create problems at totally different levels, and that the specific value of each of them will be diminished if this is not recognized and if the attempt is made to force them into the same category. (1978, p. 79)

This difference of levels entails

> the appreciation, quite simply, of the possibility that ultimate values might diverge, in principle and irreconcilably. For neither is it the case that 'to understand all' means 'to forgive all,' nor is there in general any path leading from mere understanding of someone else's point of view to approval of it. Rather it leads, at least as easily and often with much greater reliability, to an awareness of the impossibility of agreement, and of the reasons why and the respects in which this is so. (1978, p. 81)

Weber's argument may be clarified as follows. In order to understand and explain the conduct of human agents, the historian or social scientist must hypothesize that certain typical values inspired or guided their actions.

This hypothesis can be reinforced or modified by critical analyses of the objective evidence found in documents or other related empirical sources. Therefore, reference to values is not incompatible with objectivity. Nevertheless, historians and social scientists must refrain from expressing their own value judgments on the actions under consideration, that is, from making assessments of objectively recognized facts from the point of view of any value, because this would inevitably be a *subjective* assessment, which might even distort the objective representation of facts.

For example, a sociologist might objectively ascertain that vendetta is a value imposing certain norms of conduct within a given community, but the sociologist must refrain from expressing a judgment of approval or rejection regarding this value. This need becomes particularly clear when ideological or political values are involved in the understanding-explanation of historical or social events, because the personal value-options of the social scientist can easily induce an offer of a positive or negative portrayal of the objective situation by forcing its interpretation according to social scientist's sympathy with or hostility to the values actually followed by the people acting in this situation. This separation of objective, factual knowledge and value judgments is therefore an issue of intellectual integrity that also demands that scientists should not take advantage of objective results in their research to support their own (very legitimate) values, simply because these values are not a matter of objective knowledge. It is clear that this position is far from seeing axiology as a scientific assessment of values.

Challenges to Axiological Neutrality in Science

Weber's doctrine was widely accepted for decades: Science must be value-free, no mixture of science and values is legitimate, and the two spheres defend their legitimacies precisely by remaining clearly distinct. An initial challenge to this position occurred shortly after the middle of the twentieth century in disputes about the *neutrality of science*, or the extent to which science should and could properly remain independent from supposedly external powers and influences that might jeopardize its objectivity. Values, especially moral and political values, were included in this discussion, so that science was sometimes spoken of as "axiologically neutral." Advocates of neutrality admitted that it is often difficult to grant this requirement for science, but affirmed that it could and must be defended so as not to lose the most fundamental good of science—that is, objectivity. Others argued that the neutrality of science was impossible and not even desirable, and that so-called objectivity was only a fictitious mask placed on science for ideological and political purposes.

This debate may be adjudicated by noting that science is a complex phenomenon. Science as a system of *knowledge* must be distinguished from science as a system of human *activities*. Objectivity is the most fundamental feature of scientific knowledge, but several other motivations and values correctly concern the *doing* of science. Therefore, the real and challenging problem is that of not giving up scientific objectivity while at the same time recognizing that the scientific enterprise has to satisfy other values as well. For instance, society has much concern and expectation regarding the possibility of defeating AIDS, lending great support to biomedical and pharmaceutical research in this direction. Society's interest could not justify, however, inflating the objective purport of partial results obtained in AIDS research in order to respond to public expectation or to obtain more financial support. In another example, opposite parties in the ecological debate often force the interpretation of available scientific knowledge and information in order to make it subservient to their position, whereas a more appropriate attitude would be one of respect for the objectivity of scientific knowledge, using it as a basis for finding an equitable balance between the values of respect for the environment and technological progress.

A first admission of the presence of values in science occurred in a rather ambiguous form, in the discussion of the issue of theory comparison. Because neither empirical adequacy nor logical consistency are often decisive criteria for choosing between two rival scientific theories, a reasonable choice occurs by taking into account other criteria, such as simplicity, precision, generality, elegance, causal connection, fertility in predictions, and so on. These "virtues" (McMullin 1983) actually give rise to certain value judgments and in this sense it is said that one cannot dispense with values in science. It must be noted, however, that these values (and similar ones that have been discussed by Thomas Kuhn, Hilary Putnam, Larry Laudan, and others) are still related to the cognitive aspect of science. They are *epistemic values* and, as such, do not really respond to the question of whether non-cognitive values also have the right to be of concern in science.

The answer to this last question became irresistibly affirmative around the turn of the twenty-first century, owing to the increasing intensity and latitude of the debates regarding ethical and social problems posed by the development of technology and also of science, to the extent that these became inextricably nested and were called *technoscience*. The consideration of such non cognitive values is appropriate because it regards science and technology from the point of view of *action*. It has become clear that a broader range of values actually concerns the *doing* of technoscience, imposing a serious consideration of its axiological contexts that deserves to be included in the philosophy of science (formerly limited to a logico-methodological analysis of science), and even more significantly in a philosophy of technology. All this has implied a criticism of Weber's doctrine of value-free science that was developed especially by the Frankfurt School and also by several authors of different philosophical orientations (see, for example, Robert Proctor 1991).

In connection with its application to technoscience, axiology is finding again a rather broad circulation, not in the sense of a technically robust version of the philosophical theory of values, but in the more colloquial sense of a discourse concerned with values, a sense that is often better expressed in the forms of the adjective "axiological" or the adverb "axiologically" that do not strictly refer to a precise discipline. However, an in-depth discussion on values, their ontology, their logical relations, and their possible coordination is having an important revival, in particular in relation to science and technology, especially because one cannot escape the problem of making compatible the mutual respect of all such values. This discussion has given rise to certain technically-elaborated proposals, such as that of making use of the conceptual and formal tools of general systems theory (Agazzi 2004), or of a logical interpretation of values as non-saturated functions similar to the Fregean predicates (Echeverrìa 2002). This means that an axiology conceived as a rigorous theory of values, sensitive to applications to concrete issues, is among the intellectual needs of the twenty-first century, especially because this is deeply influenced by the presence of advanced science and technology.

EVANDRO AGAZZI

SEE ALSO *Fact/Value Dichotomy; Husserl, Edmund; Italian Perspectives; Values and Valuing; Weber, Max.*

BIBLIOGRAPHY

Agazzi, Evandro. (2004). *Right, Wrong, and Science*. Amsterdam and New York: Rodopi.

Echeverrìa, Javier. (2002). *Ciencia y valores*. Barcelona: Destino.

Husserl, Edmund. (1969). *Formal and Transcendental Logic*, trans. D. Caims. The Hague, Netherlands: Nijhoff.

Lapie, Paul. (1902). *Logique de la volonté*. Paris: Alcan.

Laudan, Larry. (1984). *Science and Values*. Los Angeles: California University Press.

McMullin, Ernan. (1983). "Values in Science." *Proceedings of the Philosophy of Science Association* 2: 3–26.

Proctor, Robert. (1991). *Value Free Science?* Cambridge, MA: Harvard University Press.

Putnam Hilary. (1981). *Reason, Truth, and History*. Cambridge, UK: Cambridge University Press.

Scheler, Max. (1973). *Formalism in Ethics and Non-Formal Ethics of Values*. Evanston, IL: Northwestern University Press.

Urban, Wilbur Marshall. (1909). *Valuation*. London: Sonnenschein; New York: Macmillan.

von Hartmann, Eduard. (1908). *Grundriss der Axiologie*. Bad Sachsa: Hermann Haacke.

Weber, Max. (1949). *The Methodology of the Social Sciences*. Glencoe, IL: Free Press.

Weber, Max. (1978). *Selections in Translation*. Cambridge, UK: Cambridge University Press.

B

BACON, FRANCIS

Francis Bacon (1561–1626) was born in London, England on January 22. His life combined politics and philosophy. As a politician, Bacon became a prominent lawyer, judge, member of Parliament, and adviser to the British monarch during the reigns of Queen Elizabeth I (1533–1603) and King James I (1566–1625). He reached the peak of his political power in 1618, when he was appointed Lord Chancellor, the highest judge in England. He fell from power in 1621 when he was impeached by Parliament for accepting bribes in his judicial cases, although he insisted there was no evidence that his judgments had been unfairly biased by the gifts he received. He died in London on April 9.

The idea that human beings should use science and technology to conquer nature for human benefit was first elaborated in the seventeenth century by Bacon. He supported that idea with five kinds of arguments—philosophical, theological, ethical, methodological, and political. Although the scientific and technological mastery of nature has become a fundamental idea in modern life, some people have challenged the wisdom of that idea by questioning Bacon's arguments.

Sir Francis Bacon, 1561–1626. A philosopher, statesman, and author, Bacon was the chief figure of the English Renaissance. His advocacy of "active science" influenced the culture of the English-speaking world. *(Source unknown.)*

Philosophy of Technological Science

As a philosopher, Bacon sought to move beyond traditional learning and establish a new intellectual world based on an observational and experimental science of nature that would give human beings power over nature for human benefit. In *The Advancement of Learning* (1605), he defended the pursuit of knowledge and surveyed the whole world of knowledge as it existed in his time. In *The Great Instauration* (1620), Bacon sketched a vast plan for his new scientific philosophy with technological powers, including the *The New Organon*, which proposed a new logic of inductive reasoning. Although he never completed this plan, he published many writings that worked out parts of it. In his *Essays*

(1625), his most popular work, he offered scattered but penetrating observations on human life. In *New Atlantis* (published posthumously in 1627), he wrote a utopian fable about a society ruled by what would today be called a technoscientific research institute.

Bacon's philosophical argument was that human beings needed to reconstruct all knowledge based on natural philosophy or physics, which required studying the laws of nature as physical regularities that can be established by observation and experimentation. Beginning with Socrates (470–399 B.C.E.), many philosophers have regarded natural philosophy as less important for understanding human life than moral philosophy and theology. But Bacon thought that natural philosophy should be regarded as "the great mother of the sciences" (Bacon 2000, pp. 64–65). In particular he praised the natural philosophy of Democritus (460–370 B.C.E.), who thought that everything in nature could be explained ultimately as caused by the physical motion of atoms (Bacon 2000, 2002). Such knowledge will give people both a theoretical understanding of nature and a practical or technological power over it, because understanding the causes will give them the power to produce effects. Human knowledge and human power will be combined. This power will be limited, however, by nature itself. "Nature is conquered only by obedience," Bacon declared. And "all that man can do to achieve results is to bring natural bodies together and take them apart; Nature does the rest internally" (Bacon 2000, p. 33).

Bacon's theological argument was that this new natural philosophy would be compatible with biblical theology, although the two needed to be separated. True science is the study of God's works as revealed in nature. True religion is the study of God's words as revealed in the Bible. The book of nature and the book of scripture are separated yet compatible. Through reason, people can discover the causal laws of nature. Through faith, they can ascend to God as the miraculous First Cause of nature's laws (Bacon 2002). Humans believe in miracles as a matter of faith. But this goes beyond natural science, because "miracles are either not true or not natural; and therefore impertinent for the story of nature" (Bacon 2002, p. 177). In using scientific knowledge of nature to exercise technological mastery over nature, people show a dominion over nature that manifests their dignity as the only creatures created in God's image (Bacon 2000, 2002).

Bacon's ethical argument was that this new science would be good both as an end in itself for the pleasure of understanding and as a means for its practical benefits. To know the truth about nature is satisfying in itself for those who choose a contemplative life, because such knowledge is "the sovereign good of human nature" (Bacon 2002, p. 342). Scientific knowledge also gives the power to control nature for human benefit through discoveries and inventions that make human life more secure. By thus securing "the empire of man over things," the new science will show a love for the good of humanity that expresses the Christian virtue of charity (Bacon 2000, p. 100).

Bacon's methodological argument was that the success of this new knowledge would depend on a rigorously inductive method of reasoning from observations and experiments. Humans will need a universal natural history that allows them to move from particular facts to general ideas that suggest experiments; and from these experiments they can move gradually to ever more general ideas, until they finally grasp the fundamental laws of nature (Bacon 2000). The theoretical understanding of these laws of nature as rooted in experimental science will then yield a practical mastery of nature through mechanical inventions and discoveries. Bacon pointed to printing, gunpowder, the compass, microscopes, telescopes, and other examples of technological discoveries of his time as illustrating the practical power of natural science (Bacon 2000).

Bacon's political argument was that the observational and experimental work required for the new science would necessitate the cooperative activity of many people over many years, which could be sustained only through public institutions devoted to scientific education and research. Bacon attempted to persuade Queen Elizabeth and King James to support his intellectual project (Bacon 2000, 2002). He suggested that political rulers should be guided by natural philosophers. For example, he thought that Aristotle's influence with Alexander the Great illustrated *the glory of learning in sovereignty*. In *New Atlantis*, he described an imaginary society organized to support a scientific research institute, which would produce discoveries and inventions that would benefit the whole society.

Influence and Critics

Bacon's proponents have included many of the leaders of modern science. In seventeenth-century England, scientists such as Robert Hooke (1635–1703) and Robert Boyle (1627–1691) undertook the cooperative experimental research advocated by Bacon. They set up the Royal Society of London in 1662 with a charter from King Charles II (1630–1685) to carry out Bacon's project. In the eighteenth century, Denis Diderot (1713–1784), Jean d'Alembert (1717–1783), and others in the French Enlightenment acknowledged the influence of Bacon in pointing them toward the promotion of the arts and sciences for human benefit. In America, Thomas Jefferson (1743–1826) praised Bacon as one of the three greatest human beings who ever lived (along with Isaac Newton and John Locke). In the nineteenth century, Charles Darwin (1809–1882) adopted Bacon's view of inductive science and his metaphor of the *two books* of God as showing how religion and science can be compatible. In the twentieth century, the increase in scientific discoveries and inventions from publicly supported research institutes seemed to vindicate Bacon's optimism. In *Consilience* (1998), Edward O. Wilson (b. 1929) sketched a program for the unification of all knowledge based on the physical laws of nature that would complete Bacon's project.

At the same time, since Joseph de Maistre (1753–1821) attacked him early in the nineteenth century, the number of Bacon's opponents has also grown. De Maistre was a French conservative who saw Bacon as a source for the morally corrupting atheistic materialism of the Enlightenment and the French Revolution. De Maistre argued that in basing all knowledge on physical causes, Bacon was denying the importance of moral and religious knowledge and undermining the dignity of the human soul as a spiritual power beyond the material world. Devout Christians such as Boyle had defended Bacon's science against the charge of atheistic materialism, and Bacon had written a "Confession of Faith" that conformed to the Protestant theology of John Calvin (1509–1564) (Bacon 2002). Yet de Maistre insisted that Bacon had hidden the atheistic implications of his scientific materialism through false professions of faith.

Since the twentieth century, Bacon's opponents have warned that his project for exploiting nature shows a disrespect for nature and nature's God, and a willful determination to replace the naturally given and divinely ordained with the artificially constructed and humanly manipulated. From C. S. Lewis (1898–1963) to Leon Kass, these critics worry that the abolition of nature through technology will remove the ethical limits on human will that come from nature or God. As biotechnology gives people the power to create new life forms and even redesign human nature, they might eventually find themselves in a totally artificial world empty of natural value.

Bacon's critics warn that to speak of humanity using science and technology to master nature for human benefit is vague in ways that hide inherent problems. To speak of *humanity* gaining such mastery suggests that all human beings will have equal power. But is it not inevitable that some human beings will have more of this power than others, and that they will use it to advance their selfish interests? Will the nations with the greatest access to scientific and technological power not use it to exploit those nations with less power? Can scientists and engineers be trusted to use their power for the good of all? If this power is publicly regulated, can the regulators be trusted to act for the common good?

To speak of the *human mastery of nature* suggests that human beings will have an unconstrained power that will set them apart from and above nature. But will that power not always be constrained by the potentialities of nature and by the limits of human knowledge? Will human beings not often change nature in ways that produce unanticipated consequences that are undesirable? And in changing nature, will human beings not change themselves as well? Does mastery of nature include mastery of human nature—meaning that some human beings will have mastery over the nature of other human beings, perhaps by genetically engineering the future generation of human beings? But would this not be the ultimate tyranny of some human beings over others? Even if individual human beings are free to use this power for changing their nature in whatever ways they desire, will this not create possibilities for foolishly choosing to use such power in dehumanizing ways? Might not the power of parents to manipulate the biological nature of their children deprive children of their dignity and freedom?

To speak of the mastery of nature for *human benefit* suggests that people have a clear grasp of the human goods about which they can all agree. But will people not often disagree about these human goods? And will these goods not often conflict with one another? Can one assume, as Bacon did, that biblical religion will guide understanding of the human goods to which human mastery of nature will be directed? Or do modern science and technology promote a materialistic and utilitarian view of the world that subverts religious belief while encouraging a hedonistic egoism? Can one still believe in the moral worth of human beings as spiritual creatures created in God's image? Or must science teach that human beings are only highly evolved animals? Even if Baconian science secures the technical means to master nature, can one trust that science to secure the moral ends of that mastery? Will human mastery of nature promote human nobility? Or will it produce a world of paltry pleasures and shallow souls? The future of science and technology as directed to the conquest of nature turns on how successful people are in thinking through such questions.

LARRY ARNHART

SEE ALSO *Atlantis, Old and New; Experimentation; Progress; Scientific Revolution; Utopia and Dystopia.*

BIBLIOGRAPHY

Bacon, Francis. (2000). *The New Organon*, trans. Lisa Jardine, and Michael Silverthorne. Cambridge, England: Cambridge University Press.

Bacon, Francis. (2002). *The Major Works*, ed. Brian Vickers. Oxford: Oxford University Press.

Jones, Richard Foster. (1982). *Ancients and Moderns: A Study of the Rise of the Scientific Movement in Seventeenth-Century England.* New York: Dover Publications. History of Bacon's influence on English science.

Kass, Leon. (1985). *Towards a More Natural Science.* New York: Free Press. Neoconservative attack on Baconian mastery of nature.

Leiss, William. (1994). *The Domination of Nature.* Montreal: McGill-Queen's University Press. Critical history of the idea of mastery of nature.

Lewis, C. S. (1947). *The Abolition of Man.* New York: Macmillan Publishing. Criticism of Baconian mastery by a Christian apologist.

Maistre, Joseph de. (1998). *An Examination of the Philosophy of Bacon,* trans. Richard A. Lebrun. Montreal: McGill-Queens University Press.

Merchant, Carolyn. (1980). *The Death of Nature: Women, Ecology, and the Scientific Revolution.* San Francisco: Harper & Row. Feminist history and criticism of the idea of mastery over nature.

Peltonen, Markku, ed. (1996). *The Cambridge Companion to Bacon.* Cambridge, England: Cambridge University Press. Surveys scholarly studies of Bacon.

Urbach, Peter. (1987). *Francis Bacon's Philosophy of Science.* LaSalle, IL: Open Court Publishing. Best study of Bacon's scientific method.

Wilson, Edward O. (1998). *Consilience: The Unity of Knowledge.* New York: Knopf.

Zagorin, Perez. (1998). *Francis Bacon.* Princeton, NJ: Princeton University Press. General survey of Bacon's thought.

BARUCH PLAN

The first atomic bombs were detonated in 1945. The Baruch Plan of 1946 served as the first proposal to control the spread and use of this awesome new power. President Harry Truman's original announcement about the bomb included a promise that it would not be used only for destructive purposes. In the words of the Baruch Plan, "Science, which gave us this dread power, shows that it can be made a giant help to humanity, but science does not show us how to prevent its baleful use. So we have been appointed to obviate that peril by finding a meeting of the minds and the hearts of our peoples. Only in the will of mankind lies the answer" (Baruch Plan, presented to the United Nations Atomic Energy Commission on June 14, 1946).

Background

At the end of World War II the United Nations passed a resolution to create a commission that would examine the use of nuclear energy and determine what institutional frameworks were needed to steer the technology toward peaceful uses. The creation of the United Nations Atomic Energy Commission (UNAEC) in January 1946 prompted the then U.S. secretary of state, James F. Byrnes, to convene a committee that would direct American policy on this issue. The committee was headed by Undersecretary of State Dean Acheson, who, in concert with a board of consultants that included leaders in business and science as well as members of the Manhattan Project, published the Report on the International Control of Atomic Energy (more commonly referred to as the Acheson-Lilienthal Report) on March 16, 1946.

The Acheson-Lilienthal Report proposed an American policy to create international frameworks to manage the use and dissemination of nuclear energy and technology. The main premise of the report was the creation of an international Atomic Development Authority that would control and monitor the use of atomic energy and its dangerous elements. The Acheson-Lilienthal Report did not propose to outlaw nuclear weapons but instead to globalize cooperation among states to encourage the use of the technology for productive and peaceful ends. This international body would promote research on and development of atomic energy innovation and be the sole owner of that technology. The Baruch Plan, the first proposal of the United States to the UNAEC, was drawn largely from the text of this report.

The Plan

Bernard M. Baruch, the U.S. representative to the UNAEC, submitted the report to the commission on June 14, 1946. The Baruch Plan, like the Acheson-Lilienthal Report, proposed the establishment of an Atomic Energy Development Authority that would control the development and use of atomic energy, beginning from the mining stage and including the development and implementation of atomic energy and its uses. The plan also demanded the termination of the development of the atomic bomb for use as weaponry and mandated an inspections team to investigate violations of that framework. The United States, at that time, was the sole possessor of nuclear weapons, although the Soviet Union was far along in the development process. The Baruch plan called for the immediate cessation of weapons development programs from all countries, and the close monitoring of peaceful nuclear programs in exchange for the United States giving the AEDA its nuclear devices. The purpose of the Baruch Plan was not to eradicate the use of nuclear energy from the world but to manage, monitor, and internationalize its peaceful benefits.

Immediately after the United States submitted its proposal to the UNAEC, the United States and the Soviet Union began deliberations on ways to implement the plan. The Soviet Union offered a counterproposal that differed from the U.S. version on several key points. The United States insisted on retaining control of its nuclear weapons while all fissile material was put under international control, while the Soviet Union demanded that the United States cede its weapons to international control before other countries gave up their fissile material. In addition, not only did the Soviet proposal mandate the cessation of the development, storage, and deployment of atomic bombs, it also directed that all preexisting weaponry be destroyed within six months of entrance into the convention.

The Soviet Union objected to several other points in the Baruch Plan. Another critical difference was the Soviet disagreement with the proposal that called for automatic sanctions for noncompliance with the proposed regulations. Discussions between the two countries lasted for several years, but it was evident early on that because of irreconcilable differences the Baruch Plan would never be implemented.

Legacies

While there is still debate on whether or not the United States ever seriously expected the Baruch plan to pass, it did leave the United States with a better understanding of its own moral responsibility in the cold war arms race. From 1946 on, Americans believed they had proven to the world their willingness and desire to eliminate nuclear weapons altogether, and blamed the Soviet Union for standing in the way of that goal. As long as there was a Soviet threat, the United States could feel that it was reluctantly but obligingly taking on the role of protector of the world.

Failure and Achievement

Although the Baruch Plan was never codified formally into international law, it put in place the basic tenets of the modern nonproliferation regime. The Acheson-Lilienthal Report that formed the contextual basis for the Baruch Plan never proposed a ban-the-bomb approach but instead was intended to create an international organization that would control every stage of nuclear energy development. Because the international agency would be the reigning authority and would have the authority to distribute the sites of nuclear energy processing around the world, it would create a global strategic balance. Many countries could profit from the peaceful benefits of nuclear energy. However, if one country tried to use its materials for malevolent purposes, other countries would be similarly equipped to defend themselves. These ideas led to many of the Cold War disarmament programs and treaties such as Atoms for Peace, the IAEA, and ultimately the nonproliferation treaty.

MARGARET COSENTINO
JESSICA COX

SEE ALSO *Atomic Bomb; International Relations; Military Ethics; Nuclear Ethics; Limited Nuclear Test Ban Treaty; Nuclear Non-Proliferation Treaty; Weapons of Mass Destruction.*

BIBLIOGRAPHY

Bailey, Emily; Richard Guthrie; Daryl Howlett; and John Simpson. (2000). *Programme for Promoting Nuclear Non-Proliferation Briefing Book*. Volume I: *The Evolution of the Nuclear Non-Proliferation Regime*, 6th ed. Southampton, UK: Mountbatten Centre for International Studies.

Sokolski, Henry. (2001). *Best of Intentions: America's Campaign against Weapons Proliferation*. Westport, CT: Praeger.

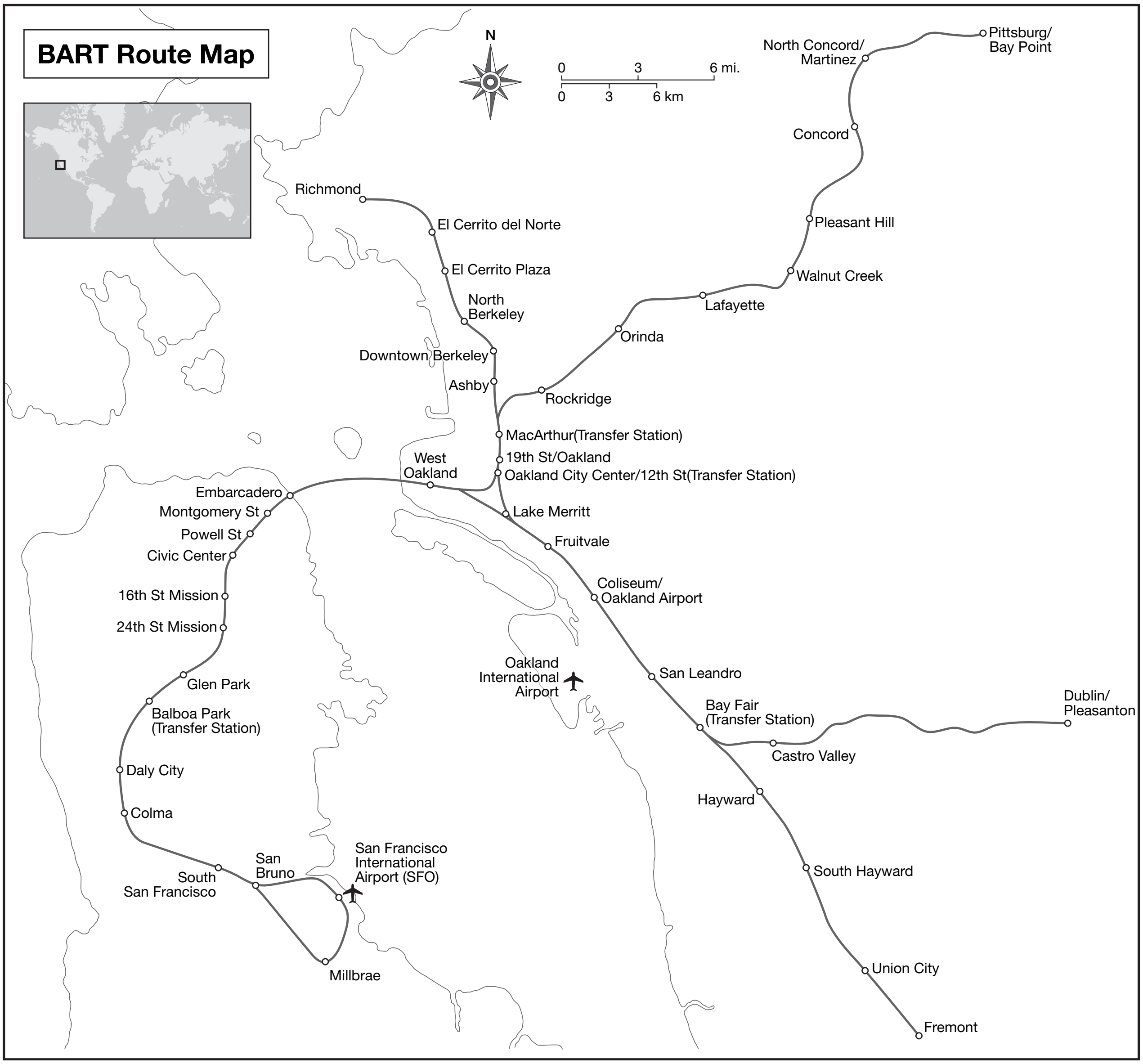
INTERNET RESOURCES

"The Acheson-Lilienthal Report." Available from http://www.atomicmuseum.com/tour/acheson.cfm.

"Early U.S. Arms Control and Disarmament Initiatives." Available from http://usinfo.state.gov/products/pubs/armsctrl/pt3.htm

"Glossary of Nonproliferation Terms." Available from http://www.cnsdl.miis.edu/npt/gloss/glossary.htm.

Schell, Jonathan. "The Unfinished Twentieth Century—Attempt to Find a Designation for the 20th Century." *Harper's Magazine*, January 2000. Available from http://www.findarticles.com/p/articles/mi_m1111/is_1796_300/ai_58509210.



BAY AREA RAPID TRANSIT CASE

• • •

The Bay Area Rapid Transit (BART) system is a fast (eighty miles per hour top speed) commuter rail system serving three counties in the San Francisco Bay Area. It was authorized by public statute in 1957 and went into service in 1972. The prime contractor for the BART project was PBTB, a consortium of three large engineering firms, Parsons-Brinkerhoff, Tudor, and Bechtel. During the course of design and construction, three engineers undertook principled actions that played a significant role in advancing the development of engineering ethics in the United States.

The Engineers and Their Actions

Holger Hjortsvang, an experienced systems engineer, was involved with the Automated Train Control System (ATC). Max Blankenzee, a young programmer analyst, worked with Hjortsvang. They became concerned about the way the ATC subcontractor, Westinghouse Corporation, was doing its job. A principal issue with Hjortsvang was the absence of a systems engineering group to oversee the development of control and propulsion systems. Hjortsvang and Blankenzee reported their concerns to their managers, both orally and in writing. The response was "don't make trouble." Simultaneously electrical engineer Robert Bruder, monitoring the contractors installing and testing control and communications equipment, found that reports to his managers about sloppy work were ignored.

In November 1971 the three engineers brought their concerns in confidence to BART Board of Directors member Daniel Helix, providing him with written material. This led Helix to bring up the issues of ATC safety before a meeting of the Board. The Board, however, rejected the position of the anonymous engineers, as represented by Helix, by a large majority.

In short order BART management was able to identify the three engineers who had provided Helix with the information he brought to the meeting. Hjortsvang, Blankenzee, and Bruder were then fired without written cause or appeal. There are indications that their efforts to find new jobs were impeded by BART management. About a year later, they filed a wrongful discharge suit against BART.

Subsequent Events

Prior to the BART board meeting, Bruder, a licensed Professional Engineer, phoned William F. Jones, President of the California Society of Professional Engineers (CSPE), outlining the situation and requesting support. At Jones's request, CSPE Diablo Chapter members Roy W. Anderson and Gilbert A. Verdugo reviewed the situation and corroborated the essentials of the arguments made by Hjortsvang, Blankenzee, and Bruder.

Following the firings, Jones unsuccessfully tried to reach BART's general manager, B. R. Stokes. A meeting with Chief Engineer David Hammond was of no avail. BART management declined all requests to discuss the firings on the grounds of possible or pending legal action.

The CSPE then wrote a report about poor engineering at BART, which it sent to the California State Senate. This led to a staff study concluding that the BART project was not going well, but ignoring the plight of the three engineers whose action triggered the investigation.

The validity of the engineers' concerns was decisively confirmed on October 2, 1972, three weeks after BART began carrying passengers. A speed control command, corrupted by a short circuit in a transistor, caused a BART train to accelerate instead of slow down, resulting in a crash at the Fremont station. Fortunately there were no fatalities and only a few injuries.

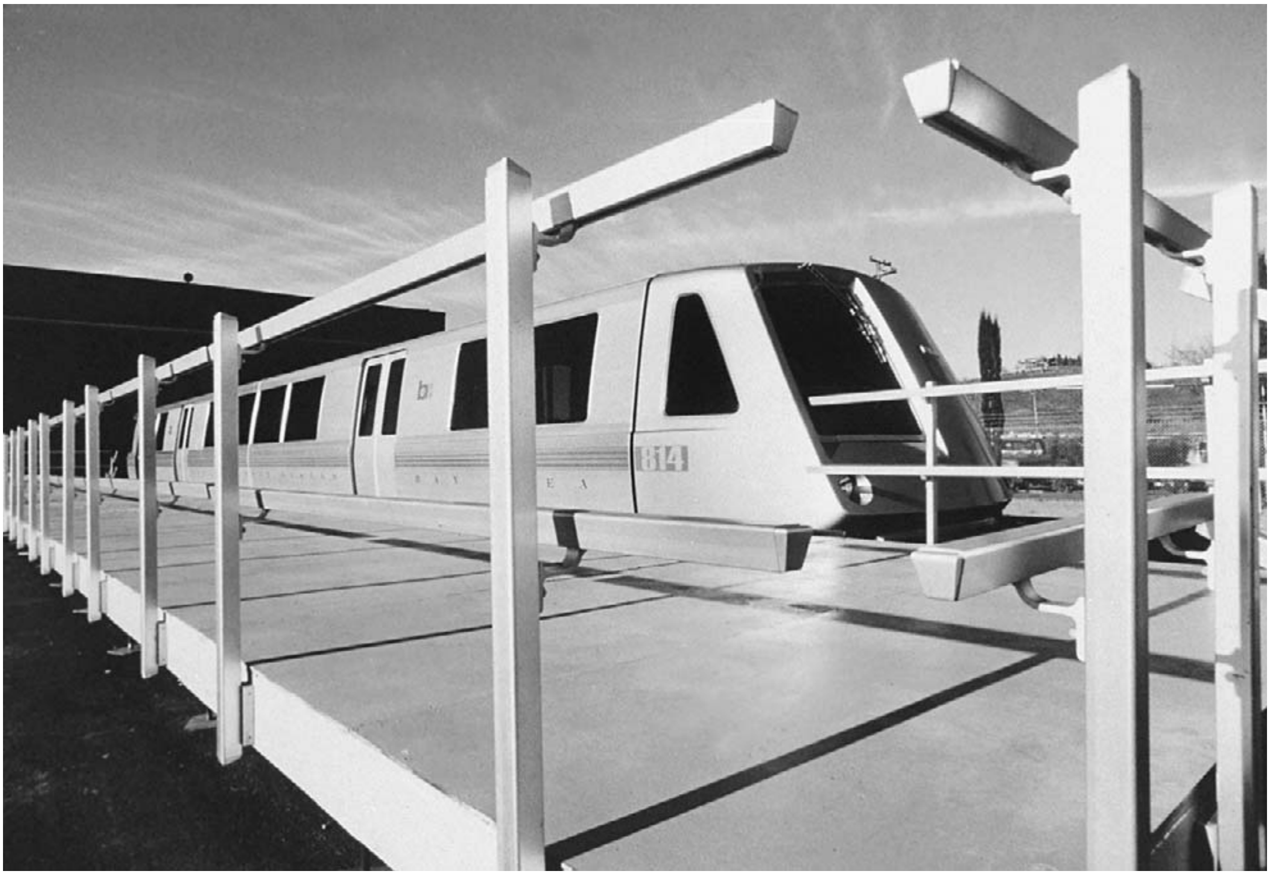
The California State Senate commissioned a study by a three-member Blue Ribbon Committee of distinguished engineers that confirmed that the engineering of the ATC and some other aspects of the BART system were below par. Panel member Bernard Oliver, a past president of the Institute of Electrical and Electronics Engineers (IEEE), sent an incisive letter to a Westinghouse vice president specifying poor decisions that suggested to him that "the design [of the ATC] did not enjoy the attention of your top people" (Unger 1994, p. 252).

In November 1972, some CSPE officers, including, incredibly, Jones, charged the Diablo CSPE Chapter with unethical behavior in connection with their investigation of the BART project. They cited an ethics code provision against criticizing other engineers. This effort backfired when the CSPE Board of Directors, following the recommendation of the committee that adjudicated the case, not only rejected the charges, but commended the chapter for its efforts to protect the public safety, health, and welfare. However the CSPE faded out of the picture toward the end of 1972, apparently as a result of pressure from members employed by the consortium of large engineering firms running the BART project.

The IEEE Response

In September 1973 the IEEE Committee on Social Implications of Technology (CSIT) published an article in its newsletter describing the treatment meted out to the three BART engineers. The following March, the CSIT unanimously passed a two-part resolution addressed to the IEEE Board of Directors (BoD). Part (a) called for the establishment by the IEEE of mechanisms to support engineers whose acts in conformity to ethical principles may have placed them in jeopardy. Part (b) asked the IEEE to intervene on behalf of the BART engineers.

The BoD, advised by the IEEE U.S. Activities Committee (USAC), and an ad hoc committee that included Joel Snyder, Victor Zourides and Frank Cummings (USAC legal counsel), responded to part (b) by commissioning an amicus curiae brief to be presented to the court hearing the engineers' law suit. The brief was to enunciate general principles, rather than to side directly with the engineers. As ultimately drafted by Frank and Jill Cummings, the brief urged the court to determine that, if an engineer was discharged because of a bona fide effort to conform to an ethical obligation to protect the public safety, the termination should be considered a breach of an implied term of the employment contract. The brief was filed in January 1975. Shortly afterward, the engineers accepted an out-of-court settlement reported to be $75,000. The legal concepts argued have been used in subsequent cases, sometimes strengthened by a court's permitting the plaintiff to allege an *action in tort,* which opens the door to punitive damages.



One of the aluminum cars of the Bay Area Rapid Transit System. Problems with the system's development were revealed when one of the trains experienced a crash about a week after it began carrying passengers. *(John Dominis/Getty Images.)*

The response to part (a) of the resolution took longer. In 1978 procedures were implemented whereby IEEE members (later extended to include other professionals in fields covered by the IEEE) could appeal to the IEEE Member Conduct Committee for help if their careers were jeopardized in retaliation for acts in conformity to the principles underlying the IEEE Ethics Code.

The BART engineers underwent a painful ordeal that impacted their professional and personal lives. It took them between one and two years to get back on track professionally. Looking back, they felt that they could not have justified any other course of action. And the BART case became a major teaching tool for engineering ethics courses during the following decades.

STEPHEN H. UNGER

SEE ALSO *Engineering Ethics; Institute of Electronical and Electronics Engineers.*

BIBLIOGRAPHY

Anderson, Robert; Robert Perrucci; Dan Schendel; and Leon Trachtman. (1980). *Divided Loyalties—Whistle-Blowing at BART*. Ashland, OH: Purdue University Press. Mainly presents management point of view.

Friedlander, Gordon. (1972–1973). "The BART Chronicle" *IEEE Spectrum* 9, no 9 (September): 34–43; no. 10 (October): 60–72; and no. 11 (November): 41–54; 10, no. 3 (March): 32–37; and no. 4 (April): 40–44. A series of five articles on the BART system; includes detailed discussion of the Blue Ribbon Committee report.

Unger, Stephen. (1994). *Controlling Technology: Ethics and the Responsible Engineer*. 2nd edition. Hoboken, NJ: Wiley. Includes Oliver letter and amicus curiae brief.

BELL, DANIEL

Daniel Bell (b. 1919) was born in New York City on May 10, to an immigrant Jewish family; though religion would later play a central role in his sociological theorizing, he considered his Jewishness to be ethnic rather

Daniel Bell, b. 1919. A Harvard academic and prominent figure in the American Academy of Arts and Sciences, Bell is best known as one of the theorists of post-industrialism. *(The Library of Congress.)*

than religious. He graduated from City College of New York in 1938, and after a year of graduate study at Columbia University spent the next twenty years in journalism, writing and editing for the *New Leader, Fortune* (as labor editor), and *The Public Interest,* which he cofounded with Irving Kristol in 1965. In 1958 he became an associate professor at Columbia, where he received a Ph.D. in 1960 and was promoted to full professor in 1962. In 1969 he moved to Harvard University, where he received a Henry Ford II endowed chair in 1980, from which he retired in 1990.

Bell's importance is based primarily on three books: *The End of Ideology* (1960); *The Coming of Post-Industrial Society* (1973); and *The Cultural Contradictions of Capitalism* (1976). In these and related works, Bell defends a complex relation between science, technology, and ethics. On the one hand, he believes passionately in the science-based expertise of a technological elite; on the other, he clearly laments the loss of traditional cultural (including ethical) values in the anti-culture that accompanies technical elitism. As he explained in a new preface to the paperback edition of the third book just mentioned, he is "a socialist in economics, a liberal in politics, and a conservative in culture." In elaboration:

> (1) I am a socialist in economics. For me, socialism is not statism, or the collective ownership of the means of production. It is a judgment on the priorities of economic policy. I believe that *in this realm,* the community takes precedence over the individual. (2) I am a liberal in politics—defining both terms in the Kantian sense. I am a liberal in that, within the polity, I believe the individual should be the primary actor, not the group. And the polity has to maintain the distinction between the public and the private. (3) I am a conservative in culture because I respect tradition; I believe in reasoned judgments of good and bad about the qualities of a work of art. I use the term culture to mean less than the anthropological catchall and more than the aristocratic tradition which restricts culture to refinement and to the high arts. Culture, for me, is the effort to provide a coherent set of answers to the existential predicaments that confront all human beings. (Bell 1979, pp. xii, xiv, xv)

In a critical intellectual biography, Malcolm Waters (1996) questions all three self-characterizations by challenging the sociological distinctions in which they are grounded. Adapting the structural-functionalism of Talcott Parsons, Bell rejects any holistic understanding of contemporary society and instead distinguishes between three realms, each ruled by a different axial principle and displaying a different axial structure. In terms of their different central values, the techno-economic realm pursues material growth, the polity consent of the governed, and cultural novelty or originality. Each of these three realms may also be characterized by special relationships between the individual and the social order, basic processes, and structural problematics. Waters summarizes these distinctions in a grid supplied by Bell himself (see Figure 1).

Waters's criticisms—which are those of a friendly critic who is convinced that Bell is a major sociological theorist—are as follows. First, with regard to economic socialism, Bell's position is singularly weak. It entails no more than commitment to a minimum standard of living, for example in health care. A more robust socialist would question the capitalist ownership of the means of production. In fact in the economic sphere Bell is no more than a liberal.

Second, with regard to political liberalism, Bell is more convincing. "Bell makes explicit statements consistent with Jeffersonian democracy about individual rights, small government (notwithstanding a grudging

FIGURE 1

The General Schema of Society

Realm	Techno-economic (social) Structure	Polity	Culture
Axial principle	Functional rationality	Equality	Self-realization
Axial structure	Bureaucracy	Representation	Reproduction of meanings and artifacts
Central value-orientation	Material growth	Consent of the governed	Novelty and originality
Relationship of individual to social order	Role segmentation	Participatory	Sovereignty of the whole person
Basic processes	Specialization and substitution	Bargaining and legal reconciliation	Disruption of genres by syncretism
Structural problematics	Reification	Entitlements, meritocracy and centralization	Postmodernist anti-nomianism

SOURCE: Adapted from Waters (1996), p. 35.

approval of the New Deal) and the sanctity of the private sphere. [However] in [*Post-Industrial Society*] politics is not a source of last-resort interventions but rather an arena within which primary steering, namely planning, takes place" (Waters 1996, p. 168).

Third, with regard to cultural conservatism, Waters accepts this self-characterization but sees a problem with "his insistence that the three realms are [interdependent]. If he wants a return to authoritative standards in culture then there must be a source of such standards, and its only possibility is an illiberal state" (Waters 1996, p. 168–169).

Waters concludes that Bell is neither a neo-conservative, socialist, nor much of a liberal. "Despite all interest in the future possibilities of technology and post-industrialism Bell is an old-fashioned, traditionalistic, elitist conservative" (Waters 1996, p. 169). Bell might respond that Waters has simply misunderstood the nuances of his positions, while others, especially leftist critics, have good grounds for arguing that Bell is a neo-conservative despite his denials.

PAUL T. DURBIN

SEE ALSO *Critical Social Theory; Democracy; Industrial Revolution; Information Society; Socialism.*

BIBLIOGRAPHY

Bell, Daniel. (1960). *The End of Ideology: On the Exhaustion of Political Ideas in the Fifties*. Glencoe, IL: Free Press.

Bell, Daniel. (1973). *The Coming of Post-Industrial Society: A Venture in Social Forecasting*. Basic Books.

Bell, Daniel. (1976). *The Cultural Contradictions of Capitalism*. New York: Basic Books. Paperback edition with new preface was published in 1979; twentieth anniversary edition with a new 50-page afterward by the author was published in 1996.

Waters, Malcolm. (1996). *Daniel Bell*. London: Routledge. A critical but favorable intellectual biography.

BENJAMIN, WALTER

Walter Benjamin (1892–1940), a German-Jewish intellectual born in Berlin on July 15, was a cultural sociologist, literary critic, and translator of Charles Baudelaire and Marcel Proust. His works are informed by a mixture of Marxism and Jewish mysticism. Benjamin most often is associated with the Frankfurt School as well as with his friends and colleagues Teodor Adorno (1903–1969), Gerschom Scholem (1897–1982), and Bertolt Brecht (1898–1956), all of whom influenced his thought. Believing that the Gestapo was about to capture him, Benjamin committed suicide on September 27 at Port Bou on the French-Spanish border while fleeing from the Nazis. He left behind a large collection of notes and published and unpublished writings, most of which have been compiled, edited, and translated since his death.

Benjamin's books and essays deal with a multitude of subjects, with their most common themes being the degradation of contemporary experience and the need for a radical break with tradition and the past. Among his best-known works are *Einbahnstrasse* [One-way street] (1928), the essay "Das Kunstwerk im Zeitalter seiner technischen Reproduzierbarkeit" [The work of art in the age of mechanical reproduction] (1936), *Geschichtsphilosophische Thesen* [Theses on the philosophy of history] (1939 but published posthumously), and the monumental *Das Passagen-Werk* [*The Arcades Project*] (written between 1927 and 1940 and published posthumously). Among these works *The Arcades Project* is the most pertinent to science, technology, and ethics because it deals with the ways in which modern technology in the form of new architectural constructions altered human perception and experience.

Left unfinished at his death, *The Arcades Project* is an extended set of notes and quotations loosely arranged in thirty-six categories with titles such as "Dream City," "Baudelaire," "Fashion," and "Prostitution." For Benjamin the glass-enclosed streets of nineteenth-century Parisian arcades exemplified the commodification of experience and the distracted perception of reality. At home in these arcades is the *flâneur*, the "heroic pedestrian" or tourist who wanders aimlessly in the crowd, deriving pleasure from the exercise of what might be called a shopper's gaze. For the *flâneur* the city is a text to be read, but only from always changing vantage points and thus distractedly, with shifting glimpses of meaning in the kaleidoscope of signs. For Benjamin such distraction is the defining characteristic of contemporary perception, and some interpreters have argued that such perception has been extended in MTV-style editing, multitasking, channel and Web surfing, and the experience of cyberspace in general.

Benjamin also dealt with this issue in the essay "The Work of Art in the Age of Mechanical Reproduction," which considers how technology has altered not just aesthetic perception but the nature of art. For millennia even the most perfect artistic reproduction lacked the essential element of the original, "its presence in time and space, its unique existence at the place where it happens to be." That uniqueness bestowed authenticity. However, contemporary technologies of reproduction, especially sound recording, photography, and film, have undermined the traditional appreciation of originality and authenticity. Indeed, reproduction may favor the copies, which can be placed into situations impossible for the original: "The cathedral leaves its locale to be received in the studio of a lover of art; the choral production, performed in an auditorium or in the open air, resounds in the drawing room."

Among all technological media, Benjamin considered film especially significant for two reasons. First, like contemporary life, film is saturated by and dependent on technology, with the performance of a film actor mediated by a series of machines (camera, editor, projector). Second, it is film that best accommodates the distracted perception of the *flâneur*. At the cinema people simply sit back, relax, and watch the movie; they do not have to discipline themselves to pay attention: "The public is an examiner, but an absent-minded one." ("Work of Art in the Age of Mechanical Reproduction")

Benjamin's writings, including meditations on literature, history, philosophy, sociology, and art, are so broad that they have stimulated numerous fields of scholarship, and his meticulously crafted, indirect, and at times enigmatic style has influenced succeeding generations of reflections on technological culture. At the same time Benjamin has been criticized for a nostalgia that does not always appreciate the democratizing ethos at the core of the new forms of technological art he examined.

JAMES A. LYNCH

SEE ALSO *Consumerism; Science, Technology, and Literature; Tourism.*

BIBLIOGRAPHY

Benjamin, Walter. (2002). *The Arcades Project*, trans. Howard Eiland and Kevin McLaughlin. Cambridge, MA: Harvard University Press.

Benjamin, Walter. (2003). *Selected Writings*, Vol. 4: *1938–1940*. Cambridge, MA: Harvard University Press. Contains the third and final version of the essay here titled "The Work of Art in the Age of Its Technological Reproducibility."

Brodersen, Momme. (1996). *Walter Benjamin: A Biography*, trans. Malcolm R. Green and Ingrida Ligers. New York: Verso.

Rochlitz, Rainer. (1996). *The Disenchantment of Art: The Philosophy of Walter Benjamin*, trans. Jane Marie Todd. New York: Guilford Press. A critical study of Benjamin's thought and works.

Smith, Gary, ed. (1991). *On Walter Benjamin: Critical Essays and Recollections*. Cambridge, MA: MIT Press. Twelve critical essays by colleagues of Benjamin and contemporary scholars dealing with a wide range of Benjamin's interests.

BENTHAM, JEREMY

SEE *Consequentialism; Liberalism.*

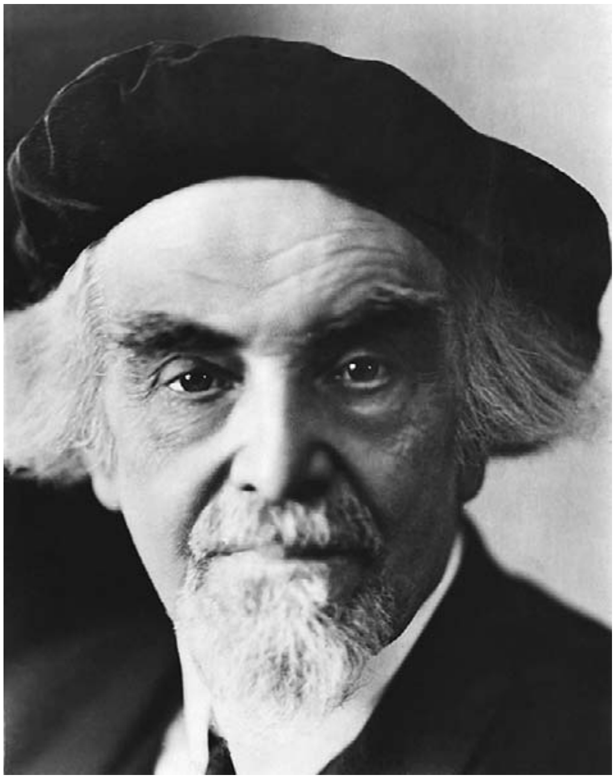
BERDYAEV, NIKOLAI

Nikolai Alexandrovich Berdyaev (1874—1948) was born in Kiev, Russia, on March 6, and became a leading critic of positivism and scientism among the Russian intelligentsia. Forced into exile by the Communists in 1922, Berdyaev (also transliterated as Berdiaev, with the first name often anglicized as Nicholas) died in Clamart, France, on March 23.

Berdyaev's religious philosophy emphasizes human freedom and the person as distinct realities, not reducible to the empirical forms of choice behavior or individualism as described in the partial perspectives of the social sciences. On the basis of his personalism, Berdyaev argues against superficial pseudoreligious faith in the power of science and technology, a faith that he finds expressed in the ideology of materialistic determinism prominent among Russian intellectuals during the nineteenth and early-twentieth centuries. In *The Russian Idea* (1946), Berdyaev examines this century-long history of revolutionary intellectual culture that culminated in the Communist Revolution during his own generation, in an analysis that justifies his own odyssey from atheistic materialism to philosophical idealism and then back to a deepened religious faith in Orthodox Christianity.

In his earlier *The Meaning of the Creative Act* (1916), Berdyaev sees creativity as central to humanity and is stimulated by the biblical account of humans as created in the image of God to argue for a creative response to all aspects of life. The ground of meaning lies more with the free response to phenomena than with their objective descriptions. Indeed cognitive knowledge itself involves an intuitive symbolic realism akin to that of the orthodox experience of icons, which are understood as symbols that participate in the reality they symbolize, and in whose presence truth is revealed. Furthermore contrary to the philosophical traditions derived from Greek thought, Berdyaev sees being as part of a dynamic spiritual and revelatory process. From this perspective, world history is divided into three great epochs: one in which the existence of sin is revealed, another in which redemption from sin is made possible through divine adoption, and a third in which humans themselves become divinized cocreators of reality. What is important for Berdyaev is to recognize the ways in which creativity in science and technology can serve as false substitutes for spiritual cocreation in this third epoch.

In *The Destiny of Man* (1937) Berdyaev draws on the thought of the German mystic Jacob Boehme (1575–1624) concerning the *Urgrund* or nothingness from which God creates within eternity. The primordial uncreated freedom of human beings derives from the *Urgrund;* freedom is not created by God, although God freely participates with humans in the God-Human Christ and the tragic process of redeeming the world from evil, suffering, and death. Berdyaev likewise adapts Boehme's thought on *Sophia* to develop an arguably more orthodox theology than found, for example, in the erotic mysticism of Vladimir Solovyev (1853–1900). *Slavery and Freedom* (1939) contains Berdyaev's most



Nicholas Berdyaev, 1874–1948. Berdyaev was a Russian philosopher and religious thinker. He was a leading exponent of Christian existentialism and bridged the gap between religious thought in Russia and the West. *(The Library of Congress.)*

extensive reflections on the person and the necessity of relation to others, while describing in detail human self-enslavement (Hegel's bad faith) to the various allures of nature and culture. Berdyaev's thought here parallels that found in *I and Thou* (1923) by the Jewish thinker Martin Buber (1878–1965).

As one of the earliest thinkers to recognize how science and technology can pose special problems for Christian culture, in an essay on "Man and Machine" (1934), Berdyaev argues that science and technology destroy the earth-centered, telluric or autochthonic forms of religious life, and threaten to ensnare human freedom in a depersonalized world. In such circumstances, the spiritual becomes more important than ever. Technical civilization calls for a spiritual renewal to challenge the limitations of science and technology just as science and technology challenged the limitations of nature.

Through his extensive writing Berdyaev gained an audience beyond the narrow Russian emigree circle in France. He became a *forbidden writer* widely read in the Soviet Union, and remains a vital source for critical reflection on science and technology. Perhaps because of this a Berdyaev revival has led to many of his writings being made available on the internet in both Russian and ongoing translations.

STEPHEN JANOS

SEE ALSO *Christian Perspectives.*

BIBLIOGRAPHY

Allen, Edgar Leonard. (1951). *Freedom in God: A Guide to the Thought of Nicholas Berdyaev.* New York: Philosophical Library.

Berdyaev, Nicholas. (1934). "Man and Machine." In *The Bourgeois Mind and Other Essays.* New York: Sheed and Ward. Collects four journal articles. Reprinted in *Philosophy and Technology,* eds. Carl Mitcham, and Robert Mackey (New York: Free Press, 1972).

Berdyaev, Nicholas. (1937). *The Destiny of Man,* trans. Natalie Duddington. London: G. Bles.

Berdyaev, Nicholas. (1944 [1939]). *Slavery and Freedom* trans. R. M. French. New York: C. Scribner's Sons.

Berdyaev, Nicholas. (1962 [1916]). *The Meaning of the Creative Act,* trans. Donald A. Lowrie. New York: Collier.

Berdyaev, Nicholas. (1992 [1946]). *The Russian Idea,* trans. R. M. French. Hudson, NY: Lindisfarne Books.

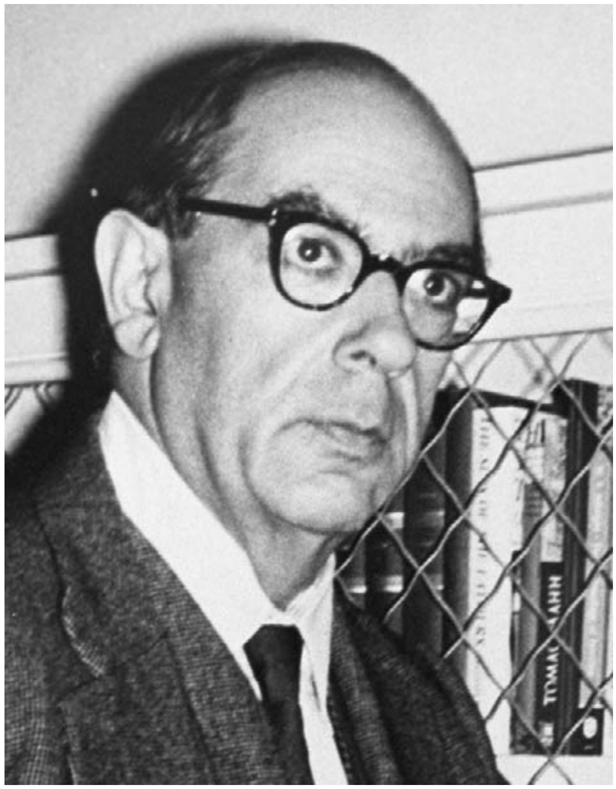
Lowrie, Donald A. (1974). *Rebellious Prophet: A Life of Nikolai Berdyaev.* Westport, CT: Greenwood Press.

Slatte, Howard Alexander. (1997). *Personality, Spirit, and Ethics: The Ethics of Nicholas Berdyaev.* New York: P. Lang.

BERLIN, ISAIAH

Isaiah Berlin (1909–1997), historian of ideas and political theorist, was born to Jewish parents in Riga, Latvia, on June 9, but spent most of his life after 1921 in Great Britain, studying and then holding various positions at Oxford University, where he served as professor of social and political theory (1957–1967) and founding president of Wolfson College (1966–1975). He also served as president of the British Academy (1974–1978), and was the recipient of numerous awards and honorary degrees, including a knighthood and the Order of Merit. After his biography of Karl Marx (1939), Berlin's published work consisted entirely of essays, one of which, "Two Concepts of Liberty" (1958) became one of the most influential expressions of liberal political theory of the latter half of the twentieth century.

Berlin saw scientific and technological advance as one of the dominant forces in the twentieth century. He followed developments in the philosophy of science, and was a close observer of the political domination of science in the Union of Soviet Socialist Republics (U.S.S.R.) during the later years of Joseph Stalin's reign. Although he did not write explicitly about the philosophy or morality of science and technology, Berlin's work provides significant insights into their ethical implications.



Isaiah Berlin, 1909–1997. British philosopher Berlin wrote widely on topics involving the history of ideas, political philosophy, and the relationship of the individual to society.

Berlin was opposed to the application of a single, dominant model to all subjects, arguing instead that different approaches are appropriate to different facets of experience. He recognized the validity of the scientific method in studying the natural world, but suggested that its application to the understanding of human beings (beyond the discoveries of the medical and biological sciences) was often mistaken, an example of pseudo-scientific ideology rather than genuine scientific knowledge. Berlin warned against the application of scientific models to the humanities and social sciences, which he believed should aim at capturing the unique qualities of particular human experiences, rather than the development of general laws and formulae (which he took to be the goal of science).

Berlin sought to explain, and seemed to endorse, the view that science is concerned with empirically discoverable facts, and with processes and relationships that can be explained in terms of identifiable rules or *laws*, while moral philosophy and politics are concerned not with facts about the way things are, but with values, or human beliefs about the way things should be. However, Berlin also argued that values are *objective*, deriving their validity from the realities of a common, universal human nature. This common nature encompasses great variety, is expressed differently in different cultures, and cannot be reduced to simple formulae. But it does allow people to understand one another, and places limits on the goals they can intelligibly and rightfully pursue.

Berlin insisted that science cannot tell people what to be or do; this they must decide for themselves, from among the possible, and often conflicting, values to which as human beings, they feel drawn. While he believed that the acquisition of scientific knowledge should be pursued as a goal in itself, Berlin believed that it would not point the way to any conclusions about ethics. The only way in which science might change thinking about ethics would be by transforming the understanding of human nature in such a way as to force human beings to change their ideas about morality. For instance, if science were to reveal that human beings lack free will, humanity would have to abandon its notions of individual moral responsibility. But Berlin warned against jumping to conclusions based on insufficient or inconclusive evidence, and the tendency to use science, or pseudo-science, as an excuse for evading moral responsibility.

On a practical level, Berlin was sharply critical of what he identified as a *managerial* approach to political problems. He reacted strongly against the vision of a final resolution of human conflicts through the application to human life of techniques of conditioning and management. Berlin did not deny the tremendous good produced by the advance of technology; but his writings reflect an anxiety that the very success of technology could be morally blinding, leading to a view of human beings as *material,* to be molded in such a way as to be conducive to social harmony. This opposition to blind devotion to technological advancement, which excluded moral considerations and ignored the dignity of individuals as free and unique beings, was an important influence in the development of Berlin's political thought.

Berlin's work is significant as a warning against the dangers of intellectual and practical misapplications of science, a critique of reductive understanding of human nature and experience, and a defense of individual liberty and dignity against technocratic control.

JOSHUA L. CHERNISS

SEE ALSO *Ethical Pluralism; Scientific Ethics.*

BIBLIOGRAPHY

Berlin, Isaiah. (1991). *The Crooked Timber of Humanity: Chapters in the History of Ideas*, ed. Henry Hardy. London: John Murray.

Berlin, Isaiah. (1996). *The Sense of Reality: Studies in Ideas and their History*, ed. Henry Hardy. London: Chatto and Windus.

Berlin, Isaiah. (1997). *The Proper Study of Mankind: An Anthology of Essays*, ed. Henry Hardy and Roger Hausheer. London: Chatto and Windus. This volume contains Berlin's major contributions to philosophy and political theory, as well as a sampling of his writings on the history of ideas.

INTERNET RESOURCE

The Isaiah Berlin Virtual Library. Available from http:://berlin.wolf.ox.ac.uk//. Contains a full listing of Berlin's published and unpublished works, as well as an extensive list of writings about Berlin and links to some of these, as well as photographs and reminiscences of Berlin.

BERNAL, J. D.

John Desmond Bernal (1907–1971), an eminent X-ray crystallographer and pioneer in the field of social studies of science and the movement for social responsibility in science, was born in Nenagh, County Tipperary, Ireland, on May 10, and died in London on September 15.

Life and Science

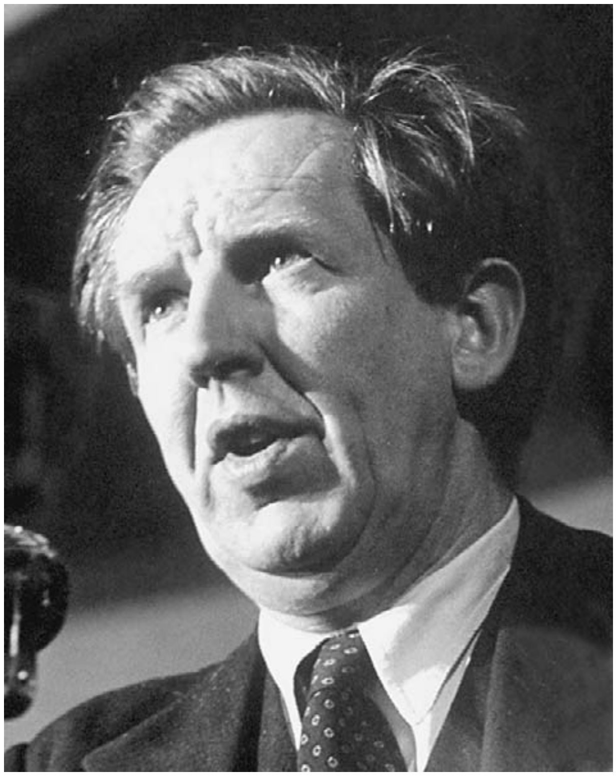
Following his education at Cambridge University, Bernal began his crystallography research at its Davy-Faraday Laboratory in London in 1923. After returning to Cambridge for a short period (1934–1937), he went to Birkbeck College, University of London, where he served as professor of physics (1937–1963), professor of crystallography (1963–1968), and professor emeritus (1968–1971). He initiated groundbreaking research on the crystals of sterols, proteins, and viruses and established the three-dimensional structures of nucleic acids, proteins, and viruses.

Bernal's work in molecular biology led to the conjecture that clays concentrated chemical compounds leading to the origins of life. He speculated in many directions and stimulated scientific research in many areas, arguing for the importance of space exploration and investigation of the possibilities of extraterrestrial life and was considered to be a founder of the field of astrobiology. In an early work, *The*

World the Flesh and the Devil (1929), he set out a futuristic sketch of further evolution, showing how scientific rationality could overcome obstacles in the physical, physiological, and psychological domains. A number of important women scientists worked in Bernal's lab, including Dorothy Hodgkin, with whom he made the first X-ray photograph of a protein (pepsin), and Rosalind Franklin, who did the empirical research that led to the discovery of the double helical structure of DNA.

During World War II, Bernal was a scientific adviser to combined Allied operations, serving in Lord Mountbatten's *department of wild talents*. After the war, he was active in the international peace movement. He was elected a fellow of the Royal Society in Britain in 1937 and, in the postwar period, became a member of the scientific academies of many eastern European countries. His awards included the Royal Medal of the Royal Society (1945), the Lenin Peace Prize (1953), and the Grotius Medal (1959).

Beyond laboratory results, it was Bernal's voluminous knowledge, breadth of vision, and conscientious activism that distinguished him. He led a complicated life, sitting on hundreds of committees and playing a leading role in many scientific and political organizations. He was a dazzling thinker and talker; indeed his contemporaries called him *Sage*. At the experiment level, however, he tended to generate seminal ideas while leaving the details to others. He was a mentor to several Nobel Prize winners.



J. D. Bernal, 1907–1971. Marxist in thinking and communistic in politics, Bernal is perhaps most well-known for his philosophical studies of the social aspects of science. He was also highly instrumental in the pioneering stages of x-ray crystallography and microbiology. *(Nat Farbman/Getty Images.)*

Science of Science

Although Bernal reached the heights of the academic establishment, he engaged in radical critique of its cherished assumptions and structures of power. Bernal was a Marxist in philosophy and a communist in politics. He participated in the Second International Congress of the History of Science and Technology in London in 1931, at which the unexpected arrival of a Soviet delegation created a great stir. Bernal was struck by the unity, philosophical integrality, and social purpose of the Soviet scientists, which contrasted with the undisciplined philosophies and remoteness from social considerations of their British colleagues.

In response Bernal became a leading force in a new movement for social responsibility in science that took a number of organizational forms, such as the Association of Scientific Workers and the Division for Social and International Relations of Science, a part of the British Association for the Advancement of Science. The movement had impact as well as opposition. John Baker's *Counterblast to Bernalism* (1939) led to formation of the Society for Freedom in Science (1940–1945), which devoted itself to the defense of pure science and rejected any form of social control of science.

Bernal argued for the necessity of a science of science. He saw science as a social activity, integrally tied to the whole spectrum of other social activities, economic, social, and political. His book *The Social Function of Science* (1939) quickly came to be regarded as a classic in this field. Based on a detailed analysis of science, under both capitalism and socialism, Bernal's dominant themes were that the frustration of science was an inescapable feature of the capitalist mode of production, and that science could achieve its full potential only under a new socialist order. According to Bernal, science was outgrowing capitalism, which had begun to generate a distrust of science that in its most extreme form turned into rebellion against scientific rationality itself. The cause of science was, for Bernal, inextricably intertwined with the cause of socialism. He saw science as the key to the future and the forces of socialism alone able to turn it.

For Bernal, the scientific method encompassed every aspect of life. There was no sharp distinction between the natural and social sciences. He regarded science as the starting point for philosophy. Science, philosophy, and politics were bound together in Bernal's highly integrated mind. He considered the Marxist philosophy of dialectical materialism to be the most suitable philosophy for science. Bernal saw it as a science of the sciences, a means of counteracting overspecialization and achieving the unity of science, which should reflect the unity of reality.

Bernal was unsympathetic to positivist philosophies of science, but also to criticisms of positivism that would undermine science itself; he thought of irrationalist and intuitionist currents as the backwaters and dead ends of human knowledge. He objected most to scientists, such as Arthur Eddington (1882–1944) and James Jeans (1877–1946), who brought irrationality into the structure of science by making what science did not know, rather than what it did know, the basis for affirmations about the nature of the universe. His enduring legacy is a defense of science that ties it inextricably to philosophy and politics.

HELENA SHEEHAN

SEE ALSO *Communism; Marxism; Science, Technology, and Society Studies.*

BIBLIOGRAPHY

Aprahamian, Francis, and Brenda Swann, eds. (1999). *J. D. Bernal: A Life in Science and Politics.* London: Verso.

Bernal, J. D. (1939). *The Social Function of Science.* London: Routledge.

Bernal, J. D. (1949). *The Freedom of Necessity.* London: Routledge and Kegan Paul.

Bernal, J. D. (1969). *Science in History,* 3rd edition. Cambridge, MA: MIT Press. 1st edition, 1954; 2nd edition, 1957.

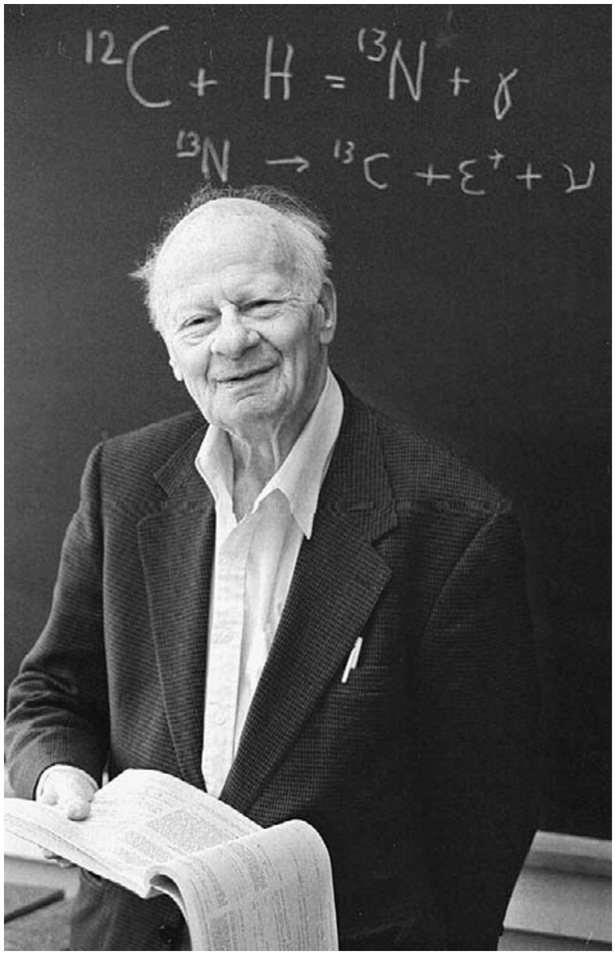
Bernal, J. D. (1969 [1929]). *The World, The Flesh, and the Devil: An Enquiry into the Future of the Three Enemies of the Rational Soul.* Bloomington: Indiana University Press.

Goldsmith, Maurice. (1980). *Sage: A Life of J. D. Bernal.* London: Hutchinson.

Sheehan, Helena. (1985). *Marxism and the Philosophy of Science: A Critical History.* New Jersey: Humanities Press.

BETHE, HANS

Hans Albrecht Bethe (1906–2005) was a Nobel physicist and leader in efforts to promote social and ethical



Hans Bethe, (1906–2005). An Alsatian-born American theoretical physicist, Bethe is a prolific and creative contributor to several vital fields of nuclear physics. He also discovered the mechanism of energy production by stars, including the sun. *(AP/Wide World Photos.)*

responsibilities among scientists and engineers. Born in Strassburg, Germany (now Strasbourg, France), on July 2, Bethe received his doctorate from the University of Munich in 1928 and began teaching at Cornell University in 1935, where he continued throughout his career. Bethe died in Ithaca, New York, on March 6. In 1938 he published three papers on nuclear physics that became known as "Bethe's Bible," and he received the 1967 Nobel Prize for discoveries concerning energy production in stars.

During World War II, the U.S. government recruited Bethe to work on military technologies, and in 1943 he was made director of the theoretical physics division in the Manhattan Project at Los Alamos, New Mexico, where he helped develop the first atomic bomb. The use of nuclear weapons created a strong sense of social responsibility in Bethe, and during the Cold War he worked to reduce the danger posed by nuclear weapons.

In 1945 Bethe became one of the original supporters of the Federation of Atomic (later American) Scientists, which focused on educating others about the implications of nuclear weapons. Bethe also served as a member of the President's Science Advisory Committee from 1956 to 1964. Beginning in 1957, he headed a presidential study of nuclear disarmament, known as the "Bethe panel," and served the following year as scientific advisor to the U.S. delegation at the Geneva nuclear test-ban talks. Bethe was "one of the heroes" in the campaign that culminated in the limited nuclear test-ban treaty signed by the United States, Great Britain, and the Soviet Union on August 5, 1963 (Schweber 2000).

Complex Ethical Response to Nuclear Weapons

During this time, Bethe developed a complex response to the ethical dilemma created by his dual roles as an advisor to the Los Alamos National Laboratory and as a political and moral critic of the development of nuclear technologies—a tension that challenged many scientists and engineers. For fifty years, Bethe led the struggle to address such questions as: When should various nuclear technologies be developed? What is the proper role of scientists and engineers in a democracy? What moral and political responsibilities do they have for the use of the knowledge they create? Although Bethe believed that scientists should always feel responsible for the consequences of their work, he argued for no simple answers.

Bethe's response is founded on a distinction between pure and applied science and the criterion of political necessity. For Bethe, knowledge is a good in itself, and pure scientific research should proceed even when it might be used for immoral purposes. It is only at the point of application "that people should debate the question: Should we or should we not develop this? But the gathering of scientific knowledge preceding that debate, and certainly pure science itself should not be stopped" (Bethe 1983, p. 5).

Development in turn should be guided by necessity. For instance, during World War II, Bethe was convinced of the necessity of the atomic bomb because of the Nazi threat. The hydrogen bomb, however, was a weapon of such magnitude to be of little practical military value. "It was unnecessary. It should not have been done. And we would now be very much better off if [it] had never been invented" (Bethe 1983, p. 3).

Yet once Edward Teller (1908–2003) and Stanislaw Ulam (1909–1984) realized how to build the hydrogen bomb, Bethe believed that it needed to be developed before the Soviets. Caught in this dilemma, he wrote, "If I didn't work on the bomb somebody else would. . . . It seemed quite logical. But sometimes I wish I were more consistent an idealist" (Edson 1968, p. 125). He maintains that the only justification for the hydrogen bomb is to prevent its own use (Bethe et al. 1950).

Who Should Make Decisions about Controversial Projects?

Bethe was careful to distinguish between the duties of the individual scientist and those of the scientific community as a whole. He was aware that a single individual is powerless to change the trajectory of weapons development. When asked whether it is justified to participate in immoral research projects just because others will do the research anyway, he replied, "No, but that is just to save my own soul. My refusal does not save the world" (Bethe 1983, p. 7). A group of scientists, not a single individual, needs to make decisions about what research to pursue and which findings to publish. Especially within the cold war context, the scientific community should not refuse to work on weapons as a group, because that would set them up as a superpolitical body that is the sole judge of their actions.

According to Bethe, elected representatives should make decisions about weapons research and other controversial projects. But scientists ought to have a large influence in these decisions. "By working on these weapons one earns the right to be heard in suggesting what to do about them" (Schweber 2000, p. 170). This in turn creates a dilemma for scientists, because in order to earn the right to be heard they must be willing to work for the government in developing weapons systems. Decisions about the use of technology are both scientific and political in nature, and such decisions should not be driven solely by technical feasibility (Bethe 1983).

In the 1980s, Bethe argued against the Strategic Defense Initiative (SDI) (a system, dubbed "Star Wars" by opponents, proposed by president Ronald Reagan in 1983 that would use space-based technology to protect the United States from attacks by strategic nuclear missiles), claiming that it would be much easier to simply reduce nuclear arsenals rather than developing a massive missile defense shield. In 1995 Bethe published an open letter to all scientists claiming that a new political era had made the further development of nuclear weapons unnecessary. He called "on all scientists in all countries to cease and desist from work creating, developing, improving and manufacturing further nuclear weapons—

and, for that matter, other weapons of potential mass destruction such as chemical and biological weapons."

ADAM BRIGGLE

SEE ALSO *Atomic Bomb; Nuclear Ethics; Weapons of Mass Destruction.*

BIBLIOGRAPHY

Bethe, Hans. (1983). "The Ethical Responsibilities of Scientists." *Center Magazine* 16(5): 2–11. A collection of Bethe's thoughts in this area with comments and counterarguments by an interdisciplinary panel of scholars.

Bethe, Hans, et al. (1950). "Let Us Pledge Not to Use an H-Bomb First." *Bulletin of Atomic Scientists* 6(3): 75. Signed by Bethe and eleven other prominent physicists.

Edson, L. (1968). "Scientific Man for All Seasons." *New York Times Magazine* March 10, pp. 29, 122–127. A brief look at Bethe's accomplishments and concerns.

Schweber, Silvan S. (2000). *In the Shadow of the Bomb: Bethe, Oppenheimer, and the Moral Responsibility of the Scientist*. Princeton, NJ: Princeton University Press. The best source for Bethe's involvement in the social and political aspects of nuclear weapons, chronicling his and Oppenheimer's roles in postwar developments and restrictions of nuclear arms.

INTERNET RESOURCE

Bethe, Hans. "Letter to the Science Community." Pugwash Online. Available from http://www.pugwash.org/about/bethe.htm. A plea to end the development of all weapons of mass destruction, originally issued July 23, 1995.

BHOPAL CASE

In December 1984, a gas leak of approximately forty metric tons of methyl isocyanate (MIC) from a pesticide plant in Bhopal, India, resulted in as many as 3,000 deaths and injuries to thousands. MIC, an organic chemical used in the production of pesticides, is a volatile liquid that reacts violently with water. MIC is highly toxic to humans and short-term exposure can cause respiratory diseases, if not death, and can seriously affect reproduction. The circumstances and results of what was the industrial accident with the largest death toll in history has been widely used as a case study in engineering design and technology management.

Union Carbide of India, Limited (UCIL), a company controlled by U. S.-based Union Carbide Corporation (UCC), operated the Bhopal plant. UCC provided the basic plant design, supervised its engineering, and defined its operating procedures. Prior to the catastrophe, the plant had been losing money for several years due to weak demand in India for pesticides. This resulted in major personnel reductions, particularly in production and maintenance. At the time of the accident, the plant had been shut down for more than a month for a complete maintenance overhaul. Important safety devices were out of commission and personnel with no MIC training were in supervisory roles. Consequently, when a large amount of water entered an MIC tank due to a mistake during normal maintenance procedures (according to the Indian government version of events), the ensuing reaction caused a large gas leak; defects in the MIC unit and a lack of staff safety training prevented containment.

Developing countries often lack the infrastructure to safely support and maintain complex technologies. Companies based in countries such as India offer cheap labor and low operating costs for multinational corporations, but little incentive to promote environmental quality, safety procedures, and community investment (Bowonder, Kasperson, and Kasperson 1994). Increased risks posed by establishment of a MIC production unit close to slum colonies were never recognized by either UCIL or the Indian government.

UCC maintained safety standards at the Bhopal plant well below those at a sister plant in West Virginia; computerized data loggers, for example, were not employed at Bhopal. Furthermore, there was no attempt to follow up and implement safety recommendations of an Operational Safety survey conducted by a UCC team in 1982 (Shrivastava 1994). Specific safety problems that contributed to the disaster included: unreliable temperature and pressure gauges; the leaking MIC storage tank was filled beyond recommended capacity; a reserve storage tank for excess MIC already contained MIC; the community warning system had been shut down; a refrigeration unit that keeps MIC at low temperatures had been shut down; the gas scrubber designed to neutralize escaping gases had been shut down; the flare tower intended to burn off any MIC escaping from the scrubber had both a design defect and had been shut down; a water curtain intended to neutralize any remaining gas was too short to reach the top of the flare tower, where the gas exited (Patel 1997).

According to some observers, UCIL (and UCC) showed disregard for victims of the catastrophe, prolonging their suffering through failing to deal with their immediate needs. When MIC was released, the public alarm was not sounded until hours later. UCIL provided misleading information on treatment for toxic effects of MIC, resulting in inadequate treatment by local physicians. UCC blamed local workers for sabotage and conducted a media blitz to divert attention from the corporation (Morehouse and Subramaniam 1986).

The UCC strategy for negotiations focused on a fixed settlement. UCC fought hard to ensure the legal battle took place in India and the lawsuits filed in U.S. courts were rejected on the basis that the catastrophe occurred in India, the victims were Indian, and the plant was run by UCIL, an Indian subsidiary of UCC. In 1985, the Indian government passed the Bhopal Gas Leak Disaster Act, which made the government sole representative of all claimants. Later, using this act, the Bhopal Gas Leak Disaster Scheme emerged, further controlling registration, processing, and future compensation (Patel 1997).

UCC eventually settled out of court for $470 million, in the process denying any legal liability. To reciprocate, the Indian Supreme Court provided immunity from any future prosecution. A subsequent change in government prompted the court case to be reopened. Criminal proceedings against UCC and Warren Anderson (UCC Chairman at the time of the accident) have been pending in India since 1992. Under Indian law, the company has been deemed "fugitive" and India

Bodies of victims of the Bhopal accident, waiting to be identified by relatives at the Hamidia Hospital. As many as 3000 people lost their lives in the tragedy. (*© Bettmann/Corbis.*)

seized assets of UCIL to benefit victims of the catastrophe (Appleson 1999).

The Bhopal disaster illuminates ethical issues throughout the chain of development of a technology, from the decision to build and operate a hazardous facility in a developing region that lacked the technical and institutional infrastructure to properly support it, to design decisions that compromised the plant's margin of safety, to failure to properly operate and maintain the plant. Perhaps the most troubling aspect from an ethical perspective is the failure of both industry and government to look beyond the legal issues and adequately confront the human suffering caused by the accident.

DEENA MURPHY-MEDLEY
JOSEPH R. HERKERT

SEE ALSO *Engineering Ethics.*

BIBLIOGRAPHY

Bowonder, B.; Jeanne X. Kasperson; and Roger E. Kasperson. (1994). "Industrial Risk Management in India Since Bhopal." In *Learning From Disaster*, ed. Sheila Jasanoff. Philadelphia: University of Pennsylvania Press. Review of basic issues in industrial hazards management and disaster prevention and the impact of the Bhopal catastrophe on industrial risk management practices in India.

Morehouse, Ward, and M. Arun Subramaniam. (1986). *The Bhopal Tragedy*. New York: Council on International and Public Affairs. Critical examination of the history and conditions that led to the Bhopal disaster and industry and government attitudes that put U.S. chemical workers at risk; strategies for preventing future disasters.

Shrivastava, Paul. (1994). "Societal Contradictions and Industrial Crises." In *Learning From Disaster*, edited by Sheila Jasanoff. Philadelphia: University of Pennsylvania Press. Uses Bhopal as case study to explore contradictory societal demands on technology and their role in causing and escalating social and economic crises arising from industrial accidents.

INTERNET RESOURCES

Appleson, Gail. (1999). "Bhopal Victims Sue Union Carbide Over '84 Disaster." Available from http://www.bhopal.org/newsstories/reuters.html. News story on victims' lawsuit; the site is maintained by a clinic in Bhophal sponsored by a charitable trust.

Patel, Trupti. (1997). "TED Case Studies: Bhopal Disaster." Available from http://www.american.edu/TED/bhopal.htm. Trade and Environment Database (TED) is an online compilation of environment-related case materials maintained by the Mandala Projects at American University.

BHUTAN

Bhutan is a small landlocked country in the eastern Himalayas that is attempting to pursue an alternative to the common approaches to the relationships among science, technology, and ethics. Bordered on the north by Tibet and on the south by India, this Buddhist kingdom is approximately one-third the size of nearby Nepal, with a population estimated at around 1 million persons. In 1959, after the Chinese invasion of Tibet, Bhutan departed from a period of isolation that had lasted for centuries to accept assistance from India in building its first major road, thus initiating close diplomatic and economic ties with its southern neighbor. Despite its international ties, since 1960 Bhutan has pursued a cautious and circumspect approach to technology and development.

The vision guiding Bhutan's approach has emerged from the core values of Vajrayana Buddhism, specifically the Drukpa Kagyu and Nyingma lineages that dominate the country's spiritual landscape. The effect of those values on modern technological development is suggested in the frequently quoted maxim of Jigme Singye Wangchuck, the king of Bhutan: "Gross national happiness is more important than gross national product."

Ideas such as *ley jumdrey*, the law of *karma; tha damtshig*, the sacred commitment to interpersonal relationships; and the interdependence of all things are illustrated in the ubiquitous iconography of *thuenpa puenshi*, "the Four Friends," four animals that achieve a common good through thoughtful cooperation, an image that is painted on the walls of classrooms, government offices, hotels, shops, and homes throughout the country. Hagiographies of successful Buddhist practitioners convey the importance of self-discipline, the efficacy of ritual and contemplative practices, and the perfectibility of human beings, along with universal values such as honesty, compassion, harmony, and nonviolence. Divine madmen such as the antinomian folk hero Drukpa Kunley offer a corrective to pretentious, self-important authority and the soporific effects of habituation to mundane, consensus reality.

Guided by those core Buddhist values, Bhutan has approached the ideal of sustainable development, linking technological innovation, environmental conservation, cultural continuity, and good governance through development programs aimed at increasing human welfare rather than focusing only on industrialization and economic diversification. Conservation of the last remaining unspoiled forests in the Himalayan region is a national priority that is grounded in a preexisting indigenous conservation ethic. Protected conservation areas account for about 26 percent of the country's land area. Education in environmental science begins at the kindergarten level, and public banners reinforce that ethic with admonitions such as "Healthy Forest for a Healthy Environment, Let Us Maintain It." The Bhutan Trust Fund of Environmental Conservation, established in 1991, is widely acknowledged as the first national environmental trust in the world and has been a model for similar trusts in other countries.

Foreign exchange primarily involves tourism and hydroelectricity sold to neighboring India. Learning from the experiences of regional neighbors such as Nepal, Bhutan gradually opened its borders to foreign tourists but in 1974 adopted a policy of "high-value, low-volume" tourism to avoid the negative consequences of unrestrained tourism on the natural environment and the indigenous culture. A similar caution has been displayed in the development of hydroelectricity. According to 1996 estimates, only 2 percent of the hydroelectric potential of the nation has been tapped. In addition to the major dam at Chukha, many mini- and micro-hydroelectric projects are scattered throughout the country in order to avoid the watershed damage associated with larger projects while providing electricity directly to remote locales.

Perhaps the most dramatic and far-reaching technological change occurred in 1999 with the lifting of a government ban on broadcast television and the introduction of Internet access. The extent to which traditional Bhutanese values will be displaced by an ideology of consumerism and the values of an advertising culture remains to be seen.

JEFFREY R. TIMM

SEE ALSO *Buddhist Perspectives; Social Indicators.*

BIBLIOGRAPHY

National Environmental Commission, Royal Government of Bhutan. (1998). *The Middle Path: National Environment Strategy for Bhutan*. Bangkok, Thailand: Keene Publishing. This book was produced by the National Environment Commission and a policy statement of the Royal Government of Bhutan on conservation and sustainable development.

Priesner, Stefan. (1999). "Gross National Happiness—Bhutan's Vision of Development and Its Challenges." In *Gross National Happiness: Discussion Papers*. Thimphu, Bhutan: Centre for Bhutan Studies. This is the first book published by the Centre for Bhutan Studies and contains nine papers exploring various aspects of development *vis-á-vis* the "gross national happiness" concept.

Wangyal, Tashi. (2001). "Ensuring Social Sustainability: Can Bhutan's Education System Ensure Intergenerational Transmission of Values?" *Journal of Bhutan Studies* 3(1): 108–133. This article explores the role of public education in Bhutan in the transmission of Buddhist values and perspectives in face of increasing globalization of culture.

BIODIVERSITY

Life on earth began as bacterial cells at least 4,000 million years ago, and it has—with notable, but rare, catastrophic declines in diversity subsequently—expanded, evolved, and complexified across time. In the early-twenty-first century the earth teems with countless species arranged in many diverse patterns and relationships spread across varied landscapes. As human populations have expanded since the industrial revolution, with technologies becoming more powerful and increasingly capable of pervasive impacts, biodiversity is again in decline, this time as a result of human activities, especially the fragmentation of forests and other wild habitats. How to reverse the dangerous trend toward biological simplification has become one of the most urgent global environmental questions.

What Is Biodiversity?

Biodiversity, a contraction of *biological* and *diversity,* was introduced as a convenient abbreviation during preparations for a national symposium on the subject in the United States, which was sponsored by the Smithsonian Institution and the National Academy of Sciences (NAS) in 1986. This term, though technically difficult to define, has come to refer to the rich and textured web of life on earth. The term, and the concepts and ideas associated with it, gained world political prominence at the World Conference on Environment and Development in Rio de Janeiro in 1992, where the United Nations Convention on Biodiversity, a document that was subsequently ratified by a majority of nations, was passed. This convention called for the sustainable use and protection of the earth's biological resources, and the term biodiversity has become the rallying point for conservationists and others concerned about the rapid simplification of natural systems in the face of human development.

There are two approaches to defining biodiversity (Wood 1997, 2000). Perhaps the most popular approach is to define it as an *inventory* of diverse biological items.

One such inventory, which has been described as the *standard* definition of biodiversity, defines it as the sum total of species, genetic variation within species, and diversity of habitats and ecosystems in which species are found (Takacs 1996). Difference definitions, in contrast, define biodiversity as the total of differences among biological entities and processes (Takacs 1996; Wood 1997, 2000). These two approaches differ in that inventory definitions, which simply count elements of different types (species, genes, habitats), tend to count elements of the same type equally in their contribution to total diversity, whereas difference definitions highlight degrees of differentiation. Accordingly, under a difference definition, a species that is the lone member of its genus would be considered to contribute more diversity than a species that shares its genus with others (Solow et al. 1993, Weitzman 1998).

As noted, there are serious technical problems in defining biodiversity. It clearly would be desirable to have a definition that represents biodiversity as a measurable quantity—so that, for example, one could say that a given system is measurably more diverse than another, or that a given system is losing or gaining diversity at a specifiable rate. Unfortunately both inventory and difference definitions fail to provide a measurable index of biodiversity. Decisive arguments show that biodiversity cannot be represented as a list of countable and additive elements. This conclusion follows from the unavoidable fact that living nature can be organized into multiple, but incommensurable, hierarchies. For example, there is a phylogenetic hierarchy of species and genera, among others, as well as a spatial hierarchy of cells, organs, organisms, and ecosystems. Both hierarchies add significantly to the total diversity of life, but the elements of these hierarchies cannot be added together to create a meaningful sum. Similar arguments apply to difference definitions: Biological entities vary across many parameters and aspects, and these cannot be added together to represent a meaningful index of biological diversity (Wood 2000, Sarkar 2005).

This difficulty implies that biodiversity is too complex and multifaceted to be represented by a single measure or to be made a countable quantity, and has led to a search for *proxy* measures for biodiversity (Sarkar 2005). One popular proxy is simply to use species counts as conventional markers to represent total diversity, which has gained wide acceptance in practice because it is clear and allows relatively unambiguous measures. The consensus view of scientists, however, is that simplified measures such as this cannot capture the full richness and diversity of life. In the United States this simplification was nevertheless embodied in the Endangered Species Act of 1973 (ESA), which has become, despite its narrow focus on endangered species, one of the most important pieces of environmental legislation ever passed by a national legislature. The act concentrates heavily on avoidance of species extinction through a process that lists species as *threatened* or *endangered*, limiting damage to the listed species, subspecies, and special populations. Protection of habitat is mainly treated by the act as instrumental to the protection and recovery of endangered and threatened species.

Accordingly it has been suggested that the U.S. strategy—which can be referred to as a *rare species paradigm*—may be less effective than an alternative strategy developed by Australian practitioners, who develop algorithms that rank possible reserve designs according to their effectiveness, per area set aside, in saving biodiversity (defined in terms of a chosen proxy). The Australian approach, referred to as the *declining species paradigm* (Caughley 1994), has increasingly been applied in international settings. This approach is to develop and refine an algorithm that ranks various protection strategies according to their efficiency in using space to protect proxy variables chosen to represent managerial goals. This pragmatic approach—which emphasizes shared actions rather than abstract measures—can provide a rough operationalization of biodiversity: Biodiversity is what is saved by the actions of professionals who design reserves that are effective in responding to identifiable forces of simplification that are addressed in a real place (Sarkar 2005).

Speaking more generally, biodiversity can be thought of as the result of a magnificent and eternal process of change, as life has explored countless strategies for survival in countless climates and habitats. These explorations have led to an inexorable increase in diversity across time, because each increment in diversity opens up new possibilities and adaptations for other species, and to the hypothesis that diversity itself causes increases in diversity. This theory also has a negative side: Losses in diversity can increase the likelihood that further losses will occur as species are stressed by loss of mutualist species and populations (Whittaker 1970, Norton 1987). Thus whereas biodiversity has, in the big picture, increased over time, there have also been cataclysmic periods of species loss, and paleontologists speculate that there have been as many as six extinction events in which half or more species disappeared. At least some of these events are associated with meteor strikes on earth and, possibly, as a result of dust from enormous volcanic eruptions. Increasing rates of extinction and endangerment have led some scientists to speculate that the Earth is entering another such event, for the first time as a result of human activities. Whether the human species can survive such an event is not known, but the exponential effects of human activities are impacting the world at a scale previously produced only by global cataclysms.

Fear that the simplification of nature may cause an irreversible spiral of losses inspires scientists and conservationists to advocate strong measures to reverse simplification processes before it is too late. As noted, there exists a broad, practical consensus among experts about what actions are necessary to reverse, or at least slow, such processes such as establishing protected riparian corridors along rivers and developing core reserve areas while managing buffer zones around them. Whether the means, and the will, exists to rein in development that encroaches on wild habitats and drives species toward extinction remains uncertain. Conservationists agree that it is important to save as much biodiversity as possible, though there are seldom adequate resources to do even a fraction of the things that are widely recommended by experts for the protection of sensitive areas and diversity *hotspots*. Thus whereas success in protecting biodiversity is not assured, broad agreement in strategies to maximize biodiversity does inspire confidence that practitioners know what they are talking about—that the concepts used are *clear enough* to allow communication and cooperative action—even if no abstract definition of biodiversity can be considered to correspond precisely to any measurable quantity in nature (Norton 2005).

What Is the Value of Biodiversity?

Despite considerable agreement in conservation strategies and protective practices, there remain several cross-cutting disagreements regarding *why* biodiversity protection is important (Norton 1987, 1986). These are: (1) the *nature* of the value biodiversity has; (2) the *units* of diversity that should be valued; and (3) the appropriate *measures* of the value of biodiversity. These disagreements are important because they affect the prioritization given biodiversity protection in competition with other socially valued objectives, and also among various possible conservation objectives.

Disagreements regarding the *nature* of the value of biodiversity reflect differing theories of value. Monistic theories of value account for all value in nature according to a single measure. Utilitarians, economically oriented and otherwise, advocate decisions based on impacts on human well-being or satisfaction. Other monists have extended ethical concepts, usually applied only to humans, to other species and even to ecosystems, treating elements of nature as *ends-in-themselves*, as possessing *moral considerability*, and as having *goods-of-their-own* that compete with human welfare. The prominence of these two opposed, monistic theories, has resulted in a polarized discussion, often pitting economists against environmental ethicists, and no consensus regarding how to place measurable value on biological diversity has emerged.

The value of biodiversity is better captured by a pluralistic evaluative method, which treats the many social values derived from biodiversity as reinforcing each other. Actions that protect biodiversity protect complex natural systems, reduce soil erosion, promote aesthetic enjoyment and scientific interest, hold open options for economic uses, and support the values of the many individuals who value nature noninstrumentally.

Pluralism, though unpopular within academic disciplines, seems more consistent with the many ways that humans express their dependence upon, and love for, nature. Under a pluralist approach, multiple competing values must be balanced and prioritized against each other, but opportunities also arise to protect multiple social values simultaneously, opening up the possibility of win-win management policies through the protection of natural habitats as homes for biodiversity and many other values. The pluralist approach encourages a more political understanding of the value of biodiversity. Some authors conceptualize the problem of biodiversity protection as one of accepting responsibility for conveying a *trust*, or a gift from previous to subsequent generations as an obligatory legacy (Weiss 1989, Brown 1994). In a variant on the trust idea, other theorists argue that future generations have rights to a full complement of species and ecosystems, and that these rights should be protected by constitutional constraints that require governments to protect biodiversity (Schlickeisen 1994, Wood 2000). These trust doctrines and the constitutional amendment recommendation, built on a moral concern for the future, complement the idea of sustainable use and development of resources. The goal of protecting the evolved web of life, what scientists call biodiversity—whether for its possible uses in fulfilling human needs, the diverse aesthetic experiences it affords humans, or its noninstrumental value to the fulfillment of human needs—will be one of the great challenges of the future.

BRYAN G. NORTON

SEE ALSO *Biophilia; Deforestation and Desertification; Ecology; Environmental Ethics; Rain Forest; United Nations Environmental Program.*

BIBLIOGRAPHY

Brown, Peter G. (1994). *Restoring the Public Trust: A Fresh Vision for Progressive Government in America*. Boston: Beacon Press.

Caughley, Graeme. (1994). "Directions in Conservation Biology." *Journal of Animal Ecology* 63: 215–244. Outlines the differences between *rare species* and *declining species* paradigms.

Norton, Bryan G. (1987). *Why Preserve Natural Variety?* Princeton, NJ: Princeton University Press. A monograph surveying the science, values, and policies associated with biodiversity.

Norton, Bryan G. (2005). "What Are We Trying to Save? And Why? Toward a Policy-Relevant Definition of *Biodiversity*." In *The Endangered Species Act at 30*, ed. J. Michael Scott, Dale Goble, and F. Davis. Washington, DC: Island Press.

Norton, Bryan G., ed. (1986). *The Preservation of Species: The Value of Biological Diversity*. Princeton, NJ: Princeton University Press. An anthology providing a multidisciplinary review of nature protection.

Sarkar, Sahotra. (2005). *Biodiversity and Environmental Philosophy: An Introduction*. Cambridge, UK: Cambridge University Press. A highly recommended survey of issues and methods, written from the viewpoint of a philosopher of biology.

Schlickeisen, Rodger. (1994). "Protecting Biodiversity for Future Generations: An Argument for a Constitutional Amendment." *Tulane Environmental Law Journal* 8: 181–221.

Solow, Andrew; Stephen Polasky; and James Broadus. (1993). "On the Measurement of Biological Diversity." *Journal of Environmental Economics and Management* 24: 60–68.

Takacs, David. (1996). *The Idea of Biodiversity: Philosophies of Paradise*. Baltimore: Johns Hopkins University Press. A very useful examination of biologists' ideas on biodiversity.

Weiss, Edith Brown. (1989). *In Fairness to Future Generations: International Law, Common Patrimony, and Intergenerational Equity*. Tokyo: United Nations University; Dobbs Ferry, NY: Transnational Publishers. An analysis based in the theory of international law, of obligations to the future.

Weitzman, Martin L. (1998). "The Noahs's Ark Problem." *Econometrica* 66(6): 1279–1298.

Whittaker, Robert H. (1970). *Communities and Ecosystems*. New York: Macmillan. Whittaker introduced many of the concepts used to discuss biodiversity.

Wood, Paul M. (1997). "Biodiversity As the Source of Biological Resources: A New Look at Biodiversity Values." *Environmental Values* 6: 251–268. A focused argument for a difference definition, including also a discussion of the value of biodiversity as a *source* of biological resources.

Wood, Paul M. (2000). *Biodiversity and Democracy: Rethinking Society and Nature*. Vancouver, British Columbia: UBC Press. An examination of the moral and political obligations associated with protecting biodiversity.

BIODIVERSITY COMMERCIALIZATION

The Convention on Biological Diversity (CBD), which entered into force on December 29, 1993, established an international treaty for the conservation and sustainable use of biological diversity and set up a process for the further development of legal, policy, and scientific activities related to biodiversity. The treaty has been highly controversial, however, provoking strong differences in perspectives, especially between those claiming to speak for indigenous peoples and for commercializing enterprises.

Historical Background

Concerns about the global loss of biodiversity that emerged in the late 1970s took their initial legal form in the International Undertaking on Plant Genetic Resources voluntarily adopted by members of the Food and Agriculture Organization (FAO). This 1983 agreement, based on a proclaimed "universally accepted principle that plant genetic resources are a heritage of mankind and consequently should be available without restriction," aimed to "ensure that plant genetic resources of economic and/or social interest . . . will be explored, preserved, evaluated and made available for plant breeding and scientific purposes."

Discussion of the costs and responsibilities for implementing such an agreement stimulated the United Nations Environment Programme (UNEP) in 1987 to establish an Ad Hoc Working Group of Experts on Biological Diversity to harmonize existing related conventions. Negotiations that produced the CBD began in 1990 among representatives from governments, corporations, and various interest groups including universities, research institutes, botanic parks and gardens, and community-based nongovernmental organizations (NGOs). The CBD was opened for signature at the United Nations Conference on Environment and Development in Rio de Janeiro, June 1992. According to the CBD itself, its objectives are "the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding" (Article 1).

The forty-two articles of the CBD not only create substantive provisions for conservation, commercial development, scientific research, and education regarding biological diversity (articles 6–20), but also outline mechanisms for further development of these provisions through a Conference of Parties (article 23), Secretariat (article 24), and a Subsidiary Body on Scientific, Technical, and Technological Advice (article 25). One of the first actions of the Conference of Parties (COP) was to add a Protocol on Biosafety, negotiation on which began at a COP meeting in Cartagena, Colombia, in 1999, and continued in Montreal, Canada, in 2000, when agreement was reached. Although negotiations were concluded in Montreal, the results are still known as the Cartagena Protocol on Biosafety, which implements CBD article 19 with procedures for the "safe transfer, handling and use of any living modified organism resulting from biotechnology that may have adverse effect on the conservation and sustainable use of biological diversity."

Ethical Debates

As Kerry ten Kate and Sarah A. Laird (2001) have summarized them, there are two basic responses to the CBD and its issues. On the one side are those representing private commercializing enterprises (most prominently transnational agricultural and pharmaceutical corporations); on the other are those of indigenous or local interests from the source countries in the developing world.

BIOPROSPECTING. From the point of view of private corporations, they are involved in bioprospecting for what might be thought of as "green petroleum" in a process that will bring wealth to gene-rich but financially poor countries. Corporations argue that just as in the cases of other resources such as minerals, the commercialization of biological resources requires major capital investments in research and development over long periods of time with no guarantee of rewards. The only way a business enterprise can justify such investments is through an ability to patent those processes and products of its work. Moreover, the ultimate rewards will be in the long-term best interests not only of the corporations and their shareholders but of the source countries as well.

Demands by source countries for more up-front payments for raw biological resources access and for more explicit informed consent processes will ultimately destroy the bioprospecting market. Biological research and development work is in competition with genetic engineering of pharmaceuticals, bioinformatics, and new forms of synthetic and combinatorial chemistry including molecular biology and nanotechnology. Only if bioprospecting can remain competitive with such alternatives will it be pursued. Requiring that local populations be given extensive education about the biological resources to which they sell the rights, along with full disclosure of potential research and development trajectories, both negative and positive, only adds another level of costs that can easily drive corporations away from the kinds of investment that are ultimately beneficial to source countries.

BIOPIRACY. From the point of view of critics representing source countries, however, bioprospecting is better described as biopiracy. This term was coined in 1993 by the Rural Advancement Foundation International (RAFI), an NGO subsequently renamed the Action Group on Erosion, Technology and Concentration (ETC Group), and then widely disseminated when deployed as the title of Vandana Shiva's *Biopiracy: The Plunder of Nature and Knowledge* (1997). The word is part of the rhetorical critique of globalization or the anti-globalization movement, an equally controversial name for political and economic action that representatives themselves often prefer to describe as an alternate globalization (alter-globalization) or fair-trade (as opposed to free trade) movement.

According to the ETC Group, biopiracy involves the unjust appropriation of indigenous knowledge and genetic resources by individuals or institutions seeking control (usually patents or breeders' rights) over them, leading to the loss of control of their own resources by traditional peoples. In this sense, biodiversity commercialization is simply a new form of colonialization, in which developed countries through global corporations scour the world, extract genetic material, then patent these finds as their "discoveries." Colonization is now focused on life itself—plants, micro-organisms, animals, and even human organs, cells, and genes. From this perspective, the CBD may be used as a means to regulate access to biological resources in ways that lead to sharing with the communities the results of research and development and the benefits arising from the commercial utilization of genetic resources in a fair and equitable way. It may also function to protect diversity not only in biology but also in culture, not only facilitating advancements of knowledge in modern science but preserving the knowledge present in indigenous science.

IGNACIO AYESTARÁN
CARL MITCHAM

SEE ALSO *Agricultural Ethics; Biodiversity; Globalism and Globalization*.

BIBLIOGRAPHY

Kate, Kerry Ten. (1995). *Biopiracy or Green Petroleum? Expectations and Best Practices in Bioprospecting*. London: Overseas Development Administration.

Kate, Kerry Ten, and Sarah A. Laird. (1999). *The Commercial Use of Biodiversity: Access to Genetic Resources and Benefit-Sharing*. London: Earthscan.

Khor, Martin. (2002). *Intellectual Property, Biodiversity and Sustainable Development: Resolving the Difficult Issues*. London: Zed Books.

Secretariat of the Convention on Biological Diversity. (2001). *Handbook of the Convention on Biological Diversity*. London: Earthscan.

Shiva, Vandana. (1997). *Biopiracy: The Plunder of Nature and Knowledge*. Boston: South End Press.

BIOENGINEERING ETHICS

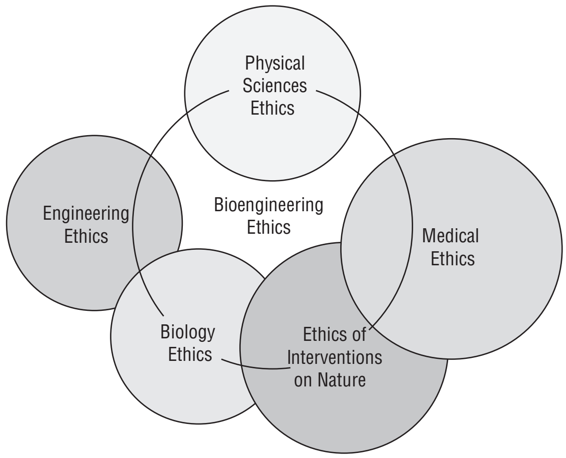
All of engineering can be viewed as a continuation of biology by other means—a metabiological activity. Bioengineering arose relatively recently with specific focus on living systems, for medical purposes in a close alliance with medicine, for scientific and industrial purposes and for other purposes.

A vast array of specializations and subfields have emerged, not always closely related and sometimes predating the overall recognition of bioengineering as a field. An ever expanding and at times confusing and overlapping taxonomy includes biomechanics (encompassing also biorheology and biofluid mechanics), instrumentation, biochemical engineering, bioastronautics, environmental engineering, biomaterials, tissue engineering, biological systems engineering, engineering of drug design and delivery, biotechnology instrumentation, bionanotechnology, and bioinformatics (Blanchard and Enderle 1999, Bronzino 1999, Fung 2001).

Bioengineering, as a field of research and applications, brings to bear not only engineering on medicine and biological organisms, but also a knowledge of biology on engineering designs. This helps assessing the meaning of engineering as the extender of biology and ultimately helps engineering develop a clearer sense of its own nature and address the ethical issues involved in its modification of nature and the creation of machines, that is, artifacts.

TABLE 1

The Interaction of Various Disciplines with Bioengineering Ethics



SOURCE: Courtesy of George Bugliarello.

The intersection of Bioengineering Ethics with Cognate Ethics.

Biomechanics

Biomechanics began to flourish in the 1960s, but interventions on the human body through artifacts have a long history that originated with prehistoric supports for fractured bones and skin decorations such as scarification, implanted rings, and tattoos. Daedalus with his mythical wings and the Tailor from Ulm with his arm-extending wings for gliding (Eyth 1885) were precursors of biomechanics, one in legend and the other in reality. After medieval times this process progressed to encompass eyeglasses, artificial teeth, and rudimentary artificial limbs. Eventually the interventions on the human body fulfilled other needs through diagnostic and curative tools and processes, from the application of bioengineering to bioastronautics starting in the 1960s (Konecci 1968) to X-ray visualization through computed tomography (CT), ultrasound scans, and magnetic resonance imaging (MRI), to hearing aids, surgical robots, autoanalyzers, DNA-sequencing machines, tissue engineering, and the application of engineering knowledge to the understanding of biological (Bejan 2000) and therapeutic processes. Most of these developments were strongly interdisciplinary, blending engineering, physiology, physics and mathematics. Interdisciplinarity continues to characterize the field.

Other bioengineering milestones include the first artificial organs. The artificial kidney was given practical form through the application of engineering principles by the Dutch physician Wilhelm Kolf in the 1940s, and the first heart pacemaker was implanted in 1958 in Sweden through the collaboration of the surgeon Åke Senning and the physician-inventor Rune Elmquist.

Pioneering studies of the brain were conducted by John Von Neumann and Walter Roseblith, and the study of neurons was initiated by Walter Pitt and Warren McCullogh. They opened a new domain for bioengineering, and also provided significant insight for the design of new kinds of computers.

An early example of the application of biology to engineering that has had an immense impact on human health is biological water and waste-water treatment processes. Biomimesis—the mimesis of biological designs, materials and processes—is another aspect of engineering applications that range from the creation of artifacts for medical and industrial purposes to genetic engineering and to ergonomics.

Other developments include the embryonic emergence of biomachines, as in the case of cardiac pacemakers and of bioelectrical sensors (biological sensors implanted on an electronic platform), and the biosoma concept of the integration of biological organisms and their two metabiological offshoots: society and machines (Bugliarello 2003).

Toward an Ethics of Bioengineering

Harmonization of the comprehensive ethical canons needed to address modifications of nature through the design and operation of artifacts and respond to conflicting views of the public good that engineering is committed to serve presents limitations and contradictions, as occurs when engineers develop products in which commercial motivation overshadows social goals. As a consequence, the flourishing of bioengineering as an offshoot of engineering has outpaced a focus on the ethical issues that confront it.

The complexity of formulating a bioengineering ethics arises from the need of bioengineering to be coherent not only with the ethics of engineering but also with those of biology, medicine, and the physical sciences, the fields with which bioengineering interacts most strongly (see Figure 1). Those specialized ethics, which are congruent with general ethics but distinct from it and complementary, must be rooted in the fundamental philosophical issues of each field: In the physical sciences, how do researchers obtain and verify knowledge? In biology, how can this be done in the context of living organisms and what is the nature of life, including the body-mind problem of consciousness? In medicine, what is the nature of disease? In engineering, what is the nature of the machine, why are there machines, and how far can humankind go with machines, for example, in making them self-reproducing?

The associated key ethical issues in physics and biology are concerned primarily with the purpose and conduct of research and the impacts and limits of research as exemplified by controversies in nuclear energy and cloning. In medicine, those issues relate to the limits of therapy, safety and risk, the Hippocratic imperatives, informed consent, and the role of the patient as well as the dilemma of individual versus societal benefit. In engineering, they have to do with the purposes and benefits of machines and interventions in nature, biosocial and environmental impacts, and risk and appropriate safety factors. The host of specific ethical issues associated with bioengineering arises from the need to incorporate the ethical questions of physics, medicine, and biology in addressing the domain, focus, and impact of bioengineering; its risks and safety factors; the views of nature that govern its activities; and the issues of activism and intellectual responsibility.

Domain, *focus*, and *impact* questions start with the positioning of the biomachine interface: Where should it be placed in the polarity between biological organisms and machines? To what extent should biomachines retain the essential characteristics of biological organisms *versus* those of machines? Also, should there be limits to biomimesis, the imitation of biology in creating devices? Are there potential dangers as well as benefits, and if so, what should guide the bioengineer? Should the ethical responsibility of bioengineering be exclusively humancentric, or should it extend to a broader biocentric domain with responsibility to other advanced life forms?

Relevant to urgent social needs are questions of prevention versus therapy. Historically, many medically oriented bioengineering activities have focused on therapy and very costly devices. This has improved medical capabilities, but to what extent should escalation of medical costs and principles of social equity make it an ethical imperative for bioengineering to focus more on prevention? Indeed, what should be the appropriate interface with medicine; what should be the specific role and responsibility of the bioengineer in a clinical environment? The dilemma of the individual versus society affects medicine and bioengineering alike and is at the core of the debate about health care: Should the focus be exclusively on the individual? To what extent should the cost to society also be taken into account?

The issues of medical versus industrial purposes, with their different motivations, also can be a source of contradictions and conflicts for bioengineers: Should they participate in a medical procedure or in the development of an industrial process merely for the technical challenge, without a clear understanding of the ultimate consequences? Should the imperative ethical requirement for bioengineers be to act as independent-minded professionals regardless of the pressure that may be put on them by a hospital, research laboratory, factory, or granting agency?

A closely related issue is the depersonalization of health care brought about by its increasing technicization. To what extent should bioengineers focus on the design of the clinical environment in which bioengineering machines are placed and processes are carried out and endeavor to reduce that depersonalization by taking into account the emotional component of human nature (a component that depends in turn on physiological factors, themselves amenable to medical and bioengineering research)?

What are acceptable *risks* and appropriate *safety factors* of bioengineering designs (a meeting point of the ethics of medicine and engineering with political, economic, and legal theories)? Do the efforts expended and the risks generated by a solution produce benefits that justify its development? A correlate ethical issue is the bioengineer's responsibility to follow up on the performance of a design or process, communicate the results whether they are positive or negative, and strongly advocate the adoption of satisfactory, safe, effective designs or processes and the elimination of dangerous and counterproductive ones.

Bioengineering interventions in natural processes must take into account the many basic and often conflicting values involved in *different views of nature*. These views range from utilitarian (an emphasis on the way in which humans derive benefits from nature) to the doministic (the drive to dominate nature for the sake of doing so) (Kellert 1996). Each view involves ethical dilemmas for bioengineering, starting with the basic issue of whether or to what extent to accept nature as is or to modify it teleologically; this can be thought of as an aspect of the conflict between biology (and at times religion) and engineering or medicine. The dilemma leads to different ethics—the ethics of discovery (science) versus that of design (engineering)—and to contemporary debates about genetic engineering (under what conditions should discovery lead to design?).

Activism and Intellectual Responsibility

In terms of *activism and intellectual responsibility*, to what extent should bioengineers intervene in the philosophical dialogue about the modification of nature, the future of humans and the human responsibility for other species? Should they participate actively in the political arena by pressing for new visions and their realization rather than seeing their role as a purely technical one? What is the ethical responsibility of bioengineers in projecting the potential modifications of nature that bioengineering can make possible and to inform society as to how beneficial modifications can be safely accomplished?

Provisional Answers

Even a cursory view such as the one presented here conveys the broad, complex, and fundamental nature of the ethical questions involved in bioengineering. Like all of ethics, bioengineering ethics deals with questions that are beyond the realm of the legal responsibility of bioengineers and may conflict with it. However, these are issues for which bioengineers should seek to define and enhance a professional conscience and behavioral guidance. So far only some of these questions have been addressed, and often only in a rudimentary way. Until a comprehensive bioengineering ethics has been formulated, a provisional set of tenets is needed. Those tenets might include the following:

- The *harm avoidance tenet* (essentially a restatement of the Hippocratic oath): to minimize the side effects of a design or intervention and devise something that bioengineers would use on themselves if necessary
- The *professional tenet:* to act as independent-minded professionals regardless of pressure from the environment in which bioengineers operate and intervene in professional and public discussions about engineering, medical, biological, and societal issues that bioengineering could illuminate
- The *approval tenet:* not to participate in medical procedures or in the development of industrial or military processes of which bioengineers do not personally approve no matter how technically challenging those procedures or processes are
- The *conflict of interest tenet:* not to advocate an unsafe, ineffective, or inferior design because one has a vested interest in it

- The *risk tenet:* to weigh the risks to human society and the environment of a bioengineering device or process
- The *effectiveness tenet:* to make the cost and risk of a design or intervention commensurate with the expected benefits
- The *responsibility tenet:* to assume the responsibility to follow up the performance of a design or process and communicate the results whether they are positive or negative
- The *finality tenet:* to attempt to expand the capabilities of humans, and, where appropriate, other biological organisms, being mindful of the metabiological nature of bioengineering as an activity that synthesizes two human drives: understanding nature and modifying it to preserve and enhance life

It is unrealistic to believe that a consistent and comprehensive bioengineering ethics will emerge rapidly from all the disparate elements and concerns that will contribute to its formation. A bioengineering ethics cannot be independent from the fundamental philosophical conceptions and ethics of the society in which bioengineering is embedded. These issues in turn are shaped and modified by advances in knowledge, social and political events, and the progress of bioengineering. It is, however, realistic and necessary to endeavor to establish some ethical principles that can guide the actions of bioengineers beyond their contingent legal obligations or at least to increase bioengineers' awareness of the ethical dilemmas that may confront them.

Ultimately, all forms of engineering are involved—directly or indirectly—in the modification of the biological world: For example, a highway, by bisecting a habitat, affects the ecology of that habitat and hence its biology. In the future, greater awareness and knowledge of biological processes resulting from advances in bioengineering will blur some of the boundaries between bioengineering and other fields of engineering, as in the creation of biomachines—intimate combinations of machines and biological organisms. This will add to the complexity of the ethical issues confronting the bioengineer and society.

GEORGE BUGLIARELLO

SEE ALSO *Bioethics; Biotech Ethics; Engineering Ethics; Medical Ethics.*

BIBLIOGRAPHY

Bejan, Adrian. (2000). *Shape and Structure, from Engineering to Nature*. New York: Cambridge University Press. Considers the application of engineering systems principles to patterns of biological forms and structures.

Berger, S. A.; W. Goldsmith; and E. R. Lewis eds. (2000). *Introduction to Bioengineering*. Oxford and New York: Oxford University Press. An introduction to mechanical, electrical, chemical, and biomehanial aspects of bioengineering.

Blanchard, Susan, and John Enderle. (1999). *Introduction to Biomedical Engineering*. San Diego: Academic Press. An overview of the field, including historical perspectives.

Bronzino, Joseph D. (2000). *Biomedical Engineering Handbook*. Vol. 2. Boca Raton, FL: CRC Press. A user-friendly, comprehensive handbook for bioengineering, including also ethical issues.

Bugliarello, George. (2003). *The Biosoma—Reflections on the Synthesis of Biology, Society and Machines*. New York: Polytechnic University. Considers the concept of machines (artifacts) as metabiological entities; covers the implications of their interactions with living systems and societal entities.

Eyth, Max. (1885). *Der Schneider von Ulm—Geschichte eines zweihundert Iahre zu früh Geborenen* [The tailor of Ulm: The history of someone born two hundred years too early]. Stuttgart, Germany: Deutsche Verlags-Anstalt. An account of one of the first non-mythical attempts at biomimesis.

Fung, Y.C. (2001). *Introduction to Bioengineering*. Singapore and River Edge, NJ: World Scientific, 2001. A biomechanics-focused treatise.

Kellert, Stephen R. (1996). *The Value of Life: Biological Diversity in Human Society*. Washington, DC: Island Press. A taxonomy of views of nature.

Konecci, Eugene B. (1968). "Impact of Bioastronautic Program Based Management on Planning Our Future Technological Base." In *Bioengineering: An Engineering View*, ed. George Bugliarello. San Francisco: San Francisco Press. An early view of the nature and significance of bioastronautics.

National Academy of Engineering. (2002). *The Bridge* 32(3). Washington, DC: Author. Contains articles detailing several views by engineers of the ethics of engineering.

BIOETHICS

Bioethics is a broad subject connecting advances in biological and medical science with moral concerns. Medical ethics is one large part of bioethics but by no means the only part. Bioethics has grown as a discipline precisely as science and technology have increasingly demonstrated that human beings are biological beings. Scientists have mapped the human genome and scanned the human brain. Researchers have evermore precisely shown the neural correlates of mental states, the genetic roots of behavior and illness. Through these developments, serious new ethical questions have been raised about studying and even modifying human biology. Bioengineering has also been used to replace parts of the human body that are no longer working or working well: dialysis kidney function, pacemakers stabilize irregular heartbeat, and respirators keep lungs pumping oxygen. Bioethics as a field is rooted in advances in technology just as is the case with the narrower field of medical ethics.

Broadly speaking, four sorts of issues in bioethics transcend the more restricted confines of medical ethics and the more global issues of environmental ethics. First are those that involve the tension between the needs of the few and possible risks to the many. The best example of this is biomedical research and the issues it poses of need, risk, consent, validity, and conflicts of interest. A second large set of issues relates the present to the future. How much and how quickly should humans change human biological nature with such technologies as cloning, stem cell research, genetic screening, selection, and therapy? A third set has to do with the response to pandemics such as AIDS and emerging "diseases of globalization" such as West Nile virus in the United States. The final set involves issues rooted in the way in which sophisticated technology enhances the disparity between rich and poor globally and provides opportunities for severe exploitation of the poorest of the poor.

Individuals and Society

Biomedical research, especially since the mid-twentieth century, has dramatically transformed medicine. The research itself, however, has been controversial and led to major national commissions reviewing the process of consent in the research setting as well as the establishment of federal oversight of clinical research funded by the government. The gold standard for research has always been the classic "double-blind" study in which matched sets of patients are given either the old standard treatment or the new treatment. Researchers do not know which patients are given which treatment so their conclusions about the efficacy of the new treatment supposedly cannot be biased by such knowledge.

But this can put health care professionals in a seriously compromising position. At some point before the end of the study a researcher may have reached a preliminary conclusion about which treatment is best. As a health care professional this person would appear obligated to provide the best available care for any patient. As a researcher, however, the individual should not destroy a study by stopping it too soon. Preliminary results are often superseded by longer-term studies. An example from the early 2000s is the case of hormone replacement therapy for postmenopausal women. The tension between individual and societal benefit in research is inevitable. What may benefit a few may raise risks for many.

For example, since the early 1990s many AIDS patients have demanded faster access to possible treatments, including vaccines that might give them short-term comfort. The AIDS community has argued that they have nothing to lose from looser access to unproven treatments or vaccines. They have a fatal disease and should, therefore, have access to any treatment that might, even hypothetically, offer some benefit even where no long term cure for AIDS is on the horizon. But mass access to unproven therapies can be dangerous for the many. A vaccine based on the use of live HIV could backfire and spread the disease. Treatments may work for a short time and encourage risky sexual behavior. If the virus then mutates around the treatment, then the result of not fully testing the treatment before widely using it may be increased suffering.

For the persons who are fatally ill, access to new therapeutic technology essentially adds no new risk to their situation. If the therapy does not work or even spreads the disease, they are no worse off. For society at large, however, the risk is much different.

The same tension between the individual and the group can also be seen in reverse. For example, if a mentally ill patient is doing well on a specific combination of medicine, it may be dangerous to this patient's health to change to a new experimental medication. Yet without studies that accurately compare older therapies with newer ones the larger community of patients that needs to be treated with psychotropic drugs will have to forgo any benefit from newer medication.

A third example of the tension between benefit to the individual and risks to the group comes from the emerging technology of xenotransplantation. This is the technology of animal-to-human transplants. Though tried sporadically since the 1960s, the use of animal organs to make up for the lack of human donor organs has never proven effective. The human body's rejection system rapidly recognizes that an animal organ, such as a pig liver, does not belong in a human body. The rejection of the foreign organ is immediate and complete.

New genetic technologies at least suggest a solution to these problems. Companies have created transgenic pigs that have two human genes. These are the precise genes that control the immediate rejection process. This means that morphologically compatible organs, such as those from pigs, might indeed be used as organs for human transplantation, at least until a human organ becomes available.

The problem is that organs from other species may carry new viruses or other diseases into the human population, diseases for which human beings have never developed any immunity. One such virus has been discovered in pigs, and others may be found. Here again is the tension between the individual and the group. No individual would accept a risky xenotransplant unless it was his or her last chance to prolong life. Persons high on the donor organ waiting would surely wait for a human organ. It is only the most desperate who would accept a transplant from transgenic pigs. For these persons the risk of a new infection is clearly outweighed by the certainty of death. For them the risk-to-reward ratio points in only one direction: Go for it. For society in general, however, the question is not nearly so easy. The general public is not terminally ill. For members of the public the risk of a new virus such as the notorious HIV is serious and likely outweighs the chance that they will need any transplanted organs in the future. For the sick individual a new technology carries one set of risk-to-reward ratios, whereas for a larger group the ratio reverses.

Can rules and policies be constructed that protect the group while providing opportunity for the desperate? At a minimum, perhaps, biological monitoring of patients and of those close to them should be required to uncover any new possible sources of disease. Should, therefore, the gravely ill be required to secure the consent of close family and friends to such monitoring before they can receive a transplant? What about possible rules for quarantine for those possibly exposed to an emergent new viral illness? These are some of the new bioethical questions that advances in genetics and transplant technology have raised.

A fourth area that displays the tension between benefits for the individual and risks to society concerns conflicts of interest within biomedical research. Research, to be valid, must remain rigorous and as far as possible objective. But care is not neutral or objective. Care focuses on one specific patient who needs help. Nowhere is the challenge of objectivity more serious than the evaluation of new drugs and other technologies that may enrich their inventors or discovers. Researchers studying the effect of a new drug may very well own stock in the company whose product they are evaluating. At the very least researchers hope to be funded again by their supporting companies. Can they really evaluate the results in a neutral way with such financial gains at stake? Can the heart surgeon who has perfected a new stent really be expected to ignore a potential windfall in evaluating this invention? But who else to go to for the best analysis of a new drug or technology? Not just any physician should be entrusted with such a serious evaluation. It seems obvious that the best specialists should perform the evaluation rather than just any individual with a medical degree. The specialists, however, are the very persons who will likely have the most to gain from positive evaluations. They are the ones whose knowledge of the field will allow them to invest wisely in just those companies whose cutting-edge technology they may very well be asked to evaluate. A positive evaluation may increase their wealth substantially. Even if they are not so invested, they certainly will want to continue doing substantial research for this company. If they offer too many negative evaluations, then they may not have their research funded in the future.

The problem of evaluating new biomedical technologies and their relationship both to individuals and to society is crucial as technology comes evermore to dominate the biological lives of humans. Specialists come to design, create, and evaluate the new technologies with less and less input from the public at large. This fact is not conspiratorial. It reflects the reality of increasingly specialized knowledge of technologies that influence human lives. The point made by Jacques Ellul in the 1950s, that humans live in a technological society from which they cannot easily abstract themselves, is nowhere better exemplified than in bioethics. Many people alive on the planet owe their lives to some biologically rooted technology, from vaccines to crops to gadgets. Without these technologies, many people would not be alive; with them humans exist as a result of technology, which transforms the biological face of the planet.

Bioethics and the Future

A second great area of bioethical inquiry concerns the use of technology to change the biological future of humanity. The first and most immediate question concerns human reproduction and the rising human population. The twentieth century witnessed a rapidly rising population not because the birthrate increased (in much of the world it actually declined) but because of increases in human longevity. The theoretical lifespan of a human being has not increased. Rather with technically improved sanitation, nutrition, and medical care, the average longevity of individuals has been dramatically increased. This increase has seriously outweighed any reduction in population from lower birthrates. The technology that has enabled this dramatic population increase has brought to the fore other questions about individual liberty to make reproductive choices and produced a rash of other technologies to control birthrates such as various forms of artificial contraception.

The development of technologies to control reproduction has produced rapidly declining birthrates in advanced countries such as Europe where declining births and aging populations has produced an "aging crisis" with too few workers to support the elderly and to supply workers for business. This sort of crisis would not be a problem if it were not for technology altering the rhythms of birth, life, disease, and death with which humans evolved for millennia.

A second form of technically driven effort to control and manipulate the human future comes in the form of attempts to screen out individuals with various forms of inborn, usually genetic, abnormalities. Of course, crude eugenics programs existed in the early part of the twentieth century whereby the "feebleminded" were permanently sterilized in an attempt to improve the biological future of humanity. Thirty thousand were sterilized in the United States. This process reached its horrible zenith in Nazi racial programs with their combination of ancient tribalism and modern technology.

More acceptable approaches to screening began in the early 1970s with the development of technologies enabling the screening of the unborn for abnormalities and of parents as carriers of genetic traits that when reproductively combined with a partner who had the same trait would produce a child with a genetic disease such as cystic fibrosis or sickle-cell anemia. These technologies provided parents ways to influence their own genetic offspring by selective abortion of any fetus that was abnormal. Over time, it could have substantial effects on the human future especially in technically advanced countries where pressures to have a "healthy child" are pronounced because it may be the only child that a specific couple has.

With the mapping of the human genome, scientists are increasingly able to pin down the specific genetic correlates of disease, from those cases in which a specific genetic abnormality causes a disease to cases in which genetics are only part of the cause of a human disease, or even to identify traits such as homosexuality. Because technology enables the identification of the genetic roots of many human traits, it increasingly empowers individuals to control their own fate and the fate of their progeny. If a woman knows, for example, that she has the BRCA1 breast cancer gene, and a first-degree relative actually has breast cancer, she then knows that she is very likely to get breast cancer. The data suggest that with these two factors, genetics and a case history, 85 percent of the time she will get breast cancer. With knowledge comes the opportunity for more rigorous screenings and the use of technology to avoid breast cancer. Knowledge of the gene changes her future and possibly that of her daughters.

Another example of how genetic knowledge changes the future is Huntington's Disease. This is a recessive genetic disorder that does not manifest itself until a person is in their late 30s After that the person progressively loses muscle control and eventually dies after a 5–7 year period. In the process they often need to be tied down to avoid hurting themselves with spastic movements. One can know even before birth whether one will have the disease or is a carrier. Knowledge of this fact surely will alter marriage, career, and family plans.

But the power of selection immediately raises the question of whether there is one "correct" sort of choice in various situations. Should some choices be encouraged, and others financially or otherwise discouraged? Should parents be encouraged to abort fetuses with some abnormality that will be costly to treat and denied insurance for future related treatments if they bear the child? In another actual example a young woman who had breast cancer in her family tree was considering the test for the breast cancer gene. Her insurer insisted that if they paid for the test they owned the results. If the results were positive, then it was highly likely that she would come down with breast cancer. The insurer made her an offer: They would pay for double radical mastectomy, or they would drop coverage for breast cancer from her policy. Knowledge changed a risk into a near certainty. It was no longer insurance against risk but a prepayment scheme for almost certainly needed services.

Genetic screening and testing thus raise direct and lively issues in the present. Issues that loom in the near future involve genetic engineering. Most authors reflect one of three possible responses: (1) passionate advocacy of human genetic engineering (Silver 1997, Stock 2002); (2) cautious acceptance (Buchanan et al. 2000); or (3) wary hostility (Kass 2002). Authors commonly begin arguing that the possibility of genetically designing human offspring is at hand. Actually, the capacity for genetic design is decades away if it is even possible. Many experts are increasingly doubtful that any rapid breakthroughs are likely. Despite several years of effort, cloning primates is turning out to be much more difficult than anticipated.

Supporters and critics of "redesigning humans" claim that whatever the current difficulties, it will eventually be possible to add or delete targeted genes. Combined with in vitro fertilization, this technology will allow people to choose the genetic destiny of their offspring. Because at some point in the future this scenario is likely to be possible, it should be the subject of discussion now. The technology would first be developed to treat genetic diseases such as Tay-Sachs or Huntington's chorea; no responsible parent could ever want such a disease to strike their descendants. But the technology that enables gene addition or deletion, that is, the "knockout" of something such as the specific gene for Huntington's or retinoblastoma, could just as easily be used to eliminate color blindness, male pattern baldness, or a tendency toward depression or addiction. But retinoblastoma, which leads to early blindness, seems clearly different than male pattern baldness, which is specifically genetic, or more loosely genetic dispositions to shyness or alcoholism. Both baldness and retinoblastoma are genetic but the argument for using knockout technology in the case of inherited blindness such as retinoblastoma seems much clearer than in baldness to which the term disorder or disease seems only loosely, if at all, to apply.

Some who have carefully studied these matters are moderate, voluntaristic optimists. They argue that, with care, patience, and thoughtfulness, humans can use technology wisely to eliminate Tay-Sachs or retinoblastoma from pedigree without committing to a complete redesign of human beings. Others such as Gregory Stock combine a sort of naive optimism with technological determinism. For them, the technology of redesign is fast approaching and will be used. So sign up to the inevitable future and go along for the ride.

The third group of writers, including conservatives such as Francis Fukuyama (2004) and Leon Kass (2002), or leftists such as Andrew Kimbrell (1998), seem like lonely fatalists who fear there is no realistic possibility of stopping the redesign of humanity. They seem fatalistic about the attempt and depressed at the prospect. Some have forsaken revealed religion as a means of guiding technology, so they cast their lot with human nature as a standard. Now, however, they seem to accept that Eden will be remade. Humankind's ability to do so, however, seems to undermine the very appeal to nature for guidance about the attempt. Hence, they are left rudderless in an ocean of uncertainty.

The same set of three views also appear in debates over human cloning. Passionate advocates such as Lee M. Silver (1997) and Stock (2002) see nothing wrong with the inevitable occasional practice of reproductive cloning. They think that in fact it will be used only occasionally, but are in principle not opposed to its widespread practice. Cautious acceptance is illustrated by Robert Wachbroit (1997), who argues that cloning can be used wisely and infrequently in cases of special need, for example, bone marrow for a child, without promoting widespread or general acceptance. Finally, Leon Kass (2002) and others, based on their conclusion that human cloning is an affront to human dignity, propose legal prohibitions on all such cloning, reproductive and therapeutic (arguing they cannot be separated and that the potential benefits of therapeutic cloning can be secured by other means).

Contemporary issues in bioethics thus pose a fundamental technological question with respect to the future: Does technology unleash the human passion for improvement in ways that reason cannot control? Is reason, as Thomas Hobbes (1588–1679) argued, a slave to the passions? If so, then technology, the supreme product of scientific reason, is only a tool to satisfy human desire for longevity, pleasure, and domination. Humans want a life of ease not disease. Technology thus aims to please by manipulating human biology to satisfy desires. Is this destiny or choice? If the former, then bioethical reflection is beside the point. If the latter, what choices should the collective bioethical wisdom of humankind encourage humans to make? Are humans now fated to a technological civilization from which they cannot escape as was argued by Martin Heidegger in his seminal essay "Question Concerning Technology" and by Ellul, Marcuse and others?

Bioethics and Globalization

A third area of bioethical inquiry especially related to science and technology concerns issues of globalization. Globalization is profoundly the result of technology. Technology has standardized production methods for low-skill workers in low-wage countries. It has increased information and travel networks to enhance information and capital flows across national and continental boundaries. Finally it has enhanced transportation of raw materials and finished goods from low-wage mines and factories to markets in the developed world. The first place where bioethics meets globalization is in the discussion of agricultural biotechnology and its impacts on peoples in developing countries.

But globalization and biology meet as well in the increasing flow of diseases around the world from those places where they have developed and coevolved with human and other species to new locations where they have created new problems for human life. The slave trade created an early instance of such problems. Sickle-cell anemia, which affects persons of African descent, carries no evolutionary advantage. Carrying the sickle-cell trait, which is recessive, does not produce the disease but nevertheless carries a resistance to virulent strains of malaria. In North America, which is malaria free, carrying the trait has no advantage, and a couple who both have the same recessive trait may conceive offspring with the disease. In sub-Saharan Africa, however, where as much as 40 percent of the population carries the trait, selective advantage is conferred. Thus moving the disease out of its evolutionary nest has raised issues for advanced countries, such as the need for screening programs for prospective parents of African descent, that would have not existed except for the global slave trade.

In another case, AIDS is a global pandemic that has grown rapidly with increased contact between human beings. HIV developed in Africa, but the effects have become global, and it has raised a number of serious new issues such as quarantine, the right to health care for those whose illness is the result of their own behavior, and a search for vaccines and specialized therapies that has consumed large amounts of research funds. Globalization has raised questions about competing needs to develop, for example, AIDS therapies versus an effective malaria vaccine—malaria being a disease that kills more persons who are much less responsible for their illness.

One final example is the appearance of West Nile virus in North America. As the name indicates, the historical location of this disease has been Africa and the Middle East. Borne by mosquitoes, it first appeared in the New York area in 1999. Over the next few years it spread virtually over the whole North American continent. It has become biologically fixed in this new location. It can be contained and treated, but will not be eradicated.

In a profound way, technology has become a part of the biological process of evolution. Technologies of globalization have spread disease from historic locations such as those of West Nile virus. Technology has become a sort of disease vector, a route by which new diseases travel to distant targets. If technology brings new populations into deep contact with what for them are new diseases, it also provides these same populations with means for evolutionary survival in the face of these and other diseases. Technology, for example, gives treatment for AIDS, means for tracking the spread of disease, and possibilities for other treatments. When technology is used to extend the power of humanity over a disease, the disease may become a serious one but one with which humanity can coevolve. Technology both causes the need for coevolution for North Americans with something such as West Nile virus and provides the means for such evolution, from spraying for mosquitoes to treatments, and if necessary to the development of vaccines. Technology thus becomes part of the Darwinian enterprise of evolutionary survival.

These problems have antecedents in the European colonization of the Americas where new diseases were brought by the settlers. But they now have more rapid global movement as a result of technology and technology can be aimed at providing cures or effective treatments of diseases of globalization.

Bioethical Justice

A final way in which global growth of technology both in medicine and transportation affects bioethics is by creating an emerging transnational trade in medical services. One example is the creation of a transnational market for so-called back-office operations. Billing has been outsourced to foreign low-wage countries for years. With information networks now available it is just as easy to bill insurers from Jamaica as it is from Kansas. The benefit is that Jamaicans or Indians will work for half or less of the U.S. minimum wage. But with increasingly sophisticated computer technology and education in less developed countries, even "back-office" physician or pharmacy services can be outsourced. Highly qualified radiologists in China could read standard X rays on their monitors for a third of the cost in the United States. Complicated readings might require a physician on the scene in the United States, but the yearly mammogram and similar procedures could be sent abroad. Billing is one thing, but how would patients personally discuss their test results with physicians halfway around the globe?

Pharmacy services will also increasingly be outsourced. With pharmaceutical prices in the United States still high and transportation increasingly efficient, it will become increasingly common for such drugs as Viagra to be made in China and shipped by anonymous clerks to U.S. addresses. The key issue here is the balance between price and safety. Can or should the government interfere to "protect" individuals from possibly unwise purchases of drugs from foreign sources that lack serious regulatory frameworks?

The transnational trade in medical services also includes highly technical services, which, being provided transnationally, are available only to those who can pay up-front. The best known and most troubling of these developments is the international trade in organ transplants, chiefly kidney or liver transplants. A person needs only one kidney to survive, and in some cases people have donated a kidney to save the life of a close relative. But enter a market made possible by technology: Highly qualified surgeons in India or China or elsewhere provide transplant services in fully staffed clinics primarily for other Asians with a desire for life and the wealth to pay. The surgeon and staff are well compensated. But in India, for example, the poorest of the poor are paid about $1,500 for a kidney. This amounts to a lifetime savings for the donor, but possibly no more than the cost of a plane ticket for the recipient. This raises enormous questions of justice and exploitation. Does money exploit the poorest of the poor who desperately need assistance? Does the whole practice raise questions of justice, where the rich can pay and the poor only suffer?

These questions also occur in increasing ways in the United States. At any one time hundreds of individuals in the United States are advertising a kidney for sale on the Internet. For the most part these are desperate lower or lower middle class people trying to avoid bankruptcy, home foreclosure, or property repossession. They see such a sale as one of the few ways to improve their fortune short of illegal activity or hitting the lotto. But does their very poverty make them subject to coercion and thus unable to give free and informed consent? In the United States researchers are forbidden from using prisoners for drug experiments because of the problems of coercion and lack of the ability to give informed consent. Would not the same argument apply to the desperate and the hopeless, who are ready to sell body parts via Internet technology? Technological power to commodify even the most personal of things, one's own body, creates bioethical issues that previous eras could avoid. Technological fatalism may overstate the case, but it does seem that the questions raised are inevitable.

Thus, technology may provide a means of evolutionary development in the face of changing biology. As such, technology develops around the fundamental biological and thus bioethical imperative of preserving human life. In the context of such a nexus between technology and Darwinism, bioethics provides both the comprehensive understanding of the problem and the subsidiary rules of honesty, disclosure, integrity, and justice that provide the moral ambit within which technology may be a morally acceptable vehicle for human well-being in a fundamentally Darwinian world.

What remains is the fundamental question of all technology. Can modern technology be contained within reason, or does the eternal passion for life and health overwhelm reason's capacity to moderate human desires within an ambit of moral principles and virtues?

RICHARD SHERLOCK

SEE ALSO *Agriculural Ethics; Bioengineering Ethics; Bioethics Centers; Bioethics Committees and Commissions; Biotech Ethics; Environmental Ethics; Genethics; Medical Ethics; Neuroethics; Posthumanism.*

BIBLIOGRAPHY

Brody, Baruch A. (1998). *The Ethics of Biomedical Research.* New York: Oxford University Press.

Buchanan, Allen; Dan W. Brock; Norman Daniels; and Daniel Wikler. (2000). *From Chance to Choice: Genetics and Justice.* New York: Cambridge University Press.

Ellul, Jacques. (1954). *La technique; ou, L'en jeu du siècle.* Paris: A. Colin. Translation by John Wilkinson as *The Technological Society* (New York: Knopf, 1964).

Fukuyama, Francis. (2004). "Transhumanism." *Foreign Policy* (September/October): 67–69.

Heidegger, Martin. (1977). *The Question Concerning Technology, and Other Essays.* New York: Harper and Row.

Kass, Leon R. (2002). *Life, Liberty, and the Defense of Dignity.* San Francisco: Encounter.

Kimbrell, Andrew. (1998). *The Human Body Shop.* Washington, DC: Regnery Books.

Land, Walter, and John B. Dosseter, eds. (1991). *Organ Replacement Therapy: Ethics, Justice, Commerce.* New York: Springer-Verlag.

Levine, Robert J. (1986). *Ethics and Regulation of Clinical Research,* 2nd edition. Baltimore: Urban and Schwarzenberg.

Loue, Sana. (1999). *Textbook of Research Ethics.* Dordrecht, Netherlands: Kluwer Academic.

Murphy, Timothy F. (2004). *Case Studies in Biomedical Research Ethics.* Cambridge, MA: MIT Press.

Nuffield Council on Bioethics. (1996). *Animal-to-Human Transplants: The Ethics of Xenotransplantation.* London: Author.

Robertson, John A. (1994). *Children of Choice.* Princeton, NJ: Princeton University Press.

Silver, Lee M. (1997). *Remaking Eden: Cloning and Beyond in a Brave New World.* New York: Avon.

Stock, Gregory. (2002). *Redesigning Humans: Our Inevitable Genetic Future.* Boston: Houghton Mifflin.

U.S. Institute of Medicine. (1996). *Xenotransplantation: Science, Ethics, and Public Policy*. Washington, DC: National Academy Press.

Youngner, Stuart J.; Renée C. Fox; and Laurence J. O'Connell, eds. (1996). *Organ Transplantation*. Madison: University of Wisconsin Press.

INTERNET RESOURCE

Wachbroit, Robert. (1997). "Genetic Encores: The Ethics of Human Cloning." Report from the University of Maryland Institute for Philosophy and Public Policy, Volume 17, Number 4. Available from http://www.ifgene.org/wachbroit.htm.

BIOETHICS CENTERS

Although there have been concerns involving medical ethics since ancient times, bioethics is an invention of the late twentieth century. The first freestanding center devoted to bioethics was created in 1969. By the beginning of the twenty-first century, most major American institutions of higher learning and most American medical schools had centers, institutes, or programs devoted to the study of biomedical ethics. The bioethics center is no longer a uniquely American institution but an international phenomenon, with new centers continuing to be established all over the world.

Hastings Center

The first bioethics center resulted from the work of a newly minted Harvard Ph.D., the philosopher Daniel Callahan. In the late 1960s, while writing a book on abortion, Callahan found himself engaging with a complex interdisciplinary literature that took him outside the boundaries of traditional philosophical inquiry. As a result of the sharp disciplinary boundaries of that time, Callahan was forced to investigate areas of law, social science, public policy, and medicine. Realizing that advances in science and medicine would continue to generate ethical dilemmas that would require interdisciplinary study and reflection, Callahan set out to create a place where those issues could receive serious, focused attention from multiple perspectives and academic disciplines.

Because that type of center would attempt to cross disciplinary boundaries, it had no natural academic home. To realize the vision of being truly interdisciplinary—bringing together individuals from the fields of theology, philosophy, law, medicine, and science—the new institute would have to be a freestanding institution that was not constrained by the boundaries of traditional academic disciplines. Callahan presented his proposal to a casual acquaintance and fellow resident of the town near New York City where he lived, Hastings-on-Hudson. The physician-psychoanalyst Willard Gaylin, a professor at the Columbia University College of Physicians and Surgeons, thought that the idea for a new institute was timely and appropriate. Together they sought financial support from individual donors and foundations to establish an institute that would examine ethics and the life sciences, and in 1969 the Hastings Center was founded. Originally called a Center for the Study of Value and the Sciences of Man, the Hastings Center opened in September 1970.

Kennedy Institute

In the same year a similar dialogue took place at Georgetown University in Washington, DC. Dr. Andre Hellegers, a faculty member in the department of obstetrics and gynecology in the School of Medicine, was concerned that discussions of the ethical issues in reproductive medicine were being relegated to conferences and professional meetings rather than being the subject of sustained and concentrated scholarship. He proposed the creation of a center to study reproductive ethics to the president of Georgetown, Reverend Robert Henle. In December 1970 they sought support from the Kennedy Foundation. In July 1971 the Kennedy Institute of Ethics opened at Georgetown University. Unlike the Hastings Center, which avoided academic ties for fear of losing its interdisciplinary orientation, the Kennedy Institute embraced its connection to Georgetown University. The institute established faculty chairs and a degree program run in conjunction with the university's philosophy department.

Although different in organizational structure, the Hastings Center and the Kennedy Institute quickly became crucial entities in the creation of the field of bioethics. Both institutions created libraries, issued publications, amassed grants, set out research agendas, and brought together scholars who became the early leaders in the field.

Expansions

Over the next thirty years dozens of bioethics centers and institutes were created. Almost all were housed within universities. By the 1980s many were established in academic medical centers.

Early bioethics centers were populated mostly by philosophers and theologians. In the 1970s those scholars were joined by lawyers and physicians as well as a few nurses, social scientists, and economists. The shift toward locating bioethics centers in academic medical centers reflected both the increasingly large role played by physicians in bioethics and the increasing legitimacy of bioethics as an area of inquiry important to the health sciences.

Beginning in the mid-1990s, a greater emphasis on what Arthur Caplan called empiricized bioethics emerged. Pressure to conform to the norms of academic medical centers meant that faculty members and students at bioethics centers had to be able to publish in leading medical and scientific journals. As a result, the empirical study of ethical issues and norms became a key aspect of the responsibilities assigned to bioethics centers. By the early 2000s social scientists and empirically trained clinicians held significant numbers of faculty positions in those centers, in some cases constituting the majority of their membership. Many bioethics centers continue to be shaped by the criteria for scholarship and promotion that prevail at medical schools in the United States and Europe. Whereas normative analysis once dominated bioethics discourse within and outside centers, many bioethicists have begun to speak in the language of descriptive facts, economic realities, and culturally based moral practices.

The location of bioethics centers in academic institutions has had another professionalizing influence on the field: the creation of professional degree programs. In 2003 there were over sixty master's programs in bioethics, and most of those degrees were granted through the centers in conjunction with the schools of which they were a part. Scholars who joined the field in its early days were all "immigrants," entering from disciplines as diverse as anthropology, sociology, philosophy, theology, medicine, law, public policy, and religion. Because of their institutional structure, centers provided appropriate homes for persons with very different disciplinary backgrounds. However, bioethics scholars in the future will be required to have specific bioethics credentials, either master's degrees or doctorates in the field. Increasingly, they may be employed in academic departments rather than in centers or institutes.

Assessment

The extent of the influence of bioethics centers on science, technology, and ethics is hard to gauge. Unlike traditional academic disciplines or centers whose goal is erudite scholarship, bioethics centers see as their mission not only the creation of new scholarly knowledge, but also engagement with professional groups, the public, and public officials who set policies. Bioethics centers commonly have elaborate outreach programs that include websites, newsletters, a strong media presence, public conferences, writings for the lay press, and distance learning programs. Many members of bioethics centers are public figures, scholars whose work extends beyond their academic base. They have shaped policy and public opinion on issues as far-ranging as informed consent, stem cell research, abortion, euthanasia, cloning, organ donation, research ethics, patenting, and genetically modified foods.

Bioethics centers first appeared as a response to emerging moral challenges, often technologically driven, in American health care. They became the locations where interdisciplinary work on complex moral problems could be done. Their future is uncertain. Bioethics has matured and become a discipline with journals, encyclopedias, awards, and book series. Although new ethical concerns continue to emerge in health care in the United States, in Europe, and internationally, the future of bioethics centers is not clear. With the emergence of a "professionalized" discipline that is both empirical and normative, it is likely that the work done in bioethics increasingly will be accomplished in academic departments. The success of the early bioethics centers and institutes may have created a field that has outgrown its older institutional structures.

ARTHUR CAPLAN
AUTUMN FIESTER

SEE ALSO *Bioethics; Bioethics Committees and Commissions.*

BIBLIOGRAPHY

Callahan, Daniel. (1973). "Bioethics as a Discipline." *Hastings Center Studies* 1: 66–73.

Fox, Daniel. (1985). "Who Are We?: The Political Origins of the Medical Humanities." *Theoretical Medicine* 6: 327–341.

Jonsen, Albert. (1998). *The Birth of Bioethics.* New York: Oxford University Press.

Post, Stephen G., ed. (2004). *The Encyclopedia of Bioethics,* 3rd ed. New York: Macmillan Reference USA.

Potter, Van Rensselaer. (1971). *Bioethics: Bridge to the Future.* Englewood Cliffs, NJ: Prentice-Hall.

Reich, Warren. (1994). "The Word 'Bioethics': Its Birth and the Legacies of Those Who Shaped Its Meaning." *Kennedy Institute of Ethics Journal* 4: 319–336.

BIOETHICS COMMITTEES AND COMMISSIONS

Since its inception in the 1970s, bioethics has been manifested not only in academic debate but also in committees or commissions directed toward the guidance of public discussion and policy making. In the research and clinical settings, Institutional Review Boards (IRBs), Institutional Biosafety Committees (IBCs), and Hospital Ethics Committees (HECs) serve the practical functions of bringing reflective expertise and modest public consensus to bear on ethical implementations of advancing scientific and technological forms of medicine and other biological research. At the state, national, and international levels, more general committees and commissions have sought to provide reflective consideration and policy guidance. These committees come in three types: term-limited, ad hoc, and permanent. The role these committees and commissions play in government and society depends on their structure and mission, the larger historical and social contexts, and trade-offs between broader, more fundamental inquiry and narrower, more policy relevant recommendations.

Bioethics Commissions in the United States

There are two broad classifications for federal bioethics commissions and committees in the United States: general and topic specific. General bioethics commissions have been appointed by Congress or the President to conduct inquiries into a diversity of issues and have both fostered wide-ranging public discussion and produced targeted policy recommendations. Topic-specific initiatives have in turn been created by different government agencies or the President to address specific technologies or aspects of scientific research. Other important elements in this context include the former Office of Technology Assessment (OTA) and other research and assessment agencies of government, state-level bioethics committees, and academic and nongovernmental bioethics centers and committees.

GENERAL FEDERAL BIOETHICS COMMISSIONS. Between 1974 and 2004, there were six general federal bioethics commissions (see Table 1 for a summary). The first public body on the national level to shape bioethics policy was the National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research (National Commission). Created by the National Research Act of 1974 under Republican President Gerald Ford, the National Commission operated until 1978 and was administered by the Department of Health, Education and Welfare (DHEW). It contributed to the first federal regulations for the protection of human subjects of biomedical and behavioral research. The principles that served as the basis of these regulations were outlined in its 1978 Belmont Report, and the regulations became institutionalized in the form of Institutional Review Boards (IRBs). The National Commission also produced reports on research involving vulnerable subjects including prisoners, those institutionalized as mentally infirm, fetuses, and children.

One of the recommendations of the National Commission led to the creation of the Ethics Advisory Board (EAB) in 1978. During its approximately two-year existence, the EAB focused on issues involving fetuses, pregnant women, and human in vitro fertilization (IVF), but it had a broad charter that allowed it to investigate many bioethics issues. Originally intended as an ongoing standing board, the EAB was nonetheless disbanded by the Office of Science and Technology Policy in 1980 after producing four documents. Two major outcomes were the stipulation of criteria for federally-funded research in IVF and a pronouncement on human embryo research, which began a fifteen-year moratorium on such research.

One of the reasons the EAB was disbanded was because policy makers failed to distinguish its purposes from those of the President's Commission for the Study of Ethical Problems in Medicine and Biomedical and Behavioral Research (President's Commission) created by Congress in 1978 under Democratic President Jimmy Carter. The President's Commission had a broad mission and the authority to initiate its own reports on emerging issues judged important by its members. It was elevated to independent presidential status (by contrast, the National Commission had operated autonomously within the DHEW). Also unlike the National Commission, the President's Commission produced fewer specific recommendations targeted at federal agencies. Instead, it produced consensus reports that articulated mainstream views. These reports are highly regarded and "many have had sustained policy influence" (United States Office of Technology Assessment 1993, p. 12). Its report on foregoing life-sustaining treatments was most influential, and it led to the development of living wills. After a three-month extension, the President's Commission expired in March 1983 under Republican President Ronald Reagan.

The Biomedical Ethics Advisory Committee (BEAC) was the fourth government-sponsored general bioethics body. In 1986, Congress established the Biomedical Ethics Board (BEB), which was composed of six

Senators and six Representatives (this was modeled on the Technology Assessment Board, which oversaw the United States Office of Technology Assessment [OTA]). It took the BEB more than two years to appoint all the members of the BEAC, and in September 1988 (less than a week before it was originally scheduled to expire) the BEAC held its first meeting. Largely due to partisan politics around the abortion issue, BEAC's appropriations were frozen and it was unable to produce any reports before it officially expired in September 1989 under Republican President George H. W. Bush.

There followed an extended hiatus until Democratic President Bill Clinton signed an executive order to create the National Bioethics Advisory Commission (NBAC) in 1995. Chaired by Harold T. Shapiro, the NBAC held its first meeting in 1996, and its original mission was to investigate the two priority areas of human subjects research and genetic information. After the cloning of the sheep Dolly in 1996, however, President Clinton also requested a report on cloning. This became the NBAC's first report, which recommended that federal regulation be enacted to ban research using somatic cell nuclear transfer cloning to create children. It recommended that such legislation be crafted so as not to interfere with other uses of cloning that may not be as ethically problematic. The NBAC also produced reports on research involving biological materials, stem cells, and persons with mental disorders that may impair decision-making abilities. The NBAC recommended that federal funding be used only on stem cells derived from two sources: cadaveric fetal tissue and embryos remaining after infertility treatments. The NBAC expired in 2001.

The stem cell issue sparked the creation of the President's Council on Bioethics by George W. Bush (via executive order) in 2001. In his first national address, Bush created a new policy for the federal funding of stem cell research and announced the formation of the Council under the direction of Dr. Leon R. Kass.

TOPIC-SPECIFIC INITIATIVES. Other committees and commissions have been created by the U.S. government in order to provide topic-specific guidelines and recommendations (see Table 2 for a summary). The first noteworthy example is the Recombinant DNA Advisory Committee (RAC), which was created in 1976 in accordance with the National Institutes of Health (NIH) Guidelines for Recombinant DNA Research. The RAC is a permanent committee housed in the NIH that serves a threefold function: to provide a public forum for discussion about issues involving recombinant DNA, to make recommendations to the director of NIH, and to review certain individual research protocols. In this last role, the RAC often works in conjunction with IRBs and IBCs.

TABLE 1

General U.S. Bioethics Commissions

Name	Duration
National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research (National Commission)	1974–1978
Ethics Advisory Board (EAB)	1978–1980
President's Commission for the Study of Ethical Problems in Medicine and Biomedical and Behavioral Research (President's Commission)	1978–1983
Biomedical Ethics Advisory Committee (BEAC)	1986–1989
National Bioethics Advisory Commission (NBAC)	1995–2001
President's Council on Bioethics (Council)	2001–

SOURCE: Courtesy of Adam Briggle and Carl Mitcham.

Most other topical committees have been temporary. In March 1988, the Assistant Secretary for Health directed the NIH to appoint an ad hoc panel that became known as the Human Fetal Tissue Transplantation Research Panel. The panel met three times and issued its final report in December 1988, which approved federal funding for research involving the transplantation of human fetal tissue from induced abortions. Although not a commission, the Ethical, Legal, and Social Implications (ELSI) research program marks a landmark investment in bioethics research by the federal government. ELSI was begun in 1989 by the NIH and the Department of Energy (DOE) as a joint project to fund research on the social implications of developments associated with the Human Genome Project (HGP).

The NIH formed the Human Embryo Research Panel in January 1994. This panel classified human embryo research into three categories and drafted guidelines for the review and conduct of acceptable research. Also in 1994, President Clinton created the Advisory Committee on Human Radiation Experiments, and charged it to investigate and report on the use of human beings as subjects of federally-funded research using ionizing radiation. The committee found the government blameworthy for not having procedures in place to protect the rights of human research subjects exposed to radiation without their consent. One final example of a topical commission is the Advisory Commission on Consumer Protection and Quality in the Health Care Industry. Created by executive order in 1996, this thirty-two-member commission focused on patient protections and consumer satisfaction in the health care industry. It developed the *Consumer Bill of*

TABLE 2

Topic Specific U.S. Bioethics Commissions

Name	Duration and Agency
Recombinant DNA Advisory Committee (RAC)	Permanent (created in 1976); NIH
Human Fetal Tissue Transplantation Research Panel	March–December, 1988; NIH
Ethical, Legal, and Social Implications (ELSI) program	Begun in 1989, the Human Genome Project expired in 2003 (but other ELSI programs continue); NIH and DOE
Human Embryo Research Panel	1994; NIH
Advisory Committee on Human Radiation Experiments	1994–1995; created by President Bill Clinton, reported to Cabinet-level group
Advisory Commission on Consumer Protection and Quality in the Health Care Industry	1996–1998; created through executive order by President Bill Clinton

SOURCE: Courtesy of Adam Briggle and Carl Mitcham.

Rights and Responsibilities in 1997, and issued its final report, *Quality First: Better Health Care for All Americans*, in 1998.

STATE LEVEL AND NONGOVERNMENTAL COMMISSIONS. Many state legislatures and executive branches must incorporate bioethics into their public policy making. Given this growing need, several states have created committees and commissions, most of which have been devoted to a single issue. Access to health care has been the single largest issue addressed by state-level committees. Some states, however, have created commissions designed to consider a broad range of issues. Two examples of state-level commissions are the New Jersey State Commission on Legal and Ethical Problems in the Delivery of Health Care, created in 1985 as a permanent legislative committee, and the New York State Task Force on Life and the Law, also created in 1985, with a broad mandate to make recommendations for policies involving medical technologies.

In addition to academic bioethics centers, several nongovernmental organizations in the United States have created bioethics centers or committees. For example, the American Medical Association, the nation's largest professional association of physicians, houses the Institute for Ethics, which studies ethical issues related to health care and biomedical research. Many churches and religious groups have also established bioethics committees. Two examples are the American Bioethics Advisory Commission, founded by the American Life League, and the Center for Bioethics and Human Dignity, founded by several Christian bioethicists.

International Bioethics Commissions

Before the term *bioethics* was used, the Nuremberg War Crimes Tribunal in 1945 made the treatment of human subjects in scientific research a major issue. Subsequent work by the World Medical Association led to the Declaration of Helsinki in 1964, which outlined ethical principles for medical research involving human subjects.

The first explicitly-named bioethics group on the international level was the Steering Committee for Bioethics (CDBI), which is a multidisciplinary ad hoc group created by the Council of Europe in 1983 (although it underwent name changes in 1985 and 1993). CDBI adopted the first international treaty on bioethics in 1996. The Commission of the European Union has also established bioethics committees, including the Working Group on Human Embryos Research; the Working Group on Ethical, Social, and Legal Aspects of Human Genome Analysis; and the Working Party on Ethical and Legal Issues Raised by New Reproductive Technology (also known as the Glover Commission), which produced the Glover Report in 1989.

On an even broader international level, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) division of Ethics of Science and Technology created two bioethics advisory bodies in 1993 under the umbrella term of Bioethics Program: the International Bioethics Committee (IBC) and the Intergovernmental Bioethics Committee (IGBC). A major outcome of this program was the adoption of the Universal Declaration on the Human Genome and Human Rights by the General Conference, the only international instrument in the field of bioethics, endorsed by the United Nations General Assembly in 1998.

Bioethics Commissions Outside the United States

Susan Poland (1998) compiled a comprehensive list of bioethics committees and commissions around the world (see also Martinez 2003). Although dominated by the United States, Canada, and Europe, there have been commissions in the Philippines, Mexico, Japan, Turkey, Russia, Israel, and elsewhere. What is most striking about this list is the diversity in structure, function, duration, context, and other variables. For example, although many commissions are temporary, there are some permanent and semi-permanent bodies. Canada and Australia have established permanent law reform commissions to make recommendations to parliament (Kasimba and Singer 1989, Williams 1989).

An example of a permanent committee more strictly focused on bioethics is the French National Consultative Committee on Ethics in the Biological and Medical Sciences (CCNE). Created in 1983, this agency is the first broad bioethics commission on a national level in France with the power not only to review research protocols but also to advise the government on appropriate legislative action (Isambert 1989). Another example of a permanent advisory body is the Human Genetics Commission in the United Kingdom, which is a non-statutory, independent advisory committee established in 1999. Its role is to advise Ministers on the appropriate response to developments in human genetics. Yet another example is the Standing Committee on Ethics in Experimentation established by the Medical Research Council of Canada (a grant-funding institution for health science research) in 1984. This committee aids in the development of federal policy as well. In 2004, Israel began formalizing plans for a National Council of Bioethics, which will serve as a governmental statutory authority, allowing it to monitor existing bioethics committees and giving it rather unusual legislative power for a bioethics panel.

Other bioethics commissions are special instantiations of a broader model of commission-based inquiry used by governments to investigate problems that face decision makers. Several European parliaments utilize the model of Enquete commissions, which are temporary bodies established to provide policy advice on vast range of issues. Many Enquetes have focused on bioethical issues; for example, the German commission studying "Law and Ethics of Modern Medicine" (2000; reinstated in 2003). Moreover, as in the United States, not all bioethics commissions are established by governments. For example, in Canada nongovernmental organizations such as the Canadian Medical Association and certain churches have formed bioethics committees.

Some bioethics commissions have exerted their influence on the future work of other commissions around the world. The Warnock Commission in the United Kingdom (chaired by philosopher Dame Mary Warnock) is one example. This fifteen-member committee met from 1982 to 1984 in order to examine the social, ethical, and legal implications of developments in assisted reproduction. Its report, *The Warnock Report on Human Fertilization and Embryology* (1984), is a landmark in the field because of its treatment of moral issues and its forthright explanation of the difficulties in seeking moral consensus. This distinguished it from previous reports (such as Peel [1972] and Black [1980]). Furthermore, the report was concise, readable, and showed respect for dissenting views (Campbell 1989). Both the process and product of this commission have influenced the work of other bioethics committees.

Historical and cultural contexts are crucial elements in determining the parameters for both the style and content of bioethics commissions. For example, in Japan there is a long tradition of paternalistic and authoritative relationships between medical professionals and patients and their families. Although there is a deep respect for elders in Japanese culture, there is also an ingrained research-oriented mentality that treats patients more as medical cases than persons (Kimura 1989). The culture is rapidly changing in Japan, but these traditions shape the challenges faced by bioethics commissions, because democratic deliberation and the "rights based" approach to medical ethics are both relatively new. In Germany, the Nazi legacy has left a "culture of remembrance" that vows to never again relive the horrors of state-sponsored eugenics and applied biology (Brown 2004). The protection of the sanctity of persons is written directly into its constitution, and Germany has a history of strict bioethics policies. Germany's unique history has impacted the way it structures inquiries into matters of bioethics. For the most part, German bioethics commissions have been conservative, control-oriented, paternalistic, and skeptical of scientific and technological developments (Sass 1989). The creation of the National Ethics Council by Chancellor Gerhard Schröder in 2001, however, signified a break in this dominant culture as once-taboo topics were made available for more serious discussion.

In contrast to the United States, many bioethics commissions in other nations have more limited public access policies. However, like the United States, most of these commissions include members who are not health care professionals or scientists.

Assessment

Bioethics commissions and committees have been created to serve a variety of purposes, including helping heterogeneous societies articulate common values and foster consensus about biomedical advances; serving as a crucial interface for science and politics; providing specific policy recommendations, technical advice, and even serving the judiciary; reviewing the implementation of existing laws; educating the general public about complex ethical issues arising from the rapid development of science and technology; serving as a forum for public participation in policy making; undertaking research; legitimizing action; and delaying action (see United States Office of Technology Assessment 1993; Walters 1989). Although they can be powerful due to their prestige and access to resources, no specific committee or commission can be all-encompassing. Tradeoffs among the above functions are inevitable, perhaps the most important being between a wide-ranging, fundamental inquiry and a more topical, focused investigation geared toward the needs of decision makers. The wider commissions are more adept at educating the public and guiding long-term debates about basic ethical principles, whereas the narrower commissions tend to be more immediately policy relevant.

Maximizing the value of bioethics commissions requires utilizing relationships with bioethics centers, government, and society. A multitude of bioethics centers, professions, and organizations provides a widespread, pluralistic approach to bioethics debates, which promotes diversity of perspectives and propinquity to patients and researchers. Federal bioethics commissions can command the resources necessary to address nationwide issues, foster broad discussions, and articulate conflicting views, but can also be inflexible or captured by political interests. Understanding when to create permanent versus term-limited or ad hoc bodies is also an element influencing the utility of commissions and committees (see United States Office of Technology Assessment 1993).

Another important variable is membership composition, including the roles of different forms of expertise and public input. Membership is usually the most politically charged element of committees. Two examples are the U.S. President's Council on Bioethics and Israel's National Council of Bioethics, which have both been accused of being biased and captured by narrow political interests. In the former case, Chairman Leon Kass is seen as overly pessimistic about technology, while in the latter case Chairman Michel Ravel is seen as overly permissive of scientific research and its applications. Those who criticize these councils claim that common interest goals are not being served. This highlights the need to craft wise membership selection mechanisms in order to lend credibility to the commission.

An alternative path to institutionalizing bioethics is what Eric Juengst (1996) calls the "un-commission" model, best represented by the original design of the ELSI program, which adapted NIH mechanisms to create extramural grant support for research, education, and public participation projects on the social implications of genome research. The main critique of this program is that it could not affect policy, but Juengst argues that even national commissions are severely constrained in their ability to communicate policy recommendations effectively. He suggests that the "un-commission" model is better capable of providing adequate social-impact assessments to serve as a sound contextual base for policy making. This model of complementary research and public deliberation attached to scientific research funding provides another option for identifying and developing responses to emerging bioethics issues. The charge still stands, however, that such a model fails to immediately impact policy, and only adds "basic ethics research" to the basic science research, neither of which can truly aid decision makers or the public. Perhaps the best method is to provide distinct forums for both policy-relevant inquiry and basic ethical and social impacts research.

Commissions and committees gather interdisciplinary panels of experts to ponder questions that arise at the interface of science, technology, and society. However, most of these questions cannot be answered by specialists. In fact, delegating this decision-making responsibility to experts may undermine the public participation necessary to uphold strong democratic practices in the face of rapid changes. In this light, then, the proper role of bioethics commissions may be to clarify values and educate the public in order to ensure the "very possibility of a democratic future in the biotechnical age that is now upon us" (McClay 2004, p. 18). What bioethics commissions should provide are not final answers, but rather a clearer understanding of the questions and the consequences different answers may pose.

ADAM BRIGGLE
CARL MITCHAM

SEE ALSO *Enquete Commissions; President's Council on Bioethics; Royal Commissions.*

BIBLIOGRAPHY

Brody, Baruch A. (1989). "The President's Commission: The Need to be More Philosophical." *Journal of Medicine and Philosophy* 14(4): 369–384. Argues that greater philosophical clarity on terms such as "life" and "death" would have led to more coherent policies.

Brown, Eric. (2004). "The Dilemmas of German Bioethics." *The New Atlantis* 5(Spring): 37–53. Provides a historical overview of bioethics in Germany and assesses recent and potential future developments.

Campbell, Alastair B. (1989). "Committees and Commissions in the United Kingdom." *Journal of Medicine and Philosophy* 14(4): 385–402.

Isambert, Francois-Andre. (1989). "Ethics Committees in France." *Journal of Medicine and Philosophy* 14(4): 445–456.

Juengst, Eric T. (1996). "Self-critical Federal Science? The Ethics Experiment within the U.S. Human Genome Project." *Social Philosophy and Policy* 13(2): 63–95. Evaluates the ELSI experiment as a model for addressing policy issues raised by innovations in science. Illustrates the tensions inherent in the dual missions of providing policy advice and undertaking inquiry and the difficulty for any bioethics commission (or "un-commission") model in communicating policy recommendations.

Kasimba, Pascal, and Peter Singer. (1989). "Australian Commissions and Committees on Issues in Bioethics." *Journal of Medicine and Philosophy* 14(4): 403–424. Examines contributions of government commissions to ethical issues raised by medical and biological sciences.

Kimura Rihito. (1989). "Ethics Committees for 'High Tech' Innovations in Japan." *Journal of Medicine and Philosophy* 14(4): 457–464.

Martinez, Julio Luis, ed. (2003). *Comites De Bioetica* [Bioethics committees]. Madrid: Universidad Pontificia. A Spanish publication that provides an overview and evaluations of bioethics committees.

McClay, Wilfred M. (2004). "Science and Self-Government." *The New Atlantis* 4(Winter): 17–22. Gives a positive assessment of a report issued by the President's Council on Bioethics.

Poland, Susan Cartier. (1998). "Bioethics Commissions: Town Meetings with a 'Blue, Blue Ribbon.'" *Kennedy Institute of Ethics Journal* 8(1): 91–109. Available as a monograph from National Reference Center for Bioethics Literature, Kennedy Institute, Georgetown University, Washington, DC. A comprehensive listing of bioethics commissions around the world.

Sass, Hans-Martin. (1989). "Blue-Ribbon Commissions and Political Ethics in the Federal Republic of Germany." *Journal of Medicine and Philosophy* 14(4): 465–472.

United States Office of Technology Assessment (OTA). (1993). *Biomedical Ethics in U.S. Public Policy*. Reviews the history of four Federal bioethics initiatives: the National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, the Ethics Advisory Board, the President's Commission for the Study of Ethical Problems in Medicine and Biomedical and Behavioral Research, and the Biomedical Ethics Advisory Committee.

Walters, LeRoy. (1989). "Commissions and Bioethics." *Journal of Medicine and Philosophy* 14(4): 363–368. The lead paper in a special issue of the journal devoted to bioethics commissions.

Williams, John R. (1989). "Commissions and Biomedical Ethics: the Canadian Experience." *Journal of Medicine and Philosophy* 14(4): 425–444.

INTERNET RESOURCE

The President's Council on Bioethics. Available from http://www.bioethics.gov/. Provides a list of past U.S. commissions and committees with several links to reports.

BIOETHICS COUNCIL

SEE *Bioethics Commissions and Committees; President's Council on Bioethics*.

BIOLOGICAL WEAPONS

Biological weapons constitute an increasingly important ethical and political issue for science and technology. This entry examines that issue by defining biological weapons (BWs), reviewing the history of their use, considering efforts to deal with future threats, and analyzing the ethical and political aspects of BWs.

Definition

Biological warfare is the intentional use of disease-causing microorganisms or other entities that can replicate themselves—such as viruses, infectious nucleic acids, and prions—against humans, animals, or plants for hostile purposes. It also may involve the use of toxins, which are poisonous substances produced by living organisms, including microorganisms (such as botulinum toxin), plants (for example, ricin derived from castor beans), and animals (snake venom, for instance). The synthetically manufactured counterparts of those toxins are considered BWs when they are used for purposes of warfare.

Although biological agents have the potential to cause mass casualties, the numbers are often more a matter of scare mongering than real: when it is claimed, for example, that a pound of botulinum toxin can kill six billion people, which is not a real possibility. It nevertheless remains the case that one-quarter of all deaths worldwide and about 50 percent of all deaths in developing countries are attributed to infectious diseases. Although human beings have developed several physiological defenses against disease and in certain cases have acquired immunity through evolution, these natural defenses may be minimal in societies weakened by war or by famine, drought, stress, or other natural disasters.

Early Biological Warfare

Biological warfare may be as old as civilization. In the earliest forms it involved drawing enemy troops into disease-ridden areas on the basis of an etiological belief that epidemics were caused by inhaling air infected by particular telluric emissions. Animal and plant toxins also were used commonly in many societies to poison arrows and other kinetic weapons. In later times disease was spread by means of pollution of the environment (for example, dropping human or animal carcasses into wells or catapulting them into besieged cities), the use of kinetic weapons that were dipped into decaying corpses, and the distribution of objects contaminated by people with highly infectious illnesses such as smallpox.

However, it was not until the end of the nineteenth century that the propagation of disease and thus the effectiveness of such actions began to be understood. By 1914 microbiology had advanced considerably: Major bacterial disease-causing organisms had been isolated and cultivated; the existence of viral diseases had been discovered, although the pathogens were not yet well understood; and parasitic diseases were being studied. There was also an improved understanding of disease transmission, and that understanding contributed to better prophylaxis, prevention, and countermeasures. Not surprisingly, those insights and new techniques soon were applied for hostile purposes. World War I witnessed the first acts of sabotage (against animals) with cultivated disease-causing organisms.

Firefighters remove suspicious-looking packets from a post office distribution center. Harmful biological agents such as anthrax are sometimes distributed through mail. *(© Reuters NewMedia Inc./Corbis.)*

During the 1920s and 1930s the fear of biological warfare increased significantly in parallel with scientific progress and as a consequence of experiences with the Spanish flu epidemic in 1918. In World War II only Japan actually used biological agents, employing them during military operations in China. Nazi Germany and the Allies did not produce an operational offensive BW before the end of the war apart from a limited British retaliatory capability to infect German cattle with anthrax.

The Cold War and Afterward

After World War II the Soviet Union and the United States, and to a lesser extent the United Kingdom, were the principal states continuing research, development, and production of offensive BWs. The United States formally halted its program in 1969 and then destroyed its existing BW stockpiles. An internal review had demonstrated the military utility of biological warfare, but the United States concluded that a BW capability would not contribute significantly to its existing security posture. The announcement of the termination of the offensive BW program was accompanied by the argument that BWs were of low military significance, which other countries were happy to adopt. To many diplomats a moral imperative became the driving force to achieve an international treaty, and the unilateral U.S. gesture thus helped pave the way for the 1972 Biological and Toxin Weapons Convention (BTWC). The Soviet Union, however, did not reciprocate and even accelerated its BW program despite being one of the three co-repositories of the BTWC, along with the United Kingdom and the United States. The program survived the 1991 breakup of the Soviet Union essentially intact, and despite assurances by the Russian leadership, there remain considerable doubts about whether Russia has terminated all prohibited BW activities.

BW proliferation became a major worry in the late 1980s in part as a consequence of the use of chemical weapons in the Iran–Iraq war. The concerns were heightened significantly in the 1990s when the United Nations Special Commission on Iraq (UNSCOM), which was set up after the liberation of Kuwait in 1991, revealed the advanced and extensive nature of Iraq's

BW programs. As the invasion of Iraq by American-led coalition forces in March 2003 illustrated, the mere assumption of the presence of BW can be highly destabilizing to international security. Countries such as China, Egypt, India, Iran, Iraq, Israel, North Korea, Pakistan, Russia, South Korea, and Taiwan are mentioned in connection with BW proliferation, but there is considerable uncertainty about whether those programs are offensive or defensive and about their level of sophistication.

Biological weapons involve dual-use technologies and processes that can be employed for both legitimate and prohibited activities. The ambiguities that result from the dual-use potential of those technologies are increased by the facts that (1) the active ingredient of the weapon (that is, the biological agent) is central to the making of the offensive weapon as well as to the development of some key means to protect against or manage the consequences of exposure to the biological agent (such as vaccines and medication) and (2) the final stage of the armament dynamic during which the applied technologies have no purpose other than weaponization may not become apparent until the biological agent is placed in a delivery system. As a consequence, the judgment of the true nature of certain activities comes down to a judgment of intent, and a country that has an antagonistic relationship with the state making the intelligence assessment is at greater risk of being called a proliferator than is one that has a friendly relationship. The perceived intent of a state is a major subjective component in the threat assessment.

Terrorism with pathogens became a primary concern in the 1990s after it was learned that the Japanese religious cult Aum Shinrikyo, which had conducted two deadly attacks with the nerve agent sarin in 1994 and 1995, also had unsuccessfully released BWs. Although another religious cult, the Rajneesh, had infected some 750 people with salmonella in an attempt to influence local elections in Oregon in the United States in 1984, the threat was not taken seriously until 2001, when an unknown perpetrator killed five people and infected seventeen more with anthrax spores delivered in letters. The fact that those attacks occurred in the wake of the terrorist strikes against the United States on September 11, 2001, heightened threat awareness around the world.

Future Threats and Ways to Deal with Them

The principal tool against biological warfare is the BTWC. The convention was the first disarmament treaty: It ordered the total destruction of all BW stockpiles, and it contains a comprehensive ban on the development, production, and possession of BWs. The core prohibition of the BTWC is based on the so-called General Purpose Criterion (GPC), which prohibits not specific objects as such (for instance, pathogens) but rather the objectives to which they may be applied (hostile purposes). The main advantage of the GPC is that its application is not limited to technologies that existed at the time of the conclusion of the treaty negotiation but to all innovations. This has proved critical in the light of the rapid advances in biology and biotechnology at the end of the twentieth century and the beginning of the twenty-first. As a result of the GPC the parties to the BTWC have been able to reaffirm the prohibition in the light of those technological developments at the periodic review conferences of the convention. However, the treaty lacks meaningful tools to verify and enforce compliance. Since its entry into force in 1975 there have been several allegations and some confirmed cases of material breaches, but the inability to deal with them under the treaty provisions has contributed to the perception of its weakness.

The BTWC also is being challenged by rapid developments in biotechnology and genetic engineering despite the availability of the GPC. Although these developments hold out the promise of improving the quality of life, much of the knowledge can be employed for hostile purposes by improving the stability and virulence of existing warfare agents or even by creating new agents based only on some components of an organism. The dual-use potential of many products, processes, and knowledge implies that any strengthened BTWC regime would require inspection rights in relevant scientific institutions and biotechnology companies. Many establishments are extremely reluctant to grant international inspectors access to their facilities for fear of losing propriety information.

As a consequence, efforts to strengthen the BTWC by means of a supplementary legally binding protocol have failed. The stalled multilateral negotiation process has shifted attention to a range of initiatives to be undertaken by individual states that are parties to the BTWC, including enhanced export controls, encouragement to establish ethical standards and professional codes of conduct, and the enactment of national legislation criminalizing activities contrary to the objectives and purpose of the BTWC by natural and legal persons and corporations.

Moral and Ethical Standards

The argument often is made that investments in technologies that contribute to the design and production of armaments are unethical because they ultimately contribute to the destruction of humans or consume resources that otherwise could have contributed to the improvement of humankind. Because of widespread moral aversion to biological warfare, involvement in BW development and production programs is condemned by many people.

The question of moral judgment is, however, complicated. First, work in the field of biology can be conducted without any link to the military establishment but still contribute to the development of biological weapons. Second, many activities are directed toward enhancing defence and protection against and the detection of biological warfare agents as well as toward the improvement of prophylaxis and the development of new pharmaceuticals. However, improvement in defence necessarily implies an understanding of the offensive characteristics of existing biological warfare agents as well as those of new pathogens, including genetically modified variants. The distinction between offensive and defensive research and development is difficult to make. In fact, the source of the complications with respect to moral judgment is the dual-use potential of most of the technologies involved.

Some scientists, researchers, and technicians, whether as individuals or as members of professional groups, have objected to participation in BW-relevant programs. However, international conventions do not always provide unambiguous moral guidance. International law governs behavior among states, not the conduct of individuals. In a narrow sense all state activities that fall outside the scope of an international prohibition are legal, contributing to a continuing tension between morality and legality.

This becomes clear in the justification of so-called biochemical nonlethal weapons despite the fact that both the BTWC and the Chemical Weapons Convention (CWC) prohibit any weapon that uses toxicity or infectivity whether or not its primary effect is incapacitating or lethal. Several states continue to pursue such weapon programs and justify them on humanitarian grounds. However, the use of a fentanyl derivative by Russian forces in the Moscow theater siege in October 2002 demonstrated that the margin between incapacitation and killing is very narrow. Fentanyl and its derivatives are obtained from opium-producing plants, and thus fentanyl is a biochemical toxicant that is covered by both disarmament treaties. Several U.S. agencies are actively pursuing several nonlethal technologies based on biochemical action. Since the 1920s the United States has systematically objected to the inclusion of harassing and incapacitating agents in the prohibitions against chemical and biological warfare.

Finally, the belief in the value neutrality of scientific activities and technology—the denial that the introduction of new insights or technologies has societal ramifications—held by many scientists constitutes a considerable obstacle to having discussions of ethical and moral issues. Especially if the potential negative societal effects are obvious and cannot be denied, the neutrality of science will be proclaimed (this does not happen if the societal benefits are clear). Indeed, many scientists feel actively discouraged to take part in ethical discussions and accept social responsibility for their work, convinced that research should be guided by its own thrust, independent from and indifferent to the outside political and social world. This view is sustained by early specialization and the lack of sufficient overlap and interaction between disciplines in teaching programs. Also, many scientists and professionals in the fields of biology and biotechnology are unaware of the existence of the BTWC.

The Future

In the early twenty-first century the BTWC, as well as the CWC with regard to toxins, is the main legal instrument to prevent biological warfare. However, an international treaty is subject to continuing pressures as a consequence of changes in the international security environment and technological developments that have a direct bearing on the objectives and purpose of the agreement.

Although the BTWC has a broad scope, the document governs only state behavior. Many developments relevant to the BTWC take place on substate (universities, research laboratories, and companies as well as terrorism) and transnational levels (transnational corporations and international organizations as well as terrorism). The responsibilities of these actors in supporting the goals of the BTWC is great but not well recognized. The impact of the convention on their economic activities is also great because certain transactions may be prohibited and certain goals are forbidden.

Both the research and industry sectors in the field of biology have a large stake in the successful implementation of the convention because otherwise their reputation could be tarnished. The introduction of ethical codes of conduct with respect to issues involving biological warfare in educational curricula and industry practices not only reinforces the treaty regime of the BTWC but also protects the economic interests of the research establishments and companies involved. To assess the moral or ethical aspects of their activities scientists and professionals must be aware not only of international rules and norms but also of how those rules and norms evolve.

JEAN PASCAL ZANDERS

SEE ALSO *Chemical Weapons; Just War; Military Ethics; Terrorism; Weapons of Mass Destruction.*

BIBLIOGRAPHY

Alibek, Kenneth, with Stephen Handelman. (1999). *Biohazard.* London: Hutchinson.

British Medical Association. (1999). *Biotechnology, Weapons and Humanity.* Amsterdam: Harwood Academic Publishers.

Dando, Malcolm R. (2001). *The New Biological Weapons: Threat, Proliferation, and Control.* Boulder, CO: Lynne Rienner.

Geissler, Erhard, and John Ellis van Courtland Moon, eds. (1999). *Biological and Toxin Weapons: Research, Development and Use from the Middle Ages to 1945.* SIPRI Chemical & Biological Warfare Studies no. 18. Oxford: Oxford University Press.

Lederberg, Joshua, ed. (1999). *Biological Weapons.* Cambridge, MA: MIT Press.

Roffey, Roger. (2004). "Biological Weapons and Potential Indicators of Offensive Biological Weapon Activities." In *SIPRI Yearbook 2004: Armaments, Disarmament and International Security.* Oxford: Oxford University Press.

Sims, Nicholas A. (2001). *The Evolution of Biological Disarmament.* SIPRI Chemical & Biological Warfare Studies, no. 19. Oxford: Oxford University Press.

Stockholm International Peace Research Institute. (1970–1975). *The Problem of Chemical and Biological Warfare,* 6 volumes. Stockholm: Almqvist & Wiksell.

Wright, Susan, ed. (1990). *Preventing a Biological Arms Race.* Cambridge, MA: MIT Press.

Zanders, Jean Pascal, ed. (2002). "Ethics and Reason in Chemical and Biological Weapons Research." *Minerva* 40(1): 1–91.

Zilinskas, Raymond A., ed. (2000). *Biological Warfare: Modern Offense and Defense.* Boulder, CO: Lynne Rienner.

INTERNET RESOURCES

American Society for Microbiology. "American Society for Microbiology Cautions That Scientific Publication Restraints May Have Negative Impact on Public Health and Safety." Available from http://www.asm.org/media/index.asp?bid=2813.

"Biological Weapons and Codes of Conduct." Available from http://www.ex.ac.uk/codesofconduct/Chronology/index.htm. Of particular interest are the sections "BW Codes" and "Conducting Research during the War on Terrorism: Balancing Openness and Security."

BIOMETRICS

Biometrics is the use of a person's physical or behavioral characteristics for the purpose of identification and verification. Leading biometric technologies based on direct imaging, measurement, and analysis of physical patterns are fingerprint recognition, eye and retinal scans, face (facial) recognition, and hand geometry. Biometric technologies that identify a person based on behavioral characteristics are voice (speech) recognition and signature recognition. DNA, body odor, and stride are all considered biometrics; however they are not deployed due to technical challenges in quantitative measurement and analysis.

Development and Uses

The term biometrics or *biometry* actually has an older meaning from the early twentieth century referring to the development of statistical and mathematical methods for data analysis in the biological sciences. In this sense the term has been largely replaces by *biostatistics*.

The development of biometrics in the sense relevant here if not the precise term can be traced back to the late nineteenth and early twentieth centuries when technologies of photographic portraiture, anthropometry, and dactyloscopy, as fingerprint reading and comparison was known, were used for purposes of bodily identification by law enforcement. In the 1930s, local laws required fingerprints and photo identification for birth certificates and driver's licenses. The next two decades witnessed widespread registration of personal identifiers through the expansion of passports and driver's licenses (Parenti 2003). Building on research conducted during the Cold War, the development and use of biometric technologies expanded significantly in the 1980s and 1990s.

Among biometric technologies, fingerprint recognition is the best known and most widely used. The development of fingerprinting goes back to the mid-nineteenth century when Sir William Herschel, a British colonial administrator in India, used inked handprints on contracts he made with the locals. In the 1870s, Henry Faulds, a British physician working in Japan, introduced a preliminary system of classification of human prints and proposed the use of fingerprinting for identification. In 1892 Francis Galton, father of eugenics, refined Faulds' system of classification and identified certain characteristics (minutia) for fingerprints.

Fingerprinting for law enforcement purposes was used for the first time in 1891 by an Argentine police officer, Juan Vucetich, who was able to arrest an offender based on a positive identification of the latter's fingerprints. Fingerprinting for criminal identification was introduced in the United States in 1903, and in a few years most major police departments started using the technique. In 1924 the fingerprint sections of the penitentiary at Leavenworth and the National Identification Bureau were consolidated to form the basis of the Federal Bureau of Investigation's (FBI) Bureau of Identification (Parenti 2003). With the introduction of the Automated Fingerprint Identification System (AFIS) in the early 1970s, criminal fingerprint records were computerized, enabling law enforcement to create and use searchable databases of prints.

Fingerprint recognition remains the most reliable biometric technology, but this has been challenged by some courts and researchers in recent years. For example, in 2002, a U.S. district court ruled that fingerprinting was not admissible as scientific evidence. Although the U.S. Court of Appeals modified this judgment, and researchers at the National Biometric Test Center (San Jose State University) did computer comparisons with exceedingly few errors attesting to the scientific validity of fingerprinting, there are still concerns. Security experts warn that wet, dirty, scarred, creased, or worn fingerprints might interfere with the scanning and recognition process. For example, in 2002 a Japanese researcher demonstrated that gelatin-based fake fingers could fool optical scanners.

Since the 1990s federal agencies, the intelligence community, and law enforcement have used hand geometry and fingerprint recognition to control access to facilities, identify criminals, check for false driver's license registrations, and maintain border security. Healthcare, financial, and transportation sectors use fingerprint and hand scans to eliminate badges, keys, and passwords and provide more secure and controlled access to facilities, computers, and databases.

In the early-twenty-first century lower costs and wider availability of biometric technologies together with a growing interest in convenience and security benefits have led to multiplication of biometric applications in varied contexts. For example, in the early twenty-first century schools increasingly use digitized fingerprints and/or hand scanners to enable students to pay for cafeteria meals, check out library books, and gain access to dormitories. The gaming industry deploys face recognition systems in casinos to identify card counters. In New York City low-risk probationers can report their whereabouts by scanning their hands at a kiosk instead of meeting with their probation officers. Plans to identify Medicaid patients at doctors' offices by fingerprint scans in order to eliminate healthcare fraud are underway in some states. Customers at some supermarkets and amusement parks will soon be able to make their payments with the touch of a fingerprint.

Spotlight Events

Although it is not entirely new, biometrics was thrust into the spotlight as a result of two early-twenty-first-century events: Super Bowl XXXV in January 2001, and the terrorist attacks of September 11, 2001. At the Super Bowl in Tampa, Florida, the police used video surveillance cameras equipped with face recognition technology to scan the faces of some 100,000 spectators in search of wanted criminals. Although it did not produce any significant results (only nineteen petty criminals were recognized), the surreptitious use of biometrics caused quite an outrage. The media dubbed Super Bowl XXXV the *Snooper Bowl,* a privacy rights group gave the City of Tampa the *2001 Big Brother Award for Worst Public Official,* and civil liberties advocates argued that the *digital police lineup* was a violation of the Fourth Amendment right to be free from unreasonable searches and seizures.

Months after the Super Bowl, the events of September 11 again focused attention on biometric technologies. In the face of growing security concerns, both governmental and nongovernmental entities (such as airports) turned to biometric technologies as part of their antiterrorism and homeland security efforts. For example, the U.S. Visitor and Immigrant Status Indicator Technology (U.S. VISIT) program and major airports, such as Logan International Airport in Massachusetts, Dallas/Forth Worth International Airport in Texas, and Palm Beach International Airport in Florida, use retina scan and/or fingerprint recognition systems to compare travelers against profiles of known or suspected terrorists in searchable databases.

Criticisms

Despite its touted benefits (security, convenience, protection of assets, and others), biometrics has been the subject of substantial criticism, which can be grouped into two categories. First, the use of biometric technologies presents certain technical challenges and limitations. Security experts note that fingerprint aging and changes in physical appearance such as hairstyle may undermine the reliability of fingerprint and face recognition systems, respectively. In terms of voice and signature recognition, experts warn that the discrepancies between the original identifier presented during enrollment may not correspond exactly to the one presented during verification and thus create difficulties in matching.

Second, biometric technologies present certain legal, ethical, and social implications as expressed by privacy and civil liberties advocates. Lawmakers and privacy experts direct attention to the inadequacy of legal protections regarding the collection, storage, and sharing of biometric data; and it is worth noting that the use of biometrics is not fully addressed in privacy legislation, and that there remain broad exemptions for law enforcement and national security purposes. In terms of ethical and social implications, some argue that biometric technologies turn the human body into nothing more than sets of data. Biometric systems, they contend, are dehumanizing because they are bureaucratic systems of identification and verification whereby people are subject to the control of others (Brey 2004). Biometric technologies can also limit freedom of movement and lead to social discrimination because they enable authorities to privilege or reject individuals based on biometric data (Lyon 2003). The most fundamental argument against biometrics relates to privacy invasion; this argument specifically targets face recognition technology.

Face recognition is the most contentious among biometric technologies because it is generally performed without one's knowledge. For fingerprinting or hand geometry to work, one must put the finger or hand under a scanner and thus is aware of being the subject of a biometric system of identification. However face recognition applications allow facial imagery to be captured without the consent or even the knowledge of the subject, and such technologies can be used for surveillance purposes. In this sense, one can argue that face recognition systems pose a plausible threat to privacy—the reasonable *control* an individual has over what information is made public, and what is not (Agre 2001).

Prior to implementing biometric technologies, policymakers, public authorities, and nongovernmental entities must consider the scientific basis, technical limitations, and possible negative consequences in order to analyze benefits and costs of biometric applications. If not, these implications might easily outweigh any security and convenience benefit, and challenge the free society in serious ways.

BILGE YESIL

SEE ALSO *Forensic Science; Police; Security; Terrorism.*

BIBLIOGRAPHY

Agre, Philip E. (2001). "Your Face Is Not a Barcode: Arguments against Automatic Face Recognition in Public Places." *Whole Earth* Winter: 74–77.

Brey, Philip. (2004). "Ethical Aspects of Facial Recognition Systems in Public Places." In *Readings in Cyberethics*, 2nd edition, ed. Richard A. Spinello and Herman L. Tavani. Sudbury, MA: Jones and Bartlett Publishers.

Lyon, David. (2003). *Surveillance after September 11*. Malden, MA: Polity.

Parenti, Christian. (2003). *The Soft Cage: Surveillance in America: From Slavery to the War on Terror*. New York: Basic Books.

BIOPHILIA

The term *biophilia* was coined by the Harvard entomologist Edward O. Wilson (born 1929) and used in the title of his book *Biophilia: The Human Bond with Other Species* (1984). It comes from the Greek *βιos*, "life," and *φιλια*, "love or affection," and means literally "love of life" or "life-loving."

Biophilia and Biodiversity

Wilson's thesis is that human beings have a deep, inbred psychological need for physical contact with a broad variety of other life forms. The concept of biophilia thus is closely linked with that of biodiversity (biological diversity). Although Wilson did not coin the term *biodiversity*—Walter G. Rosen did in the mid-1980s—he helped give it wide currency as editor of the 1988 book *Biodiversity*, the proceedings of the National Forum on Biodiversity held in Washington, DC, in 1986, sponsored by the National Academy of Sciences and the Smithsonian Institution. According to Wilson, biodiversity represents much more than a material resource for such things as medicines and genes; it represents a vital human aesthetic and psychological resource as well.

In *Biophilia* Wilson points out that *Homo sapiens* evolved in a biologically diverse matrix. That which most distinguishes humans from other species and that in which humanists take the most pride—intellect and cognitive skills—are, Wilson argues, an evolutionary adaptation to a natural environment replete with both opportunity and danger. Therefore, not only do people have as deep a psychological need for a biologically diverse environment as they do for such basic things as human companionship and conversation, the very identity of humans as a species was sculpted by interaction with other species.

The human bond with other species mentioned in Wilson's subtitle thus goes beyond a desire for aesthetic satisfaction and psychological well-being to the core characteristic of the human species, to the very essence of humanity. On the basis of this claim Wilson proposes a "deep conservation ethic" that remains nevertheless anthropocentric. If people bequeath an impoverished natural environment to future generations, they risk the intellectual degeneration—the devolution—of the human species. "Preparing for future generations," Wilson writes, "is an expression of the highest morality. It follows that the destruction of the natural world in which the brain was assembled over a million years is a risky step" (Wilson 1984, p. 121).

The Evolutionary Basis

Wilson's claim that the complexity of human intelligence reflects the complexity of the natural environment in which the human brain evolved was anticipated by the conservation biologist Paul Shepard (1925–1996). In *Thinking Animals: Animals and the Development of Human Intelligence* (1978) Shepard argued that as the progenitors of modern *Homo sapiens* were driven by climate change and competition from their ancestral arboreal habitat out onto the African savanna, they began first to scavenge and then to hunt animals as well as to forage for fruits, tubers, leaves, and seeds. They themselves were subject to predation by large carnivores. The ability to sort the animals encountered into general categories—prey of this kind or predator of that kind—Shepard suggests, was crucial to the survival and reproductive success of those "savanna waifs." Mentally classifying animals and plants into kinds was the origin of conceptualization, and the linking of those bioconcepts into webs of relationship was the origin of intellection.

Once early humans developed the ability to categorize—to conceptualize—that cognitive skill could be extended to other areas, such as meteorological and geological phenomena; kinship and other social relations; and gods, ghosts, and spirits. Shepard's title is a double entendre: Human beings became thinking animals (animals that think) by thinking animals (thinking about animals).

Wilson's claim that human beings require physical contact with a variety of other species for psychological health and well-being also was anticipated by Shepard. The early departure from the way of life (hunting and gathering) and the conditions of life (a diverse biological environment rich in other species) has produced, Shepard argues in *Nature and Madness* (1982), a kind of collective insanity that currently manifests itself in the form of a global environmental crisis. The shift first to an agricultural and then to an industrial relationship with nature has impoverished the range of human contact with nature. Moreover, the shift in social organization from small bands of peers making decisions by consensus to large hierarchical societies with leaders and followers inherent in the shift to an agricultural and then to an industrial mode of relationship with nature led, in Shepard's analysis, to an infantile demand for instant gratification of desire, ultimately at the expense of the natural environment and its other species.

Because the concept of biophilia is embedded in the theory of evolution—indeed, it is an element of evolutionary psychology—it could not have been anticipated before the advent of the Darwinian worldview. Before Shepard one finds notable intimations of biophilia in the marine works of Rachel Carson such as *Under the Sea Wind* (1941) and *The Sea Around Us* (1951) and in the montane works of John Muir such as *The Mountains of California* (1894) and *My First Summer in the Sierra* (1911).

The Biophilia Hypothesis

In the 1990s the concept of biophilia was expanded and transformed into the biophilia hypothesis, which states that "human dependence on nature extends far beyond the simple issues of material and physical sustenance to encompass as well the human craving for aesthetic, cognitive, and even spiritual meaning and satisfaction" (Kellert 1993, p. 20). Stated in the form of a hypothesis, biophilia becomes testable through standard scientific research procedures. As Wilson originally conceived it, biophilia was a largely positive "affiliation" with nature in all its biotic variety and splendor. Wilson also conceived biophilia as having in part a genetic basis. Obviously, the human need for things such as companionship and sexual intimacy is genetic: Companionship is necessary because the human species survives and reproduces most efficiently in cooperation with others, and only those who desire sexual intimacy pass their genes on to the next generation.

Wilson argues that the human need for contact with a diverse biota is also genetic, although less obviously, because that is the natural matrix in which the human species evolved. If this is true, the general biophilia hypothesis should have a qualifying aspect: biophobias of dangerous organisms. Research indicating universal biophobias—fears of certain life-forms that may be found in people irrespective of cultural differences—confirms the biophilia/phobia hypothesis. Narrowing that hypothesis down to specifics, for instance, the universal fear among humans of snakes and spiders, has been confirmed experimentally.

Biophilia is meaningful as a scientific hypothesis in the field of evolutionary psychology only if it is narrowed down to specifics. As Judith Heerwagen and Gordon Orians note, "There are fear and loathing as well as pleasure and joy in our experiences with the natural world. Thus the real issue is not whether biophilia exists, but rather the particular form it takes" (p. 139). Their research focuses on landscape aesthetics. Although the results of their testing of the biophilia hypothesis are nuanced, Heerwagen and Orians found through analysis of things as diverse as landscape painting, landscape architecture, and the selection of home sites by people who can afford to live wherever they choose that people prefer high, open ground with a wide vista overlooking water and not too far from trees. Such sites provided early humans with the ability to see from a safe distance predators and competitors approaching; the gravitational advantage of elevation for combat, if necessary; and the availability of animal and plant resources for eating and water for drinking and bathing.

Tendencies toward dichotomous thinking incline people to assume that if biophilia is inbred and genetic in origin, it is not a learned, culturally transmitted, socially constructed, and reconstructible response to nature. However, nature and nurture are more complementary than opposed. Most distinctively human traits that have a genetic basis—things that belong indisputably to human nature—are also strongly shaped by cultural context, idiosyncratic experience, education, and social conditioning. The uniquely human capacity to speak a language, for example, is genetically based, but which one of the world's thousands of languages a person learns to speak, how well, to whom to say what, and so forth, depends on history, cultural context, idiosyncratic experience, education, and social conditioning.

Consequences

Biophilia is not a human given but a human potential. Just as rhetoricians and poets maximally realize the human potential for language, natural historians such as Wilson and Carson maximally realize the human potential for biophilia. That potential can be generally fostered and nurtured or can be discouraged and stifled. The cost to a human being if the human potential to learn a language goes unfulfilled when an infant is raised in isolation from a linguistic environment is well known. What will be the cost to the human species as a whole if the biophilial potential of future generations is stanched by mass extinction and biological impoverishment? That is the millennial ethical question Wilson poses and ponders.

J. BAIRD CALLICOTT

SEE ALSO *Biodiversity; Environmental Ethics; Evolutionary Ethics.*

BIBLIOGRAPHY

Carson, Rachel. (1941). *Under the Sea Wind: A Naturalist's Picture of Ocean Life*. New York: Oxford University Press.

Carson, Rachel. (1951). *The Sea Around Us*. New York: Oxford University Press.

Kellert, Stephen R., and Edward O. Wilson, eds. (1993). *The Biophilia Hypothesis*. Washington, DC: Island Press.

Muir, John. (1894). *The Mountains of California*. New York: Century.

Muir, John. (1911). *My First Summer in the Sierra*. Boston: Houghton Mifflin.

Shepard, Paul. (1978). *Thinking Animals: Animals and the Development of Human Intelligence*. New York: Viking.

Shepard, Paul. (1982). *Nature and Madness*. San Francisco: Sierra Club Books.

Wilson, Edward O. (1984). *Biophilia: The Human Bond with Nature*. Cambridge, MA: Harvard University Press.

Wilson, Edward O., ed. (1988). *Biodiversity*. Washington, DC: National Academy Press, 1988.

BIOSAFETY COMMITTEES

SEE *Institutional Biosafety Committees.*

BIOSECURITY

Biosecurity involves preventing and minimizing intentional harm to people, crops, livestock, wildlife and ecosystems caused by biological agents that are either naturally occurring or human-made. Biosecurity technology research and development, policy formulation and operational practices principally pertain mostly to military weaponry, agriculture and medicine. The development and use of biological agents in these and related fields, such as aquaculture, are controversial primarily because they have intended and/or unintended positive or negative impacts on public health. For example, introducing naturally occurring biological agents into an ecosystem in order to control pests that are causing crop damage may have unintended negative impacts on unharmful organisms in addition to the positive impact of pest control. Consequently some leading experts distinguish biosecurity from "biosafety" which involves preventing and minimizing accidental harms caused by biological agents.

Biological Weapons and Warfare

Potential benefits and concern over threats caused by biological agents, and therefore the need for biosecurity, has existed through the ages and particularly with respect to their use as weapons in biological warfare. The first recorded instance of biological warfare occurred in 1346 when bodies of Tartar soldiers, who had died of plague, were catapulted over the walls of Kaffa (present-day Feodosiya, Ukraine) in order to infect the besieged residents. During the 1500s, Spanish conquest of South America and the Caribbean Islands spread infectious diseases to these unprotected regions. Similarly during the last of the French and Indian Wars, the English used blankets infected with smallpox to kill native populations in North America. In all such instances, naturally occurring biological agents were used to kill either enemies (during warfare), or native peoples, who were perceived as potential obstructionists to national expansionism.

Following discovery of the microbial basis of infectious diseases (i.e., germs) in the mid-to-late 1800s by European researchers Louis Pasteur (1822–1895) and Robert Koch (1843–1910), programs to research and develop chemical and biological weapons were conceived and implemented by several governments. Such weapons consist of a launching mechanism, artillery or missile delivery system, and an exploding canister or warhead capable of releasing chemicals or airborne pathogens. If inhaled, ingested or absorbed through the skin, such pathogens can cause diseases such as smallpox, anthrax, plague, or botulism, debilitating or killing people, livestock and/or wildlife.

Deaths of over 100,000 soldiers from Mustard Gas (a type of chemical weapon) during World War I heightened worldwide concern over the potential harm of biological weapons. The Geneva Protocol of 1925 banned the use of both chemical and biological weapons, although several countries including the U.S. and the former Union of Soviet Socialists Republic (USSR or Soviet Union) maintained "bioweapons" development programs and insisted on their right to use biological weapons in reprisal attacks if such devices were first used against them. During World War II, only Japan is known to have actually used biological weapons, namely during its battles against China: nevertheless, Britain, the USSR, and the United States all stockpiled biological weapons in the war's aftermath.

During the Cold War era (1945–1989) fear of biological (or germ) warfare was largely replaced with fear of radiological and nuclear weapons, although huge stockpiles of biological weapons were maintained by several nations. Offensive bioweapons programs in the U.S. were unilaterally halted by President Richard Nixon in 1972, just prior to an international convention to eliminate similar programs worldwide. Beginning in the 1990s the prospect of terrorist attacks involving chemical, biological, radiological, or even nuclear weapons of mass destruction became a new threat. Shortly after September 11, 2001, letters containing a refined preparation of dried anthrax spores were sent through the mail infecting more than twenty people and killing five individuals in cities across the Eastern U.S. Though the extent of this attack was limited, Jonathan B. Tucker notes that "it hinted at the mayhem that could result from the deliberate release of weaponized disease agents." Hence, according to a report published online by Michael Barletta in 2002, "bioterrorism — the deliberate use of microorganisms or toxins by non-state actors to sicken or kill people or destroy or poison food supplies upon which we depend — poses an uncertain but potentially devastating threat to the health and well-being of people around the world." In response there has been concerted interest in developing sensing technologies capable of detecting potentially harmful chemicals and pathogens in the environment.

Biological Threats to Livestock and Crops

Biological threats to plants and animals that are relied on by humans for food have existed since the beginnings of agriculture and domestication. Since that time there have been many instances in which biological agents have disrupted human food supplies. For example, the Irish Potato Famine (1845–1849) resulted in over 1 million deaths from starvation, a tragedy that came about because genetically invariant potato plants grown in Ireland at the time were susceptible to rapid infection by Phytophthora infestans fungi. Lack of genetic diversity limits natural defenses to disease and to biological agents that are intentionally introduced into an environment. In addition, new biological strains of livestock and plant pathogens can easily cause significant harm because they rapidly infect elements of ecosystems that have not developed immunities.

Controlling the spread of infectious diseases and associated harms may involve restrictions on growing plants or breeding animals, and controls on harvesting, shipping or processing of these for food or other purposes, as well as controlling the economic and ecological impacts of invasive alien species. Several nations including the U.S., as well as some states within the U.S. ban importation of certain types of fruits and vegetables. Most governments also require livestock owners to inoculate their animals against disease, such as foot-and-mouth disease (FMD). In 2002 a severe outbreak of foot-and-mouth disease in Britain required over 3 million animals in that country to be slaughtered. Controls to prevent the spread of infectious diseases may also need to involve quarantining livestock. The Paris-based World Organisation for Animal Health tracks infectious disease outbreaks in livestock, promotes animal health standards and makes recommendations for policy and legislation to governments throughout the world.

Government Oversight and Ethical Concerns

Introduction of naturally occurring or manmade genetically modified (e.g., recombinant DNA) viruses and experimental biotechnology into weaponry, livestock and plant and crops and medicine is controversial because, if not adequately controlled, these threaten the well-being of entire populations and ecosystems. For this reason government agencies in countries throughout the world impose health standards and carefully monitor and regulate experimental biotechnology research and development often as part of an overall biosecurity (and/or biosafety) policy. In the United States, the Department of Agriculture (USDA) has primary oversight of food production, processing, storage, and distribution; threats against the agriculture sector and rapid response to such threats; border surveillance and protection to prevent introduction of plant and animal pests and diseases; and food safety activities concerning meat, poultry, and egg inspection, laboratory support, research, education and outbreaks of food borne illness. Along with these responsibilities, the USDA also maintains a list of high consequence pathogens.

Also in the U.S. the Centers for Disease Control and Prevention (CDC) regulates several biosecurity matters and maintains a worldwide emergency biological threat response, assessment and control capability. Originally formed in 1946 to handle malaria outbreaks, the CDC now identifies and investigates outbreaks of disease and indicators of bioterrorism attacks through BioWatch. This program, which is co-sponsored by the U.S. Environmental Protection Agency and the U.S. Department of Homeland Security, includes over 4000 atmospheric monitoring stations located in cities throughout the United States, whose readings are constantly analyzed for evidence of harmful biological agents indicative of terrorist attacks.

The potential for dangerous microbes or their products being misused or mishandled and thereby causing harm to human beings and ecosystems on enormous scales also raises ethical concerns about their creation and management. Ethically, the potential for harm must be weighed against scientific, entrepreneurial or commercial freedoms to research and develop microbes for useful and even necessary reasons. Robert H. Sprinkle suggests that the classic "moral norm" shared among ethical scientists and physicians can be advanced by creating a "Biological Trust." Given ongoing invasions of ecological systems by alien species, as well as the potential for bioterrorism, other scientists including Laura A. Meyerson and Jaime K. Reaser concur that governments and scientists must work together to foster adequate and ethical policies and technological capabilities to prevent, detect, and respond to incidents involving microbes.

Today there is concern about whether or not professional ethics in science and engineering can adequately address biosecurity. Issues of particular concern pertain to international use of tax, trade and tariff policies to promote consistent biosecurity policies among nations; corporate investment in biosecurity research and development; and the fact that biosecurity in practice needs to be active and proactive for national deployments of sensing and monitoring technologies especially in unprotected metropolitan areas deemed most susceptible to potential harms caused by biological agents.

SAMUEL C. MCQUADE, III

SEE ALSO *Security; Weapons of Mass Destruction.*

BIBLIOGRAPHY

Barletta, M., (2002). *Biosecurity Measures for Preventing Bioterrorism*. Monterey, California: Monterey Institute of International Studies. Available from http://cns.miis.edu/research/cbw/biosec/pdfs/biosec.pdf

British Medical Association. (1999). *Biotechnology, Weapons and Humanity*. Report prepared under auspices of the Board of Science and Education of the British Medical Association. Amsterdam, Netherlands: Harwood Academic Publishers.

Guillemin, J. (2001). *Anthrax: The Investigation of a Deadly Outbreak*. Berkeley, California: University of California Press.

Meyerson, L. A., and J. K. Reaser. (2002). "The Biosecurity: Moving Toward a Comprehensive Approach." *Bioscience* 52: 593–600.

Meyerson, L. A., and J.K. Reaser. (2003). "Biosecurity, Bioinvasions and Bioterrorism." *Frontiers in Ecology and the Environment* 1(6): 307–314.

National Academies of Sciences. (2002). *Predicting Invasions of Non-indigenous Plants and Plant Pests*. Washington, DC: National Academy Press.

Society of Photo-optical Instrumentation Engineers. (2002). *Sensors, and Command, Control, Communications, and Intelligence (C3I) Technologies for Homeland Defense and Law Enforcement*. Conference Proceedings of the SPIE, April 1-5 (Orlando, Florida) Bellingham, Washington: SPIE.

Sprinkle, R. H. (2003). "The Biosecurity Trust." *Bioscience* 53: 270–278.

Tucker, J. B. (2003). *Biosecurity: Limiting Terrorists Access to Deadly Pathogens*. Peaceworks No 52. Washington, DC: US Institute for Peace.

BIOSTATISTICS

Biostatistics is the application of statistics to biology and medicine. It is concerned with the assessment of observed variation in living organisms, particularly human beings. It seeks better insight into the life process, with focus on the cause, treatment, and prevention of disease. It uses the theories and methodology of statistics, but has created specialized methods of its own.

The development of statistical inference in the late-nineteenth and early-twentieth centuries was motivated by problems in biology, and its growth stimulated by the subsequent explosion of research in science and technology and the advent of the electronic computer. Responding to challenges posed by large-scale biomedical research programs, biostatistics emerged as a vigorous distinct discipline. Its scope includes data collection and analysis pertaining to virtually all facets of the vast healthcare system. The study of health factors affecting populations, with emphasis on public health issues, is the realm of epidemiology, a closely related field using the theories and methods of biostatistics.

Experimentation on human subjects in clinical research involves both biostatistics and ethics, including ethical aspects of clinical trials. But the two fields also intersect on broader concerns related to medical uncertainty and complexity: poor understanding on the part of the public, conflicts of interest, manipulation by the market, and questions of responsibility. Greater awareness of these issues is needed to help address critical problems facing contemporary medicine.

Concepts and Methods of Biostatistics

In the field of descriptive statistics, biostatistics contributes to the preparation of official records characterizing the health of the nation. As participant in the biomedical research process, it provides study design based on theories of statistical inference, primarily the classical Neyman-Pearson theory of hypothesis testing. Applying a wide range of standard techniques, it considers the two types of error in testing, determines required sample size for desired power, and assesses the statistical significance of results. It estimates outcomes of interest with associated confidence intervals. Its best-known specialized technique is the randomized clinical trial (RCT) for controlled experiments. For observational research the chief methods are cohort and case-control studies.

HEALTH STATISTICS. An illustration of data provided by the National Center for Health Statistics is given in Figures 1 and 2, showing cancer death rates in the United States from 1930 to 2000 for the major sites, for males and females. Such records of health statistics are an important resource for public health policies and biomedical research, in this case for studies of the etiology, treatment, and prevention of cancer. For example, although lung cancer remains the leading cause of cancer death, the decreasing rate for males in the last decade reflects the decrease in the prevalence of smoking, with a plateau in the death rate seen thus far for women.

EXPERIMENTAL RESEARCH: THE RANDOMIZED CLINICAL TRIAL. A *clinical trial* is an *experiment* in which a selected group of patients is given a particular treatment (*intervention*), typically a drug, and followed over time to observe the *outcome*. In a *randomized clinical trial*, also called *randomized controlled trial* (both referred to as RCT), patients are assigned at random to one of two or more treatments to assess relative effectiveness. Individual differences among patients that may affect their response are assumed to be balanced out by the random assignment. Ethical mandates include *clinical equipoise* (lack of medical consensus on the superiority of any of the treatments) and *informed consent* (willing participation of fully informed patients). The *research protocol* describing the proposed trial must be approved by the local *Institutional Review Board* (IRB).

The study may conclude before an outcome is observed for each patient (for example, the patient is still alive when the outcome is death). Such patients are said to be still *at risk*, and have a *censored* observation. The graphic summary of results is the so-called *survival curve*, which shows the proportion of patients alive (or disease-free if the outcome is recurrence) at each point in time along the period of observation. It is based on the *life-table* or *actuarial method*, with time 0 representing the entry point of each patient into the trial. Showing two or more arms of a study on the same graph offers a visual comparison of treatment outcomes. Special techniques of *survival analysis* can compare groups with inclusion of censored observations. There are methods to test the hypothesis that there is no difference between treatments, including adjustment for observed patient characteristics that may affect outcome.

Figure 3 presents five-year results of a three-arm RCT comparing disease-free survival of breast cancer patients treated with total mastectomy, segmental mastectomy (lumpectomy), and segmental mastectomy with radiation therapy. All patients with positive axillary lymph nodes received adjuvant chemotherapy. The first graph shows lumpectomy to be just as effective as mastectomy; the other two indicate lumpectomy with radiation therapy to be significantly better than either surgical procedure alone.

OBSERVATIONAL RESEARCH: COHORT AND CASE-CONTROL STUDIES. The two main approaches to addressing questions for which experimentation is ethically not feasible or otherwise not practicable are the *observational designs* of *cohort* and *case-control studies*, the basic tools of epidemiology. They aim to discover or confirm an association between some *exposure* or *risk factor* and a disease, using specific criteria of statistical theory and methodology.

Cohort Study. This is usually a *prospective study* that identifies a large group (cohort) of individuals without the disease, but with information about the presence or absence of the risk factor under study. The cohort is then followed over time to observe for the occurrence of the disease. Smoking is a risk factor that cannot be studied in RCTs. In the hypothetical example shown in Table 1, a cohort of 2,000 adult males is followed to observe for a diagnosis of lung cancer; 500 of the men are smokers and 1,500 nonsmokers at the beginning of the study. As a possible outcome after twenty years, 24 percent of smokers and 2 percent of nonsmokers have contracted lung cancer. The measure of association used is the *relative risk* (RR) or *risk ratio*, 24/2 = 12.0.

Case-Control Study. This is a *retrospective* design, which identifies a group of people who have the disease (cases), selects a group as similar as possible to the cases except that they do not have the disease (controls), and then determines how many in each group were exposed to the risk factor. An actual example is shown in Table 2, in a study of the association between stroke in young adults and drug abuse, with 214 cases and 214 controls. It was found that seventy-three of the stroke victims had a history of drug abuse, compared with eighteen in the control group. The odds of drug abuse given the stroke are 73/214 to 141/214, and given no stroke, 18/214 to 196/214. The measure of association is the *odds ratio* (OR) as the estimate of relative risk, in this case .5177/.0918 = 5.64.

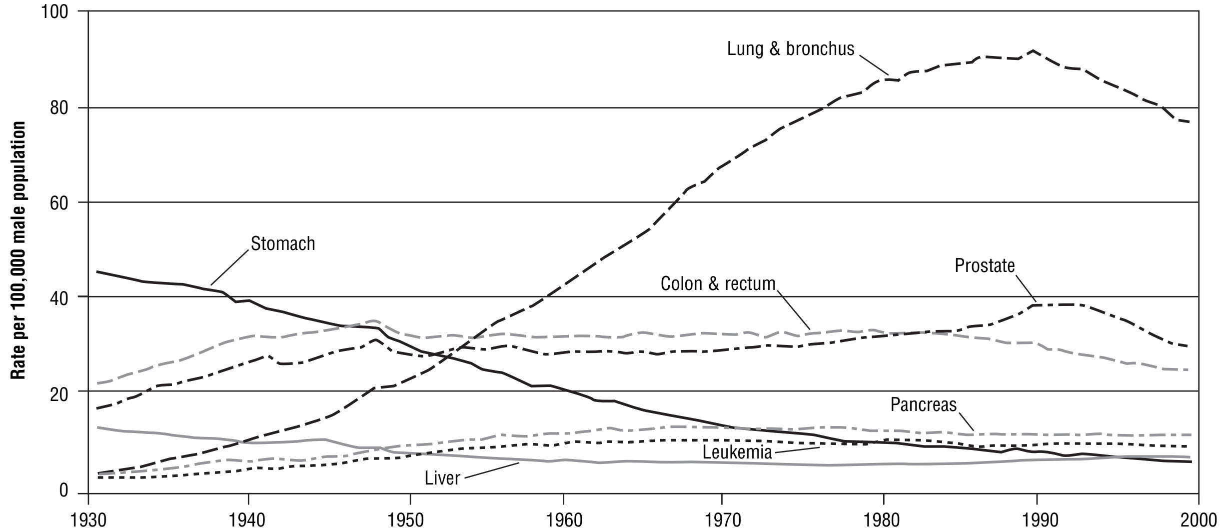
Comparison of Research Designs. The relationship between cohort and case-control studies is shown symbolically in Table 3. For both measures of association, RR and OR, a value of 1.0 indicates no association. There are statistical methods to test the hypothesis of no association and to provide a confidence interval for RR or OR. Confidence intervals that do not include 1.0 reflect a significant association; values less than 1.0 denote a protective effect of the factor being studied. The examples above (RR = 12, OR = 5.64) show strong associations. Media reports for a study claiming a 20 percent increase in relative risk, for example, would correspond to RR = 1.2, a weak association even if statistically significant.

Cohort studies permit careful selection of the study population and recording of the risk factor, and rates of disease can be calculated for both the exposed and unexposed group. But long observation of a large number of subjects is required, many may be lost to follow-up or their exposure may change, and the studies tend to be expensive. Case-control studies require fewer subjects, cost less, and can be completed in a relatively short time period. Instead of the risk of disease given the exposure, they estimate the odds of being exposed given the disease. But case-control studies rely on recall of past exposures that may be impossible to confirm and the selection of an appropriate control group is extremely difficult. A different group of controls, or just a change of a few, could completely alter the outcome. These are some reasons that so many conflicting results are reported in the medical literature. Others include small, improperly done clinical trials and those with short follow-up. But in any case, claims can only be valid for an association between exposure (or intervention) and disease. The assessment of causation is a lengthy, tentative process, with general guidelines to aid the research community (Hill 1967).

DIAGNOSIS AND SCREENING. Further uncertainties exist in the diagnosis of disease, and biostatistics provides methods to evaluate tests used in *diagnostic* and *screening* procedures. Most tests have an overlapping range of values for a healthy population and patients with the disease, so that in setting a *cutoff point* to distinguish *positive* from *negative* test results, two types of error may be made. The four possible outcomes are shown in Table 4, with the standard performance characteristics of diagnostic tests. *Sensitivity* is the ability of a

FIGURES 1–2

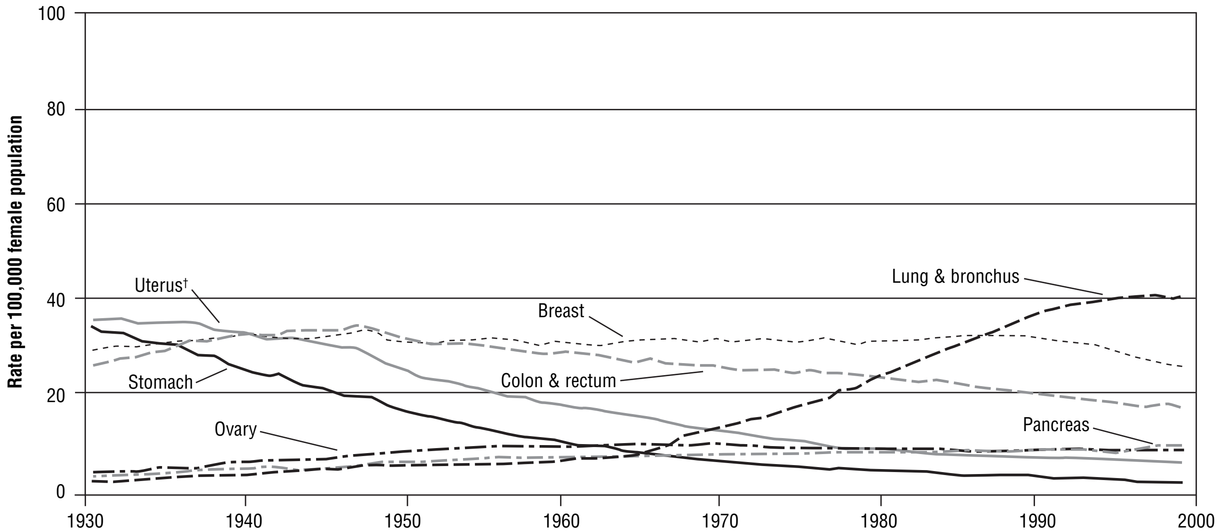
Figure 1: Age-Adjusted Cancer Death Rates, Males by Site, United States: 1930–2000



*Per 100,000, age-adjusted to the 2000 US standard population.
Note: Due to changes in ICD coding, numerator information has changed over time. Rates for cancers of the liver, lung & bronchus, and colon & rectum are affected by these coding changes.

SOURCE: American Cancer Society (2004), p. 2.

Figure 2: Age-Adjusted Cancer Death Rates, Females by Site, United States: 1930–2000



*Per 100,000, age-adjusted to the 2000 US standard population.
†Uterus cancer death rates are for uterine cervix and uterine corpus combined.
Note: Due to changes in ICD coding, numerator information has changed over time. Rates for cancers of the liver, lung & bronchus, colon & rectum, and ovary are affected by these coding changes.

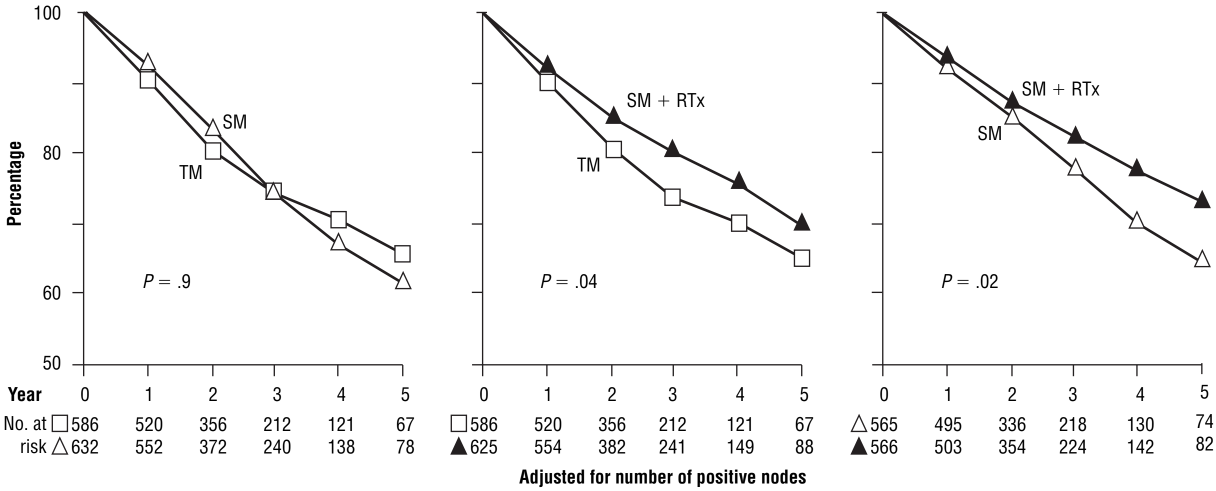
SOURCE: American Cancer Society (2004), p. 3.

test to detect disease when present, and *specificity* its ability to indicate nondisease when none is present. The numeric example shows a test for fetal malformation with ultrasonography, which has reported 56 percent sensitivity and 99.5 percent specificity. The *prior probability* that a woman with poorly controlled diabetes has

FIGURE 3

Randomized Clinical Trial for Treatment of Breast Cancer

DISEASE-FREE SURVIVAL



Comparison of survival for patients with total mastectomy (TM), segmental mastectomy (SM), and segmental mastectomy with radiation therapy (SM + RTx), using actuarial methods.

SOURCE: Dawson-Saunders and Trapp (1994), p. 204. Adapted from Fisher, Bernard, et al. (1985). "Five-Year Results of a Randomized Clinical Trial Comparing Total Mastectomy and Segmental Mastectomy With or Without Radiation in the Treatment of Breast Cancer." *New England Journal of Medicine* 312:665–673.

a malformed fetus is given as $P(D^+) = .20$. Using these numbers, one can apply a formula for conditional probabilities known as Bayes' Theorem to estimate the *predictive value* of the test, the *posterior probability* of malformation given a positive or negative test result. In this example a positive ultrasound yields a 96.6 percent probability that the fetus is malformed, and a negative result a 90 percent probability that it is normal.

In any one case a series of tests may be used to establish diagnosis, with the sensitivity and specificity of common tests established in previous studies. But there is inherent variation in the laboratory and imaging process itself, as well as the reliability of human raters. In addition, promising new markers for disease may present new uncertainties concerning cutoff points and criteria for treatment.

Decision to Treat: Prostate Cancer. For example, wide use of the test for prostate-specific antigen (PSA) has resulted in earlier diagnosis and decrease in the death rate from prostate cancer since the early 1990s (Figure 1). The test measures the blood level of PSA, a protein made by the prostate. It was defined as positive at 4.0 ng/ml, although higher levels also often indicate benign conditions. But a 2004 study reported prostate cancer on biopsy in 15 percent of 2,950 men with seven years of normal PSA levels and negative digital examinations. The prevalence of cancer was positively correlated with increasing PSA level from less than 0.5 to 4.0 ng/ml. Most of these cancers will not progress to life-threatening disease, and the question is whether to try to diagnose and treat these previously missed early cases.

Decision to Treat: Breast Cancer. About 50,000 cases of *ductal carcinoma in situ* (DCIS) are diagnosed in the United States each year, 20 percent of all breast cancers. These are cancers within the duct, not palpable, found on biopsy of suspicious regions identified by increasingly sensitive mammography. After lumpectomy an estimated 10 to 15 percent of DCIS will recur as invasive breast cancer. Prognosis is uncertain in individual cases, and variations of further treatment tend to be the recommended procedure. There has been a downward trend in breast cancer mortality (Figure 2), but breast cancer remains the second leading cause of cancer death for women, and a DCIS diagnosis creates vexing uncertainties for affected women.

NUMBER NEEDED TO TREAT (NNT): AN ESSENTIAL CONCEPT. Evaluating the results of a clinical trial, factors to consider include the type of patients studied, the length of follow-up, and the safety and effectiveness of treatment. The latter is especially important in *prevention trials*, when observed advances may involve

TABLES 1–5

Table 1: Cohort Study: Relative Risk of Lung Cancer in Smokers

Risk factor (Smoking)	Disease Yes	Disease No	Total	Risk of disease (Lung cancer)
Yes	120	380	500	120/500 = .24
No	30	1,470	1,500	30/1,500 = .02
Total	150	1,850	2,000	

Relative Risk or Risk Ratio: $RR = \frac{.24}{.02} = 12.0$

Hypothetical Example: A cohort of 2000 healthy men, of whom 500 are smokers and 1500 nonsmokers, is enrolled in the study and followed to observe for the development of lung cancer. Table shows the outcome after 20 years.

SOURCE: Courtesy of Valerie Miké.

Table 2: Case-Control Study: Odds Ratio for Stroke with History of Drug Abuse

Risk factor (Drug abuse)	Case (Stroke)	Control (No stroke)
Yes	73	18
No	141	196
Total	214	214

Odds of drug abuse in stroke patients $= \frac{73/214}{141/214} = .5177$

Odds of drug abuse in controls $= \frac{18/214}{196/214} = .0918$

Odds Ratio: $OR = \frac{.5177}{.0918} = 5.64$

Example of a case-control study to assess the relationship between drug abuse and stroke in young adults.

SOURCE: Adapted from Dawson-Saunders and Trapp (1994), p. 55.

Table 3: Symbolic Overview of Cohort and Case-Control Studies

Cohort ⟶ Risk factor	↓ Case Disease	Control No disease	Total	Risk of disease
Present	a	b	a + b	a/(a + b)
Absent	c	d	c + d	c/(c + d)
Total	a + c	b + d		
Odds of factor	$\frac{a/(a+c)}{c/(a+c)}$	$\frac{b/(b+d)}{d/(b+d)}$		

Relative Risk: $RR = \frac{a/(a+b)}{c/(c+d)}$

Odds Ratio: $OR = \frac{a/c}{b/d} = \frac{ad}{bc}$

Visual comparison of the two designs: The cohort study is prospective; it follows a group of subjects with known status of the risk factor (present/absent) and observes for the occurrence of disease. The case-control study is retrospective; it starts with cases who have the disease and controls who do not, and investigates the past exposure of each to the risk factor. The measure of association in cohort studies is the relative risk, which in case-control studies is estimated by the odds ratio.

SOURCE: Courtesy of Valerie Miké.

Table 4: Performance Characteristics of Diagnostic Procedures

Example: Ultrasonography to detect fetal malformation in cases with poorly controlled maternal diabetes.

Conclusion of test	Disease present (D^+)	Disease absent (D^-)
Positive (T^+)	True positive (.56)	False positive (.005)
Negative (T^-)	False negative (.44)	True negative (.995)

Sensitivity: Probability of true positive $= P(T^+|D^+) = .56$

Specificity: Probability of true negative $= P(T^-|D^-) = .995$

Prior probability of disease (*Prevalence*, best estimate before test) = $P(D^+) = .20$

Posterior probability of disease (*Predictive Value* of test) given by Bayes' Theorem.

• For positive test (PV^+):

$$P(D^+|T^+) = \frac{P(T^+|D^+)P(D^+)}{P(T^+|D^+)P(D^+) + P(T^+|D^-)P(D^-)}$$

$$= \frac{.56 \times .20}{(.56 \times .20) + (.005 \times .80)} = \frac{.112}{.116} = .966$$

• For negative test (PV^-):

$$P(D^-|T^-) = \frac{P(T^-|D^-)P(D^-)}{P(T^-|D^-)P(D^-) + P(T^-|D^+)P(D^+)}$$

$$= \frac{.995 \times .80}{(.995 \times .80) + (.44 \times .20)} = \frac{.796}{.884} = .90$$

The expressions above involve conditional probabilities. For example, sensitivity is the probability of a positive test (T^+) given the presence of disease (D^+). The formulas for positive and negative predictive value of a test require information on its sensititity and specificity, and the prior probability that the patient has the disease. Estimates of these may be generally known or be obtained form the literature, as in the present example.

SOURCE: Data from Dawson-Saunders and Trapp (1994), p. 232.

Table 5: Number Needed to Treat (NNT)

Example: Warfarin therapy to prevent stroke in patients with atrial fibrillation

Outcome	Control group	Experimental group
Annual risk of stroke	$p_c = .045$	$p_e = .014$

Absolute risk reduction: $p_c - p_e = .045 - .014 = .031$

Relative risk reduction: $= \frac{p_c - p_e}{p_c} = \frac{.031}{.045} = .69$

Number needed to treat: $NNT = \frac{1}{p_c - p_e} = \frac{1}{.031} = 32$

The number needed to treat (NNT) uses the same information as the other two expressions, but may be the most meaningful to consider. It indicates how many patients have to be treated for one to benefit from the treatment.

SOURCE: Data from Redmond and Colton (2001), p. 321.

long-term treatment of large populations. It is more informative to present NNT, the number of patients that have to be treated to prevent a single adverse event, than the usually reported relative percent reduction by the experimental treatment. For example, the anticoagulant warfarin was reported to achieve a 69 percent reduction in the annual relative risk of stroke in patients with atrial fibrillation. As shown in Table 5, the absolute reduction was 3.1 percent, from 4.5 to 1.4 percent, with its reciprocal as the NNT of thirty-two. This means that for every patient who benefits from the treatment, thirty-two on average have to be treated, with all thirty-two subject to side effects. For some low-risk patients the NNT is 145. People are far more critical in accepting treatment when results are expressed as NNT, rather than the large relative percent reductions heralded in promotions and the media.

Highlights of History

"One must attend in medical practice not primarily to plausible theories, but to experience combined with reason" (Hippocrates 1923, p. 313).This maxim appears in the *Hippocratic Corpus*, the writings collected under the name of the Greek physician Hippocrates (c. 460–c. 377 B.C.E.) that became the foundation of Western medicine. Nevertheless until a gradual change beginning around the mid-nineteenth century, medical practice was nearly always based on tradition and authority. Milestones in this transformation were discoveries made by two astute physicians who brought mathematics to medical investigation. One challenged the value of bloodletting, a common treatment dating back to antiquity. The other established the cause of childbed fever, a deadly disease of young mothers that was in fact an infection transmitted by physicians. The work of both met with hostility from the medical community.

PIERRE C. A. LOUIS AND THE NUMERICAL METHOD. By the early-nineteenth century there were large public hospitals in the major cities of Europe, and Paris was leading in the development of pathological anatomy, the use of autopsies to explore changes in the body caused by disease. The French physician Pierre Charles Alexandre Louis (1787–1872) spent years collecting and analyzing data on hospital patients, including the results of autopsies on fatal cases. He called his approach the Numerical Method, which involved tabulating data for groups of patients according to diagnosis and treatment received, and comparing their course of illness and survival patterns. In his major work on bleeding, published in 1835, he studied the effects of bloodletting in series of patients with different diagnoses and found essentially no difference in death rate or duration and severity of symptoms between patients bled and not bled and those bled at different stages of their disease. His findings completely contradicted the teachings of the day and met with sharp criticism, such as the argument that patients could not be compared in groups, because they differed in many respects. Louis reasoned that comparison was being made of essential features, abstracted from the general variability of other factors. The result was a systematic record of what was observed, not the anecdotal evidence of individual physicians who tended to remember the favorable cases. He developed guidelines for designing studies to evaluate different modes of treatment in his *Essay on Clinical Instruction* (1834).

Louis had great influence on the development of scientific medicine in the United States, because many young Americans were then studying medicine in Paris. One of these was Oliver Wendell Holmes (1809–1894), who in later recollections of Louis described the impact of the change he had observed: "The history of practical medicine had been like the story of the Danaides. 'Experience' had been, from time immemorial, pouring its flowing treasures into buckets full of holes. At the existing rate of supply and leakage they would never be filled; nothing would ever be settled in medicine. But cases thoroughly recorded and mathematically analyzed would always be available for future use, and when accumulated in sufficient number would lead to results which would be trustworthy, and belong to science" (Holmes 1883, p. 432).

IGNAZ SEMMELWEIS: A MEDICAL THEORY BASED ON MATHEMATICS. In July 1846 the young Hungarian physician Ignaz Semmelweis (1818–1865), trained at the medical school of Vienna, then the leading center of medicine in Europe, began work in the maternity clinic of its General Hospital. Confronted with the high death rates from childbed (puerperal) fever that would strike young women and often their babies shortly after childbirth, he undertook with passion to find the real cause of the disease. Occurring in hospitals throughout Europe and the United States, childbed fever was believed to have many different and vague causes, like cosmic-telluric-atmospheric influences and miasmas. In Vienna the first division of the maternity clinic, used for the training of medical students, had much higher mortality rates than the second division staffed by student midwives. Between January and June 1846 the death rate had ranged from 10 to 19 percent, compared with under 3 percent for the midwives, and it remained high as Semmelweis pursued his intense study of patient conditions and autopsies.

Two observations would fuse to spark the flash of insight in May 1847: (1) The staff of the first division, himself included, came to the maternity clinic directly from the dissection room where they had performed autopsies on the diseased patients (unlike the midwives); and (2) A colleague who had died of a wound sustained during a dissection revealed the same lesions on autopsy as the victims of childbed fever. Semmelweis's discovery entailed the recognition that the doctor and the women had died of the same cause, and the infectious material had been transmitted to the patients by the contaminated hands of the examining physicians. Semmelweis ordered all staff to wash their hands in chlorine of lime after autopsies, and immediately the death rate fell. When one woman with an ulcerating cancer of the uterus and another with an ulcerating knee injury gave birth, and in each case most of the patients nearby died of childbed fever, Semmelweis realized that the infectious material could also come from live tissue and be transmitted in the air, so that special precautions were needed for such cases. By 1848 the death rates were 1.27 percent in the first division and 1.33 percent in the second.

In his book *The Etiology, Concept, and Prophylaxis of Childbed Fever*, published in German in 1861, Semmelweis gave a detailed exposition of his theory, documented with extensive tables. For nearly forty years after the founding of Vienna's General Hospital, from 1784 to 1822, the death rate in the maternity clinic had averaged 1.27 percent. Between 1823 and 1840, after pathological anatomy studies were introduced, the rate rose to 5.9 percent. Then the clinic was split into two divisions, and between 1841 and 1846, the rate was 9.92 percent in the first division and 3.38 percent in the second, the pattern strongly implicating autopsies. Along these same lines, using careful observation, statistical evidence, and clear arguments, Semmelweis systematically eliminated the many other causes that had been proposed for childbed fever over the years.

Semmelweis held that invisible particles in decaying animal-organic matter were the universal necessary cause of childbed fever. Contrary to what had been claimed by others, childbed fever was a transmissible but not a contagious disease, like smallpox. Smallpox always caused smallpox, and every case of smallpox was caused by smallpox. Childbed fever was caused by resorption of decaying animal-organic matter of any source, and the latter could cause infection of any wound surface. Childbed fever was not a distinct disease, but a wound infection. The theory had complete explanatory power; it accounted for every case of the disease and its prevention. It established the etiologic approach to defining disease, the foundation of scientific medicine.

The Semmelweis theory was validated by the French chemist Louis Pasteur (1822–1895), founder of microbiology, who in 1879 identified streptococci as the chief microorganism causing childbed fever, and the English physician Joseph Lister (1827–1912), who introduced antiseptic methods in surgery. The germ theory of disease would follow. If *invisible particles in decaying animal-organic matter* is replaced by a current phrase containing *bacteria*, the Semmelweis theory remains valid and it has become a textbook case study in the philosophy of science (Hempel 1966).

Childbed fever is a tragic chapter in the history of medicine, not primarily because of the sad fate of Ignaz Semmelweis. (Suffering some sort of mental breakdown, he died abandoned, under suspicious circumstances, shortly after being committed against his will to a Viennese insane asylum.) Known from antiquity, childbed fever assumed serious proportions when childbirth became a hospital procedure, with doctors replacing midwives. Coupled with the rise of medical research in the autopsy room, progress cost the lives of hundreds of thousands of healthy young women who came to the charity hospitals to deliver. And the real tragedy was how long it took for the old theories to fade after the evidence was in, how long the debate went on about the causes of childbed fever as mothers went on dying. The problem of childbed fever was not definitively solved until the late 1930s, with the introduction of the sulfonamide drugs and then penicillin.

"Quels faits! Quelle logique!" was Pierre C. A. Louis's exasperated response as his critics proclaimed the merits of bloodletting. "Oh Logik!! Oh Logik!!" echoed Semmelweis in the closing paragraph of his great work, urging enrollment in a few semesters of logic before answering the noble call to argue the etiology of disease.

MODERN STATISTICAL INFERENCE. During the nineteenth century probability theory came to be used in the analysis of variation in astronomy, the social sciences, physics, and biology. The intense study of heredity, stimulated by the theory of evolution, spawned the birth of modern statistics around the turn of the twentieth century, associated with the names of Sir Francis Galton (1822–1911), Karl Pearson (1857–1936), and Sir Ronald Fisher (1890–1962). Formal statistical inference, with methods of hypothesis testing and estimation, was gradually introduced across a wide range of disciplines, including medicine.

In his work on the design of experiments in agriculture, Fisher proposed the idea of randomization, to make the experimental plots as similar as possible except for the treatment being tested. Applied to medicine, the approach led to the randomized clinical trial. The first strictly controlled clinical trial using random assignment of patients was set up by the British Medical Research Council in 1946 to evaluate streptomycin in the treatment of pulmonary tuberculosis. The trial was designed by the statistician Sir Austin Bradford Hill (1897–1991), who played a key role in bringing modern statistical concepts to medicine. In the United States randomized clinical trials were introduced in the mid-1950s when Congress authorized the National Cancer Institute to establish the Cancer Chemotherapy National Service Center to coordinate the testing of new compounds as possible anticancer agents. This launched the formation of national cooperative groups that became the mechanism for large-scale clinical trials, with funding provided for related research in statistical methodology.

Contemporary Biostatistics

Biostatistics is a strong academic discipline, with its professionals engaged in teaching and research, and working as consultants and collaborators throughout the healthcare field. The range of developments in theory and methodology—there is now a six-volume encyclopedia—as well as the increasing complexity of biomedical science and technology make the biostatistician an essential member of the research team.

In planning quality studies to assess risk factors of disease or the effectiveness of treatments, questions pertaining to research design, proposed controls, sample size, type of data to collect, length of study, and methods of analysis need to be guided by statistical considerations. *Historical,* rather than *concurrent controls,* may be appropriate for new treatment of a rare, usually fatal disease. In a randomized clinical trial, *stratified randomization* may be used, where patients are assigned at random within subgroups known to affect prognosis (for example, menopausal status in breast cancer). There are methods to assess the effect of multiple risk factors on outcome, such as *Cox regression, logistic regression,* and *loglinear analysis*. The essential means of modern analysis is provided by electronic database management and statistical software systems.

In approaches to statistical inference there is lively interest in *Bayesian methods* and *decision theory*. Within medicine there are the movements of *outcomes research,* to explore the effectiveness of medical interventions in the general population, and *evidence-based medicine,* to make more effective use of the medical literature in everyday practice. A related area is *meta-analysis,* which seeks to combine the results of published studies to obtain the best possible assessment of risk factors and treatments. Evaluating *alternative medicine* has become a pressing issue. The broader field of *health services research* also studies the *cost-effectiveness* of medical procedures.

Biostatistics and Ethics

The Hippocratic maxim, "Help or at least do no harm," has for 2500 years been the basis of medical ethics. How this can be done is explained by the Hippocratic precept cited earlier. To this end, medical practice should be based on experience combined with reason, namely, carefully collected observations (experience) analyzed with the tools of scientific methodology (reason). Biostatistics has assumed this function, and played a significant role in the great achievements of medical science and technology. Since the closing decades of the twentieth century, it has been faced with a crisis in U.S. (and Western) medicine, as the costs of health care spiral out of control.

Important advances include antibiotics and immunization, control of diabetes and hypertension, treatments for heart disease, cancer, and psychiatric disorders, diagnostic imaging, neonatal and trauma medicine, biomechanics, and organ transplants, with research continuing unabated on every front. But past successes have led many to unrealistic expectations of perpetual progress, putting them at risk for exploitation by a profit-driven healthcare industry. Medical technology tends to be oversold by the market, and an often poorly informed, vulnerable public is buying. Promotion in the media focuses on conditions that affect large segments of the population, such as chronic pain, which requires safe and effective individualized treatment for adequate control.

DEBATE OF MARKET VS. SCIENCE. In September 2004 the arthritis pain medication Vioxx, with sales of $2.5 billion in 2003, was withdrawn from the market by its manufacturer Merck because of findings of an increased risk of heart attacks and strokes. This triggered charges that the company had ignored earlier warnings, and the rival drugs Celebrex and Bextra, made by Pfizer, also came under scrutiny. Although helpful for many, these Cox-2 inhibitor agents did not claim greater effectiveness, only fewer gastrointestinal side effects than older alternatives like aspirin, ibuprofen, and naproxen. In the absence of adequate comprehensive studies, controversy continued concerning the relative risks and benefits of the various agents and the indications for their use. The larger debated issue is that of postmarketing surveillance (safety monitoring of drugs after release on the market), and the role of the Food and Drug Administration (FDA). The high cost of new drugs like Vioxx, challenged by medical critics, raises a further ethical concern. It is not only the physical harm done to so many, but the emotional and financial harm to all those struggling on limited means.

The individual must be more assertive in asking questions: Is this drug treatment necessary? What is the effectiveness (NNT) of the drug for a patient with the given characteristics? What are the side effects for this class of patient and how long is the follow-up of observation? Is there a less expensive, better-evaluated alternative? What are the interactions of the drugs the patient is taking? All drugs have side effects, and harmful effects of legally prescribed drugs are estimated to cause over 100,000 deaths in the United States each year. Ultimately it is up to the public to demand answers.

THE ETHICS OF EVIDENCE. An approach has been proposed for dealing with medical uncertainty, called the *Ethics of Evidence*. (Miké 1999, 2003). It can be expressed in two simple rules or imperatives: The first calls for the creation, dissemination, and use of the best possible scientific evidence as a basis for every phase of medical decision making. Complementing it, the second focuses on the need to increase awareness of, and come to terms with, the extent and ultimately irreducible nature of uncertainty.

There is a need for greater insight and closer involvement on the part of the public. Biostatistics can help to discern what is necessary, safe, and effective treatment, and should be fully utilized to produce the best available evidence. But even when it is properly used, uncertainties remain that are intrinsic to the techniques themselves and the limitations of medical knowledge. Most major diseases do not have a single cause, but result from the complex interplay of genetic and environmental factors. Systematic study of individual risk factors and their interactions must continue, in the search for better prevention and control. When Semmelweis made his great discovery, the numeric results were so dramatic that no formal statistical procedures were needed (and they did not yet exist). In the early twenty-first century it is a slow, incremental process to find and confirm small improvements. The real promise for medicine in the near future points to changes in lifestyle.

A study released in July 2004 estimates that 195,000 Americans die each year as a result of preventable medical error, and the data pertain only to hospitals. More open and direct participation of patients in their own treatment would help reduce error rates, keep in the forefront questions about the safety and effectiveness of proposed interventions, and curb the reflexive urge for malpractice litigation. An alert, educated public has a realistic view of medicine and does not expect it to solve all of life's problems. But it insists on well-funded biomedical research and its careful assessment, with effective government policies in place to ensure the best possible healthcare for all.

VALERIE MIKÉ

SEE ALSO *Meta-Analysis; Social Indicators; Statistics.*

BIBLIOGRAPHY

American Cancer Society. (2004). *Cancer Facts and Figures 2004*. Atlanta, GA: American Cancer Society. Annual report issued by the American Cancer Society, also available online at http://www.cancer.org/docroot/STT/content/STT_1x_Cancer_Facts__Figures_2004.asp.

Angell, Marcia. (2004). *The Truth about the Drug Companies: How They Deceive Us and What to Do About It*. New York: Random House. Documented critique of the pharmaceutical industry by a former editor of the *New England Journal of Medicine*.

Armitage, Peter, and Theodore Colton, eds. (1998). *Encyclopedia of Biostatistics*, 6 vols. New York: John Wiley & Sons.

Carter, H. Ballentine. (2004). "Prostate Cancer in Men with Low PSA Levels—Must We Find Them?" *New England Journal of Medicine* 350: 2292–2294.

Carter, K. Codell, and Barbara L. Carter. (1994). *Childbed Fever: A Scientific Biography of Ignaz Semmelweis*. Westport, CT: Greenwood Press.

Dawson-Saunders, Beth, and Robert G. Trapp. (1994). *Basic and Clinical Biostatistics*, 2nd edition. New York: McGraw-Hill/Appleton & Lange.

Evidence-Based Medicine Working Group. (1992). "Evidence-Based Medicine: A New Approach to Teaching the Practice of Medicine." *Journal of the American Medical Association* 268: 2420–2425.

Gehan, Edmund A., and Noreen A. Lemak. (1994). *Statistics in Medical Research: Developments in Clinical Trials*. New York: Plenum Medical Book. History of clinical trials, with emphasis on statistical aspects.

Hempel, Carl G. (1966). *Philosophy of Natural Science*. Englewood Cliffs, NJ: Prentice Hall. Includes case study of Semmelweis discovery.

Hill, Austin Bradford. (1967). *Principles of Medical Statistics*, 9th edition. New York: Oxford University Press. A classic text of biostatistics by one of its pioneers. Includes discussion of criteria for establishing causality in observational studies.

Hippocrates. (1923). "Precepts." In *Works*, Vol. 1, trans. W. H. S. Jones. London: Heinemann.

Holmes, Oliver Wendell. (1883). "Some of My Early Teachers: A Farewell Address to the Medical School at Harvard University, November 28, 1882." In *Medical Essays: 1842–1882*. Boston: Houghton, Mifflin.

Kohn, Linda T.; Janet M. Corrigan; and Molla S. Donaldson, eds. (2000). *To Err Is Human: Building a Safer Health System*. Washington, DC: National Academy Press. Includes discussion of large studies of medical errors in hospitals.

Louis, Pierre C. A. (1834). *An Essay on Clinical Instruction*, trans. Peter Martin. London: S. Highley. Original in French.

Miké, Valerie. (1988). "Modern Medicine: Perspectives on Harnessing Its Vast Emerging Power." *Technology in Society* 10: 327–338. Analysis of the need for better assessment of medical technology and related issues.

Miké, Valerie. (1999). "Outcomes Research and the Quality of Health Care: The Beacon of an Ethics of Evidence." *Evaluation & the Health Professions* 22: 3–32. Commentary by Edmund D. Pellegrino, "The Ethical Use of Evidence in Biomedicine," is included in this issue.

Miké, Valerie. (2003). "Evidence and the Future of Medicine." *Evaluation & the Health Professions* 26: 127–152. Further development of the Ethics of Evidence.

Miké, Valerie, and Robert A. Good. (1977). "Old Problems, New Challenges." *Science* 198: 677–678. Introduction to Birnbaum Memorial Symposium "Medical Research: Statistics and Ethics." International multidisciplinary conference with focus on ethical issues in biostatistics. Proceedings published in *Science*.

Miké, Valerie, and Ralph C. Marcove. (1978). "Osteogenic Sarcoma under the Age of 21: Experience at Memorial Sloan-Kettering Cancer Center." In *Immunotherapy of Cancer: Present Status of Trials in Man*, eds. William D. Terry, and Dorothy Windhorst. New York: Raven Press. Example of a clinical trial where use of a historical control was the appropriate procedure.

Miké, Valerie, and Kenneth E. Stanley, eds. (1982). *Statistics in Medical Research: Methods and Issues, with Applications in Cancer Research*. New York: John Wiley & Sons. Includes multidisciplinary discussion of clinical trials, including ethical aspects.

Redmond, Carol, and Theodore Colton, eds. (2001). *Biostatistics in Clinical Trials*. New York: John Wiley & Sons. Includes articles on Bayesian methods and NNT.

Shryock, Richard Harrison. (1969). *The Development of Modern Medicine: An Interpretation of the Social and Scientific Factors Involved*. New York: Hafner Publishing.

Semmelweis, Ignaz. (1983). *The Etiology, Concept, and Prophylaxis of Childbed Fever*, trans. K. Codell Carter. Madison: University of Wisconsin Press. Originally published in German as *Die Aetiologie, der Begriff, und die Prophylaxis des Kindbettfiebers* (1861).

Topol, Eric J. (2004). "Good Riddance to a Bad Drug." *New York Times*, October 2, p. A15. Op-Ed article by chairman of department of cardiovascular medicine at Cleveland Clinic, who in 1991 published results on cardiac risks of Vioxx.

INTERNET RESOURCE

Health Grades Inc. "Patient Safety in American Hospitals." Health Grades. Available from http://www.healthgrades.com/PressRoom/index.cfm?fuseaction=PressReleases. July 2004 study.

BIOTECH ETHICS

In the seventeenth century the philosophers Francis Bacon (1561–1626) and René Descartes (1596–1650) advocated a new way of doing science that would have the power to conquer nature for human benefit. (The old science had seemed to be more concerned with contemplating nature than controlling it.) In the contemporary world biotechnology is providing the technology for controlling and changing living nature, including human nature. However, because biotechnological power over the living world offers not only the promise for doing good but also an opportunity for doing evil, this has provoked an ethical debate over the modern scientific project for the mastery of nature through technology.

Biotechnology in History

Biotechnology can be defined as the technical manipulation of living organisms or parts of those organisms to provide products and services to satisfy human desires. If it is defined in this broad way, one can see that biotechnology has been employed throughout human history.

The history of biotechnology can be divided into three periods: ancient, modern, and contemporary. Ancient biotechnology began more than 10,000 years ago with the emergence of agriculture in ancient Mesopotamia. Modern biotechnology began in the nineteenth century with the development of industrial microbiology. Contemporary biotechnology began in the 1970s with new techniques for genetic engineering. In each period one can see the power humans have acquired to manipulate nature. But one also can see the natural limits of this power, which is constrained by the natural potentialities available in wild plants and animals and the natural complexities of behavioral traits in the living world.

Ancient biotechnology began when human beings started to domesticate plants and animals for human use. Throughout most of the history of the human species, spanning approximately six million years, human beings fed themselves by gathering wild plants and hunting wild animals. Then some people in a few parts of the world began to produce food by cultivating domesticated plants and herding domesticated animals. As a consequence those farmers and herders bred for and selected genetic modifications in domesticated organisms that were more suitable to human desires. Even in the early twenty-first century all of human civilization depends on this project in agricultural biotechnology.

The human power of domestication is limited, however, by the natural potentiality of wild plants and animals. Most plant and animal species in the wild are not suitable for domestication. For example, most wild plants are not good as a source of food because they are woody or do not produce fruit, leaves, or roots that are edible. Most wild animals are not susceptible to successful domestication because they cannot be bred and herded in a manner that makes them useful for human beings. Although advances in biological knowledge have increased human biotechnological power over living nature, that power will always be limited by the potentialities found in nature.

Modern biotechnology arose in the nineteenth century as growing knowledge in the biological sciences was applied to the technological manipulation of the living world for human purposes. For example, the chemist Louis Pasteur's (1822–1895) microbiological explanation of fermentation as resulting from the activity of microscopic organisms allowed improvements in the brewing of beer and other industries that depend on using fermentation by yeast to produce food and beverages. Pasteur also showed that infectious diseases are caused by disease-producing microorganisms and perfected techniques for vaccination that would create immunity to some of those diseases. Later, in the twentieth century, the discovery of the ways in which some fungi produce antibiotics such as penicillin revolutionized the medical treatment of bacterial infections. In the early 2000s there are hundreds of pharmaceutical agents derived from fungal fermentation.

However, even modern biotechnology shows the technical limits set by nature. Bacteria vulnerable to fungal toxins can evolve to become resistant to those toxins. Indeed, bacteria have been so successful in evolving tolerance to antibiotics that there is a growing fear in the medical profession that the age of antibiotic protection against infectious diseases is reaching its end. The power of this aspect of biotechnology for controlling living nature is great but limited.

The contemporary biotechnology that began in the last half of the twentieth century arose from a deeper knowledge of genetics and molecular biology and has provided humans with greater power over the living world. Even so, contemporary biotechnology is limited in its technical means by the physical and chemical limits of nature.

Contemporary biotechnology began in 1973 when Herbert Boyer and Stanley Cohen developed the technology for recombinant DNA, which allows scientists to alter DNA molecules and thus artificially create new forms of life. They did this by combining a number of discoveries. Bacteria protect themselves against certain viruses through the use of restriction enzymes that cut up viral DNA at specific sequences of nucleotide bases; this allows a scientist with the right restriction enzyme to cut out a specific genetic sequence. Bacteria contain plasmids, which are small loops of DNA that can pass from one bacterium to another. This allows bacteria to develop antibiotic resistance quickly if the genes for resistance are passed by plasmids. Boyer and Cohen showed how one could use a restriction enzyme to cut out a specific genetic sequence and then glue that sequence into a bacterial plasmid. That plasmid, with its new combination of genetic sequences, could be introduced into a bacterial cell. As the bacterial cell divided, it would produce copies of the recombinant plasmid, which then could be extracted from the bacteria.

An illustration of the value of this recombinant DNA technique is provided by the production of human insulin. People with diabetes do not have enough of the protein insulin to regulate blood-sugar levels. After the 1920s diabetic patients were treated with injections of insulin extracted from pigs and cattle. This is an example of modern biotechnology. Although pig and cow insulin is very similar to human insulin, there are enough differences that some people with diabetes have had allergic reactions. Contemporary biotechnology provided a solution to the problem by using recombinant DNA techniques. The human gene for insulin was identified and then could be inserted into a bacterial cell through a plasmid so that the bacterium would produce human insulin that could be harvested for use by human patients. In 1982 human insulin produced in genetically modified bacteria became the first drug of contemporary biotechnology to be approved by the U.S. Food and Drug Administration.

Contemporary biotechnology has developed hundreds of products with agricultural, environmental, and medical benefits. Agricultural biotechnology uses reliable techniques for genetic manipulation to produce new kinds of plants and animals to provide food that is cheaper and more nutritious. Environmental biotechnology is used to design genetically modified organisms that can clean up environmental pollution by consuming toxic materials. Medical biotechnology is used to devise new drugs and vaccines and therapeutic techniques that relieve or prevent suffering, cure disease, and enhance physical and mental well-being.

Ethical Issues

Despite its many benefits, biotechnology has provoked ethical controversy in six areas of moral concern: safety, liberty, justice, environmental nature, human nature, and religious beliefs.

SAFETY. Safety is a moral concern for opponents of biotechnology who worry that its power disrupts the complex balance in living nature in ways that are likely to be harmful. Individuals such as Jeremy Rifkin (1977) and groups such as Greenpeace have warned that genetically modified crops and foods could endanger human health as well as the health of the environment. Critics of medical biotechnology fear that biotechnology medicine alters the human body and mind in radical ways that could produce harmful consequences—perhaps far into the future—in ways that are hard to foresee.

Proponents of biotechnology such as James Watson (2003) and Michael Fumento (2003) argue that its techniques are so precise and controlled that it tends to be far safer than older forms of technology. Breeders of plants and animals have genetically modified organisms for thousands of years without understanding exactly what they were doing. But biotechnology in the early 2000s provides a better understanding of and greater power over genetic mechanisms so that it is possible to minimize the risks. In fact, there is no clear evidence that any human being among the hundreds of millions who have been exposed has become sick from eating genetically modified foods. Similarly, the risks to human health from medical biotechnology can be reduced by means of careful testing and new techniques for designing drugs and therapies that are designed specifically for individual patients with unique genetic traits. Nevertheless, the history of unforeseen harm from all technologies justifies a cautious approach.

LIBERTY. Liberty is a moral concern for those who fear that biotechnology will give some people tyrannical power over others. The history of eugenics, in which governments used coercion to eliminate those judged to be biologically "unfit," illustrates the danger of encroachments on liberty. Libertarian proponents of biotechnology such as Fumento and Virginia Postrel (1998) insist that there should be no threat to liberty as long as biotechnology is chosen freely by individuals in a free market economy. But conservatives such as Leon Kass (2002) worry that people could be coerced informally by social pressure, employers, and insurance companies so that they will feel compelled to adopt biotechnology products and procedures. Moreover, Kass and others suggest that biotech can give parents the power to control the nature and behavior of their children in ways that threaten the liberty of the children.

JUSTICE. Justice is a moral concern for people who anticipate that biotechnology will be so expensive that only the richest individuals will benefit from it so that the rich will have an unjust advantage over the poor. Even proponents of biotechnology such as Lee Silver (1998) worry that reproductive biotechnology eventually could divide humanity into two separate species based on the wealth or poverty of their ancestors: the "genrich" who would be genetically designed to be superior and the "genpoor" who would be left behind as biologically inferior beings. Of course in some ways this problem is not unique to biotechnology because rich people always have unfair advantages over the poor, but the libertarian defenders of biotechnology foresee that in a free-market society prices for biotechnology products and services eventually will decline as a result of competition, and this will lessen the advantages of the rich over the poor. Similarly, critics of biotechnology argue that the rich nations of the world will benefit more from this new technology than will the poor nations, yet libertarians predict that international free trade will spread the advantages of biotechnology around the world.

ENVIRONMENTAL NATURE. Environmental nature is a moral concern for environmentalists such as Rifkin and Bill McKibben (2003). Those environmentalists predict that biotechnology will promote the replacement of the natural environment with a purely artificial world and that this will deprive human beings of healthy contact with wild nature. They also fear that introducing genetically modified organisms into the environment will produce monstrous forms of life that will threaten human beings and the natural world.

Proponents of biotechnology respond by noting that beginning with agriculture, human beings have been creating genetically modified organisms that transform the environment for thousands of years. All organisms modify their environments, sometimes with global effects. For example, the oxygen in the earth's atmosphere has been produced over billions of years by photosynthetic organisms. Biologists such as F. John Odling-Smee (2003) have called this "niche construction." So human beings are not unique in their capacity for changing their environments. Although this sometimes has produced disasters such as the extinction of plants and animals and the emergence of new disease-causing agents, people have learned to adjust to these dangers, and contemporary biotechnology provides more precise knowledge and techniques to recognize and avoid such dangers. Moreover, environmental biotechnology is developing new organisms, such as bacteria genetically engineered to metabolize toxic wastes, to restore dangerous natural environments to a condition that is safe for human beings.

HUMAN NATURE. Human nature is a moral concern for anyone who fears that biotechnology could change or even abolish human nature. Both environmentalists such as Rifkin and McKibben and conservatives such as Kass and Francis Fukuyama (2002) worry that the biotechnological transformation of human nature will produce a "posthuman" world with no place for human dignity rooted in human nature. On the other side of this debate Nick Bolstrom (2003) and others in the World Transhumanist Association welcome the prospect of using biotechnology to move toward a "transhuman" condition. More moderate proponents of biotechnology dismiss both positions for being based on exaggerated views of the power of biotechnology.

In a report by the President's Council on Bioethics (2003) Kass and other members of the council contend that biotechnology expresses a willful lack of humility in pursuing a scientific mastery of nature that carries out the modern scientific project first described by Francis Bacon. When a physician uses medical therapy to restore the health of a patient, the physician cultivates the body's natural capacity for healing to serve the natural goal of health. Such medical treatment is guided in both its means and its ends by nature. But when biotechnologists use genetic engineering or psychotropic drugs to extend human bodily or mental powers beyond their normal range, they act not as nature's servant but as nature's master because they are forcing nature to serve their own willful desires.

As an example Kass and other members of the council point to the use of psychotropic drugs such as Prozac that alter the biochemistry of the brain to elevate mood. Using such drugs to cure severely depressed patients can be justified as therapy directed toward restoring normal mental health, but their use to change human personality radically—perhaps by inducing feelings of contentment that never yield to sadness—would violate the normal range of human mental experience set by nature. The ultimate aim of such a psychopharmacological science would be a drug-dependent fantasy of happiness that would be dehumanizing. Furthermore, scientists such as David Healy (2004) have warned that any drug powerful enough to change human personality is likely to have severely harmful side effects.

The President's Council (2003) warns against the excessive pride inherent in Bacon's project for mastering nature, which assumes that nature is mere material for humans to shape to their desires. Rather, it urges people to adopt an attitude of humility and respect and treat the natural world as a "gift." To respect the "giftedness" of the natural world is to recognize that the world is given to humans as something not fully under their control and that even human powers for changing the world belong to human nature as the unchanging ground of all change (Kass 2003).

Proponents of biotechnology could respond by defending Bacon's project as combining respect for nature with power over nature. At the beginning of the *Novum Organon* Bacon observed that "nature to be commanded must be obeyed" because "all that man can do is to put together or put asunder natural bodies," and then "the rest is done by nature working within" (Bacon 1955, p. 462). Kass has used the same words in explaining how the power of biotechnology is limited by the potentialities inherent in nature (Kass 1985).

Throughout the history of biotechnology—from the ancient Mesopotamian breeders of plants and animals, to Pasteur's use of microorganisms for fermentation and vaccination, to Boyer and Cohen's techniques for gene splicing—people have employed nature's properties for the satisfaction of human desires. Boyer and Cohen did not create restriction enzymes and bacterial plasmids but discovered them as parts of living nature. They then used those natural processes to bring about outcomes, such as the production of human insulin for persons with diabetes, that would benefit human beings. Biotechnology has the ability to change nature only insofar as it conforms to the laws of nature. To command nature people must obey it.

Baconian biotechnology is thus naturally limited in its technical means because it is constrained by the potentialities of nature. It is also naturally limited in its moral ends because it is directed toward the goals set by natural human desires. Kass and the President's Council

(2003) acknowledge this by showing how biotechnology is employed to satisfy natural desires such as the desire of parents for happy children and the desire of all human beings for life and health. As they indicate, it is not enough to respect the "giftedness" of nature because some of the "gifts" of nature, such as diabetes and cancer, are undesirable. People accept some of nature's gifts and reject others on the basis of the desires inherent in human nature.

RELIGIOUS BELIEFS. To appreciate life as a gift that should elicit a feeling of humility rather than mastery is a religious emotion. Some of the moral concerns about biotechnology express the religious attitude that life is sacred and therefore the biotechnological manipulation of life shows a lack of reverence for the divinely ordained cosmic order. The biblical story of the Tower of Babel (*Genesis* 11:1–9) suggests that the human lust for technical power over the world provokes divine punishment.

In 1977 the environmentalist Jeremy Rifkin wrote a book attacking biotechnology with the title *Who Should Play God?: The Artificial Creation of Life and What It Means for the Future of the Human Race*. The title conveys the direction of his argument. The "creation of life" is proper only for God. For human beings to create life "artificially" is a blasphemous transgression of God's law that will bring punishment upon the human race. Rifkin often uses the imagery of the Frankenstein story. Like Doctor Frankenstein, biotech scientists are trying to take God's place in creating life, and the result can only be the creation of monsters. When people such as Rifkin use the phrase "playing God," they evoke a religious sense that nature is a sacred expression of God's will and therefore should not be changed by human intervention. Rifkin has said that "the resacralization of nature stands before us as the great mission of the coming age" (Rifkin 1983, p. 252).

In contrast to Rifkin, Bacon thought that regarding nature as sacred was a pagan idea contrary to biblical religion. In pagan antiquity the natural world was the sacred image of God, but the Bible teaches that God is the transcendent Creator of nature; therefore, God's mysterious will is beyond nature. Although nature declares God's power and wisdom, it does not declare the will and true worship of God. Bacon believed that true religion as based on faith in biblical revelation must be separated from true philosophy based on the rational study of nature's laws (Bacon 1955).

Some biblical theologians, such as Philip Hefner (2003) and Ted Peters (2003), have restated this Baconian claim that the biblical conception of God as the supernatural creator of nature separates the sacred and the natural and thus denies pagan pantheism. They argue that because human beings have been created in God's image and God is the Creator, human beings must share somehow in God's creativity. The Bible declares that when God made humanity in his image, this was to include "dominion" or "mastery" over all the earth, including all the animals (Genesis 1:26–28). Hefner reads the Bible as teaching that human beings are "created cocreators." As "created," humans are creatures and cannot create in the same way as God, who can create *ex nihilo*, "from nothing." However, as "cocreators" people can contribute to changes in creation. Of course, Hefner warns, people must do this as cautious and respectful stewards of God's creation, but it is not appropriate to worship nature as sacred and thus inviolable.

The theological idea of human beings as cocreators was affirmed by Pope John Paul II in his 1981 encyclical *Laborem Exercens* and criticized as a "remarkably bad idea" by the Protestant theologian Stanley Hauerwas (Houck and Williams 1983). In his 1991 encyclical *Centesimus Annus* the Pope stressed the importance of human technological knowledge in improving the conditions of life (Novak 1993).

That God transcends nature, that nature is thus not sacred, that human beings as created in God's image share in God's creative activity, that human beings have the power and the duty to master nature by artful manipulation, and that they have the moral duty to do this as an activity of charity for the improvement of human life—all the precepts Bacon drew from the Bible to support his view of the new science—have been accepted by some biblical believers. But many of those believers worry that modern science promotes an atheistic materialism that denies the dignity of human beings and of the natural world generally as God's Creation. In particular they worry about whether biotechnology expresses an unduly willful attitude toward the world as merely raw material for human manipulation and survival.

LARRY ARNHART

SEE ALSO *Bioengineering Ethics; Bioethics; Biological Weapons; Food Science and Technology; Genethics; Genetically Modified Foods; Nanoethics.*

BIBLIOGRAPHY

Arnhart, Larry. (2003). "Human Nature Is Here to Stay." *The New Atlantis* 2: 65–78. Argues that biotechnology will not abolish human nature.

Bacon, Francis. (1955). *Selected Writings of Francis Bacon*. New York: Random House.

Bud, Robert. (1993). *The Uses of Life: A History of Biotechnology*. Cambridge, UK: Cambridge University Press.

Diamond, Jared. (1997). *Guns, Germs, and Steel: The Fates of Human Societies*. New York: Norton. A history of how agricultural biotechnology has shaped human civilization.

Fukuyama, Francis. (2002). *Our Posthuman Future: Consequences of the Biotechnology Revolution*. New York: Farrar, Straus, and Giroux. A neoconservative argument for legally restricting biotechnology.

Fumento, Michael. (2003). *Bioevolution: How Biotechnology Is Changing Our World*. San Francisco: Encounter. A detailed survey of all forms of biotechnology by a libertarian proponent.

Healy, David. (2004). *Let Them Eat Prozac: The Unhealthy Relationship between the Pharmaceutical Industry and Depression*. New York: New York University Press.

Hefner, Philip. (2003). *Technology and Human Becoming*. Minneapolis, MN: Fortress Press.

Houck, John, and Oliver Williams, eds. (1983). *Co-Creation and Capitalism: John Paul II's Laborem Exercens*. Washington, DC: University Press of America.

Kass, Leon. (1985). *Toward a More Natural Science*. New York: Free Press.

Kass, Leon. (2002). *Life, Liberty, and the Defense of Dignity*. San Francisco: Encounter.

Kass, Leon, ed. (2003). *Beyond Therapy: Biotechnology and the Pursuit of Happiness: A Report of the President's Council on Bioethics*. Washington, DC: Dana Press.

McKibben, Bill. (2003). *Enough: Staying Human in an Engineered Age*. New York: Times Books. An environmentalist attack on biotechnology.

Novak, Michael. (1993). *The Catholic Ethic and the Spirit of Capitalism*. New York: Free Press.

Odling-Smee, F. John; Kevin N. Laland; and Marcus W. Feldman. (2003). *Niche Construction: The Neglected Process in Evolution*. Princeton, NJ: Princeton University Press.

Peters, Ted. (2003). *Playing God?: Genetic Determinism and Human Freedom*, 2nd ed. New York: Routledge.

Postrel, Virginia. (1998). *The Future and Its Enemies*. New York: Free Press. A libertarian defense of technological innovation as the basis for human freedom.

Rifkin, Jeremy. (1977). *Who Should Play God?: The Artificial Creation of Life and What It Means for the Future of the Human Race*. New York: Delacorte Press.

Rifkin, Jeremy. (1983). *Algeny*. New York: Viking.

Rifkin, Jeremy. (1998). *The Biotech Century: Harnessing the Gene and Remaking the World*. New York: Penguin Putnam.

Ruse, Michael, and David Castle, eds. (2002). *Genetically Modified Foods: Debating Biotechnology*. Amherst, NY: Prometheus Books. An excellent collection of statements on all sides of the ethical debate over agricultural biotechnology.

Sherlock, Richard, and John D. Morrey, eds. (2002). *Ethical Issues in Biotechnology*. Lanham, MD: Rowman and Littlefield. An excellent anthology of material on the ethics of biotechnology.

Silver, Lee. (1998). *Remaking Eden: Cloning and Beyond in a Brave New World*. New York: Avon. A libertarian celebration of the power of biotechnology for changing the world.

Watson, James D. (2003). *DNA: The Secret of Life*. New York: Knopf. A broad history of genetics and biotechnology by the codiscoverer of DNA.

INTERNET RESOURCE

Bolstrom, Nick. (2003). *The Transhumanist FAQ*. Available from http://www.transhumanism.org/resources/faq.html.

BIOTECHNOLOGY ETHICS

SEE *Biotech Ethics*.

BIRTH CONTROL

Birth control, or contraception, is the practice of preventing or reducing the probability of pregnancy without abstaining from sexual intercourse. In premodern texts references to the enhancement of fertility and birth outweigh references to their restriction, and the development of contemporary contraceptive technologies emerged from work on fertility enhancement. Today, however, one of the most common ways in which scientific and technological advances are experienced is through people's control of fertility and birth.

History of Birth Control

The desire to control fertility has always existed in tension with the desire to procreate and with social motives to preserve population sizes. Infanticide and abortifacients were used frequently in premodern and early modern societies to control the number of offspring. However, diverse contraceptive techniques also existed, including the natural rhythm method (avoiding intercourse during ovulation), coitus interruptus (withdrawal before ejaculation), coitus obstructus (using pressure to block the male urethra), and coitus reservatus (avoiding ejaculation). Other methods included suppositories such as crocodile dung in ancient Egypt, cervical barriers, and intrauterine devices (IUDs).

Neither the ancient Greeks nor the Romans considered contraception immoral. That also was the case among the Germanic, Celtic, and other non-Mediterranean peoples in much of the medieval period. It is not surprising that the Christian Church had difficulty enforcing rules and moral norms against contraception. Early Church fathers made the moral standing of sexual intercourse an important feature of their teachings. Most important, Augustine (354–430) saw the procreation of children as one of the three justifications for Christian marriage. If sexual intercourse was performed with the specific intent of engendering offspring, it was done without sin. Augustine's views influenced subsequent treatments of contraception in the Catholic Church (Dupré 1964), and certain medieval canons criminalized contraception.

Life in modern industrial societies removed the agrarian incentive to produce numerous children. Emerging individual perspectives on procreation clashed with received social norms and many religious teachings. Technological improvements in contraceptive techniques decreased their cost and increased their availability. For example, the vulcanization of rubber in the mid-nineteenth century by Charles Goodyear (1800–1860) led to the mass production of condoms, which were made from animal intestines in seventeenth-century Europe, and other birth control devices.

Although most Catholic authorities reacted with renewed criticism of contraception, several groups that were promoting birth control challenged them. For example, neo-Malthusians in England in the early nineteenth century wanted to increase the standard of living of the poor by reducing birth rates. Others argued that birth control techniques promoted greater sexual freedom or aided eugenic attempts to improve the hereditary "stock." Many women went to extreme lengths to avoid pregnancy because of the disproportionate burden it placed on them. Those efforts were made more difficult by the declining authority of midwives in the nineteenth century in favor of male doctors, many of whom did not recognize the right of women to terminate or prevent pregnancy.

By the end of the nineteenth century many people were interpreting the increasing prevalence of birth control as a sign of social decadence and moral degradation. Some people in the United States argued that women, especially upper-class women, were shirking their "patriotic duty" to have children, sinning against nature, and committing "race suicide" (Reed 1978). Anthony Comstock (1844–1915) became the most eminent crusader against the dissemination of contraception literature. In 1873 Congress passed the Comstock Act, which defined information about contraception as obscene and prohibited the dissemination of contraceptives through the mail or across state lines. Several states also banned or restricted the dissemination of contraceptives. The strictest laws were passed by Connecticut, where married couples could be arrested for using birth control.

The most common arguments against birth control were that it promoted lewd or sinful behavior, weakened the stability provided by large families, signified a rebellion by women against their primary social role of motherhood, and undermined certain racial ideals. By contrast, those in favor of birth control argued that it promoted autonomy for women, stronger families and marriages, economic equality, and environmental health.

In the early twentieth century Margaret Sanger (1879–1966), an advocate for contraceptives who coined the phrase *birth control,* attempted to increase access to birth control by using arguments based primarily on socioeconomic justifications (Reed 1978). She crusaded against the Comstock Act, beginning with the creation of a birth control clinic in 1916. Sanger popularized the image of birth control as a means of individual freedom, self-determination, and gender equality. Legislative changes slowly followed, along with the growing legitimization of birth control methods by much of society, especially the medical community. Sanger's American Birth Control League and other organizations became known as Planned Parenthood in 1942.

In the 1960s population control became a popular movement to reduce poverty and conserve natural resources. Some anthropologists argued that irresistible reproductive pressures arising from the lack of safe, effective contraception had led all past cultures into a self-destructive pattern of production intensification and environmental degradation. Modern contraceptive technologies, however, offered an opportunity to alter that perennial pattern by lowering fertility rates (Segal 2003). The new emphasis on birth control in response to concerns about the disparity between lowered death rates and continued high birth rates in the developing world was made clear in the "Proclamation of Teheran" (paragraph 16) by the 1968 International Conference on Human Rights.

In the United States anticontraceptive laws remained in effect until the U.S. Supreme Court struck down the Comstock Act as unconstitutional in 1965. Until that time most pharmaceutical companies had refrained from investing in birth control technologies because of those laws and fear of religious objections, especially from the Catholic Church. The independent development of synthetic progesterone in the early 1950s by Frank Colton, a chemist at J. D. Searle Pharmaceutical, and Carl Djerassi, working for Syntex, a pharmaceutical company based in Mexico, allowed Gregory Pincus to create what would become known as the birth control pill. That development sparked a revolution in contraception.

The pill received approval from the U.S. Food and Drug Administration (FDA) as a contraceptive in 1960 after controversial research was done on women in third world nations. Five years later more than 6.5 million U.S. women were taking oral contraceptives. In the 1970s and 1980s contraceptive technologies continued to develop, including lower-dose birth control pills (the initial doses were found to be ten times higher than the necessary amount, causing many dangerous side effects) and a T-shaped IUD. The IUD fell out of favor because it was linked to pelvic inflammatory disease. In the 1990s the FDA approved the first hormone injections and emergency contraceptives.

The twenty-first century continues to bring new contraceptive technologies, including the birth control patch, continuous birth control pills that schedule fewer menstrual cycles per year, and male birth control pills. Despite the increased use of these technologies contraception still stimulates a wide range of ethical judgments that range from mortal sin to moral imperative. It also spans the legal and policy spectrum from laws that ban birth control to those, such as the 1979 "one child per couple" policy in China, that practically mandate it.

Issues of birth control and reproductive rights remain highly controversial elements of modern politics. Hence, whereas rising rates of teenage pregnancy lead many people to applaud the greater use of birth control, others have promoted abstinence. However, there were increasing debates about the abstinence-only education programs encouraged by the administration of U.S. President George W. Bush. Many critics argued that the administration was misusing science to promote an anticontraception moral agenda (Union of Concerned Scientists 2004).

Technological Methods

Contraceptive techniques can be divided into three categories: blockage of sperm transport to the ovum, prevention of ovulation, and blockage of implantation. Both men and women can use methods in the first category, whereas those in the latter two categories are available to women only. Each technique presents different tradeoffs among variables such as comfort, price, availability, safety, and effectiveness.

BLOCKAGE OF SPERM TRANSPORT TO THE OVUM. Natural contraception, also known as the rhythm method of birth control, relies on abstinence from intercourse during a woman's fertile period. Carefully tracking menstrual cycles and/or monitoring fluctuations in body temperature can predict ovulation. Neither method is very effective (average failure rates range from twenty to thirty annual pregnancies per hundred women) because of variability in ovarian cycles. Coitus interruptus has a similar failure rate.

Other techniques in this category involve chemical contraceptives such as spermicidal foams, sponges, creams, jellies, and suppositories. When inserted into the vagina, those contraceptives can remain toxic to sperm for roughly an hour. These techniques are usually not very effective and are used mostly in conjunction with barrier methods that mechanically prevent sperm transport to the oviduct. Those methods include condoms (thin, strong rubber or latex sheaths), which are available for both male and female use. Females also can use the diaphragm, which is a flexible rubber dome positioned over the cervix. An alternative to the diaphragm is the cervical cap, which is smaller and is held in place by suction. Sterilization is a more permanent and highly effective method of birth control. It involves the surgical disruption of the ductus deferens (vasectomy) in men and the oviduct (tubal ligation) in women.

PREVENTION OF OVULATION. Oral contraceptives, or birth control pills, function by manipulating the complex hormonal interactions in the ovarian cycle. They contain synthetic estrogen-like and progesterone-like steroids and are taken for three weeks and then discontinued for one week. The steroids inhibit the secretion of certain hormones, preventing follicle maturation and ovulation. The one-week period of discontinuation allows menstruation to occur, although without the presence of an ovum. Recent developments prolong the length of the menstrual cycle and thus can reduce the annual number of menstruations. Oral contraceptives also prevent pregnancy by increasing the viscosity of cervical mucus, making the uterus less likely to accept implantation, and decreasing muscular contractions in the female reproductive tract.

Birth control patches also have been developed. They are applied directly to the skin and secrete synthetic steroids that work in the same way as do those in the contraceptive pill. Also available are long-acting subcutaneous contraceptives such as Norplant®. Norplant® consists of six matchstick-size capsules that gradually release progestin. The patches are inserted under the skin in the inner arm above the elbow. Once implanted, these contraceptives are effective for roughly five years. Additionally, injectable time-release synthetic hormones, which provide contraceptive effects for one to three months depending on the product, can be obtained. In the United States all these methods are available only with a prescription and are quite effective, with average failure rates of less than one annual pregnancy per hundred women.

BLOCKAGE OF IMPLANTATION. These are the most controversial techniques because they act after fertilization has taken place by preventing the implantation of a fertilized ovum in the uterus. The most common technique in this category is the IUD, which is inserted into the uterus by a physician. The mechanism of action of the IUD is not completely understood, but evidence suggests that the presence of this foreign object in the uterus produces a local inflammatory response that prevents implantation of the fertilized ovum. Early IUD techniques were associated with serious complications. More recent methods are much safer, but the popularity of IUDs has waned.

Implantation also can be blocked by emergency contraception, or "morning-after" pills. These pills can prevent pregnancy when they are taken within seventy-two hours after intercourse. Often used in the case of rape, emergency contraceptive kits usually involve high doses of hormones that either suppress ovulation or cause premature degeneration of the corpus luteum. The latter effect removes the hormonal and nutritive support required by a fertilized ovum. The controversial "abortion pill" RU 486 (Mifepristone®) blocks the female hormone progesterone, making it impossible for the body to sustain a pregnancy. The association of this pill with abortion explains why it took twenty years after its invention in 1980 by a French pharmaceutical company for the FDA to approve it in 2000.

CURRENT RESEARCH. Research continues in all these categories, partly because unplanned pregnancies continue to present personal and public health problems (Institute of Medicine 2004). Advances in genome sequencing, materials science (a multidisciplinary field focused on the properties of functional solids), and drug delivery are important factors in new techniques. Longer-lasting hormone-releasing IUDs are being developed along with improved methods for inserting and removing them. Other techniques target chemical reactions between ova and sperm or manipulate the pituitary secretion of certain reproductive hormones in both males and females.

In 2005 researchers in the United States partnered with a European biotechnology company to develop a male contraceptive pill. Such contraceptives could be based on a variety of techniques, ranging from inhibiting spermatogenesis to disabling the motility of sperm. Research involving reversible chemical sterilization also is being carried out.

Additionally, efforts are under way to develop immunocontraception that would allow the use of vaccines that prod the immune system to produce antibodies targeted against a protein that is critical to the reproductive process (Ada and Griffin 1991). Such vaccines would work for both males and females. In males vaccines would create antibodies against the production of gonadotropin-releasing hormone (GnRH), which is essential for sperm production. In this case supplemental testosterone injections would be needed because of the loss of GnRH. In females some vaccines that are being tested induce the formation of antibodies against the creation of human chorionic gonadotropin (hCG), which is essential for supporting the corpus luteum during pregnancy. These techniques present concerns about endocrine disruption and autoimmune pathologies. Immunocontraception is fairly commonly used as a strategy for the control of wildlife populations. Although research on human applications has proceeded since a special working group was formed by the World Health Organization (WHO) in 1973, no safe and effective methods had been developed by 2004. Clinical trials continue.

Ethical and Political Issues

The association of contraceptive practices with prostitution, extramarital affairs, and the perceived breakdown of sexual mores is related directly to the discomfort with which most religious traditions have responded to these methods. Today, however, most laypeople, along with most scholars in different traditions, accept the morality of contraception within marriage. However, that acceptance has not extended to all religious traditions.

The clearest example of continuous opposition to the use of artificial birth control methods comes from official Roman Catholic teachings. Catholic teachings on contraception remain important for contemporary debates, especially the 1930 encyclical issued by Pope Pius XI titled *Casti Cannubii* [On Christian Marriage], which called birth control a sin and opposed birth control by artificial means. In 1968 Pope Paul VI condemned contraception but permitted the use of natural rhythm methods. Today, although Catholic doctrine still advocates the use of natural methods such as abstinence during fertile periods, it completely condemns the use of artificial contraception or voluntary sterilization. The grounds for this rejection are related to what is claimed to be an inseparable connection between the sexual and procreative acts. Because many developing countries have large Catholic communities, many have criticized the official position of the Catholic Church as insensitive to overpopulation problems and to the effects of continuous childbearing on the well-being of women and children. The spread of HIV and AIDS in many developing countries has provided an important reason for criticizing Catholic opposition to methods that can be effective in preventing the spread of a deadly disease.

In spite of Catholic opposition to artificial contraception many other Christian churches have become more accepting of the role of birth control within marriage. In most cases the reasons for that openness are related to the consequences unlimited procreation can have on a marriage, other children, or the community in general. For many Christian denominations the use of both natural and artificial contraceptives methods is a way to express responsible parenthood. Other religion traditions, such as Islam, Orthodox Judaism, and Hinduism, also accept the morality of contraception as long as it is not harmful to the persons involved. Islamic teachings, for example, historically have been fairly tolerant of contraception. That allowed discussion and development of birth-control techniques by medieval Arabic writers, including the Muslim physician Ibn Sina (980–1037). The Jewish tradition also tends to support birth control, although with many qualifications, and makes it primarily the responsibility of women (Feldman 1968).

Feminists' attitudes toward artificial birth control methods are, as with many other reproductive technologies, ambivalent. On the one hand, contraception has freed women from unlimited reproduction, facilitated their incorporation into the labor force, and allowed them to make autonomous choices about whether and when to have children and about how many of them to bring into the world. On the other hand, birth control methods are developed, implemented, and used in the context of patriarchal societies that still are involved in controlling women's lives and in many cases continue to show little interest for women's well-being.

In this context the fact that most contraceptive methods have been developed for women is a matter of concern, especially because women rarely have been involved in making decisions about what technologies to develop. Also a matter of feminist concern is the fact that many contraceptive methods, such as those involving hormones, appear to have been developed with more interest in their efficacy than in their safety. Similarly, although male reproductive biology seems to be more difficult to interrupt, it appears that part of the scarcity of research in that area can be attributed to fear of affecting the male libido, a concern that has not affected research on female contraception.

Many feminists have objected to the testing of new contraceptives on women in developing countries and have expressed worries about possible social abuses in both industrialized and nonindustrialized nations arising from the use of long-acting implantable contraceptives such as Norplant®. Once implanted, Norplant® can be removed only surgically. That makes this contraceptive far more effective than many others in which compliance can be a problem. These worries are not easily dismissible in light of the fact that in the United States, for example, several state legislatures have considered regulations that would pay women on welfare to use Norplant®. Some judges have imposed the use of this drug as an alternative to a lengthy prison sentence for women convicted of child abuse.

In developing countries the likelihood of abuses resulting from the use of this type of contraceptive is even more obvious. Powerful population control interests can result in subtly or clearly coercive methods to assure women's use of birth control. The fact that Norplant® requires surgery, together with the scarcity of health care resources, makes concerns about the possibility of coercion even more pressing.

Also feeding feminists' worries about possible abuses of birth control methods were attempts by members of eugenics movements in the early twentieth century to control the reproductive activities of those considered undesirable. In most cases involuntary sterilization was the method of choice to prevent those with mental problems, criminals, immigrants, and poor and minority women from reproducing under the idea that if they were not stopped, lower-class offspring would outnumber the upper classes' progeny.

New demographic trends such as below-replacement birth rates in some European nations, together with what appears to be an environmentally caused decline in fertility among both men and women in industrialized countries, may put discussions of birth control in a different framework in the future, especially in nations with strong welfare systems. In those nations the aging population has been putting a serious strain on public resources. In this context some might argue for the need to encourage births rather than control them.

INMACULADA DE MELO-MARTÍN
ADAM BRIGGLE

SEE ALSO *Bioethcs; Eugenics; Population.*

BIBLIOGRAPHY

Ada, G. L., and P. D. Griffin, eds. (1991). *Symposium on Assessing the Safety and Efficacy of Vaccines to Regulate Fertility*. Cambridge, UK, and New York: Cambridge University Press. Sixteen essays collected by the Special Program of Research Development and Research Training in Human Reproduction at the World Health Organization.

Bullough, Vern. L., ed. (2001). *Encyclopedia of Birth Control*. Santa Barbara, CA: ABC-CLIO.

Dupré, Louis. (1964). *Contraception and Catholics: A New Appraisal*. Baltimore: Helicon. Examines the arguments that the Catholic Church has proposed against the use of artificial birth control.

Feldman, David M. (1968). *Marital Relations, Birth Control, and Abortion in Jewish Law*. New York: Schocken.

Holmes, Helen; Betty Hoskins; and Michael Gross, eds. (1980). *Birth Control and Controlling Birth: Women-Centered Perspectives*. Clifton, NJ: Humana Press.

Institute of Medicine. (2004). *New Frontiers in Contraceptive Research: A Blueprint for Action*. Washington, DC: National Academies Press. Provides recommendations on how science can best address concerns of fertility regulation and reproductive health.

Moskowitz, Ellen, and Bruce Jennings, eds. (1996). *Coerced Contraception? Moral and Policy Challenges of Long-Acting Birth Control*. Washington, DC: Georgetown University Press.

Reed, James. (1978). *From Private Vice to Public Virtue: The Birth Control Movement and American Society since 1830*. New York: Basic Books. Focuses on the strategies and efforts of a small group of U.S. citizens in the birth control movement.

Segal, Sheldon J. (2003). *Under the Banyan Tree: A Population Scientist's Odyssey*. New York: Oxford University Press. Stresses the importance of education in achieving population control and poverty reduction and chronicles personal experiences with international family-planning efforts to increase understanding about population issues.

INTERNET RESOURCE

Union of Concerned Scientists. (2004). *Scientific Integrity in Policy Making: An Investigation of the Bush Administration's Misuse of Science*. Cambridge, MA: Author. Available at http://www.ucsusa.org/documents/RSI_final_fullreport.pdf.

BLACKETT, PATRICK

Patrick Maynard Stuart Blackett (1897–1974) was born in Kensington, London, on November 18, and became a Nobel Prize–winning physicist who at once promoted scientific research to defeat Nazism and criticized the World War II Allied bombing of cities. After serving in the Royal Navy during World War I and establishing a successful career in physics, he became a science advisor on military matters during World War II and later to both the Indian and British governments on science and technology policy. He died in London on July 13, as a leading figure in the British scientific community and a defender of science in the service of socialist political ideals and of "small science" practiced independent of large government grants.

Physics

After earning a Ph.D. in physics in 1921 from Cambridge University, Blackett did postdoctoral work in the Cavendish Laboratory and was appointed professor at the University of Manchester in 1937. He developed an international reputation for masterful experimental work in cosmic-ray and particle physics using cloud chambers, Geiger counters, and magnetic fields. He also made important contributions to the study of nuclear transformations as the first to photograph the mutation of one element into another (nitrogen into oxygen after bombardment by an alpha particle) and matter arising out of energy (electrons and positrons from gamma rays). In 1933 Blackett and the Italian physicist Giuseppe Occhialini confirmed the existence of the positively charged electron or positron, but were cautious in publishing the results.

When the 1936 Nobel Prize in physics was awarded to the American scientist Carl Anderson for the discovery of the positron, many argued that Blackett deserved equal credit. But Blackett himself never engaged in disputes on this issue and emphasized instead the importance of Anderson's work. Such conduct highlighted his integrity and collegiality in the scientific community as well as his cautious and disciplined style of research. He subsequently received the 1948 Nobel Prize in Physics "for his development of the Wilson cloud chamber method, and his discoveries made therewith in the fields of nuclear physics and cosmic radiation."

Blackett began defense related research even before the outbreak of World War II by helping build an air defense network through the establishment of radar stations and antisubmarine research for the Royal Navy.

He was central to the development of operations research, which for him meant the analysis of data in such a way as to provide advice to military and political decision makers.

After the war, Blackett returned to Manchester where he took up research on the origins of interstellar magnetic fields and those of Earth. When his hypothesis that the magnetic fields of large bodies were a fundamental property of their rotating mass failed to be supported by the evidence, he readily acknowledged his error. Blackett later researched the magnetism of rocks and continental drift. In 1953 he was appointed head of the Physics Department at the Imperial College of Science and Technology in London. In addition to his focus on integrity and patience in research, he crafted his laboratories according to the ideal of small science performed with modest-sized instruments, which ran contrary to the postwar practice of "big physics" with massive instruments. He ended his career serving as the official representative of the British scientific community as president of the Royal Society from 1965 to 1970.

Ethics and Politics

Although there is unanimous agreement on Blackett's contributions to physics, his engagement in public affairs caused controversy concerning the proper role of scientists in politics and tensions between the ideals of science as objectively removed from society and science as a means to serve or even shape societal goals. Blackett's life is a study in "how (and at what price) one can reconcile a scientific career with political activism" (McCray 2005, p. 186). Most mainstream scientists emphasized the freedoms that allowed for scientific autonomy. But fueled by his belief that science can provide societal benefits by being more thoroughly integrated with politics, Blackett spoke out for more government investment in science, greater science education, and tighter links between science and industry. For his biographer, Mary Jo Nye, "Achieving these aims required cultivating popular interest in science and taking on the role of public scientist, no matter how uncomfortable or inconvenient this role might become" (2004, p. 6). As he grew older, Blackett devoted more and more time to political matters.

He maintained that the best relationship between knowledge and governance would unfold under socialism, and he allied himself with the scientists for social responsibility movement (known as "Bernalism" in Great Britain) that held that a scientifically oriented socialism could solve economic and political troubles. Blackett's career showed how the external ethics of science relates not only to questions of scientists' responsibilities for applications of their work, but also to larger questions about scientists' roles in shaping public policies more generally.

Blackett was not a pacifist and argued that it was the duty of scientists to engage early in the war efforts to defeat Germany. He was one of the pioneers in the newly emerging role of scientists as advisors to political and military decision makers, choosing both to perform scientific work in support of the war and to join the forum of political debates about the war. He criticized the Allied wartime civilian bombing strategies as both immoral and ineffective. It dehumanized victims and perpetrators, and led to postwar atomic policies, which seemed to countenance further brutalization as a normal course of political and military policy.

An early proponent of international control of atomic energy, Blackett opposed British development of atomic weapons, favored a neutralist foreign policy and greater cooperation with the Soviet Union, and proposed bilateral disarmament strategies for both atomic and conventional weapons. He also found the application of game theory to nuclear war scenarios morally repugnant and another sign of the dehumanizing consequences of weapons of mass destruction. His views ran contrary to mainstream attitudes and were often dismissed as dangerous because of his sympathy toward the Soviet Union and participation in socialist organizations such as the World Federation of Scientific Workers.

Blackett published his unpopular and contentious criticisms of U.S. and British policies in *Military and Political Consequences of Atomic Energy* (1948), which appeared in the United States under the title *Fear, War, and the Bomb* (1949). Most controversial was his notion that the bombing of Hiroshima and Nagasaki were the first acts of the Cold War, carried out to intimidate the Soviet Union. Many critics attacked Blackett's expertise and legitimacy to discuss matters of politics, arguing that he misused his prestige as a scientist to bolster a political agenda. But attitudes changed over the following decade, and Blackett's *Studies of War* (1962), which presented the same basic argument as his earlier publications, received praise from scientists as well as politicians.

Blackett was later instrumental in the development of the Ministry of Technology (serving as its advisor from 1964 to 1969) and more general science and technology policies for the British government. He also advised the Indian government on research and development strategies, especially for the military. Jawaharlal Nehru, the first prime minister of independent India, and Blackett agreed that modern science and technology were crucial for the future of India, and that atomic weapons should be banned but atomic energy should be used for electricity generation in developing countries. Blackett favored applied research in developing countries (based on technology transfers from the West) rather than the development of basic research institutions. This recommendation was widely attacked as a form of outdated colonial prejudice (Nye 2004).

Along with other prominent scientists in the post–World War II era, he helped forge a new identity of the twentieth-century scientist as public citizen (Nye 2004). This identity remains controversial as modern science and technology continue to influence so many facets of life. Blackett's career serves as a sounding board to explore important questions about the role of scientists in politics and the nature of their social responsibilities.

ADAM BRIGGLE

SEE ALSO *Bernal, J. D.; Military Ethics; Operations Research.*

BIBLIOGRAPHY

Blackett, Patrick. (1949). *Fear, War, and the Bomb: Military and Political Consequences of Atomic Energy*. New York: McGraw-Hill. First published in 1948 in London by Turnstile Press. Critiques U.S. and British atomic energy policies after World War II as militarily unrealistic and politically dangerous and concludes with his recommendations.

Blackett, Patrick. (1962). *Studies of War: Nuclear and Conventional.* New York: Hill and Wang.

McCray, Patrick. (2005). "Political Science." *American Scientist* 93(2): 186–187. A review of the Nye biography.

Nye, Mary Jo. (2004). *Blackett: Physics, War, and Politics in the Twentieth Century*. Cambridge, MA: Harvard University Press. The most comprehensive source on Blackett's life, physics, and politics.

BODY

The role of the body in relation to science and technology is complex. The first book on the philosophy of technology, Ernst Kapp's *Grundlinien Einer Philosophie der Technik* (1877), analyzes technologies in terms of body parts and organs. Stoves are technological "stomachs," machines are extensions of "arms and legs," and so forth. In contemporary times bodies and embodiment have become increasingly important. There is a great deal of discussion about "posthuman" and disembodied development with respect to "cyberspace" and electronic systems of communication such as the Internet and other virtual processes. Ironically, this discussion has brought the role of human bodies back into consideration.

From Ancients to Moderns

Twenty-first century discussions echo much older traditions with respect to the human body. Ancient Greek philosophers often distinguished between body, soul, and spirit (Plato), with the strongest distinction being made between the materiality of the body and the immateriality of soul and spirit. In early modernity those distinctions were simplified into variations on a body-mind dualism (René Descartes) that continue to motivate much philosophical debate.

In antiquity religio-ethical ideas also were associated with the distinction between bodily materiality and soul-spirit immateriality. Generally speaking, materiality was conceived of as being of lesser worth, clearly finite and mortal and perhaps evil. Whether merely restrictive of the higher tendencies of the immaterial soul-spirit or deceptive and actively negative, the materiality of body carried negative associations. The Platonist trajectory emphasized a learning process that involved movement from a kind of captivity in the body, its deceptive senses, and the "body as prison" to an ascent toward the ideal realms of the good, the true, and the beautiful.

The early modern simplification of that trajectory weakened the ancient religio-ethical associations and replaced tainted materiality with the "mechanical" as the interpretation of the body. Body becomes the mechanical means by which motion is possible, but mind is enclosed "inside" a body object as a subject aware only of its impressions, sensations, or ideas caused by things that are external to itself. The model for this notion of body, used by the philosophers Descartes (1596–1650) and John Locke (1632–1704), was the *camera obscura,* in which the body was a dark room inside of which was the subject or mind that could view the images or representations cast on the *tabula rasa* inside. In this formulation the mind was situated inside a mechanical contrivance and could know or experience only its own sensations or representations.

Later modernity began to develop two less dualistic concepts of the body. One direction was physicalist and attempted to reduce all mental phenomena to physical ones (Ryle 1949) and the other was existentialist, using phenomenology to analyze a "lived body" or experiential body (Husserl 1970, Merleau-Ponty 1962). Both schools of thought lessen or deny a body-mind distinction and drive the analysis toward oneself *as* body. However, physicalism retains a basically mechanistic view of body, whereas phenomenology elevates bodily experience to include materiality. In the phenomenological sense all intelligent behavior presupposes bodily activity.

Body in Science

With the rise of early modern science the role of body began to take on a different significance. After the seventeenth century science was both technological and observational; those dimensions usually were termed experimental: Science practice included devices both for measurements and for making new discoveries achieved through (perceptual) observations displayable.

Galileo Galilei's (1564–1652) optics—telescopes but also microscopes—were the means by which new celestial phenomena were sighted, inclined planes were used to measure acceleration, and experiments were developed as proofs of specific scientific insights. Through the use of the telescope sun spots, Jupiter's satellites, the phases of Venus, and the mountains of the moon became new phenomena for emergent science. However, the instrumental means were also those which mediated perceptions, in this case vision. Although as a scientist Galileo paid little attention to the body itself, he did proclaim the new vision made possible by the telescope to be superior to that of the body by itself. Scientific vision was enhanced vision, but it also was mediated by means of instruments.

The body in this sense remained a background phenomenon but one that nevertheless had to be taken account of. In contemporary science this is even more important. For example, in contemporary technologized observations, only since the twentieth century have imaging technologies been able to present phenomena that lay far beyond the limits of unmediated human perception. In astronomy wave frequencies ranging from gamma waves to radio waves can be imaged, whereas until the twentieth century only optical light imaging was available.

In the early twenty-first century, however, all such imaging must implicitly take account of human perception insofar as "false color" imaging, the transformation of data into images, and simulations and modeling with computerized tomography all produce visualizations that translate data into visual gestalts that are available for human perception. The body is thus the background referential focus for science imaging. Increasingly, philosophers of science have begun to take visualizations into account (Galison 1997, Ihde 1998).

Bodies in Technology

The role of body with respect to technologies is even more ancient. When Kapp analogized technologies by using organ and body-part metaphors, he was drawing on a much older convergence of body roles. The Medieval thinker Roger Bacon (1220–1292) began to imagine machines that could fly, go under water, and be protected with armor from arrows and missiles; those fantasy machines were visualized much later in Leonardo da Vinci's technical drawings. Many of those imaginary machines utilized amplified human bodily powers (and thus could not actually work) because engines and motors had not yet been invented. However, those fantasy machines also reflected a new attitude toward bodily work. Those which could work on the basis of ancient physics—the simple machines of screw, wedge, levers, and pulleys—did magnify bodily powers, and with that magnification one could do more than unaided bodies could.

As the historian Lynn White, Jr., pointed out, by medieval times technologies such as cranes, lifting devices, gears, and above all mechanical clocks had begun to transform what was possible through machine-aided work. Windmills pumped out the lowlands of Holland and cathedrals of astonishing heights were built with weight-lifting machinery that magnified human bodily power, but more powerful animal bodies also were enlisted. One can still see the large drum-powered lifting device in Mount Saint Michel, which used donkeys to make it rotate. Later still came the artificial engine that launched yet another revolution: the steam engine.

Here, as in science, the measure of the human body, extended technologically, lay in the background. Machines now produced work, leaving the felt sense of effort and power on the sidelines. The previous multiplication of powers through the use of slaves could take a different direction through the use of technologies. In this case the ethics related to bodies is a social-political ethics. From slavery to the working class, bodies are embedded in work practices that are mediated by technologies. Clocks were used to regulate social time, and the panopticon was used to regulate prison behavior (Foucault 1977).

Body in Medicine

In yet another dimension bodies play other roles, particularly in medical practices. Here the interplay between bodies as objects and subject bodies often becomes focal. Historically, as with early modern science, medical practice underwent significant changes precisely by displaying the body as object, particularly as *visualizable* object. Leonardo da Vinci (1452–1519), later followed by Andreas Vesalius (1514–1564), depicted bodies as visualized objects. Dissections and autopsies became favorite matters for those depictions. Corpses showed bodily biological structures. That knowledge could be used indirectly to treat living bodies. However, the delicate problem that led to technological trajectories involved finding a way to observe what was going on physiologically without destroying or making into a dead object a living body that was under investigation.

One can trace the history of changes in diagnostic techniques, beginning with direct hands-on examinations, which were late to arrive in modernity (eighteenth century), proceeding to perceptual mediating instruments such as the stethoscope, which produced ausculatory imaging through sound (nineteenth century), and ending with contemporary largely visual imaging (from X-rays to magnetic resonance imaging and positron emission tomography scans).

This trajectory culminates in techniques that are used to display the internality of the body without using a physically invasive process. The preservation of health within this trajectory is one that recognizes that only a subject, or lived body, is the ethical object of therapeutic medical practice. The ethical considerations in this case involve the need to evaluate and preserve levels of healthfulness through the application of knowledge. However, respect and care for living bodies remains the implicit central focus.

In addition to the changing notions of the human body noted above, contemporary studies related to feminism are of importance. In early modern science visualism was prominent. Feminists have joined phenomenologists in taking account of perspectivalism and situatedness. Some authors, however, also have pointed out that observation not only is objectivistic but may include aspects from the human biological heritage; even scientific curiosity may harbor a *predatory* dimension (Haraway 1991). Moreover, vision may entail gendered differentiations, with the "male gaze" being a form of perception that is constructed differently from those found in other human gendered practices (Bordo 2004, Butler 1999). Here the questions of gender relations with associated questions of mutual respect and interpersonal relations move to the forefront of ethical concerns.

Response

Returning to the topic of technologies and human bodies, with the massive impact of transportation, information, and imaging technologies it becomes obvious that what is often a background role for bodies takes on more explicit form in the uses of those technologies.

The bodily-perceptual experiences of space-time transformations are perhaps the most dramatic. In science imaging the near distance of observation, made ordinary with the close-up imaging of Mars and Saturn, has changed the sense of "apparent distance," providing a near distance to those planetary bodies. In medicine the development of distance surgery that calls for eye-hand coordination using robotics and visualizations has changed the way in which bodily skills are utilized and thus has implicated body-technology relations. Even in debates about artificial intelligence and related neurological studies the role of bodily motility has become a prominent issue, one that also is related to contemporary robotics studies (Dreyfus 1992). With electronic and virtual communications the role of the human body has taken on yet different experiential qualities. Experiments with virtual reality equipment and later with augmented reality equipment have made the role of whole body movement, balance, and kinesthesia newly important so that cognitive science has become aware of how action is experienced at a distance through prostheses and other material extensions of technologies.

The overall result has been a renewed emphasis on studies of the body. Many disciplines show this, including philosophy, women's studies, cognitive sciences, and robotics, as well as new forms of sociology, anthropology, and cultural studies.

DON IHDE

SEE ALSO *Bioethics; Cosmetics; Phenomenology; Virtual Reality.*

BIBLIOGRAPHY

Bordo, Susan. (2004). *Unbearable Weight: Feminism, Western Culture, and the Body.* Berkeley: University of California Press. Bordo's work draws from phenomenology and is sensitive to both sensory and social aspects of bodily experience.

Butler, Judith. (1999). *Gender Trouble: Feminism and the Subversion of Identity.* New York: Routledge. Butler is a radical thinker who has been able to introduce gender construction into many philosophical debates.

Dreyfus, Hubert. (1992). *What Computers Still Can't Do: A Critique of Artificial Reason.* Cambridge, MA: MIT Press.

Dreyfus's work has been particularly important for a current generation of computer designers interested in bodily motion and robotics.

Foucault, Michel. (1977). *Discipine and Punish: The Birth of the Prison,* trans. Alan Sheridan. New York: Pantheon. Foucault has been a primary author influencing those who would understand the institutional and social dimensions of discourses.

Galison, Peter. (1997). *Image and Logic: A Material Culture of Microphysics*. Chicago: University of Chicago Press. Galison's work in the history and philosophy of science is sensitive to the instrumentation and technologies of science, as well as its contemporary interdisciplinary social structures.

Haraway, Donna. (1991). *Simians, Cyborgs and Women: The Reinvention of Nature*. New York: Routledge. Haraway, whose background was originally in biology, has become a foremost "technoscience" thinker. Her figure of the "cyborg" has inspired a very large number of thinkers.

Husserl, Edmund. (1970). *The Crisis in European Science and Transcendental Phenomenology: An Introduction to Phenomenonological Philosophy,* trans. David Carr. Evanston, IL: Northwestern University Press. Husserl's last major work became the inspiration for a number of contemporary styles of thought, including what became known as the "social constructionist" movements.

Ihde, Don. (1998). *Expanding Hermeneutics: Visualism in Science*. Evanston, IL: Northwestern University Press. This book begins a reframing of philosophy of science in hermeneutic terms by analyzing the "visual hermeneutics" employed in science imaging.

Kapp, Friedrich. (1877). *Grundlinien Einer Philosophie der Technik: Zur Ensehungsgeschichte der Cultur au neuen Gesichtspunkten*. [Foundations of a philosophy of technology]. Braunschweig, Germany: G. Westermann. The first major philosophy book to use the term, philosophy of technology.

Merleau-Ponty, Maurice. (1962). *Phenomenology of Perception,* trans. Colin Smith. New York: Humanities Press. Merleau-Ponty's best known book which emphasizes the role of perception within bodily activity, taken as the basis for all intelligent behavior.

Mumford, Lewis. (1962). *Technics and Civilization*. New York: Harcourt, Brace. Mumford was an early twentieth-century intellectual historian, one of the few who focused upon the role and development of technologies in relation to human history.

Ryle, Gilbert. (1949). *The Concept of Mind*. London and New York: Hutchinson's University Library. This is one of the first books to attack the doctrine of dualism as proposed by Descartes; it was influential on later analytic philosophy and the physicalist directions taken.

White, Lynn, Jr. (1962). *Medieval Technology and Social Change*. Oxford: Clarendon Press. This book contended that there was a massive "technological revolution" in Europe that preceded the Renaissance and early modernity.

BOMBS

SEE *Atomic Bomb; Weapons of Mass Destruction*.

BOVINE SOMATOTROPIN

SEE *Agricultural Ethics*.

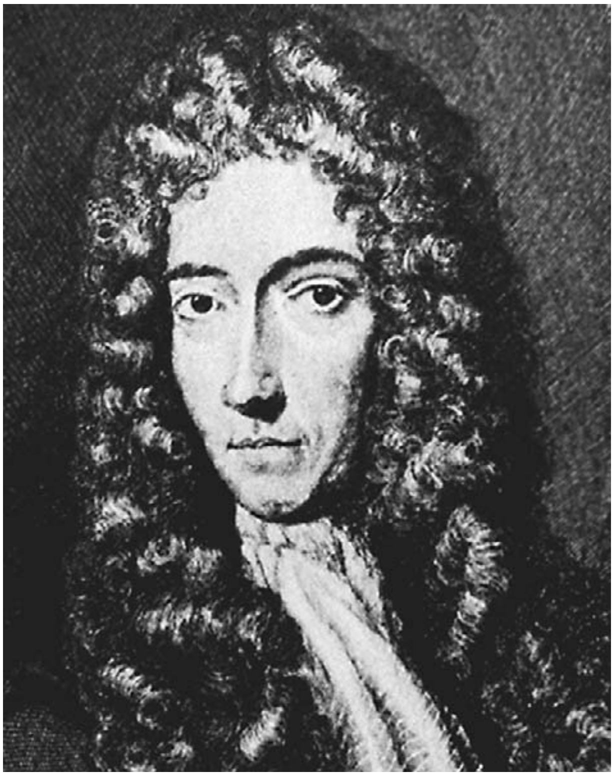
BOYLE, ROBERT

Born at Lismore Castle in Munster, Ireland, on January 25, 1627, Robert Boyle (1627–1691) was an experimentalist who made fundamental contributions to chemistry, hydrostatics, philosophy of science, and the relationship between science and religion, including morality and natural theology. Before he penned his first work on natural philosophy, the deeply pious Boyle wrote several essays and treatises on religious themes, and his early interests in morality, theology, and casuistry remained undiminished throughout his life. In some of his most important mature works he linked his religious interests explicitly with his scientific pursuits, but implicit connections are often just beneath the surface in many of his writings.

The intensity of Boyle's interest in moral philosophy is readily seen in his earliest treatise, the *Aretology*, an unpublished work on ethics, vocation, and self-knowledge. This work reflects influences from Aristotle and the Christian humanist tradition, especially the German theologian Johann Alsted (1588–1638), whose enormous *Encyclopedia* (1630) served Boyle as a quarry to mine. Boyle's first published essay was dedicated to Samuel Hartlib (1600–1662), a Prussian-born disciple of the Czech educational reformer Johann Comenius (1592–1670). Its theme—that physicians should disavow secrecy and openly disseminate recipes for effective medicines, as an act of Christian charity—would be repeated numerous times in other works. An ethical impulse to improve the human condition through the application of chemistry to medicine motivated Boyle, as much as anything else, to become a scientist. A further motivation came from his conviction that nature was the third divine book in the human library—scripture and conscience were the others. The study of nature was divinely mandated, and the knowledge it produced would point unambiguously to the creator.

The Bible and the Christian Experiment

No influence was more important, however, than the Bible. Although he was not a Puritan himself, Boyle



Robert Boyle, 1627–1691. A chemist, physicist, and natural philosopher, Robert Boyle was a leading advocate of "corpuscular philosophy." He made important contributions to chemistry, pneumatics, and the theory of matter. *(The Library of Congress.)*

sought before all else to be biblical in everything he did, like the Puritan divines he counted among his friends. His devotion to the Bible, which he read daily in Hebrew and Greek, was nothing short of profound. At the urging of biblical scholar James Ussher (1581–1656), Boyle wrote *Some Considerations Touching the Style of the Holy Scriptures* (1661), in which he rejected the claims of courtly "wits" that biblical language was too poorly chosen for a divinely authored book. He also rejected courtly mores, which promoted the sinful vices of vanity, promiscuity, and greed, rather than the biblical virtues of humility, chastity, and charity.

Boyle sought to bring such virtues not only to his private life as an anonymous giver of alms, but also to his public life as the leading English natural philosopher of his generation. His stated policy was "to speak of Persons with Civility, though of Things with Freedom," instead of "railing at a man's Person, or wrangling about his Words," for "such a quarrelsome and injurious way of writing does very much mis-become both a Philosopher and a Christian" (Hunter and Davis 1999–2000, Vol. 2, p. 26). In an age known for the strongly negative tone of its scientific controversies, Boyle was remarkable for his consistent avoidance of derision. In his last major theological work, *The Christian Virtuoso* (1690–1691 and 1744), he reflected on other ways in which Christianity mirrored the moral attitude and experience of the scientist (the *virtuoso*). Living the Christian life, he argued, is like "trying an experiment" that leads to personal peace and happiness, in this world as well as in the world to come. Just as "personal experience" could show the evil consequences of "a vicious course of life," so the same experience could "assure him of the practical possibility of performing the duties and functions of a Christian." Likewise, "heedful observations" would "satisfy a man of the vanity of the world, and the transitoriness of . . . sinful engagements, and of the emptiness of those things, for which men refuse the ways of piety and virtue" (Hunter and Davis 1999–2000, Vol. 12, pp. 431–432). The Christian virtuoso, Boyle claimed, would put truth over personal gain; cultivate humility, generosity, and trustworthiness; promote open communication over secrecy (as far as possible, given his vital interest in alchemy); and show devotion to scientific work as a kind of religious vocation. In short, it is no accident that Boyle considered himself a "priest" in the "temple" of nature.

The Mechanical Philosophy and Natural Theology

Although Boyle often spoke of nature as a temple, his favorite metaphor was much more impersonal. The world was "a great piece of Clock-work" (Hunter and Davis 1999–2000, Vol. 8, p. 75), containing numerous smaller engines—the bodies of animals, sometimes likened to "watches," and of humans—with God the clockmaker. By the mid-seventeenth century, artisans could build and repair a great variety of clockwork mechanisms that were capable of following the motion of the heavens and imitating the motions of animals and humans. This encouraged natural philosophers to think that the universe and its parts could best be explained in terms of matter and motion, giving rise to what Boyle himself first called the *mechanical philosophy*. Although he saw the possibility that some would have the great clockwork run on its own, without divine involvement or supervision, Boyle nevertheless found the new mechanical science theologically superior to the prevailing Aristotelian concept of nature. His subtle book on the doctrine of creation, *A Free Enquiry Into the Vulgarly Received Notion of Nature* (1686), argued that the *vulgar* (i.e., commonplace) view was idolatrous for the way in which it personified nature—for example, *nature abhors a vacuum*, or *nature does nothing in vain*—effectively placing an intelligent, purposive agent, "much like a kind of 'Goddess'" (Hunter and Davis

1999–2000, Vol. 10, p. 456) between the creator and the creation. It was far more appropriate, Boyle believed, to explain phenomena in terms of impersonal, "mechanical" properties and powers created by a personal God. In this way the sovereignty of God would be underscored—and people would be more likely to worship their creator, the real source of intelligence and purpose in nature.

For Boyle, as for many of his contemporaries, science had a central religious function: to make plain the signature of God in creation. Echoing his own lifelong struggle with religious doubt, Boyle saw the design argument, especially but not exclusively in its biological form, as a powerful foil against unbelief. He did not seek merely to confute philosophical atheism, which he realized was rare in his day, but fully to persuade people of the existence of the divine creator and legislator, that they might thereby live piously in the full sight of God. Changed lives and hearts, not just changed minds, were his goal. Here again, the Christian virtuoso had much to contribute. It is "very probable," Boyle noted, "that the world was *made*, to manifest the existence, and display the attributes of God; who, on this supposition, may be said to have made the world for the same purpose, for which the pious philosopher studies it" (Davis and Hunter 1999–2000, Vol. 12, p. 483). In keeping with this attitude, Boyle left funds in his will to establish a lectureship for "proveing the Christian Religion against notorious Infidels [and] Atheists," including even Jews and Muslims, although lecturers were expressly forbidden from discussing "any Controversies that are among Christians themselves" (Madison 1969, p. 274). Ultimately, however, Boyle believed that the best evidence for the truth of Christianity came not from the testimony of nature, but from the testimony of those who had witnessed the miracles of Jesus and his disciples. Through the eyes of the biblical authors one could have a trustworthy vicarious experience, sufficient to establish the authenticity of the gospels as a divine revelation. Although a systematic treatment of this topic remained unfinished at his death, Boyle's published works contain much information about his views on miracles, including their consistency with the mechanical philosophy.

However, the mechanical philosophy, especially as it was articulated by the French philosopher René Descartes (1596–1650), also had a darker side. Animals were typically seen as little or nothing more than complex machines, with full rationality and sensitivity reserved only for humans, angels, and God. When coupled with a nearly universal desire to improve the human condition by advancing the knowledge of anatomy and physiology, the temptation to engage in animal experimentation was often too great to resist. Boyle, who sought as much as anyone to enhance what he called "the Empire of Man over Other Creatures" (Hunter and Davis 1999–2000, Vol. 3, p. 193), carried out numerous diverse experiments involving both vertebrate and invertebrate live animals—dogs, cats, birds, butterflies, worms, and many others. Yet he did so with considerable sympathy and even regret; on several occasions, he even released animals that had survived one experiment precisely in order to spare them further suffering. Unlike Descartes Boyle was not convinced that animals lack sensation, and he considered gratuitous cruelty to animals blasphemous, since all creatures belonged to God. At the same time he believed that God intended the creatures to serve humankind, thus sanctioning a certain amount of animal experimentation.

Boyle's Legacy

Boyle's influence on subsequent thinking about science, religion, and morality has been larger than many writers realize, much larger (for example) than that of Isaac Newton (1642–1727)—who actually published very little of importance about religion, although he devoted many years to the study of theology and church history. The Anglo-American tradition of natural theology derives substantially from Boyle's extensive treatment of the subject, and his outstanding example of a pious scientist writing about the Bible and morality has been much imitated.

EDWARD B. DAVIS

SEE ALSO *Christian Perspecitves; Scientific Revolution.*

BIBLIOGRAPHY

Davis, Edward B., and Michael Hunter, eds. (1996). *Robert Boyle: A Free Enquiry into the Vulgarly Received Notion of Nature*. Cambridge: Cambridge University Press.

Harwood, John T., ed. (1991). *The Early Essays and Ethics of Robert Boyle*. Carbondale: Southern Illinois University Press.

Hunter, Michael. (1993). "Casuistry in Action: Robert Boyle's Confessional Interviews with Gilbert Burnet and Edward Stillingfleet, 1691." *The Journal of Ecclesiastical History* 44(1): 80–98.

Hunter, Michael, and Edward B. Davis, eds. (1999–2000). *The Works of Robert Boyle*, 14 vols. London: Pickering & Chatto.

Madison, R. E. W. (1969).*The Life of the Honourable Robert Boyle* London: Taylor & Francis.

Oster, Malcolm. (1989). "The 'Beame of Diuinity': Animal Suffering in the Early Thought of Robert Boyle." *British Journal for the History of Science* 22: 151–180.

Shapin, Steven. (1994).*A Social History of Truth: Civility and Science in Seventeenth-Century England*. Chicago: University of Chicago Press.

BRAIN DEATH

Physicians could not reliably diagnose death in all cases until the early nineteenth century when a new technology, the stethoscope, was invented and medical scientists began to understand cardiorespiratory anatomy and physiology. Ironically, it was the introduction in the late twentieth century of more new technologies, such as the mechanical ventilator, that once again caused uncertainty about the definition and determination of death.

Before life-sustaining technology was introduced, critical vital functions such as heartbeat, breathing, and brain activity were so interdependent that when one function ceased, they all did. For example, when a person suffered a massive heart attack and cardiac arrest, breathing and consciousness were lost almost simultaneously because the heart pumps nutrient rich, oxygenated blood to the brain and the rest of the body. If a person stopped breathing, say from drowning, heartbeat and consciousness were almost immediately lost for the same reason—no oxygen reached the brain and heart. Similarly, when a massive brain injury occurred, consciousness and spontaneous breathing stopped because of destruction of the respiratory center in the brain stem. There was thus no need to choose between cardiac, respiratory, and brain function as the unique function whose loss signaled the transition from human being to corpse.

With the introduction of the mechanical ventilator and the modern intensive care unit (ICU), patients with severe head injuries, who previously would have died, were sustained with beating hearts and healthy functioning of all other organs such as kidney, liver, and pancreas. These patients, when they have lost all brain function, are termed "brain dead." In 1968 an ad hoc committee at Harvard Medical School proposed that such patients, who were legally and medically considered to be alive, be classified as dead.

Two Types of Death

Although brain death as death was quickly accepted in the United States by legal and medical communities and, seemingly, by the public at large, new debates began, at least in academic circles, about just what made these warm, pink, heart-beating patients dead. Interestingly, the Harvard Ad Hoc Committee did not address this issue. Rather, they gave two utilitarian reasons to reclassify brain-dead patients as dead. Brain death is relatively easy to diagnose and the prognosis is dismal: No person accurately diagnosed has ever recovered consciousness and, at least in the first decade, brain-dead patients were very unstable and would suffer cardiovascular collapse and "traditional" death within hours or days. Therefore, many people saw no point in keeping brain-dead patients "going" by mechanical ventilation. But in 1968, U.S. society had no experience with the removal of life-sustaining treatment (something that in the twenty-first century happens daily in leading hospitals), and physicians feared they would be charged with homicide if they turned off the ventilator. The Ad Hoc Committee suggested that by declaring such patients dead, this fear would be removed.

The second reason given by the Ad Hoc Committee had to do with organ transplantation, which was becoming an increasingly effective treatment for end-stage organ failure. Because of all the *life* remaining in brain-dead patients, they were potentially an excellent source of organs. But taking their vital organs would violate the so-called dead donor rule that forbids killing patients by removing their organs. Classifying them as dead would avoid this problem and quell any controversy.

It was not until 1981 that a coherent philosophical or conceptual argument was put forth to explain why brain-dead patients were actually dead. In that year, in a landmark article, James L. Bernat and his colleagues at Dartmouth College proposed that the integrating function of the brain stem was the critical one whose loss marked the transition from life to death. Bernat went on to explain that loss of integration meant the permanent cessation of functioning of the "organism as a whole"—that is, the loss of "spontaneous and innate activities carried out by all or most subsystems" and "the body's ability to organize and regulate itself" (Bernat, Culver, and Gert 1981, p. 390). He gave as examples neuroendocrine control, temperature regulation, and the ability to maintain blood pressure and fluid and electrolyte balance. Bernat gave no significance to another important brain function, consciousness and cognition.

In simple terms, the brain has two major functions. The integrative function, which Bernat found critical, resides primarily in the brain stem, the primitive part of the brain that lies buried under the much larger cerebral hemispheres, which are most developed in higher animals, especially primates. Consciousness and cognition reside primarily in the cerebral hemispheres.

Although brain death was quickly accepted legally and clinically throughout the United States, many philosophers (Veatch 1976, Bartlett and Youngner 1988, Gervais 1986) argued that consciousness and cognition were the critical functions that distinguished a living from a dead person. Their criticism was twofold. First, the integrative function was not actually lost; it was merely taken over from the brain stem by machines and ICU personnel who kept patients *alive* by breathing for them and maintaining blood pressure and other vital activities. Second, consciousness and cognition more accurately reflect what is unique about human beings—the function without which they are dead. In contrast to Bernat, who argued that loss of integrative function is what humans have always meant by death, his critics argued what people really care about is whether or not *there is anybody home*.

Practical Problems

In fact, studies of health professionals have indicated that while some accept brain death as death because of loss of integrative function, an equal number do so because the patient has permanently lost consciousness and cognition (Youngner 1989). Interestingly, these studies also demonstrate that many health professionals do not really consider brain-dead patients to be dead, but rather *good as dead* because they will die soon despite intervention and have an unacceptable quality of life. A later study demonstrated a similar diversity of opinion and belief among the general public (Siminoff, Burant, and Youngner 2004).

Other problems with brain death have emerged. First, although the clinical and legal criteria inevitably call for loss of *all* brain functions, it turns out that clinical tests commonly used to assure the criterion has been fulfilled simply do not test for some functions that often remain (Halevy and Brody 1993). For example, the production of vasopressin, a hormone essential for maintaining fluid and electrolyte balance, continues in many patients declared brain dead. Bernat responded to the dilemma by saying that it is only *critical* functions that count, but gave little guidance about how to distinguish critical from noncritical ones (Bernat 1998).

A second problem with brain death is that the clinical course of patients who have been declared brain dead is not as certain as when the syndrome was first encountered in the 1960s. Then, patients who were brain dead were notoriously unstable and suffered cardiovascular collapse and cardiac arrest within hours or days. Now, with more clinical experience and more sophisticated interventions, brain-dead patients can *survive* the period of instability to enter a chronic state in which they can be maintained at home with little more than ventilatory support. Some have continued in this state for months and years (Shewmon 1998). An editorial in a prominent neurology journal proclaimed "even the dead are not terminally ill anymore" (Cranford 1998, p. 1530), an ironic statement that captures much of the ambiguity surrounding clinical states in which some, but not all, vital functions remain.

Practical Acceptance

Despite the ambiguities about brain death and how poorly it is understood by the public, acceptance of brain death at the public policy level seems fairly solid. The prognosis for brain-dead patients is uniformly bleak, even for those retaining residual brain functions such as the production of vasopressin. None ever recover consciousness, and most die traditional deaths within days. Moreover, unlike abortion, brain death remains off the radar screen of the religious right, which is very concerned about a *culture of death* in the United States that reduces human dignity and value. Perhaps brain death was "grandfathered in" before the religious right was politically galvanized by *Roe v. Wade* in 1973.

Interestingly, while brain death was quickly accepted and remains relatively uncontroversial in the United States, the situation is quite different in some other countries, most notably Japan, where brain death was not recognized by law until 1997. Patients who have lost brain function may be declared dead only for the purpose of organ transplantation, and then only if both the patient, when living, and the family, after death, have signed written documents. Unlike in the United States, brain death has been the subject of much public discussion and controversy for more than four decades, including the publication of more than 100 books on the subject for the general public and its inclusion as subject matter in popular comic books for children (Lock 2002). While not as contentious as it is in Japan, the debate over brain death in Denmark and Germany has been much stormier than that in the United States.

Because of the growing gap between the demand and supply for transplantable organs, it is unlikely that brain death will become a subject of controversy in the United States. Controversy is more likely to come if desperate patients and transplanters try to expand the current definition of death to include patients with brain injuries less severe than brain death.

STUART J. YOUNGNER

SEE ALSO *Bioethics; Death and Dying; Persistent Vegetative State; Science, Technology, and Law.*

BIBLIOGRAPHY

Ad Hoc Committee of the Harvard Medical School to Examine the Definition of Brain Death. (1968). "A Definition of Irreversible Coma." *Journal of the American Medical Association* 205(6): 337–340. This landmark article introduced the concept of brain death to the medical community and lay public nearly 40 years ago.

Bartlett, Edward T., and Stuart J. Youngner. (1988). "Human Death and the Destruction of the Human Cortex." In *Death: Beyond Whole-Brain Criteria*, ed. Richard M. Zaner. Dordrecht, Netherlands: Kluwer Academic.

Bernat, James L. (1998). "A Defense of the Whole-Brain Concept of Death." *Hastings Center Report* 28(2): 14–23.

Bernat, James L.; Charles M. Culver; and Bernard Gert. (1981). "On the Definition and Criterion of Death." *Annals of Internal Medicine* 94: 389–394.

Cranford, Ronald. (1998). "Even the Dead Are Not Terminally Ill Anymore." *Neurology* 51(6): 1530–1531.

Gervais, Karen Grandstrand. (1986). *Redefining Death*. New Haven, CT: Yale University Press.

Halevy, Amir, and Baruch Brody. (1993). "Brain Death: Reconciling Definitions, Criteria, and Tests." *Annals of Internal Medicine* 119: 519–525.

Lock, Margaret. (2002). *Twice Dead: Organ Transplants and the Reinvention of Death*. Berkeley and Los Angeles: University of California Press.

Shewmon, D. Alan. (1998). "Chronic 'Brain Death': Meta-Analysis and Conceptual Consequences." *Neurology* 51(6): 1538–1545.

Siminoff, Laura; Burant, Christopher; and Youngner, Stuart J. (2004). "Death and Organ Procurement: Public Beliefs and Attitudes." *Social Science & Medicine* 59(11): 2325–2234.

Veatch, Robert M. (1976). *Death, Dying, and the Biological Revolution: Our Last Quest for Responsibility*. New Haven, CT: Yale University Press. One of the first discussions about brain death.

Youngner, Stuart J.; C. Seth Landefeld; Claudia J. Coulton; et al. (1989). "Brain Death and Organ Retrieval: A Cross-Sectional Survey of Knowledge and Concepts among Health Professionals." *Journal of the American Medical Association* 261(15): 2205–2210.

Youngner, Stuart J.; Robert M. Arnold; and Renie Schapiro, eds. (1999). *The Definition of Death: Contemporary Controversies*. Baltimore: Johns Hopkins University Press. A collection of essays about problems in the diagnosis and determination of death from philosophical and clinical perspectives.

BRAVE NEW WORLD

One common way to evoke unease about modern science and technology is to say that humanity is headed toward a "brave new world." Aldous Huxley's novel *Brave New World*, first published in 1932, depicts a World State in which biological technology and psychological conditioning were used to make everyone feel happy all the time, but this was achieved by creating a mechanized world in which people were reduced to soulless animals. Much of the debate over science and technology has centered on the question of how to avoid such a "brave new world."

Huxley (1894–1963) was a prominent English novelist and essayist. Of his many novels, *Brave New World* is the one that is best known in the early twenty-first century. It reflects his interest in biological science, which he shared with his grandfather Thomas Henry Huxley (1825–1895), his brother Julian Huxley (1887–1975), and his friend J. B. S. Haldane (1892–1964), all of whom were prominent biologists.

The New World State

Brave New World is about an imaginary World State in the future where a combination of genetic manipulation and social conditioning has produced a stable industrialized society governed by the political slogan that "everyone belongs to everyone else." Human eggs are fertilized in laboratories and then incubated under varying conditions for the mass production of people, who are shaped to fill their social caste roles as Alphas, Betas, Gammas, Deltas, or Epsilons. Some people have been cloned from the same fertilized egg, so that they are genetically identical. The higher castes fill managerial roles, and a few of these become Controllers ruling over the World State. The lower castes fill menial roles. There are no parental or familial attachments. The idea of being born to a mother after developing in her womb is considered obscene and primitive. People are thus freed from the emotional conflicts of family life. Because everyone is conditioned to fill an assigned role, they all feel happy doing what they do, and there is no class conflict. There are many amusements to keep people happy, including the "feelies," movies that arouse audiences not only visually and audibly but also tactually. Sexual promiscuity is a social duty, and people derive recreational pleasure from having hundreds of sexual partners. Anyone who might feel a little anxious or sad takes the drug *soma*, which induces blissful euphoria and allows people to "escape from reality" for long periods without any painful aftereffects. Medical science preserves the

Scene from the 1980 TV movie version of *Brave New World.* A subsequent film depiction of Huxley's scientific utopia was made in 1998, featuring Leonard Nimoy as Mustapha Mond. *(The Kobal Collection. Reproduced by permission.)*

youthful vigor of everyone until death. There is no interest in traditional art or religion, because people have never felt the intense suffering or conflicts that are presupposed by art and religion.

A few individuals rebel against this social conformity and emotional shallowness. They desire the intense emotions of romantic love, art, religion, or pure science. If they become too disruptive, they can be exiled to distant islands. One of the rebels is John the Savage, who originally was born to a woman and raised on an Indian reservation in New Mexico before being brought to London. The Savage has educated himself by reading William Shakespeare's plays, which give him poetic language to express his deep longings. The Savage meets Mustapha Mond, the World Controller for Western Europe, who shares his interest in art and religion. Mond has also been moved by a love of pure science for its own sake that cannot be satisfied by the applied science and technology promoted in the World State. As a young man, Mond could have been exiled to an island for rebels, but he decided to sacrifice his personal happiness to become a Controller who would rule for the greater happiness of the World State.

Antecedents and Consequents

Huxley's novel thus depicts the sort of scientific utopias that were predicted by people such as Haldane. The artificial production of children, the genetic engineering of character traits, the abolition of family life, recreational sex separated from reproduction, the use of new psychotropic drugs to induce euphoric moods, the prolongation of youthful health into old age—these and other innovations in Huxley's novel had already been predicted by Haldane in his book *Daedalus; or, Science and the Future,* first published in 1923. Haldane foresaw that these changes in scientific technology would bring changes in morality. So that what was traditionally thought to be bad would be regarded as good. Welcoming this prospect as moral progress, Haldane suggested: "We must learn not to take traditional morals too seriously" (1995, p. 49). In contrast to Haldane's optimistic attitude, Huxley's novel elicits the fear that Haldane's utopia would be dehumanizing.

Huxley takes his title from Shakespeare's assessment of utopian aspirations in *The Tempest* (1610), near the end of which the young woman Miranda marvels concerning her island home, "O brave new world, that has such people in it" (Act 5, Scene 1). The original allusion was to the New World of the Americas that was in the process of being colonized. Jamestown, the first permanent English settlement in the New World was founded in 1607, although from the perspective of the indigenous inhabitants the new world was precisely that which was created by the transplantation of European culture. The phrases "new world" and "brave new world" have thus become synonymous with major cultural transformations, especially those dependent on modern science and technology. Popular adaptations include one for radio (1956, with Huxley himself narrating), two television movies (1980 and 1998), a feature-length film *Demolition Man* (1993) with numerous allusions, and a heavy-metal music album (by Iron Maiden, 2000). "Brave New World" was also the title of a four-day New York theater event in 2002 responding to the terrorist events of September 11, 2001.

In his 1958 collection of essays *Brave New World Revisited,* Huxley said that the world described in his novel was contrary to "man's biological nature," because it treated human beings as if they were social insects rather than mammals. Social insects such as bees, ants, and termites naturally cooperate because the good of the social whole is greater than its individual members. But mammals are only "moderately gregarious," Huxley observed, in that they can cooperate with one another, but they will never subordinate their individual interests totally to the community. In social insect colonies, reproduction is communal (through the queen), so that most of the insects do not reproduce and thus do not feel any individual attachment to offspring. Among mammals, however, individuals produce offspring directly and feel a parental attachment to them. As large-brained mammals, human beings must devise arrangements for balancing social order and individual freedom. *Brave New World* shows how dehumanizing it would be for human beings to be so designed that they gave up individual freedom for the stable order of something like a social insect colony.

The very fact that people in *Brave New World* need *soma* as an "escape from reality" indicates that the World State has not succeeded in abolishing their mammalian nature and turning them into social insects. Any careful reader of Huxley's novel can see intimations of all those natural desires that distinguish the human species. These desires are expressed in the many individuals who have to be sent into exile on remote islands. Even a World Controller such as Mond feels those desires, which leaves the reader wondering why he would take a ruling office that makes him unhappy.

Critics and Criticism

Critics of modern technology—such as C. S. Lewis (1898–1963), Lewis Mumford (1895–1990), and Leon R. Kass (2002)—see the world depicted in Huxley's novel as the final stage in the modern project for the technological conquest of nature, in which human nature itself will be conquered by being abolished. Once human beings become merely raw material for technological manipulation—particularly through human biotechnology—then human beings will be replaced by "posthuman" artifacts. This will be the ultimate tyranny because humans will have absolute power over those whose nature is to be remade. These critics worry that if human nature is abolished as a given, and thus there is no natural ground for moral judgment, there remains no clear standard for judging the moral uses of technology beyond the arbitrary impulses of those who control the technology. After being advised by Kass about the moral dangers in harvesting stem cells from human embryos, president George W. Bush delivered a nationally televised speech on August 9, 2001, in which he warned that "we have arrived at that brave new world" described by Huxley (Bush 2002, p. 308).

Libertarian proponents of modern technology—such as Lee M. Silver (1997) and Virginia Postrel (1998)—reject this dark view by arguing that what is wrong with the society in Huxley's novel is its rule by a coercive World State that has eliminated individual liberty. From a libertarian position, the biotechnological conquest of nature is not harmful as long as it occurs through individual free choice. So, for instance, if parents want to use the latest reproductive technology to promote the health and happiness of their children, they should be free to do so, with the hope that parental love will move them to act for the best interests of their children. People will make mistakes, but in a free society they will learn from their mistakes.

In response, conservatives such as Kass warn that leaving biotechnology to individual choice could still lead to a "brave new world," because parents and others might be seduced into using biotechnology in ways that would bring about a degrading, dehumanized world. For example, parents with the best of intentions might choose to genetically design their children to have desirable traits without realizing how this would turn children into artificial products of human will and thus deprive them of human dignity. Or the pursuit of happiness might induce people to become dependent on mood-brightening drugs without considering the degradation in such illusory contentment.

Assessing the prospect of a “brave new world” requires judging both the technical possibility and the moral wisdom of the technological mastery of nature as extended to the mastery of human nature.

LARRY ARNHART

SEE ALSO *Huxley, Aldous; Science Fiction; Science, Technology, and Literature; Utopia and Dystopia.*

BIBLIOGRAPHY

Bush, George W. (2002). “Address To The Nation.” In *The Future is Now: America Confronts the New Genetics,* ed. William Kristol and Eric Cohen. Lanham, MD: Rowman and Littlefield.

Firchow, Peter Edgerly. (1984). *The End of Utopia: A Study of Aldous Huxley's ''Brave New World.''* Lewisburg, PA: Bucknell University Press. Best study of Huxley's novel.

Fukuyama, Francis. (2002). *Our Posthuman Future: Consequences of the Biotechnology Revolution.* New York: Farrar, Straus and Giroux. Argues for restricting biotechnology to avoid a “brave new world.”

Haldane, J. B. S. (1995). “Daedalus; or, Science and the Future.” In *Haldane's ''Daedalus'' Revisited,* ed. Krishna R. Dronamraju. Oxford: Oxford University Press.

Huxley, Aldous. (1965). *''Brave New World'' and ''Brave New World Revisited.''* New York: Harper and Row.

Kass, Leon R. (2002). “Preventing a Brave New World.” In *The Future Is Now: America Confronts the New Genetics,* ed. William Kristol and Eric Cohen. Lanham, MD: Rowman and Littlefield.

Lewis, C. S. (1947). *The Abolition of Man.* New York: Macmillan.

Mumford, Lewis. (1970). *The Myth of the Machine,* Vol. 2: *The Pentagon of Power.* New York: Harcourt Brace Jovanovich. Argues that modern technology has already created a “brave new world.”

Postrel, Virginia. (1998). *The Future and Its Enemies.* New York: Free Press.

Silver, Lee M. (1997). *Remaking Eden: Cloning and Beyond in a Brave New World.* New York: Avon. An optimistic view of the liberating effects of a “brave new world” of biotechnology.

BRECHT, BERTOLT

German playwright, poet, and theatrical reformer Eugen Berthold Friedrich Brecht (1898–1956) developed theatre as a forum for critical reflection on society in order to advance his Marxist beliefs. Born in Augsburg, Bavaria, on February 10, Brecht studied medicine in Munich and briefly served at an army hospital in World

Bertolt Brecht, 1898–1956. Brecht has been called one of the greatest German playwrights of the 20th century. His works reflect his thoughts on the technologies of film and radio, which were newly emerging during his time. *(The Granger Collection Ltd.)*

War I. During the early 1920s, he developed an anti-bourgeois attitude and studied Marxism. Brecht lived in Berlin from 1924 to 1933, where he collaborated with composer Kurt Weill (1900–1950) and developed his theory of “epic theater” and his austere, irregular verse. In 1933, Brecht went into exile, spending six years in the United States (1941–1947), where he did some film work in Hollywood. During exile, Brecht wrote most of his great plays, essays, and poems, while his work was being burned in Nazi Germany. In 1949, he moved back to Berlin and despite the controversial communist ideals of his work, he enjoyed great success. Brecht died of a heart attack in East Berlin on August 14.

Technology and Communication

Brecht realized that the emerging technologies of film and radio provided important opportunities for rethinking the formal properties of communication. He was aware of the ways in which new technologies construct their audiences in modes of reception ranging from passive, which he disliked, to active and participatory, which he favored and encouraged. Reception and representation were key to Brecht's idea of what he termed "communication with consequences." He believed that audiences perceive the real causality of the story being told only if the devices of the media solicit active inquiry.

Although he felt the new media had great potential to liberate people, Brecht also maintained that radio ignored the possibilities of organizing its listeners as suppliers of ideas. If radio were to change its focus from distribution to communication, turning listeners also into speakers, then it might generate positive social change. He did not foresee the use of radio for propaganda by right-wing (as well as leftist) ideologues. Brecht, like director Erwin Piscator (1893–1966), felt that film could be used positively within theater, and he was interested in the way new technologies of communication reconfigured content. Developments within filmmaking, for example, inspired his notion of *Gestus*, actions that are both simply themselves and emblematic of larger social practices.

In some of his productions, Brecht projected subtitles in advance of scenes to announce the plot to the audience. By abandoning the tension and surprise, this "communication with consequences" focused the audience on the more important task of thinking critically, socially, and politically. Distancing the audience from his plays was also crucial to his Marxist drama. Unlike the Aristotelian premise that the audience should be made to believe that what they are witnessing is happening here and now, the Marxist premise that human nature is historically conditioned required an "epic theater," which gave the audience critical detachment. This was Brecht's *Verfremdungseffekt* (alienation effect) that portrayed action in a "scientific spirit" and reminded the viewer that theater is not reality.

Critical inquiry that exposed the oppression and inequalities of capitalist production was central to Brecht's view of the potential of new technology. Spectators were able to regard the situations of the characters and the actions of the dramas as indicative of class warfare, thus underscoring the social, rather than psychological, genesis of the human condition.

Changing Views About Science and Technology

In a radio speech on March 27, 1927, Brecht stated, "It is my belief that [man] will not let himself be changed by machines but that he will himself change the machine; and whatever he looks like he will above all look human." In the same talk, he argued that this new human would be acutely aware that guns can be used for him or against him, houses can shelter or oppress him, and that live works can discourage or encourage him. To this neutralist position, Brecht added a general element of optimism. He argued that science could change nature and make the "world seem almost habitable," by overthrowing the oppressive religious mystification of experience that taught people to tolerate their fate.

Brecht realized that developments in science and technology were driving and shaping society, and he believed that these changes had to be reflected in the theatrical presentation of human transactions. His epic and dialectical theater with its emphasis on critical inquiry highlighted the increased responsibility created by new technological powers. Brecht's characters were never products of metaphysical forces, and their actions were not fated. Rather, they grappled with personal responsibilities shaped and conditioned by the larger world.

Brecht's *Leben des Galilei* (Life of Galileo) shows not only this fallible, striving quality of his characters, but also captures his growing unease about the human and social consequences of modern science and technology. The original 1938 version of the play portrays Galileo as a cunning, noble, and brave seeker of truth who brings light to an age of darkness. The bombing of Hiroshima in 1945, however, caused Brecht to revise the play. In this later version, Galileo is portrayed as a coward who quickly recants the truth at the sight of torture devices. He practices science only for his own gain, without regarding the possible harms or benefits to humanity. Brecht, despite his deep distrust of religion, even allows the Church to eloquently and persuasively defend its position. Ultimately, Galileo is portrayed as the initial instigator of a tradition that leads to the horrors of atomic weapons. In the play's final scene, Galileo denounces himself, because he sought knowledge for self-aggrandizement and not for the good of humanity. Brecht shows that the pursuit of truth absent considerations of the good led to the split between science and society that culminated in the use of atomic weapons on civilians. Science brings darkness rather than enlightenment.

Brecht saw the unbridled quest for knowledge and its potentially destructive consequences as a pressing concern of his age. Just as he satirized the "resistible" rise of Hitler, Brecht wanted to show how the exercise of critical thinking and personal responsibility could resist the rise of destructive technologies. Using irony, humor, and skepticism, he cautioned that human society must morally progress in order to understand and wisely direct the rapid advances in science and technology. As Brecht wrote in *Leben des Galilei*:

May you now guard Science's light
Kindle it and use it right
Lest it be a flame to fall
Downward to consume us all

CAROL MARTIN

SEE ALSO *Science, Technology, and Literature.*

BIBLIOGRAPHY

Brecht, Bertolt. (1981 [1938]). *Leben des Galilei* [Life of Galileo], eds. H. F. Brookes and C. E. Frankel. London: Heinemann. An examination of the problems that face scientists and the spirit of free inquiry when challenged by the requirements of government and official ideology.

Brecht, Bertolt. (1970–1987). *Collected Plays* 7 vols., eds. John Willett and Ralph Manheim. London: Methuen.

Esslin, Martin. (1971). *Brecht: The Man and His Work,* rev. ed. Garden City, NY: Anchor Books.

Willett, John. (1959). *The Theatre of Bertolt Brecht.* London: Methuen.

BRENT SPAR

The Brent Spar was an oil storage buoy built and owned by Royal Dutch Shell (Shell Oil) in 1976. The spar (or large cylindrical storage buoy), 147 meters tall, was used in the North Sea to temporarily store crude oil. A new pipeline made the spar unnecessary and over time Shell Oil chose to dispose of the spar by sinking it in deep water off the west coast of Great Britain. During the mid-1990s this proposal became a major environmental issue in Europe.

Disposal Options

Sinking was the cheapest (approximately $18 million) and safest option for the workers who would be performing the task. Other options, however, existed. At a greater expense, the spar could have been refurbished to perform other functions. At two to four times the cost of sinking it, the spar could have been cleaned and dismantled, with the steel then recycled. Dismantling operations, however, posed up to six times more risks to workers and the immediate coastal environment where the dismantling would be performed.

Shell Oil chose to dispose of the spar in more than 2 kilometers of water and received permission to do so from the British government in 1994. Both Shell Oil and the British government agreed that the potential damage to the local environment from oils, waxes, and other materials still inside the spar would be limited to the immediate area and that the impact would be short lived.

In April of 1995, Shell Oil began towing the Brent Spar to its deep-water burial at which time protesters associated with Greenpeace boarded the platform. The protesters demanded that Shell Oil cease its dumping plan in favor of what they contended were more environmentally benign choices and argued that disposal at sea was wrong on principle. Greenpeace and other environmental groups called for the boycott of Shell Oil gas stations across Europe and in some places sales at those stations fell by half. Two such stations in Germany were attacked with fire bombs.

On June 20, 1995, due to intense public pressure and negative publicity, Shell Oil temporarily halted its deep-sea disposal operations. Over the following years, the company evaluated a number of different disposal options, finally dismantling the Brent Spar in a deep bay in Norway, beginning in January 1998. Sections of the spar were recycled in the construction of a new ferry terminal in Norway. Total disposal cost was approximately $96 million.

During the protests, Greenpeace claimed the spar contained large amounts of dangerous chemicals that would cause serious harm to the environment. Shell Oil and the majority of independent scientists argued that deep-sea disposal was in fact the safest option. After the decision to cancel the disposal in 1995, Shell Oil hired an autonomous firm, Det Norsk Veritas, to assess the alternatives. The firm determined that the actual amount of residual oil and some heavy metals still inside the spar was slightly higher than originally claimed by Shell Oil, but significantly lower than the amount claimed by Greenpeace. Media reports discovered other inconsistencies in the organization's arguments. Greenpeace was successful in stopping the disposal operation, but lost legitimacy after its story began to unravel. The debate also left Shell Oil's reputation with the public significantly damaged.

Ethical and Policy Lessons

The Brent Spar incident has a number of ethical and policy implications. Disposal of the spar could have set a precedent for disposal of other oil facilities, and potentially caused environmental damage. Some argued that Shell Oil's risk-benefit analysis could not adequately gauge the effects of disposal. At issue was the company's ability to determine environmental harm versus its bias toward monetary benefits to it and its shareholders.

Furthermore some saw trade-offs between harm to the environment and benefit to the company as completely illegitimate and nonfungible. The feasibility of the business ethic of the triple bottom line of business, society, and environment, in which corporations consider all three outcomes in their decision making, was also at stake.

Finally a number of ethical issues arise concerning the dialogue itself. Did Greenpeace have standing to protest a legal action by Shell Oil? Was Greenpeace a legitimate speaker for the environment? Was Shell Oil obliged to speak with different stakeholders or groups, and what process should the company have pursued? These questions highlight the difficulty of convening legitimate, representative groups, and carrying out group decisions when all parties are free to opt out or otherwise dissent.

The saga of the disposal of the Brent Spar combined debate over scientific information with a political dispute over environmental values. Greenpeace was able to use inaccurate scientific information to buttress an ethics argument against dumping waste in the sea. It also argued that dumping the spar would allow Shell Oil to avoid the full cost of the spar's use and disposal. Shell Oil disputed the scientific information Greenpeace presented, but failed to adequately counter the ethics argument. The public and media largely failed to grasp the scientific dispute, and sided with Greenpeace on ethical grounds. The Brent Spar incident illustrates the difficulty of introducing scientific evidence into essentially political arguments.

ELIZABETH C. MCNIE
TIND SHEPPER RYEN

SEE ALSO *Engineering Ethics; Environmental Ethics; Nongovernmental Organizations; Oil.*

BIBLIOGRAPHY

Entine, John. (2002). "Shell, Greenpeace and Brent Spar." In *Case Histories in Business Ethics*, ed. Chris Megone and Simon J. Robinson. New York: Routledge.

INTERNET RESOURCES

Brent Spar Dossier. Shell.com. Available from http://www.shell.com/brentspar/. Shell Oil's history of the incident.

Greenpeace Brent Spar Protest in the North Sea. Greenpeace. Available from http://archive.greenpeace.org/comms/brent/brent.html. An account of the incident from the organization's perspective.

BRIDGES

Bridge building as a human activity predates recorded history, and bridges are among the earliest structures described in the historical record. In the fifth century B.C.E. Herodotus reports on a bridge over the Euphrates River made of timber resting on a stone foundation. Roman stone bridges at Segovia (Spain) and Nîmes (France) are still standing 2,000 years after their construction. In the Middle Ages, bridge building became the province of specialist monastic orders. Medieval bridges were conceived as places to live, not just as a means of passage from one side of a river to another. London Bridge in 1594 supported 100 houses and shops.

Bridge Engineering

In the nineteenth century, bridge building became a scientific discipline, after a backlash brought about by notorious disasters in which bridges failed to endure mathematically predictable loads. A fascinating 1887 monograph by George L. Vose (1831–1910) reflects the period in which bridge building crystallized into a scientific and mathematical discipline. Vose complained that any charlatan could proclaim himself a bridge builder and find customers, while ignoring the mathematics that made the calculation of safety margins simple. "There is at present in this country absolutely no law, no control, no inspection, which can prevent the building and the use of unsafe bridges" (p. 12). He pointed out that the science of bridge loads was well understood: A dense crowd of people creates a load of up to 140 pounds per square foot, while soldiers walking in step double the strain; snow and ice can create a load of 10 to 20 pounds per square foot, while heavily loaded freight trains can create a strain of 7,000 pounds per square foot.

Vose was a pioneering proponent of safety margins. He argued that bridges should be designed to carry a load four to six times greater than the actual loads they are likely to carry under any foreseeable circumstances. Many existing bridges did not meet these standards; some, in fact, were capable of carrying only the predictable load. Of these, Vose acerbically noted that such a bridge is warranted "to safely bear the load that will break it down" (p. 55). The country, in his estimation, was full of highway bridges "sold by dishonest builders to ignorant officials" and awaiting only "an extra large crowd of people, [or] a company of soldiers" to collapse (p. 16).

According to the structural engineer David P. Billington, however, a second transformation occurred when bridges (along with tall buildings) became uniquely modern works of art by exploiting the properties of new structural materials such as steel and reinforced concrete. In the period after 1880 engineers began "to explore new forms with these materials," the first maturity of which occurred in the period between the two world wars (1983, p. 7). The bridge designs of the Swiss engineer Robert Maillart (1872–1940) are archetypical achievements of this new era.

In the contemporary world the Clifton (Bristol, 1864), Brooklyn (New York, 1883), Golden Gate (San Francisco, 1937), and Tsing Ma (Hong Kong, 1997) Bridges are indeed considered works of art, objects whose function is intertwined with their beauty. For the engineer Henry Petroski "there is no purer form of engineering than bridge building" (1995, p. 14). Whereas houses and buildings are designed for appearance, and then engineered, the process followed in bridge construction is the opposite. A bridge must be designed to perform its function successfully; its beauty emerges from the engineering.

Ethics and Bridges

The ethical issues pertaining to bridges span a range of questions. Is a particular bridge really needed? What impacts do bridges have on the social and natural environments where they are constructed? What levels of safety are appropriate in bridge design?

NEEDS. Insofar as they are major public works projects, the need for bridges has to be obvious and they often have to pass a hurdle of criticism before being constructed. At the same time bridges are sometimes built so that powerful politicians can create jobs and funnel money to their districts, or reward political contributors. According to environmental groups in Alaska, the proposed Gravina Island Bridge is an example. Designed to be 1.6 kilometers long and 24 meters higher than the Brooklyn Bridge, the $200 million structure would link the depressed town of Ketchikan (and its 7,500 residents) to an island that has fifty residents and an airport with six flights a day in the busy season. The island is already well served by ferry, and the bridge would bisect a channel used by shipping and floatplanes.

SOCIAL AND ENVIRONMENTAL IMPACTS. Most people do not want a bridge in their own backyards, with the concomitant loss of views and increases in local traffic, leading to a decrease in property values. Illustrating the NIMBY (not in my backyard) syndrome, even citizens who will benefit prefer that a bridge be sited in someone else's neighborhood. The site originally studied for the George Washington Bridge in New York City was at West 110th Street in Manhattan. Two powerful local institutions, St. Luke's Hospital and Columbia University, strenuously opposed this location. Columbia's president, Nicholas Murray Butler, said that the proposed site was "little short of vandalism" (Petroski 1995, p. 242). The bridge was eventually built (1927–1931) on unused land much further north at West 179th Street.

Robert Moses (1888–1981), the motivating force behind many of New York's best-known bridges and parks, is famous for his ruthless treatment of opponents and of local communities that stood in the way. His beautiful Verrazano-Narrows Bridge, built 1959–1964 with either end in a highly populated neighborhood, caused the seizing and demolition of 800 buildings in Bay Ridge, Brooklyn, displacing 7,000 people. On the Staten Island side, 400 buildings were taken by eminent domain, displacing 3,500 residents.

Moses's determination, and his willingness to counter his opponents in the same visceral language they used to attack him, is evident in a series of monographs issued at his direction. In 1939, when the *New York Herald-Tribune* opposed his proposed Brooklyn Battery Bridge, Moses had the Triborough Bridge Authority publish a brochure entitled "Is There Any Reason to Suppose They Are Right Now?" It ridiculed the *Herald-Tribune,* excerpting two decades of editorials opposing previous Moses park and highway projects. Moses painted the newspaper as the voice of millionaires who did not want their neighborhoods tainted by projects that would benefit the common folk.

Another organization opposing the Brooklyn Battery Bridge was the Regional Plan Association, which argued that it was not a natural site for a bridge and would deface the land- and cityscape. In his counterattack, Moses noted that the association had backed a proposal for the construction of a 200-meter obelisk in the Battery, which Moses claimed would obscure the view much more than his proposed bridge. In the end, however, Moses lost the battle, and a tunnel was built in lieu of the bridge. Tunnels are frequently proposed as alternatives to bridge projects; underground, they have the virtue of not being seen, but tend to be more expensive to build and are of necessity narrower, carrying less traffic and freight.

BRIDGE SAFETY. Bridges collapse for one of two reasons. Either their design and construction fail to meet contemporary industry standards, or those standards are inadequate to ensure safety in the face of unexpected circumstances. An example of negligent construction was West Gate Bridge, in Melbourne, Australia, which fell while being erected on October 15, 1970. Thirty-five workers were killed in the collapse. The bridge was being assembled in sections, which were elevated and then bolted to one another. It was discovered that two adjoining sections were not flush with one another as designed; the difference in "camber" was about 3 inches, while the specifications called for a difference of no more than 1 inch. In order to fix the problem, the builders should have lowered the two pieces to the ground again, but this would have caused a delay and a cost overrun, so instead they decided to fix them in place.

They applied a very primitive solution, one of placing 8-ton concrete blocks on the higher span, to push it back into line with the other one. This then caused the steel plates to buckle out of shape by as much as 15 inches. In an ill-fated and foolhardy attempt to eliminate the buckling, the builders decided to remove the bolts holding the steel plates in place. After the first sixteen bolts had been removed, the plates had slipped so much that the remaining bolts were jammed and could not be unscrewed. The workers then tightened each of these until they broke, removing the pieces. Like a man sawing off a tree limb upon which he is sitting, they continued removing bolts, until the entire structure collapsed, killing many of them. A Royal Commission appointed to investigate the disaster concluded that what had happened was "inexcusable" and that the builder's performance "fell far short of ordinary competence" (Royal Commission 1971, p. 97).

An example of a structure that arguably was designed acceptably by contemporary standards, but that fell anyway, was the Tacoma Narrows Bridge (built 1938–1940), popularly known as "Galloping Gertie" because of the alarming way it flailed around under high winds before eventually tearing apart. While most bridge disasters occur when a load crosses the bridge that exceeds its carrying capacity, the Tacoma Narrows Bridge had more than an adequate margin of safety for any traffic load. What the architect had failed to anticipate was that the long and thin bridge had "aerodynamic qualities somewhat like the wing of an aeroplane" (Rastorfer 2000, p. 33). Buffeted by heavy winds on November 7, 1940, the whole span began to twist. Finally, hours after Gertie began its last gallop, the bridge tore itself apart and fell.

Petroski notes that bridge failures follow an approximately thirty-year cycle. A notorious failure leads to the use of a new model, which at first is designed conservatively, but then extended and overextended, until a new failure results, and then a new model emerges. The "high girder" design led to the collapse of the Tay Bridge (Dundee, Scotland, 1879), which resulted in the new cantilevered design, which was responsible for the double collapse (in 1907 and 1916) of the Quebec Bridge, which brought about the suspension model, of which Galloping Gertie was an example. In this sense bridges may illustrate a general dynamic, one society should always take into consideration when attempting to make informed ethical use of science and technology.

JONATHAN WALLACE

SEE ALSO *Dams; Water.*

BIBLIOGRAPHY

Billington, David P. (1979). *Robert Maillart's Bridges*. Princeton, NJ: Princeton University Press. Billington has written two other books exploring the work of this famous bridge engineer.

Billington, David P. (1983). *The Tower and the Bridge: The New Art of Structural Engineering*. New York: Basic.

Kharbanda, O. P., and Jeffrey K. Pinto. (1996). *What Made Gertie Gallop? Lessons from Project Failures*. New York: Van Nostrand Reinhold.

Mock, Elizabeth B. 1972 (1949). *The Architecture of Bridges*. New York: Arno Press, published for the Museum of Modern Art.

Petroski, Henry. (1995). *Engineers of Dreams: Great Bridge Builders and the Spanning of America*. New York: Knopf.

Rastorfer, Darl. (2000). *Six Bridges: The Legacy of Othmar H. Ammann*. New Haven, CT: Yale University Press.

Royal Commission (E. H. E. Barber, F. B. Bull, and H. Shirley-Smith). (1971). *Report of Royal Commission into the Failure of West Gate Bridge*. Melbourne, Australia: C. H. Rixon, Government Printer.

Triborough Bridge Authority. (1939). "Is There Any Reason to Suppose They Are Right Now?" New York: Author.

Vose, George L. (1887). *Bridge Disasters in America: The Cause and the Remedy*. Boston: Lee and Shepard.

BROOKINGS INSTITUTION

SEE *Public Policy Centers.*

BUDDHIST PERSPECTIVES

Buddhism arose around 500 B.C.E. as a practical response to the trouble and suffering that characterize the human condition. Uniquely among traditions concerned with those issues, Buddhism has never offered a final description of ultimate reality; it also has not proposed a universal fixed solution to the persistent and concrete problems of solely human trouble and suffering. Instead, Buddhism has developed a general yet systematic strategy for generating truly sustainable resolutions of the trouble and suffering that afflict all sentient beings in their specific contexts.

Significant common ground with the traditions of science and technology, particularly as they have developed in the West, is suggested by Buddhism's commitments to developing insight into patterns of causal relationship; challenging both common sense and other, more sophisticated forms of presupposition and authority; construing knowledge as a cumulative and consensual process; and devising concrete interventions to redirect patterns of human activity. However, Buddhism traditionally also has avoided any form of reductionism (materialist or otherwise), countering claims of both privileged subjectivity and absolute objectivity, inverting the presumed priority of facts over values, identifying the limits of (especially instrumental) rationality, and cultivating limitless capacities for emotionally inflected relational transformation. These commonalities and differences suggest that Buddhism is well positioned to complement but also critically evaluate science and technology as epistemic (knowledge-centered) and practical enterprises.

Historical Background

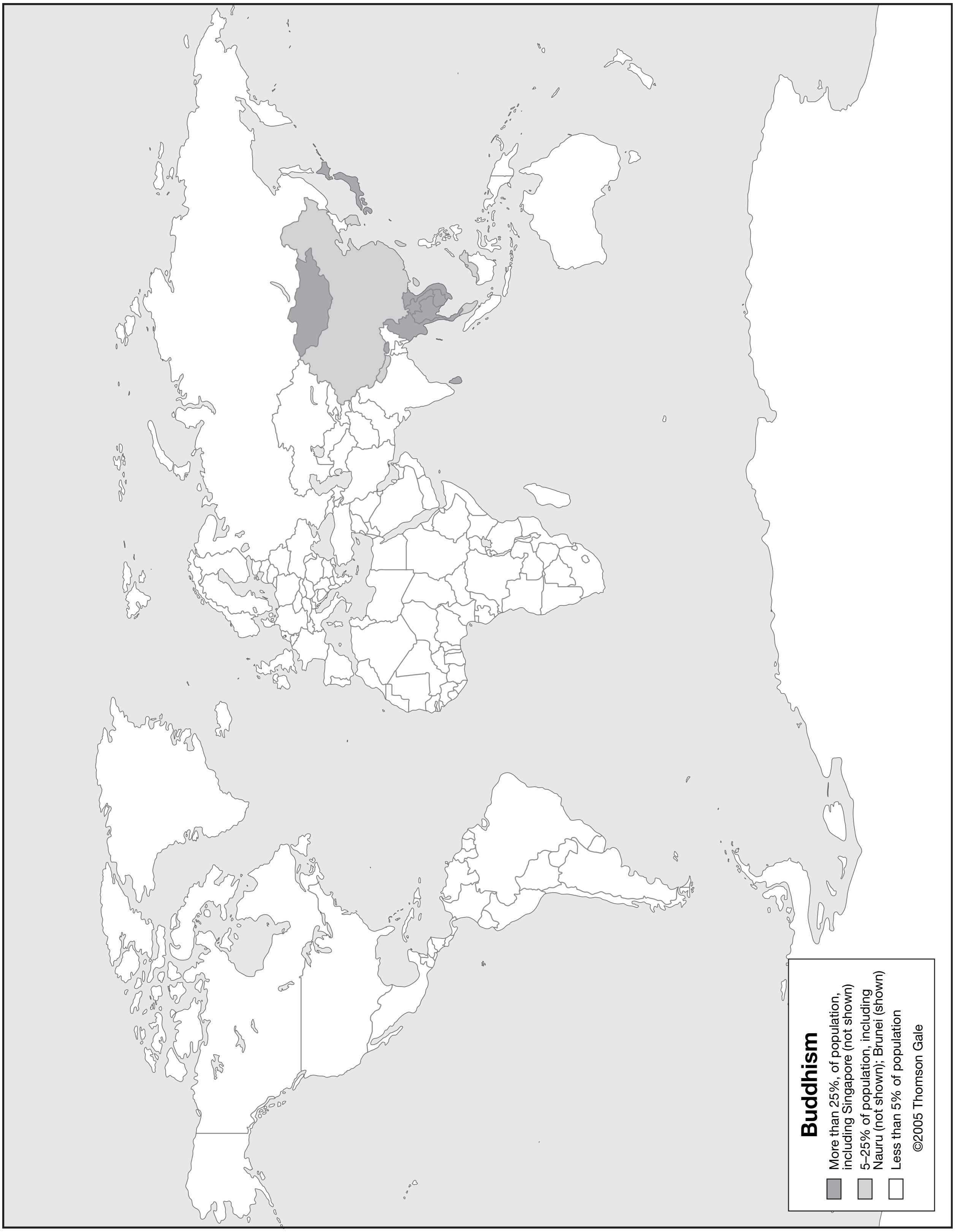
Originally promulgated in what is now northern India by Siddhartha Gautama (likely 563–483 B.C.E.), who became known as the Buddha, or "Enlightened One," the teachings of Buddhism quickly spread across the subcontinent and, over the next half millennium, throughout central, eastern, and southeastern Asia. Its emphasis on the need for context-specific responses and resolutions tailored to each new linguistic and cultural environment resulted in a distinctive pattern of accommodation and advocacy through which Buddhism steadily diversified, resulting over time in a complex "ecology of enlightenment."

Traditionally, Buddhist teachings and practices have been classified into three broad evolutionary streams: the *Hinayana* ("Small Vehicle") stream, which is prevalent today in southeastern Asia and more commonly is called the *Theravada*, or "way of the elders"; the *Mahayana* ("Great Vehicle") stream, which is most prevalent in eastern Asia; and the *Vajrayana* ("Diamond Vehicle") stream, which is associated primarily with Tibet and the societies and cultures of north-central Asia. None of these streams has a universally central text such as the Confucian Analects, the Christian Bible, or the Muslim Qur'an. There also are no globally fixed Buddhist institutions or centralized authorities. Although the analogy is not precise—especially because Buddhism is not a theistic tradition and does not advocate a pattern of belief in a supreme deity or deities—one can compare the breadth of Buddhist teachings and practices with that of the "Abrahamic" religions of Judaism, Christianity, and Islam.

A coherent axis of critical insights and practical strategies has remained constant in the course of the historical development of Buddhism. This axis is expressed most succinctly in the so-called *Four Noble Truths*, the fourth of which has come to be known as the *Eightfold Path:* All *this* is suffering, troubled or troubling (Sanskrit: *duhkha*); suffering or trouble arises with particular patterns of conditions; suffering or trouble ceases with the dissolution or absence of those patterns; and those patterns of conditions can be dissolved through the cultivation of complete and appropriate understanding, intentions, speech, action, livelihood, effort, mindfulness, and attentive virtuosity. The insights and practices summarized in the Four Noble Truths traditionally have been referred to as the *Middle Way*, a brief examination of which can introduce Buddhism's distinctive stance with respect to science and technology.

THE MIDDLE WAY: THE ONTOLOGICAL PRIORITY OF AMBIGUITY. Buddhism originated at roughly the time when early Greek thinkers were developing the precursors to natural science and philosophy. As in Greece, the intellectual terrain in India in the first millennium B.C.E. was extremely fertile. If anything, the range of Indian beliefs and debate regarding the nature of ultimate reality, its relationship to the world of experience, and the meaning and purpose of the good life exceeded that which developed on the Peloponnesian peninsula and in Asia Minor.

Recognizing the interdependent origins of all things, the Buddha saw that each individual view in the spectrum of beliefs failed to resolve the trouble and suffering afflicting all sentient beings. Moreover, he realized that the entire spectrum—encompassing a range of metaphysical and ethical positions running from hard materialist reductionism and hedonism at one end to


Buddhism
More than 25%, of population, including Singapore (not shown)
5–25% of population, including Nauru (not shown); Brunei (shown)
Less than 5% of population
©2005 Thomson Gale

theistic monism and asceticism at the other—was similarly inadequate. The very conviction that some independent ground (matter or spirit, for example) or grounds (as in the case of metaphysical dualism) underlies all things was a primary cause of trouble and suffering. Equally conducive to suffering was the belief that individual things exist independently of one another. In actuality, the Buddha realized, nothing literally exists or "stands apart" from all other things. What is most basic is relationality.

Rather than being a compromise position or a synthesis of a variety of contrasting views, the Middle Way consisted of the process of critically countering *all* epistemic and practical stances and the "horizons" associated with them. It represents a return to that which is prior to the exclusion of the "middle" between "this" and "that," between what "is" and what "is-not." This process is modeled most concisely perhaps in the teaching of the three marks, an injunction to see all things as troubled or troubling, as impermanent, and as having no self or fixed essence and identity.

THE TEACHING OF THE THREE MARKS. The distinction between is and as—that is, between existential claims and strategic claims—is particularly important in the imperative to see all things as characterized by *duhkha,* or suffering and trouble. Whereas claiming that all things are troubled or suffering can be shown to be empirically false, seeing all things as troubled or suffering causes one to perceive how even the moments of greatest happiness come at a cost to someone or something. Far from being an exercise in pessimism, seeing all things as troubled or troubling helps a person understand his or her situation from another person's perspective. In effect, this entails opening up connections that allow people to realize an ethically shared presence. It means becoming aware that in some way all people make a difference to one another and have a responsibility for asking, "What kind of difference?"

Seeing all things as impermanent (Sanskrit: *anitya*) makes it impossible for people to assume or even hope that they can hold on to anything forever. This undercuts the kinds of expectation that lead to disappointment and suffering. It also makes it impossible to sustain the belief that people can do nothing to change their current circumstances. Seeing all things as ceaseless processes means seeing that no situation is truly intractable. Because every situation continuously evidences both energy and movement, debate cannot center on whether change is possible but only on what direction it should take and with what intensity.

Finally, seeing all things, including humans, as lacking any essential nature or identity renders impossible any claims that specific people are inherently good or bad. This dissolves the primary, prejudicial grounds for racial, ethnic, religious, and political conflict; it also undercuts any pretense that people simply are who they are. Seeing all things as *anātman* (Sanskrit)—literally, as having "no-self"—forfeits the basic conditions of maintaining chronic conflicts and opposition.

It also entails abandoning any justification for separating spirit and nature, the human and the animal, the individual and its environment, and consciousness and matter. The teaching of no-self thus came to be associated with the practice of seeing all things as empty (Sanskrit: *śūnya*), that is, as a function of horizonless relational patterning. For this reason, in later Buddhist usage emptiness (Sanskrit: *śūnyatā*)—the absence of any abiding essential nature—often has been equated with fullness. Instead of signifying its privation, the emptiness of a thing consists in its unique way of bringing into focus and contributing to all other things. An observable example of this is the way species contribute both directly and indirectly to one another's welfare in a sustainable ecosystem, with each species uniquely processing, circulating, and augmenting the resources of the system as a whole. As put by the second-century C.E. Indian Buddhist philosopher Nāgārjuna (ca. 150–250 C.E.), understanding emptiness means appreciating the mutual relevance of all things.

Doing this, however, also entails realizing that what people refer to as separate, individual "things"—whether plants, animals, human beings, or histories—are nothing more than people's own editions of the total pattern of relationships that they focus and to which they contribute. For example, what people take a dog *to be* reflects their own values—the horizons of what they believe (or will allow) to be relevant—and this varies with whether a person is a laboratory worker, an only child living on a farm, or an elderly person confined to a small apartment. Because the particulars of people's experiences are conditioned by their values and intentions, people's day-to-day experiences cannot provide complete or objective pictures of their situation. In actuality, what people customarily assume to be independently existing objects are compounded or put together (Sanskrit: sa | sk | ta) out of habitual patterns of relationship.

Although many of these habits—and thus the nature of people's experience—reflect relatively individual values, intentions, likes, and dislikes, they also are conditioned by the values, goals, and desires embodied in families, communities, social and political institutions, and cultures. In Buddhist terms, the human world arises as an expression of people's karma and any practice directed at resolving the suffering or trouble that occurs in it must be karmically apt.

THE TEACHING OF KARMA. According to the Buddhist (as opposed to Hindu) teaching of karma, people should not see the topography of their life experiences as a simple and objective outcome of the intersection of their actions and the operation of universal moral law and/or divine will. It also should not be seen as a simple function of "natural law" and/or "chance." Instead, individual and communal experiences should be seen as reflecting ongoing and always *situated* patterns of consonance and dissonance among people's values and intentions. In light of the emptiness and impermanence of all things, karma can be understood as a function of sustained acts of disambiguation, a pattern of values-intentions-actions that constitutively orders the world and the individual's experienced place in it. Thus, not only do people have and share responsibility for the direction in which things are headed, the *meaning* of the human situation as a whole is continuously open to revision. The Buddhist cosmos may be described as irreducibly dramatic, a place in which all things are at once factually and meaningfully interdependent.

The Buddha most commonly discussed karma in terms of basic relational orientation: an orientation toward chronic and intense trouble and suffering (Sanskrit: *samsara*) and another toward liberation from those states (Sanskrit: *nirvana*). Orienting the individual and communal situation away from *samsara* and toward *nirvana* cannot be done through independent exertions of will aimed at bringing about the world people want. Understood karmically, controlling one's people's circumstances so that one experiences what one wants causes one to live increasingly in want, in circumstances increasingly in need of further control. Skillfully and sustainably directing one's situation away from trouble and suffering depends on seeing all things as thoroughly interdependent in a world in which differences truly make a difference and freedom is not a state of limitless choices or autonomy but a horizonless capacity for relating freely. Buddhist freedom does not pivot on matters of fact but on meaning; it is a matter not of controlling consequences—the victory of "free will" over "chance" and "determinism"—but of demonstrating appreciative and contributory virtuosity.

***PRAJÑĀ, SAMĀDHI,* AND *ŚĪLA*: WISDOM, ATTENTIVE MASTERY, AND MORAL CLARITY.** All Buddhist practice thus can be seen as directed toward healing the "wound of existence." Traditionally, this was understood as requiring three dimensions of sustained capacity building: *prajñā*, *samādhi*, and *śīla*, that is, insight into the irreducible relationality of all things; attentive mastery, a function of meditative training that implies both perceptual poise and responsive flexibility; and moral clarity arising from attunement to the currents of value and meaning constitutive of any karmically inflected situation and a capacity for discerning how to orient them away from *samsara* and toward *nirvana*.

Thus, Buddhist practice is always both a *critique of self* and a *critique of culture*. Neither of these as aspects entails a general rejection of personal or social norms and institutions. However, both necessitate continuous and context-sensitive evaluation of those norms and institutions and the material processes through which they are realized. The relative balance of these dimensions of Buddhist practice of course have varied historically. In light of the nature of contemporary societies, they entail a readiness to engage science and technology critically.

Buddhism in Relation to Science and Technology

There have been robust traditions of science and technology in many Buddhist cultural spheres, particularly in India and China. In general, those traditions were not subject to direct critical attention and did not play significant roles in shaping the patterns of accommodation and advocacy that characterized Buddhism's adaptation to its changing cultural, social, and historical circumstances. Although there are passages in early canonical teachings that indirectly address the place of technology in governance and the furthering of social good (e.g., the *Cakkavatti Sihanda Sutta*), Buddhist critiques of scientific knowledge and considerations of the ethics of technology are only implied in broader critiques of religious, philosophical, and commonsense views. This was true throughout the first two millennia of Buddhist history even when Buddhist universities were the largest and most comprehensive in the world (roughly 600–900 C.E.), with faculties of as many as 2,000 teaching international student bodies in excess of 10,000.

A major shift occurred with the rapid expansion of European colonialism from the sixteenth through the late nineteenth centuries. Resting on interwoven scientific and technological advances, the colonial era brought Buddhism to the attention of the West and also brought modern Western traditions of science and technology to the attention of the Buddhist world.

Two primary currents of interaction emerged at the beginning of the twentieth century and have remained strong since that time. The first involves Buddhist accommodations of scientific and technical knowledge, initially in the colonial states of southern and southeastern Asia. Reflecting on the course of events on the Indian subcontinent, Buddhist leaders concluded that to the extent to which Buddhism was positioned as a religion based on revelatory insights and "unscientific" practices, it would undergo rapid and probably fatal erosion. Those leaders thus began to find textual evidence that would support the claim that Buddhism was in fact a rational and empirically grounded tradition that in many ways prefigured the role of science in the modern West. This "Protestant Buddhism" positioned itself as scientifically rational, logical, and devoid of the sorts of superstitions, myths, and mysticism that were a severe liability in Western eyes. The legacy of those "reform" movements can be seen today in the "globalization" of Tibetan Buddhism.

The second current of interaction developed largely as a result of the rise of science as the West's intellectual sovereign, the associated corrosive effects on European and American religious faith, and the breakdown of classical Newtonian physics. Asian traditions, Buddhism in particular, appeared as complementary systems that could provide scientific reality with a cogent ethical dimension, with scientists and philosophers such as Albert Einstein (1879–1955), Alfred North Whitehead (1861–1947), Betrand Russell (1872–1970), and Robert Oppenheimer (1904–1967) hailing Buddhism as the religion of the future and the appropriate partner of science.

In the final third of the twentieth century, as Western knowledge about Buddhism increased, there came to light—especially in cosmology, physics, biology, ecology, and the computational sciences and neuroscience—patterns of uncanny resonance with Buddhist teachings that caused many people to conclude that they demonstrated the prescient, "postmodern" nature of Buddhism and its "anticipation" of, as well as potential for contributing to, contemporary science. More cautious commentators have seen the encounter between Buddhism and contemporary science—particularly in psychology, medicine, the biology of communication and perception, and behavioral science—as extremely fertile and mutually beneficial, with each tradition being assisted in its pursuit of truth.

Some Buddhists question the logic and wisdom of the marriage of Buddhist and scientific approaches to truth. It has been pointed out, for example, that legitimizing Buddhist teachings on the basis of their anticipation of current scientific truths is counterproductive. In light of the fact that the history of scientific change can be described as a "punctuated" evolution of essentially broad and incompatible research paradigms, many contemporary scientific truths will have no place in the science of the next decade, much less in that of the next century. Identifying Buddhism with current scientific paradigms runs the risk of discrediting Buddhism as they are replaced.

Moreover, it has been argued that although science often has been characterized as explicitly eschewing questions of meaning and claims neutrality with respect to the uses of scientific knowledge, Buddhism is centrally concerned with fostering directed revisions of the interdependence of all beings and stresses the union of knowledge and compassionate engagement.

Prospects for Critical Interaction

This suggests an opportunity for a "third stream" that would restore and enhance Buddhism's traditional role of examining patterns of belief and conduct and disclosing how they are limited and/or counterproductive in terms of understanding and resolving trouble and suffering.

Until recently most Buddhist work along these lines focused on the roles of science and technology in industrial and postindustrial patterns of economic development that have induced a drift toward materialism, consumerism, and fractious individualism. It has been noted that science and technology have played into global historical processes through which diverse patterns of sustainable interdependence have been replaced with patterns of simple coexistence. This systematic translation of diversity into mere variety has been criticized as resulting in a decrease of responsive and contributory capacity that is particularly apparent at the community level, with entire villages having been rendered unsustainable through incorporation into the global market economy. Here primary ethical attention has been given to the uses of science and technology to further elite, corporate, and national interests over and often against those of particular populations and the natural environment.

CHALLENGING THE VALUE-NEUTRAL STATUS OF SCIENCE AND TECHNOLOGY. Some Buddhist critics have begun to question whether the moral valence of science and technology can be restricted to the way in which they are used. When considered in the context of interdependence and karma, it is apparent that

Western-style development both drives and is driven by scientific and technological activity and that this symbiotic relationship is not accidental. In actuality it reveals deeply and continuously shared values. Because Buddhist ethics is concerned foremost with how both intentions and values shape human circumstances and experience, this recognition entails admitting that science and technology have a moral influence apart from any particular uses to which they are put.

At least since the time of Galileo (1564–1642), Western (and now global) science and technology have coevolved, embodying a constellation of values that include precision, predictability, objectivity, universality, power, and independence, all of which can be said to depend on the values of control and autonomy. These core values have proved to be highly compatible with short-term positive consequences in responding to trouble or suffering. Promoting these values means promoting the freedom to experience what people want in circumstances they prefer. From within a linear causal framework there is little reason to expect that the same situation will not hold in the long term.

However, in terms of the recursive processes of karmically ordered causation and change, control and autonomy—when expressed with sufficient commitment and/or on a sufficient scale—generate ironic effects and intensifying cycles of perceived trouble or suffering. For instance, a sustained commitment to control leads to increasing capacities for control but also creates circumstances that are both open to *and* in need of control. Because control always is exerted over and against another person or situation and cannot truly be shared, its widening instantiation engenders increasingly steep slopes of advantage/disadvantage, with a prime example being the income and wealth disparities endemic to technology-permeated global markets.

DISPLACING THE INDIVIDUAL AS THE UNIT OF ANALYSIS IN EVALUATING SCIENCE AND TECHNOLOGY. Although autonomy or the freedom to choose or control the nature of one's experienced circumstances may appear to be a simple ethical good, this is true only insofar as *individual* needs, desires, and values are taken as an evaluative basis or unit of analysis. In the absence of universal agreement about the desired nature of shared circumstances and the meaning of the good or the effective isolation of disagreeing parties, multiple exercises of autonomy within a population necessarily result in conflict.

The dominant Western ethical responses to this dilemma—utilitarianism and communitarianism—have not challenged the assumption that individually existing beings are the basic unit of both ethical analysis and communities. Those schools of thought thus have remained compatible with unabated commitments by both individuals and communities to technological development biased by an orientation toward control and autonomy. By contrast, the ethics associated with the Buddhist teachings of emptiness, interdependence, and karma require that qualities of relationship be taken as the basic unit of consideration. Generally stated, granted that the individual, independently existing, and rightfully autonomous self is a pernicious fiction, using the individual as the unit of analysis in evaluating science and technology can only lead to ironic consequences.

From this perspective it has been argued that control- and autonomy-biased technological development leads to mediating institutions, such as global commodity markets and mass media, that allow meaningful differences to be nullified while distracting attention from immediate personal, communal, and environmental relationships. This brings about a systematic erosion of diversity and situational capacities for mutual contributions to shared welfare. Thus, whereas control- and autonomy-biased technologies are conducive to ever-widening *freedom of choice*, they are correlated with an increasingly compromised capacity for *relating freely* and thus with ever more intense and chronic patterns of ignorance, trouble, and suffering.

In more general terms Buddhist ethics cautions against blurring the distinction between tools and technologies. Tools should be evaluated in terms of their task-specific utility for individual users (persons, corporations, or nation-states) and should permit the exercise of "exit rights," that is, choosing *not* to use them. Technologies, however, never are used in a literal sense. Instead, they consist of broad patterns of conduct that embody systems of strategic values and encompass activities that range from resource mining and tool manufacturing to marketing and the innovation of new cultural practices. Although one may choose not to use the tools associated with a particular technology, the world in which one lives continues to be shaped by that technology. With respect to technologies, there are no real exit rights.

From a Buddhist perspective technologies and the sciences with which they symbiotically develop systematize the way people conceive and promote their ends, conditioning the meaning of things, and thus can be evaluated only in terms of the ways in which their core values affect the quality of people's conduct and relationships. In Buddhist terms this entails critically assessing how and to what extent these values are consonant with the core Buddhist practices of cultivating wisdom, attentive virtuosity, and moral clarity for the purpose of realizing liberating patterns of interdependence.

It generally is agreed among Buddhists that scientific advances in people's understanding of factual processes—for example, the dynamics of climate change—should inform efforts to resolve current and future trouble and suffering sustainably. It also is agreed that scientific and technological research should be undertaken in ways that contribute not only to human welfare but to the welfare of all sentient beings. In combination, these commitments make imperative a deepening of the historically arranged "marriage" of Buddhism, science, and technology and promise an increasingly skillful furthering of the Middle Way.

PETER D. HERSHOCK

SEE ALSO *Bhutan; Chinese Perspectives; Hindu Perspectives; Indian Perspectives; Japanese Perspectives; Virtue Ethics.*

BIBLIOGRAPHY

Anonymous. (1995). *Cakkavatti Sihanda Sutta*, trans. Maurice Walsh. In *The Long Discourses of the Buddha*. Boston: Wisdom Publications. Authors are ancient and unnamed. This short text is a provocative commentary on the forces leading to social collapse and the importance of values in framing adequate responses to those forces.

Goleman, Daniel. (2003). *Destructive Emotions: A Scientific Dialogue with the Dalai Lama*. New York: Bantam Doubleday Dell. This is a fine introduction to some of the work being done at the interface between Western psychology and psychotherapy and traditional Buddhist psychology and self-cultivation.

Gombrich, Richard. (1995). *Theravada Buddhism: A Social History from Ancient Benares to Modern Colombo*. London: Routledge. This short volume includes a succinct and careful introduction to the teachings and history of early Buddhism and its historical development into the Theravada tradition, one of the three major divisions of contemporary Buddhist thought and practice.

Hershock, Peter D. (1999). *Reinventing the Wheel: A Buddhist Response to the Information Age*. Albany: State University of New York Press. This book examines the karmic implications of the core values embodied by the predominant technological lineage, considering its historical, social, political, and economic precedents, with particular emphasis on its colonial legacy and effects on consciousness and community.

Jones, Ken. (1993). *Beyond Optimism: A Buddhist Political Ecology*. Oxford: John Carpenter. This monograph provides a sustained account of the implications of using Buddhist resources to understand and reframe contemporary political, economic, and environmental institutions.

Lopez, Donald, Jr. (2002). *A Modern Buddhist Bible: Essential Readings from East and West*. Boston: Beacon Press. This is a collection of historical essays and articles by a wide range of seminal figures in the meeting of Buddhism and the contemporary West, drawn from throughout the twentieth century.

Loy, David. (2002). *A Buddhist History of the West: Studies in Lack*. Albany: State University of New York Press. A methodical reading of historical, scientific, political, and cultural changes in the history of the European and American West through the conceptual lens of early Buddhist thought.

Payutto, Bhikkhu P. A. (1993).*Towards Sustainable Science: A Buddhist Look at Trends in Scientific Development,* trans. B. G. Evans. Bangkok, Thailand: Buddhadhamma Foundation. This is an excellent introduction to contemporary Thai Buddhist critical encounters with Western science, written by one of the leading exponents of Buddhist engagement with contemporary issues.

Varela, Francisco J.; Evan Thompson; and Eleanor Rosch. (1991). *The Embodied Mind: Cognitive Science and Human Experience*. Cambridge, MA: MIT Press. Deeply informed by Buddhist teachings and practices, this is a masterly scientific assessment of the biology of consciousness, thought, and behavior by leading scientific researchers in cognitive science.

Waldron, William S. (2000). "Beyond Nature/Nurture: Buddhism and Biology on Interdependence." *Contemporary Buddhism* 1(2): 199–226. A concise look at issues surrounding nature and nurture in the development of living systems through a close examination of the implications of Buddhist readings of interdependence.

Wallace, B. Alan. (2003). *Buddhism and Science*. New York: Columbia University Press. A fine collection of papers and essays that range across the sciences, providing an excellent introduction to "second stream" encounters of Buddhism (especially Tibetan Vajrayana Buddhism) and contemporary science.

Watts, Jonathan, and David Loy, eds. (2002). *Spiritual Responses to Technology*. Special issue of *ReVision Journal* 24(4). This is a good introduction to contemporary Buddhist thought on technology and its personal, social, and cultural implications.

Williams, Paul. (1989). *Mahayana Buddhism: The Doctrinal Foundations*. New York: Routledge. This is a very good introduction to the history and thought of the Mahayana and Vajrayana traditions of Buddhism.

BUILDING CODES

Building codes are extratechnological laws that govern the design and construction of structures. They can be placed within a hierarchy that begins with metaethics, and includes ethics, laws, codes, ordinances, standards, and operating practices. A typical code provision is, for example, the government enforced specification that the exterior doors of public buildings must open outward (International Conference of Building Officials [ICBO]), or that the vertical rise of steps and stairs shall not be less than four inches nor more than seven inches (ICBO). These requirements are, however, social rather than technological in origin because they are intended to mediate human behavior in the case of emergencies such as fires in buildings.

In general one can say that building codes both reflect and enforce social values. They are, then, an historical index of how social values regarding the safety, health, and welfare of individuals are materialized as the built world. Because the ethical significance of building codes must be understood within the context of their evolution and development, a historical view of this topic is helpful.

Historical Development

The first building code is generally credited to be Article 229 of the Code of Hammurabi (Mesopotamia, 2250–1780 B.C.E.), which requires that "If a builder build a house for someone, and does not construct it properly, and the house which he built falls in and kill its owner, then that builder shall be put to death." (Harper 1904, p. 81) The ethical principle behind this code is an *eye for an eye*—the deontic idea that justice is absolute and unchanging, never moderated by local conditions or human situations.

In contrast to such moral absolutism the Greeks, Romans, and early Islamic societies developed more complex or nuanced building codes. These may be said to be of three types: *tacit codes* that regulate cultural production, *legislative codes* that regulate public resources, and *industrial codes* that regulate modern material and labor standards.

Tacit or unspoken codes are those that bind citizens to the customary practices of their community. Anthropologists argue that the way cultures build—what Kenneth Frampton (1995) calls *tectonic culture*—is as important and distinct as the way they speak. Tacit building codes are systems of ordering and inhabiting the world in a manner that is consistent with cosmological order as the community interprets it. To build well means to construct one's house and dwell righteously—in a manner consistent with divine order (Norberg-Schulz 1979). To depart too far from the tectonic order of one's culture would be to offend the god(s), or those forces responsible for ordering the universe. Tacit codes are a powerful part of vernacular societies but diminish in their influence with the self-conscious invention of modern design and construction practices. The ethical principle behind tacit or vernacular building codes is *sin* against divine authority.

Legislative codes are explicit civil laws concerned with maintaining equity and justice between private parties and that guard public resources such as streets against private exploitation or carelessness. Early examples of this type are the Byzantine Roman Treatise of Julian of Ascalon (533 C.E.) and the codes of the Prophet Mohammed during his reign in Medina (622–632 C.E.) (Hakim 1986). These codes make explicit both the rights and obligations of citizens building within previously tacit conventions. A typical example was a law regulating the construction of *party walls*, a single wall that separates and supports two houses. According to architect and planner/historian Besim Hakim, Mohammed said that "a neighbor should not forbid his neighbor to insert wooden beams in his wall" (Hakim 1986, 2003). In the context of desert dwelling, party walls are private resources that enable a public way of life by aggregating individual dwellings into an urban form that shields the community as a whole from inhospitable natural conditions created by too much sun and wind.

The ethical principle that informs these early codes is not, however, conceptually different from those that developed in England on the basis of legislative action, first in 1189 and most significantly in 1676 in response to the great London fire of 1666 (American Institute of Architects [AIA]). These ordinances were principally fire protection measures that ultimately rely upon what nineteenth-century utilitarian philosophers referred to as the *greatest happiness principle*—the notion that right actions are those that cause the greatest amount of happiness and the least amount of pain (Bentham 1962). The conditions of rapid industrialization and urban population growth in mid-nineteenth-century Britain certainly lent urgency to the development of explicit codes that suppressed some individual rights, such as the freedom to construct one's roof of highly flammable thatch, in the name of the public good. In the view of utilitarian philosophers, principally Jeremy Bentham (1748–1832), such suppression of individual rights was justified for the overall health of the *civic economy*, the ability of the society to provide for the general well being through preventative measures (Chadwick 1965). The greatest happiness principle was quickly expanded in Europe and North America to regulate not only fire, but those unsanitary conditions associated with rapid urbanization and industrialization that threatened general public health (Melosi 2000).

Industrial codes were developed by government and industry to standardize modern building materials and processes. As new building components such as glass and iron became increasingly available in the late-nineteenth century, it became progressively inconvenient and uneconomical for builders in different locations to employ materials of differing thicknesses, lengths, and strengths. In 1901 the National Bureau of Standards was created by an act of Congress to conduct research and aid small business by creating universal standards of production. In the early-twentieth century, manufacturing organizations, comprised and funded by competing producers such as the American Institute of Steel Construction (AISC, founded in 1921), recognized that it was in their common interests to self-regulate standard measures of size and quality before government did so. Without such standard codes of production, it would be very difficult, for example, to use steel produced in Pittsburgh in a building designed in Chicago to be constructed in San Francisco. Economic and political interests inspire these codes and standards. They are designed to optimize exchange value across political jurisdictions, and are linked to the general process of modernization in which the tacit knowledge of the artisan is supplanted by the formal knowledge of the engineer.

Authorization and Conflict

In the European Union and much of the world, building codes are national and international in scope. This situation has developed from the familiar historical process of modernization. In the United States, however, the legislation of building codes is a state or municipal responsibility resulting in the existence of no fewer than five major building codes and a multiplicity of municipal codes in large cities such as New York.

In 1994 the International Code Council (ICC) was established by the three dominant not-for-profit organizations responsible for the writing of model codes in an attempt to further standardize building codes throughout the Americas. Based near Washington, D. C., the ICC provides a wide range of services to its members through its sixteen regional offices in the United States. Although the ICC's International Building Code (IBC) has been approved for use by forty-four states, individual local jurisdictions are only slowly adopting and enforcing it. This effort may eventually lead to the adoption of a comprehensive building code for the hemisphere, but success will depend upon the speculative possibility of resolving the long-entrenched interests of local industries, labor unions, architects, and building engineers. Toward this end the ICC has established a quasi-democratic process for code development in which each of the dominant model code groups are equally represented.

Building codes exist within a now complex matrix of legislation from all levels of government. Strictly speaking, building codes regulate only the safety of a building structure, its materials, and the environmental systems that render architecture habitable. They are, however, closely related to other types of codes, such as federal, state, and municipal environmental laws (which regulate emissions and impacts on air, water, and land); zoning ordinances (which regulate such urban concerns as land use, drainage, density, and signage); historic preservation ordinances (which stipulate criteria and processes for mandating the preservation of private property); and design review ordinances (which stipulate criteria and processes for regulating the aesthetic compatibility of new structures in existing districts). These vary significantly from nation to nation, state to state, and city to city.

The social production of codes tends to reinforce the interests of codemakers. Historically the manufacturers of building products and systems such as Willis Carrier (1876–1950), the entrepreneur-developer of modern air conditioning, have competed for control of code making with the publicly employed professionals who now dominate the field. For this reason the authorship of building codes is the principal conflict associated with them. This lingering question fuels conflict between governmental regulators, property owners, and the construction industry. In the social democracies of the European Union or the centrally planned economies of Asia or South America, the property rights of individuals and the technological practices of industry are significantly restricted by a broad definition of the public good. In the United States, however, the public good tends to be narrowly defined through scientific criteria generally limited to human safety and health. Behind these differing approaches to the social construction of building codes is a fundamental question of political trust. In the Netherlands, for example, planners and government technocrats are generally respected and trusted to make decisions that reflect the interests of citizens. In the United States, however, citizens tend to trust the market and their own judgment over that of government. Judged on the criterion of the *sustainable development* of cities (Campbell 1996), Dutch codemakers tend to be more effective than those in the United States because citizens tend to understand building codes as a moral obligation to fellow citizens rather than as an imposed restriction on individual property rights.

Assessment

The development of tacit, legislative, and industrial building codes was never a simply a matter of economics, science, or ethics. Rather their formulation is a highly social and contentious process through which some interests are suppressed and others reinforced. In theory one may distinguish how a priori economic, scientific, or moral logic might define a building code. In practice, however, these logics are conflated by the social situation—usually a catastrophe—that mandates changed building practices.

Langdon Winner argued that "... we do not use technologies so much as live them" (Winner 1997, p. 202). His logic suggests that free democratic societies should promote citizen participation in articulating the technical codes that strongly influence the landscapes of daily life. According to Francis Ventre, "...it is the state of knowledge ... [moral, political, and practical] that drives regulation's juggernaut. But whose knowledge? The regulatory expansion after the 1920s seems to owe more to a public will rallied and given form by the cultural preferences and superior technical knowledge of articulate minorities who could link that preference and knowledge to wide social concerns" (Ventre 1990, p. 56) Employing similar logic, Andrew Feenberg proposes that the development of technical codes is the discursive process through which societies modify their fundamental values. It is important to recognize that such *civilizational change* is not what economists would call a trade-off in which an economic good is sacrificed for an environmental or public safety good. Rather such revision of technical codes redefines the cultural values within which economic activity takes place (Feenberg). From both an ethical and historical perspective Americans are no more likely to retreat from emerging environmental standards, for example, than from the Americans with Disability Act (1990), the New York City legislation requiring buildings to have fire exits (1860), or the abolition of slavery (1862).

The historical process of regulating how structures are built is indistinguishable from the social process of deciding how human beings will live together—there will be as many building codes as there are distinct societies. This is one reason why the internationalization of building codes, as proposed by the ICC, raises ethical and environmental questions related to technological colonization. The citizens of Mexico, for example, increasingly resist attempts by global institutions to standardize local building practices that sustain unique cultural practices and ecological conditions. The process of modernization does tend toward the standardization of building codes across countries and continents, but distinct tectonic cultures are not likely to disappear anytime soon. A more important question may be the degree to which citizens of any given society participate in the articulation of building codes, because it is through citizen involvement that government technocrats become accountable for how the community lives, citizens come to trust codemakers, and codes are lived as moral obligations.

STEVEN A. MOORE

SEE ALSO *Architectural Ethics; Building Destruction and Collapse; Engineering Ethics; Modernization; Science, Technology, and Law.*

BIBLIOGRAPHY

American Institute of Architects. (1990). *An Architect's Guide to Building Codes & Standards*. Washington, DC: Author. This source is both a historical and practical guide.

Bentham, Jeremy. (1962 [1838]). *The Works of Jeremy Bentham*, Vol. 1 *Introduction: An Introduction to the Principles of Morals and Legislation,* ed. John Bowring. New York: Russell & Russell. Bentham is generally considered the projenitor of the utilitarian ethics articulated in this text.

Campbell, Scott. (1996). "Green Cities, Growing Cities, Just Cities?: Urban Planning and the Contradictions of Sustainable Development." *Journal of the American Planning Association* 62(3): 296–311. Campbell's diagram of the "planner's triangle" is, perhaps, the most elegant description of sustainable development as envisioned by the authors of "Our Common Future" (1987), World Commission on Environment and Development.

Carrier, Willis Haviland. (1914). *Engineers Hand-book of Tables, Charts ....* Buffalo, NY: Buffalo Forge Co. Carrier's "Hand-book," published as a practical guide, is based upon assumptions that are considered highly ideological by twenty-first century standards.

Chadwick, Edwin. 1965 (1842). *Sanitary Conditions of the Labouring Population of Great Britain*. Edinburgh: Edinburgh University Press. This report to Parliament was Chadwick's major accomplishment. It is historically significant because the author employed empirical and statistical methods rather than the then dominant deductive method of scientific inquiry.

Duany, Andres, and Elizabeth Plater-Zyberk. (1991). *Towns and Town-making Principles,* ed. Alex Krieger with William Lennertz. Cambridge, MA: Harvard University Graduate School of Design; New York: Rizzoli. Although not the most well known treatise on "new urbanism," this volume makes a good case for the development of morphological, or formal, architectural codes.

Feenberg, Andrew. (2002). *Transforming Technology: A Critical Theory Revised*. New York: Oxford University Press. This is a revised and updated version of *Critical Theory of Technology* (1991), New York and Oxford: Oxford University Press.

Frampton, Kenneth. (1995). *Studies in Tectonic Culture*. Cambridge, MA: MIT Press. Frampton's work, including his critical regionalism hypothesis of 1983-1991, should be credited with renewing the academic study of technology within architecture and art history.

Ferguson, R. S. (1974). *The Development of a Knowledge-Based Building Code*. Technical Paper NRCC 014355. Ottawa: National Research Council Canada, Division of Building Research.

Hakim, Besim S. (1986). *Arabic-Islamic Cities: Building and Planning Principles*, 2nd edition. London and New York: KPI.

Harper, Robert Francis, ed. (1904) *The Code of Hammurabi: King of Babylon*, 2nd edition. Chicago: University of Chicago Press.

International Code Council. (2003). *International Building Code*. Falls Church, VA: Author.

International Conference of Building Officials. (1997) *Uniform Building Code*. Vol. 1. *Administration, Fire—and Life-safety and Field Inspection Provisions*. Whittier, CA: Author.

Melosi, Martin. (2000). *The Sanitary City: Urban Infrastructure in America from Colonial Times to the Present*. Baltimore, MD: Johns Hopkins University Press.

Norberg-Schulz, Christian. (1979). *Genius Loci: Towards a Phenomenology of Architecture*. New York: Rizzoli.

Ventre, Francis T. (1990). "Regulation: A Realization of Social Ethics." *VIA* 10: 51–62.

Winner, Langdon. (1977). *Autonomous Technology: Technics-out-of-Control as a Theme in Political Thought*. Cambridge, MA: MIT Press. This is an early and still significant study by the author that examines how technological choices are really social choices disguised in the name of efficiency.

INTERNET RESOURCE

Hakim, Besim S. (2003). "Style and Urbanism: New Urban Codes and Design Guidelines. *Council Report* III/IV (April 2003). Available at http://www.tndtownpaper.com/council/Hakim.htm.

BUILDING DESTRUCTION AND COLLAPSE

Engineers and architects design buildings to stand, and the vast majority of them do so without major incident. Yet occasionally a building does collapse, bringing with it questions about the science, technology, and ethics of structures. Though they happen for a variety of reasons, collapses can be clustered into three groups: those resulting from natural disasters (earthquakes, mudslides, tornadoes, and the like); inadvertent collapses (because of flaws in design, use, and/or maintenance); and intentional destruction (including both planned demolition and malevolent attacks). Each type raises different, if related, ethical questions.

Two types of explanation exist for collapses. The first is focused on the mechanics or physics of the destruction; it asks what forces were acting on (and being produced by) what parts of the structure and in what fashion. The lessons drawn from such analyses will be, necessarily, structural or mechanical in nature. Mathys Levy and Mario Salvadori (2002), for instance, declare that collapses are always due to structural failure, though this failure may come about in a variety of ways (and, though they do not explicitly say so, may or may not be accidental).

A second type of explanation focuses on what might be termed social—rather than physical—dynamics. Here, the forces are those of the designers and others involved in determining whether and how to erect (or destroy) a structure. Such forces are more difficult to analyze and impossible to quantify, but they are as much a part of building success and failure as are the physical laws that allow them to stand or fall. These two kinds of explanations often have different relative weights in examinations of natural, inadvertent, and intentional destructions.

Natural Disasters

Building destructions caused by natural disasters are the most deadly and devastating kind. The 1923 earthquake near Tokyo, Japan, measured 8.3 on the Richter scale and left 100,000 dead; the 1995 Kobe, Japan, earthquake, rated 7.2, was the costliest ever, causing an estimated US$150 billion in damage and destroying nearly 100,000 structures. Tornadoes (including the 148 that formed the Super Outbreak of 1974, killing 315) and hurricanes (such as Camille of 1969, which killed 200 and caused billions of dollars in damage) can cause massive devastation as well.

Although the basic cause of the building collapses in these disasters is structural failure (as is true in any collapse), such widespread collapses pose the immediate challenge of disaster response in the face of damaged (or even nonexistent) infrastructure. Is the community able to cope (on its own or with outside assistance) when communication, rescue, and medical systems have been damaged or destroyed?

Secondary challenges emerge as investigators study which structures failed and which survived, in an effort to learn lessons for future construction. These studies may confirm existing knowledge (e.g., the Kobe Report's confirmation that newer structures survived because of their more sophisticated designs), may point to a need for new knowledge or regulation (as in the 1923 Tokyo quake, which led to Japan's first building code), or may uncover flaws in applying existing knowledge, either because that knowledge is not sufficiently detailed or because it has been inexpertly applied (as turned out to be the case with earthquakes in Mexico City in 1985 and Turkey in 1999). The causes of devastation here are clearly beyond the scientific; cultural and economic factors play significant roles, as do settlement and development patterns. Resulting questions have to do with building standards and where (and how well) they are applied, and economics (decisions about how much safety is worth).

Once an immediate crisis has passed and investigations have been completed, then comes the most challenging phase: deciding what to do next. When the lessons are scientific, they can be codified and shared. When the lessons are cultural or economic, they are harder to learn or apply. Often the issue becomes one of conflict between governmental control and citizen freedom. How much control should local or national governments have over private construction, and how many federal dollars should go toward relief if, say, people build in known flood plains or tornado alleys, while failing to take precautions (or neglecting to purchase appropriate insurance)?

The Murrah Federal Building in Oklahoma City, Oklahoma, after the 1995 bombing. The incident prompted new levels of concern for building standards. *(© James H. Robinson/Photo Researchers.)*

Inadvertent Collapses

The effects of the power of nature may be more deadly, but the effects of the fallibility of human nature provoke a stronger urge to assign responsibility. In 1922 the Knickerbocker Theatre in Washington, DC, suffered a partial collapse, killing ninety-five people. A severe snowstorm that evening both precipitated the collapse and prevented a larger death toll, but was not the underlying cause of the collapse. Subsequent investigations uncovered shoddy design and materials, but charges against the designers and builders were dismissed, and the resulting call to institute district-wide licensing requirements for architects and engineers went unheeded until 1950 (after every other state in the union had adopted licensing laws for engineers). Twenty other states had already passed such laws at the time of the Knickerbocker collapse, seventeen of them in the four years prior to that disaster. New York—home of the American Society of Civil Engineers (ASCE)—was one of those states, passing its law in 1920, after a decade of heated debate and resistance by the ASCE.

When two walkways in the lobby of the Hyatt Regency Hotel in Kansas City, Missouri, collapsed in 1981 during a crowded dance contest, 114 people died. The Hyatt disaster challenged the resolve of a profession that, in its codes of ethics, had recently declared public safety to be the paramount goal. Licensing laws had been in place for over thirty years, but the Hyatt case posed the first test of such regulation in the face of a collapse. Disasters such as the Knickerbocker had encouraged the call for licensing, but once passed, such laws were used primarily to deal with unethical business practices. After five years of investigations and negotiations, two engineers who had supervised the design of the hotel lost their licenses, a decision decried by many of their colleagues as inappropriately harsh given the complex chain of events and professionals involved in the design and collapse of the structure. That criminal charges had been dismissed for lack of evidence strengthened such opposition.

If news of the Hyatt collapse challenged the engineering profession, the story of the Citicorp building in Manhattan renewed its faith and confidence. A 1995 *New Yorker* magazine article revealed that in 1978—a year after Citicorp Center opened—the structural engineer discovered a fatal flaw in the fifty-nine-story building. William LeMessurier blew the whistle on himself and in collaboration with the building owners, insurance agencies, and city officials devised a plan for retrofitting the building to ensure its safety. To avoid a public panic, the building tenants were not informed of the repairs being made to the structure. The case is frequently cited as an exemplar of ethical behavior on the part of those involved, most notably LeMessurier himself, yet the secrecy of the case raises questions about the public's right to know the risks they face and to decide what risks they are willing to assume.

When mercifully vacant buildings collapse, as in the cases of the Hartford Coliseum (1978, Connecticut) and Kemper Arena (1979, Kansas City, Missouri), the effects are dramatic, but far less wrenching for the public as well as for the building profession. In these two collapses, multiple factors combined in unexpected and unfortunate ways. Heavy rains and high winds exploited previously unnoticed weaknesses in the Kemper Arena roof design. In the Hartford collapse, early deformations in the structure were dismissed as insignificant for years, only to compound into the collapse of the roof just hours after an event that had drawn some 5,000 spectators. Hundreds of roof and structure collapses occurred during that winter of record snowfalls, but none so memorable as the one in Hartford. These cases (and the snow-induced Knickerbocker collapse) point to the interplay of natural and human causes in some major collapses, which complicates the matter of assigning responsibility.

As with natural disasters, accidental collapses lead to investigations. Designers strive to derive lessons about design in an attempt to extract some good from the rubble. The easier lessons to learn or reinforce about design and building practice are the scientific ones. Updating building codes and reminding designers of the need for structural redundancies are straightforward actions. The harder lessons are those related to responsibility. How far should the responsibility of a designer extend and to whom? Changes in liability and licensing in the United States over the past century have at once increased designers' authority and their obligations. That tradeoff is the underlying principle of modern professional ethics—professionals possess highly specialized knowledge, which can be used for good or ill, and the public invests professionals with the authority to make decisions and to self-regulate in exchange for a promise to serve the public granting that authority.

Intentional Destruction

In contrast to natural and human disasters are building destructions brought about intentionally, whether through intent to protect or to harm. As buildings age and congestion increases, some owners opt for planned demolition, often to clear the way for newer, safer, or larger structures. Controlled Demolition, Inc., operated by The Loizeaux family of Maryland has become famous for its skill at bringing a structure the size of Three Rivers Stadium (2001, Pittsburgh) down to the ground without harming people or the new stadium rising next door. Robert Moses was perhaps the most prolific developer of the twentieth century, yet he was, reflexively, the most prolific demolisher as well, and has as a result been both praised and vilified for his role in altering the New York cityscape. Whether controlled demolition is large or small, the collapse of each structure marks the end of potentially heated negotiations over preservation and land use.

Whether or not general agreement exists on such demolitions, they are at least planned publicly. Covert acts of intentional destruction exist as well—in the forms of arson, war, and terrorism. Ironically, the World Trade Center (WTC, 1993 and 2001, New York City) and the Murrah Federal Building (1995, Oklahoma City, Oklahoma) act as links between the public and the secret types of building destruction. The WTC began with the planned demolition of the commercial district known as Radio Row and was itself demolished by terrorists. The birth and the death of the WTC both produced victims—those in the former were fortunate to escape with their lives, if not their livelihood. The Murrah building, damaged beyond repair by U.S. terrorists, was eventually brought down by the Loizeaux family firm.

Intentional destruction, though it may be less deadly than other types, is most unsettling because it pits one group of people against another. Although the collapse of the WTC towers was probably an unplanned result of the terrorist airplane attacks, the military does study how to destroy buildings and is even designing "bunker-busting" bombs to attack special fortifications. Yet even in the civilian arena, it is common to debate who properly controls or decides acceptable tradeoffs. In both publicly and privately planned demolition, those making the decisions are rarely those who will be affected by them.

The Oklahoma City bombing ushered in a new era of concern for building standards, though it was not the first terrorist attack on U.S. soil (which dates at least to the deadly 1920 bombing of the Morgan Bank in New York City). If the Murrah bombing was a chink in the armor of U.S. confidence, that crack became a gaping hole with the destruction of the WTC. The investigations into the Oklahoma and New York cases were unusual in that they began by exploring nonmechanical causes, focusing appropriately on the role of the terrorists. But in the WTC case, behind the calls for vengeance and war were whispers asking whether the towers should have stood longer once they had been attacked. The comparatively minor damage suffered by the Pentagon during the same attack vividly demonstrated how important a role building design plays in building performance. How far does a designer's obligation to build a "safe" building extend? The two investigations converged around questions about how best to design future structures to preserve freedom and access while protecting building integrity and security.

Several stages of response are common across these three types of building destruction: the search for lessons, the discovery of complexity in the causes, the proposal to change current practice, and the reluctant acceptance that actual changes will be less sweeping than those proposed. Among the challenges faced by those responding to building collapses, two are continual. The first is that, hard as it may be to identify the causes of a particular collapse, it is inestimably harder to identify solutions that will prevent a whole category of future collapses. The second challenge is to achieve a balance between studying past failures and designing for future successes.

SARAH K. A. PFATTEICHER

SEE ALSO *Architectural Ethics; Building Codes; Design Ethics; Engineering Ethics; Fire; Hazards; Terrorism.*

BIBLIOGRAPHY

Caro, Robert A. (1975). *The Power Broker: Robert Moses and the Fall of New York.* New York: Vintage. Pulitzer-prize winning biography of developer Robert Moses detailing his far-reaching effects on the infrastructure of the city and state of New York.

Herring, Susan Davis. (1989). *From the Titanic to the Challenger: An Annotated Bibliography on Technological Failures of the Twentieth Century.* New York: Garland. Detailed, reliable guide to key primary and secondary sources on wide range of failures.

Levy, Matthys, and Mario Salvadori. (2002). *Why Buildings Fall Down: How Structures Fail,* rev. edition. New York: Norton. Accessible introduction to the physics of building destruction, written for a lay audience; sequel to *Why Buildings Stand Up*.

Liss, Helene. (2000). *Demolition: The Art of Demolishing, Dismantling, Imploding, Toppling, and Razing.* New York: Black Dog and Leventhal. The story of the Loizeaux family and their company, Controlled Demolition, with extensive photographs.

Morgenstern, Joe. (1995). "The Fifty-Nine-Story Crisis." *New Yorker* 71(14): 45–53. The article that broke the story of the averted crisis at Citicorp, after nearly twenty years of secrecy.

Petroski, Henry. (1994). *Design Paradigms: Case Histories of Error and Judgment in Engineering.* One of several books by Petroski using historical case studies to demonstrate the technical lessons engineers learn from failure. New York: Cambridge University Press.

Schlager, Neil, ed. (1994). *When Technology Fails: Significant Technological Disasters, Accidents, and Failures of the Twentieth Century.* Detroit: Gale Research. This encyclopedia of more than one hundred technological disasters includes sixteen building and structural collapses, each with a brief bibliography.

Wearne, Phillip. (1990). *Collapse: When Buildings Fall Down.* New York: TV Books. An introduction to the findings of forensic engineering investigations into 11 major structural collapses of the last half-century.

INTERNET RESOURCE

"Why the Towers Fell." NOVA Online. Available from http://www.pbs.org/wgbh/nova/wtc/. This Internet site supplements the PBS program of the same name, exploring the reasons for the collapse of the World Trade Center.

BUSH, VANNEVAR

Inventor and adviser to U.S. presidents during World War II, Vannevar Bush (1890–1974), was born in Everett, Massachusetts, on March 11, and became a major architect of postwar science policy. He earned doctorates from both Harvard University and the Massachusetts Institute of Technology (MIT), where after a few years in industry he became professor and then dean of engineering. At MIT he also contributed to development of the "differential analyzer," a precursor of the computer. In 1938 he was elected president of the Carnegie Institute of Washington, DC, and then served as director of the U.S. Office of Scientific Research and Development (OSRD), which provided oversight for federal science support from 1941 to 1947. Bush later

Vannevar Bush, 1890–1974. Bush was a leader of American science and engineering during and after World War II. He was instrumental in the development of the atomic bomb and the analogue computer, as well as an administrator of government scientific activities. *(The Library of Congress.)*

became involved in the private sector, serving as honorary chairman of the MIT Corporation from 1959 to 1971. He died in Belmont, Massachusetts, on June 30.

Policy Achievements

In 1940 Bush persuaded President Franklin D. Roosevelt to create the National Defense Research Committee, which was later subsumed under the OSRD. Arguing that success in World War II would depend largely on innovations in military technologies, Bush led the OSRD in coordinating the relationship between science, the military, and industry. Under his leadership, scientific research yielded vast improvements in military technologies such as the submarine and radar. Bush was also the top policy advisor to President Roosevelt for the Manhattan Project to create the atomic bomb. Although much OSRD work was top secret during the war, Bush obtained near celebrity status, with an article in *Colliers* magazine heralding him as the "man who may win or lose the war" (Ratcliff 1942).

In 1945 Bush wrote two works that pointed toward the future of science and technology. The first was a report titled *Science, the Endless Frontier*, addressed to President Harry S Truman. The impetus had come from President Roosevelt, whose letter of request saw in the wartime collaboration "new frontiers of the mind" to be pioneered for creating "a fuller and more fruitful America" (Bush 1945b, p. viii). In response, Bush argued that scientific progress is essential to the well-being of the nation, specifically addressing the potential of research to promote the public good by preventing and curing disease, supporting economic progress, and improving national security. Bush recommended creation of a "National Research Foundation," arguing that the government "should accept new responsibilities for promoting the creation of new scientific knowledge and the development of scientific talent in our youth" (p. 4). This idea was realized in 1950, after modification by the Steelman Commission, as the National Science Foundation (Steelman 1980 [1947]). But Bush also recognized that "progress in other fields such as the social sciences and the humanities is likewise important" (Bush 1945b, p. v).

Bush's second 1945 publication was a prescient essay, "As We May Think," that established him as a pioneer of the information age. He had been working on his differential analyzer (an analog computer) since the 1920s. This article reflected on the profound implications of such work. The specialization of the sciences had produced a glut of information that was difficult to organize, access, and share. In order to continue the expansion of the knowledge base, Bush outlined a system for storing, retrieving, and linking information. Toward this end, he imagined the *memex,* a mechanical device for storing information that could be consulted rapidly and flexibly.

A precursor to the personal computer, the memex desk was envisioned as using microfilm as an information storage device and having the ability to navigate and form associative linkages or "trails" within vast stores of information. This foreshadowed the notion of the "link" nearly fifty years before its popular usage, thus enabling Bush to be thought of as a conceptual creator of the Web and hypertext systems.

One other key contribution to the industrial development of science in the United States is that Bush instilled in one of his graduate students, Frederick Terman, a belief that regional economies would come to depend on strong relationships between business entrepreneurs and scientific researchers. Terman was later instrumental in forming Silicon Valley, one of the greatest concentrations of high-tech power in the world (Zachary 1997).

Policy Fallout

Bush is credited as an original defender of what has come to be called the "linear model" of science–society relations: give scientists money, and they will just naturally produce socially beneficial results; pure science leads to technology and innovation. Beginning in the decade of his death, however, such a theory was subject to increasing criticism. The economic decline of the late 1970s and 1980s, the end of the cold war in the early 1990s, and the ballooning federal budget deficits of the same period combined to stimulate a rethinking of post–World War II governmental policies toward the funding of science. Although the United States claimed the largest number of Nobel Prizes in science, its economy was in many sectors being bested by Japan, Germany, and other nations. The end of the cold war and the absence of an opposing superpower removed a major justification for continued U.S. investment in more and better high-tech weapons systems. Economic stagnation and budget deficits further called into question the effectiveness of federal investments in science.

Parallel to such political and economic questions, social studies of science challenged the idea of the purely nonpolitical character of science. For example, feminist criticisms of investments in cancer research (more money for prostate cancer than for breast cancer, despite more people dying of breast cancer) clearly illustrated how the interests of scientific researchers (mostly males) could influence the directions of science. Taken together these three types of questioning conspired to sponsor a broad reassessment of U.S. science policy—a reassessment whose most prominent feature has been increasing engagement with the social sciences.

Public science funding continues to be criticized for propagating the linear model that separates the production of scientific knowledge from society. Policy theorists are calling for a new "social contract for science" that would make science more directly accountable to benefits in health care, economic productivity, and national security.

Yet Bush himself was deeply aware of the societal context of science and technology. For example, in 1944 he proposed creation of an advisory committee on postwar U.S. nuclear legislation in order to deal with the threat that this new technology posed to international peace. In *Science, the Endless Frontier,* he argued for interdisciplinary science: "Science can be effective in the national welfare only as a member of a team" (1945b, p. 1). He furthermore stated that "It would be folly to set up a program under which research in the natural sciences and medicine was expanded at the cost of the social sciences, humanities, and other studies so essential to national well-being" (p. 18). In *Modern Arms and Free Men* (1949), Bush tackled important questions about the role of science in a democracy. The culmination of his understanding of science as an agent of social betterment comes in the form of his aptly titled collection of essays, *Science Is Not Enough* (1967). Insofar as American science policy has become isolated from its social context, it has done so against Bush's own vision for the proper relationship between science and the state.

ADAM BRIGGLE
CARL MITCHAM

SEE ALSO *Science Policy*.

BIBLIOGRAPHY

Bush, Vannevar. (1945a). "As We May Think." *Atlantic Monthly* 176(1): 101–108. Argues that postwar science should focus on making the inherited store of knowledge more accessible and imagines the memex as a device for achieving this goal.

Bush, Vannevar. (1945b). *Science, the Endless Frontier*. Washington, DC: U.S. Government Printing Office. A foundational document in U.S. science policy that claims science is crucial for national well-being specifically in the areas of medical research, economic progress, and national security.

Bush, Vannevar. (1949). *Modern Arms and Free Men: A Discussion of the Role of Science in Preserving Democracy*. New York: Simon and Schuster. Presents an optimistic account of the future of freedom and individuality despite the significant threats posed to democratic values by emerging weapons technologies.

Bush, Vannevar. (1967). *Science Is Not Enough*. New York: Morrow. A collection of essays that discusses the limits of science both in the quest for understanding and in the fulfillment of human values.

Ratcliff, J. D. (1942). "War Brains." *Colliers* 109(3): 28, 40. Describes Bush's role in administering the military scientific research during World War II.

Steelman, John R. 1980 (1947). *Science and Public Policy*. 5 vols. New York: Arno Press. Presents a detailed analysis of the us research system in order to permit the government to manage its growing research and development operations and to coordinate the activities of government, industry, and academia. It was instrumental in shaping U.S. science policy by supporting some aspects of *Science—the Endless Frontier* and challenging others.

Zachary, G. Pascal. (1997). *Endless Frontier: Vannevar Bush, Engineer of the American Century*. New York: Free Press. A biography that details Bush's life and evaluates his legacy.

INTERNET RESOURCES

Bush, Vannevar. (1945a). "As We May Think." *Atlantic Monthly* 176, no. 1. Available from http://www.theatlantic.com/unbound/flashbks/computer/bushf.htm.

Bush, Vannevar. (1945b). *Science, the Endless Frontier*. Available from http://www.nsf.gov/od/lpa/nsf50/vbush1945.htm.

BUSINESS ETHICS

Business ethics names both a *phenomenon* (the ethics espoused and practiced in business) and the *field of study* of that phenomenon (the serious study of business ethics). As a branch of *ethics* (or moral philosophy), the field of business ethics is interested in how judgments of right and wrong, good and bad, moral obligation and responsibility, rights and duties, and the like, are made and justified. As a branch of *applied ethics* it explores how these judgments are carried out in the specific domain of work, commerce, and economic activity.

As a *descriptive* enterprise, business ethics is an analytical exercise in understanding and explaining how people and organizations make their ethical judgments and decisions. As a *prescriptive* enterprise, business ethics seeks to arrive at defensible, normative, moral judgments of business matters in ways that are helpful to the actual practice of business. Business ethics overlaps significantly with what is often called *corporate social responsibility*—a movement calling on corporations to be responsible not just to shareholders but to the society (and the ecosystem) in which it operates. The field of business ethics is interested in more than just social and environmental responsibilities but those are certainly critical component areas.

Science and technology share a long, close, and mutually-influential relationship with business. Business needs and opportunities drive much scientific research and technological development, on the one hand, while discoveries and technological innovations transform business, on the other (Burrus 1993, Martin 1996, Tapscott and Caston 1993). Technology is widely accepted as the primary, dominating force that has transformed business around the world with rising intensity since the 1950s. Business ethics, as a reflective and sometimes reactive discipline, has typically lagged behind business changes and began to address this technological transformation only in the late-twentieth century (Gill 1999).

Historical Development of the Field

The basic questions of business ethics (for instance, fairness in wages and prices, responsibility for defective or dangerous products, fulfillment of contractual agreements, and morality of interest rates) have been of interest throughout human history and throughout the world. For example, the Jewish and Christian scriptures and the ancient Greek philosophers pay considerable attention to issues of wealth and poverty, honesty in transactions, liability for injury, justice in compensation, and other matters generally considered to be in the business ethics domain. So too, Buddhist tradition provides guidance about *right livelihood*. Medieval Catholicism considered the morality of usury and interest on loans. Karl Marx put capitalist economics on trial and called for justice and freedom for workers. Sociologist Max Weber famously studied the *Protestant ethic and the spirit of capitalism*. Thus while the constraints of nature and of social tradition have determined the work and economic experiences of most people throughout history, there have been recurring discussions of whether various aspects of this experience are right or wrong.

The rise of modern industry and the factory system, along with the great migrations of peoples across oceans and continents, especially during the nineteenth and early-twentieth centuries, brought major changes and disruptions to the ways people worked and the ways business was carried out. Business moved from a rural, agricultural, and familial base to an urban, industrial, and organizational one. The impact of these changes on individual workers, on families and communities, and on the environment, and the rise of a new class of wealthy business leaders—and of new forms of poverty—provoked intensified ethical debate not just among academic professionals but writers, politicians, preachers, poets, and populists.

Nevertheless as a discrete, self-conscious, academic field, business ethics emerged only during the 1960s and 1970s and grew steadily through the 1980s and 1990s and on into the twenty-first century. The rapid emergence of this field during the last quarter of the twentieth century was truly remarkable. Business schools created courses in business ethics; students began pursuing Ph.D degrees in the field; and centers for business ethics sprang up at many campuses. Associations, such as the Society for Business Ethics, Business for Social Responsibility, and the Ethics Officers Association, were formed to bring together scholars and practitioners in the new field. Journals were launched, such as *Business and Professional Ethics Journal* in 1981, the *Journal of Business Ethics* in 1982, and *Business Ethics Quarterly* in 1991. The quantity and quality of textbooks, monographs, and other literature on business ethics was first impressive, then daunting to those wishing to keep up with it. In the corporate arena itself, companies increasingly created ethics codes, statements, and training programs. By the turn of the twenty-first century, business ethics had won a respected and significant place in virtually all business education programs and in the consciousness of business managers (Freeman 1991, Werhane 2000).

The impetus for the development of business ethics as a field of study and of professional practice has come from several factors: First the rapid development of technology and its multifaceted deployment in business has modified and intensified the traditional list of business ethics challenges. Technology amplified old problems, created new ones, and complicated and speeded everything up.

Second social and cultural developments, in the 1960s and since, gave rise to a widespread questioning of traditional ethical authorities. Demands for recognition and equal treatment by students, women, and ethnic minorities, a new sense of urgency to care for the environment, and a growing ethnic, religious, and cultural diversity in the workplace all helped to put in question traditional ways of running businesses and of thinking about ethical right and wrong. Thus just as the technology-enhanced business ethics challenge was increasing, the assumption of a widely-shared consensus on values and ethics was becoming untenable.

Third across the intellectual and academic horizon, academic specialization grew, fueled partly by the scope and complexity of various old and emerging fields of research and partly by an explosion in the quantity of data available for consideration. The development of a specific field of business ethics (just like that of medical/bioethics) became logical, possible, and necessary. The growth of the business ethics challenge combined with the loss of a common set of values and ethics to create a fertile field of inquiry and service for a new academic specialization.

Fourth a growing number of high profile business ethics crises and scandals provoked calls for both better government regulation and oversight of business, on the one hand, and for better business ethics education and practice, on the other. Among the high profile ethics cases were trading, accounting, and financial scandals; the manufacture and sale of dangerous products (automobiles, tires, drugs); the use of child labor and sweat shops; ecological disasters (the Exxon Valdez, Bhopal); industrial pollution and depletion of natural resources; and vastly growing inequalities in wages and compensation for executives and workers. The 1991 U.S. Federal Sentencing Guidelines for white-collar criminals specified that law-breaking companies could reduce their penalties by up to 40 percent if they instituted compliance and ethics training programs.

Business Ethics: The Central Issues

The organizing question in business ethics is how to do the right thing (not just the profitable or possible or popular or even legal thing). Various philosophies, religions, and individuals answer the *what is right and how does one know it?* question in different ways, but there is widespread (if not universal) agreement that at its core, something becomes *wrong* when it *harms* (or seriously risks harm to) people. The Hippocratic Oath argued that the first duty of medical ethics was to *do no harm*. The same is true with respect to business ethics: An ethical business is one that seeks to avoid harm. What is ethically right and good is what can help people toward a free, healthy, and fulfilled human life. Obviously harm and help are elastic and debatable concepts but thinking about ethical right and wrong in these simple, historic, classic terms helps focus the ethical enterprise around a common language and concern in an important way.

In raising its questions of right and wrong, the scope of business ethics is as broad as business itself. Business ethics, perhaps because it is such a young field, has no single dominating method or paradigm. To arrive at a relatively inclusive understanding of the field, business ethics can be approached from five different perspectives. The first is a review of the range of typical *ethical dilemmas and problem cases* that arise across the business spectrum. The second briefly examines the *ethical values and methods of analysis* typically used to address the range of business ethics dilemmas. The third perspective is an analysis of the major *stakeholders* in business ethics so as to understand *who* is involved and what their ethical interests might be. A fourth perspective examines the basic components in a comprehensive organizational ethics. And finally, while the interaction of science, technology, and business ethics will be discussed as appropriate throughout this entry, a summary of business ethics will be drawn from the science/technology viewpoint.

Ethical Dilemmas and Critical Cases

One way to approach business ethics is by an analysis of specific problem cases or dilemmas (quandaries). An ethical dilemma arises when there is a question of determining the right thing to do. It often occurs because of a conflict of moral values or principles either within an individual or between two or more agents. Focus on the case method is called *casuistry* (Jonsen and Toulmin 1988; Brown 2003; Goodpaster and Nash 1998; Jennings 1999; Ferrell, Fraedrich, and Ferrell 2000). Casuistry analyzes ethical dilemmas and quandaries to aid in wise decision making and right action.

CLASSIFYING ETHICAL ISSUES. Ethical dilemmas and problem cases can be classified in several different ways. A threefold distinction can be made among (a) personal, *micro-ethical* issues; (b) organizational, *organizational* issues; and (c) systemic, *macro-ethical* issues. Another categorization can follow the functional areas of business, such as management, finance, accounting, human resources, marketing and advertising, supply chain management, sales, manufacturing, and more. Still another approach could focus on cross-cutting, thematic areas such as technology, communications, meeting, relationships, and the like.

Conflict of interest cases are often at the root of ethical dilemmas in these categories. For example, one's personal interest (for instance, a bonus for meeting a sales target or a personal gift) may conflict with one's professional responsibility (such as serving client needs and employer standards). A business interest in a foreign country may conflict with the social or environmental interest there. Bribes, kickbacks, insider trading, inappropriate use of company information, resources, or contacts to advance personal/noncompany interests, or hiring a talented friend are all examples of possible conflict of interest.

Dilemmas about truthfulness and accuracy in communication are also to be found throughout the business arena. Internal communications up and down the line, press releases and public relations, advertising and product labeling, financial reporting, and handling proprietary information and intellectual property, among other business activities raise difficult questions of ethical communication. How much information is owed and to whom? While it is clearly not right to publish immediately and fully all information one has to all people who ask for it, falsehood, deception, and evasion undermine trust and are often harmful.

Justice and fairness in policies and relationships are also a recurring ethical challenge throughout organizations. Relationships among employees at various levels and in different areas of the company may be disrespectful, inequitable, unfair, and harmful. Hiring practices, compensation, promotion, and workload differences might be unfair. Suppliers and business partners may not be treated fairly and honestly. The community may be unjustly burdened with the costs of an environmental cleanup due to a company's decision not to manage its wastes responsibly.

Technology has had a major impact on the ethical dilemmas faced in business. As the technological tools become more powerful, ever more vigilance is required to make sure they are used for good and not evil. Technologies also produce unanticipated consequences, *bite back* effects, that ethics must review (Tenner 1996). Old practices present new challenges when technology is introduced. Marketing and advertising ethics must now evaluate e-marketing practices. Customer data issues have become important as computerization makes possible tracking, profiling, and commoditization of what customers may assume is their private information.

Relationship issues are given a radical new spin when distant, extended enterprises, enabled by technology, become the order of the day. E-mail as the primary form of communication, the expectation of anytime/anywhere connectedness, and the management of employees in multiple, extremely diverse political-social settings around the world are technology-driven challenges that beg for ethical perspective.

RECOGNIZING, ANALYZING, AND RESOLVING ETHICAL DILEMMAS IN BUSINESS. A focus on ethical problem cases requires, first of all, determining whether a truly serious ethical dilemma that requires attention exists. Two compliance-oriented questions will often (though not always) identify a serious dilemma: (a) Is there a serious question of illegality? and (b) Is there a possible violation of the ethics and standards spelled out by the business's organizational code or by a related professional association? If the answer to either of these is positive, the issue is probably of serious ethical concern.

Some ethically important situations may slip under the radar of the two compliance test questions so four others must also be considered: (c) Is someone liable to be harmed by this? (d) Would individuals want this done to them or their loved ones? (e) Does this really bother human conscience and values? and (f) Would this continue if it were publicized in the evening news or on the front page of a newspaper?

If the answers to some or all of these questions are positive, the next stage is to analyze the case carefully. The facts of the situation must be clarified. Who is involved? What has happened? What are the ethical values and principles at stake? (The ultimate decision will need to be justified by appealing to such values). What are the options for response and the likely consequences of each response, short- and long-term? What help can others provide (colleagues, experts, veterans of similar cases) in analyzing and understanding this dilemma?

The third stage (after recognize and analyze) is to *resolve* the dilemma by choosing the best possible option available, acting on it with courage, and then following through, fully and responsibly. Not only the immediate decision and action but longer-term reforms might be appropriate to minimize recurrence of such dilemmas.

Casuistry is certainly an important part of business ethics. If ethics remains only a set of ideals or an abstract theory, unapplied (or inapplicable) to particular cases, it has failed. One of the virtues of casuistry is that it can quickly focus the participants' attention on something concrete, specific, and shared: the problem. Trying to begin with an agreement on abstract, general principles and values is often much more elusive. On the other hand a focus on cases alone can reduce business ethics to a reactive *damage control.* Decision making and action in response to extreme cases must not be allowed to become the whole enterprise. Even if one starts with concrete cases, part of the follow-through after responding to the case at hand is to move *upstream* in the organization and its practices to locate the sources and contributing factors to those downstream dilemmas.

Ethical Values, Principles, and Methods of Analysis

A second way into business ethics is to equip oneself with theories and insights from moral philosophy and carry these tools into the business domain (Beauchamp and Bowie 2001, DeGeorge 1999). Business ethics courses and textbooks, which frequently are designed and taught by people trained in philosophy, typically present two or more options in moral philosophy as potential tools for determining the right thing to do in business.

The two most common theories are the consequentialist utilitarianism of Jeremy Bentham and John Stuart Mill, and the non-consequentialist deontologism of Immanuel Kant. In addition to these two prominent options in Enlightenment modernity, business ethicists sometimes add brief discussions of ethical relativism, egoism, a feminist *ethics of care,* and some account of virtue (character) ethics. It is also common to include discussion of theories of justice (economic or distributive justice), often including the work of John Rawls and Robert Nozick.

After sketching such options in basic moral philosophy, business ethics textbooks of this type then counsel readers to choose one of these ethical theories to help moral philosophy to help decide ethical questions." Of course, virtually every moral philosophy (and moral theology) has some valuable insight to contribute to business ethics. Just as it can be useful to ask questions to identify an ethical dilemma, it can be helpful rather than confusing to examine one's ethical options from the perspective of several of these theories. With the utilitarians one could ask which possible response to the ethical problem would produce the best consequences for as many people as possible. With the Kantians one would ask how individuals would respond if they thought all people in comparable circumstances would copy the response. One could ask the *egoist* question—What is truly in the individual's best interest?—and, so too, questions about genuine caring, about the guidance of conscience and feeling, and about what surrounding culture thinks is right. Every insight and every theory is not equally insightful in every case, of course, so wisdom and discernment are always called for.

By focusing on moral philosophy in this way business ethics is actually showing its historic debt to Enlightenment thought. Kant and Mill and their contemporary philosophers were products of the modern scientific revolution of Isaac Newton and his colleagues, in which the physical universe was redescribed in terms of rational, universal, objective *laws*. In the footsteps of the scientists, the philosophers wished to discover moral laws of a universal, rational, objective character, independent of any notion of purpose or particularity of community. While this way of thinking about rational, universal, disinterested, objective laws contributes some helpful insights to the moral life, it has proven to be insufficient by itself (MacIntyre 1984, 1990). The young business ethics guild has slowly been waking up to the failure of Modern ethics. Viewed negatively, the Postmodern rejection of Enlightenment styles of moral philosophy points away from certainty and toward relativism or even nihilism.

Viewed more positively, the path has been opened up to explore new ways of thinking about business ethics that draw together the ethical insights of many voices and that more closely fit the actual ethical experiences of people in business. The success of some efforts to bring people together to formulate and implement business ethics principles, such as the Caux Round Table Principles, has been promising.

Business Ethics Stakeholders: Who Matters?

Business ethics can be approached by a problem focus, a theory focus, or, thirdly, a *people* focus, often called *stakeholder analysis*. To the traditional term shareholder (stockholder or investor/owner) has been added the term stakeholder (Freeman 1984; Weiss 1998; Post, Lawrence, and Weber 1999). A stakeholder is anyone affected by, or having a significant interest in, a business. They may not own financial shares of stock but they still have a significant stake, an interest, in what the business does. The assumption is that people have a moral right to some say in decisions that significantly affect their lives. In stakeholder relationships, the ethical questions concern the rights and responsibilities appropriate to each party to the relationship. Stakeholder analysis emerged from a realization that some parties were bearing costs (or reaping benefits) from business operations without being recognized. The following is a brief discussion of six major stakeholder groups.

OWNERS. One well-known view has it that the only responsibility of business is to maximize profits for its owners, provided this is done without fraud or other illegality (Friedman 1970). Certainly the owners (investors, shareholders, and financiers) of a business have a right to have their investment managed in their financial interest. It is not true, though, that profits are the only concern, even for the owners. Owner/investors also have a legitimate claim to adequate, accurate information about the business and its financial affairs.

What are the ethical rights and responsibilities of business owners in various circumstances? How does this differ under different ownership structures? What responsibility and accountability do business owners have toward other stakeholders? Are there ways of evaluating the legitimacy, fairness, and appropriateness of the owners' return on investment relative to what employees, customers, executives, and other employees receive? A stakeholder analysis approaches the business ethics arena with this sort of wider and deeper interest.

Technology has affected the ownership of business by facilitating complex, vast, high-speed new ownership patterns in the marketplace. Mutual funds own large percentages of many businesses. Under these fluid and impersonal circumstances, who are the owners to be held responsible for a business's behavior? How do small investors assume any of that responsibility even if they would like to? Perhaps the answer will become clear as information and communication technology renders the operations of both corporate management and fund management more fully transparent and as Internet-based movements organize small investors into effective lobbyists for reform (Tapscott and Ticoll 2003).

EMPLOYEES. If anyone has a clear stake in a company, it is the employees whose livelihood and vocation lies there. Business ethics pays attention to employees (including management) in several ways. First most of the ethical cases and crises that come along involve employee participation. The ethical analysis of employee choices, communications, and behavior occupies a good deal of the attention of business ethics. How managers and owners treat employees is another ethical concern. Job security, compensation, safety, harassment, prejudice, and even the quality of employee work experience, are ethically important. How should the personal ethical convictions of an employee be expressed (or not) in the workplace? How are employees trained in the company's ethics? How are ethical responsibilities related to various business roles?

Technology has modified the spectrum of ethical problems faced by employees. Perhaps the most striking impact of technology is when it eliminates employee jobs, either by replacing workers with robots and machines or by enabling jobs to be moved to locations where employees cannot follow. Is there a moral responsibility to help displaced employees to find other work?

Technology can be used or abused in monitoring employee communication and activity. Privacy must not be violated. Confidentiality must be protected. New stress-related injuries have emerged among computer users. Computers and the Internet have enabled some employee abuses such as game playing, pornography downloading, excessive personal use, and distribution of vulgar, hateful, or time-wasting messages to other employees. The same technology, however, allows for telecommuting from a home workstation, assisting a parent tending to a sick child. New issues of health and ethical management also arise concerning possible employer expectations of employees to be connected to their work anytime, anywhere.

CUSTOMERS. The most cynical non-ethical stance toward customers in the past was characterized by the Latin phrase caveat emptor—*let the buyer beware*. Viewed by stakeholder analysis, however, business ethics explores customer-related issues in marketing, advertising, product pricing, safety, quality, service, and support. What are the rights and responsibilities of customers vis-à-vis a company? Technology has made a huge impact on the development of products and services available to customers in the early twenty-first century. It also has modified marketing and advertising, as well as sales and service, by utilizing electronic media for all of these activities. Customer service and support and the privacy of customer data are among the ethical issues raised in new ways by technology. The Internet has also enabled some customers to help support each other in various user groups.

BUSINESS SUPPLIERS AND PARTNERS. Business-to-business relationships have become even more important and challenging in an era of outsourcing, complex supply chains, and virtual corporations. Government regulations and legal contracts simply cannot guarantee integrity in these relationships. The essential ingredient is trust, which depends on voluntary adherence to shared values and ethics (Fukuyama, 1995). What are the ethical responsibilities of business partners to each other? As technology enables businesses to create working relationships in distant and culturally-diverse settings where laws and local ethical values may permit child or slave labor, discrimination based on gender or religion, bribery, and environmental pollution—or where Euro-American business practices may be viewed as hopelessly corrupt, vulgar, and unjust, the challenge to business ethics is to figure out the ethically right thing to do in relation to the business partner stakeholders.

GOVERNMENT. As the presumptive guardians of the law, justice, order, and the well-being of nations, governments are also important stakeholders in business. This is true of all business-to-government interaction but in the economy of the twenty-first century, business's capacity to have both positive and negative impacts on states and their populations is extraordinary. Several multinational corporations have larger annual budgets than most nations in the world. The kind and extent of governmental regulation and oversight of business results in part from ethical values and choices. The influence of business on government (lobbying, campaign contributions) also is, and needs to be, subject to moral debate. In an era of globalization of business, earlier understandings of the proper relationship of governments to businesses must be rethought.

COMMUNITY. Communities often benefit both directly and indirectly from business. A strong business climate can bring jobs, income, and skills to communities. Even those who are not investors, employees, or customers of a business can benefit from its presence. But costs of the business are often *externalized* into the host community. Traffic congestion and environmental cleanup are two examples of costs to communities. A community may grow up around a business, creating schools, roads, and other cultural and social infrastructure that make it possible for that business to recruit good workers and thrive economically. If the business then relocates to China, based on investor demands for higher profit margins, an ethical issue arises. Communities have a stake in business.

Clearly there are other potential stakeholders in a business, such as professional associations, non-profit organizations, and schools. The strategy is to identify the relevant stakeholders and put the ethical focus on their respective rights and responsibilities.

The Basic Components of an Organizational Ethics

A fourth approach to business ethics is to work from a practical analysis of the way values actually work in organizations and communities (Solomon 1992; Batstone 2003; Trevino and Nelson 1999). This approach draws from historical and social scientific studies of business and other organizations, as well as from classical philosophical and theological approaches to ethics and values. The goal is to understand business ethics in a way that is simultaneously holistic, integrative, deep, and practical. In this approach six components in a holistic organizational ethics can be identified.

MOTIVATION. WHY BE ETHICAL IN BUSINESS? It is not at all self-evident why businesses should be run in ethically. The argument for doing so must be made in a way that will motivate business leaders and employees to make ethics a priority. A complete argument for operating a business in an ethical manner includes the following: (a) avoidance of litigation and the penal system (ethical companies generally steer clear of breaking the law; legal compliance is a sort of minimum standard of ethics); (b) regulatory freedom (increased laws and regulations result from patterns of unethical behavior); and (c) public acceptance (unethical businesses are often punished by journalistic exposes, citizen watchdog groups, and bad reputations).

In addition to the preceding three *external* reasons, having to do with the political and cultural environment in which business operates, there are four *internal* reasons to be ethical, connected to the four basic parts of any business in the early 2000s: (d) investor confidence (financial resources will be withheld from untrustworthy businesses); (e) partner/supplier trust (more than ever in the era of extended enterprise, business partnerships depend on trust, ethics, and integrity); (f) customer loyalty (customers avoid businesses that treat them in an unethical manner and also avoid brands that are associated with the unethical treatment of workers); (g) employee recruitment and performance (good employees are attracted by ethical employers; especially in the *knowledge economy*, employee sharing and teamwork flourish best in an atmosphere of trust and ethics).

Finally there are three *deep* reasons for running an ethical business: (h) personal and team pride and satisfaction (business success that comes by virtue of ethical behavior is rewarding to the individual; being ethical aligns with human nature and conscience in important ways); (i) intrinsic rightness (individuals and organizations should be ethical simply to be in alignment with a moral universe—God, reason, and human tradition argue for doing the right thing even when there is no immediate or direct payoff); and (j) missional excellence (being ethical is fundamentally about the essential values woven into the fabric of an excellent organization; ethics is less an external measuring stick than an internal set of traits).

CORPORATE MISSION AND PURPOSE. Assuming a business organization is adequately motivated to operate in an ethical manner, the next priority is to clarify the core mission and purpose of the organization. This is an Aristotelian, biblical, and traditional starting point for ethics. "The values that govern the conduct of business must be conditioned by *the why* of the business institution. They must flow from the purpose of business, carry out that purpose, and be constrained by it" (Sherwin 1983, p. 186). The first focal point in the positive construction of a sound business ethics is to clarify the *telos* of the business. An inspiring, unifying business mission that taps into basic human drives (e.g., to be creative or to be helpful to others) can leverage and guide sound ethics in an organization. For Aristotle, things, people, and organizations are embedded with *final causes*, purposes, and destinies to fulfill, and ethics is about how to achieve these. For biblical ethics, the determination of *who is God* (the First Command) is decisive for the ethical standards related to that choice (Commands Two through Ten). For great and enduring businesses, preserving the core mission and values is of primary importance (Collins and Porras 1994).

CORPORATE CULTURE AND VALUES. Given a clear and compelling mission, the next focal concern of a sound business ethics is the formal and informal corporate culture. Does the culture empower or impede the achievement of this mission? Corporate culture is not a neutral or arbitrary construction as far as ethics is concerned. No matter how excellent the mission and no matter how impressive the ethics code of a company, a defective or misaligned culture will present an insurmountable obstacle to sound ethics and business excellence. The formal systems of review, promotion, recognition, and discipline—and the informal culture of communication styles, office set-up, and so on—are what enable or disable the mission. The positive traits that assist the mission are the virtues, the values that must be embedded in what the organization *is*, not just what it *does*.

BUSINESS PRACTICES AND GUIDING PRINCIPLES. But businesses not only *are*, they *do*. After the culture, business ethics focuses on the *practices* of the company, the basic things the company needs to do, how its people spend their time and energy. The business must identify its basic practices (specific areas such as marketing, accounting, and manufacturing as well as cross-cutting activities like communicating and meeting). For each area of business practice, the company must decide which ethical principles should guide. Ethical principles and rules establish negative boundary conditions that must not be transgressed and positive mandates and ideals to pursue. Leaving important areas of practice with inadequate guidelines undermines the capacity of the business to achieve ethical excellence, the importance of the company ethics code.

ETHICS TROUBLESHOOTING AND CRISIS MANAGEMENT. Even in the best of circumstances, ethical dilemmas and crisis cases will emerge from time to time. It is therefore essential to create a method and framework for managing crises effectively. Making damage control and ethical crisis management the focal point of business ethics can unwittingly serve as an invitation to an unremitting succession of such crises. But as a component subordinated to a broader, more holistic business ethics, the crisis management, dilemma resolution part of the ensemble is essential. Corporations are increasingly creating ombudsmen, ethics and compliance offices, ethics hotlines, confidential means of raising questions or reporting questionable activities, whistle-blowing protocols, and the like. It is essential that businesses make clear what their employees and other stakeholders should do when apparent ethics questions and problems arise.

ETHICAL LEADERSHIP. Finally business ethics requires that attention be focused on leadership and management. Exemplary ethics does not exist without leadership. Ethics and values leadership must come from the executive and board levels of a company in the form of communication as well as action. Leaders must be heralds of the values and ethics that matter. They must exemplify the highest ethics in their own behavior and they must create systems, structures, and policies that support and reward ethical excellence and sanction unethical actions. Business leaders must create and maintain ethics training and evaluation programs throughout the organization. Without good leadership, good business ethics cannot be created and sustained.

The Impact of Science and Technology on Business and its Ethics

While business has often been conducted in a non-scientific and non-technological, traditional manner, ambition, competition, and the pressing need to solve business challenges of all kinds have encouraged businesses to learn from, and even sponsor, scientific and technological work. Since the eighteenth century, particularly, business, science, and technology have worked closely together. Manufacturing, construction, and transportation technologies decisively reshaped modern business beginning with the Industrial Revolution. Communication and information technologies have been the center of the most influential developments since the mid-twentieth century. Biotechnologies may be the most significant arena for business/science/technology interaction in the twenty-first century.

Science and technology have affected business and its ethics in several important ways. First they introduced radical change in the products of business. Technological products dominate virtually every area of people's lives, virtually every hour of the day. A host of specific ethical questions may be raised about these technological products, regarding their safety, reliability, cost and value, appropriateness, and side effects. Is their manufacture, usage, and disposal conducted in an environmentally responsible way? Are the trade-offs, the winners and losers, and the side effects, ethically appropriate and justifiable?

Science and technology have also transformed the workplace in important ways. The mechanization and automation of the workplace has continued unabated since the beginning of the nineteenth century. Information technology has enabled businesses to extend their operations all over the world and around the clock. How should people evaluate the outsourcing and exporting of jobs and the disruption of local economies by technologically-enabled global business? How do traditional safeguards against unethical acts by the powerful, such as national borders, local customs, and face-to-face, human-scale accountability relationships, get replaced in the early 2000s? What are the ethics of allowing, or even encouraging, workers to stay connected and available to their work twenty-four hours per day, seven days per week?

Technology acts as an amplifier of both problems and possibilities (for instance, the greater accessibility of medical records has both positive and negative sides). It also creates greater speed, reducing the time that individuals can devote to careful ethical reflection, which is required by the growing scale of the problems. Technology is much better at increasing the quantity of information and communication than the quality of knowledge and the wisdom of relationships. Technology creates many new opportunities for diversity, but also fosters standardization and repetition. Technology produces significant democratization of knowledge even as a new *digital divide* is emerging around the world.

In 1911 Frederick W. Taylor's *Principles of Scientific Management* promoted a new way of thinking about business management that privileged expert, technical judgments over those of ordinary workers and citizens. Taylor argued that efficiency was the primary goal of human thought and labor and that what could not be measured did not count. Henry Ford's automobile assembly line famously applied this kind of thinking. Workers became virtual appendages of machines. While there were certain gains in production from this approach, by the 1970s it became clear that even greater productivity was possible through the humane and respectful treatment of workers.

What is sometimes overlooked in discussions of business and technology is the way that technology itself is embedded with certain basic values, such as efficiency, quantifiability, power, speed, repetition, predictability, rationality, and so forth. As long as technology is viewed as a set of tools and methods to help a business achieve its mission, those technological values can be located in a richer cultural context that also preserves values such as openness, innovation, risk, human caring, beauty, and quality. If technology is put in the driver's seat rather than the toolbox of business, it will eventually come into conflict with human values, at a considerable (if not total) cost to workers, businesses, and the larger economy. In short business ethics in the coming years will need to pay serious attention not just to the complexities of particular technological innovations but to their collective impact on the mission and culture of businesses and their surrounding communities (French 1995).

DAVID W. GILL

SEE ALSO *Economics and Ethics; Entrepreneurism; Work.*

BIBLIOGRAPHY

Batstone, David. (2003). *Saving the Corporate Soul.* San Francisco: Jossey-Bass. Excellent review of ethical values and perspectives related to key aspects of contemporary business.

Beauchamp, Tom L., and Norman E. Bowie. (2001). *Ethical Theory and Business,* 6th edition. Upper Saddle River, NJ: Prentice-Hall.

Bowie, Norman E. (1999). *Business Ethics: A Kantian Perspective.* Oxford: Blackwell. Norman Bowie is the leading Kantian business ethicist.

Brown, Marvin T. (2003). *The Ethical Process: An Approach to Disagreements and Controversial Issues,* 3rd edition. Upper Saddle River, NJ: Prentice-Hall.

Burrus, Daniel. (1993). *Technotrends: How to Use Technology to Go Beyond Your Competition.* New York: HarperBusiness.

Collins, James C., and Jerry I. Porras. (1994). *Built to Last: Successful Habits of Visionary Companies.* New York: HarperBusiness. Influential study of successful companies shows that corporate mission and values ("more than profits") play key role in long-term success.

DeGeorge, Richard T. (1999). *Business Ethics,* 5th edition. Upper Saddle River, NJ: Prentice-Hall.

Ferrell, Odies Collins, John Fraedrich, and Linda Ferrell. (2002). *Business Ethics: Ethical Decision-Making and Cases,* 5th edition. Boston: Houghton Mifflin.

Freeman, R. Edward. (1984). *Strategic Management: A Stakeholder Approach.* Boston: Pitman. Freeman is the pioneer of business ethics stakeholder approaches.

Freeman, R. Edward, ed. (1991). *Business Ethics: The State of the Art.* New York: Oxford

French, Peter. (1995). *Corporate Ethics.* Orlando, FL: Harcourt Brace.

Friedman, Milton. "The Social Responsibility of Business is to Increase its Profits." *The New York Times,* September 13, 1970, Magazine section. A now-classic argument against corporate moral and social responsibility.

Fukuyama, Francis. (1995). *Trust: The Social Virtues and the Creation of Prosperity.* New York: Free Press. A thorough comparative historical study of high-trust and low-trust societies and their business and economic consequences.

Gill, David W. (1999). "The Technological Blind Spot in Business Ethics." *Bulletin of Science, Technology, & Society* 19(3): 190–198.

Goodpaster, Kenneth E., and Laura L. Nash. (1998). *Policies and Persons: A Casebook in Business Ethics,* 3rd edition. New York: McGraw-Hill.

Jennings, Marianne M. (1999). *Business Ethics: Case Studies and Selected Readings,* 3rd edition. Cincinnati, OH: West.

Jonsen, Albert R., and Stephen Toulmin. (1988). *The Abuse of Casuistry: A History of Moral Reasoning.* Berkeley, CA: California. The leading exponents of casuistry in business ethics.

MacIntyre, Alasdair. (1984). *After Virtue: A Study in Moral Theory,* 2nd edition. Notre Dame, IN: University of Notre Dame. Macintyre's works have influenced many to abandon Kant, Mill, and modern ethical theory in favor of Aristotle and a more holistic approach.

MacIntyre, Alasdair. (1990). *Three Rival Versions of Moral Enquiry.* Notre Dame, IN: University of Notre Dame.

Martin, James. (1996). *Cybercorp: The New Business Revolution.* New York: Amacom. How technology changes businesses.

Post, James E.; Anne T. Lawrence; and James Weber. (1999). *Business and Society: Corporate Strategy, Public Policy, Ethics,* 9th edition. Boston: McGraw-Hill.

Sherwin, Douglas S. (1983). "The Ethical Roots of the Business System" *Harvard Business Review* 61(6): 183–192.

Solomon, Robert C. (1992). *Ethics and Excellence.* New York: Oxford. Solomon is the leading Aristotelian, virtue business ethicist.

Tapscott, Don, and Art Caston. (1993). *Paradigm Shift: The New Promise of Information Technology.* New York:

McGraw-Hill. Tapscott and his various co-authors are superb analysts of the impact of technology on business.

Tapscott, Don, and David Ticoll. (2003). *The Naked Corporation: How the Age of Transparency Will Revolutionize Business*. New York: Free Press.

Taylor, Frederick W. (1911). *Principles of Scientific Management*. New York: Harper and Brothers. The classic argument for subordinating business to science and technology.

Tenner, Edward (1996). *Why Things Bite Back: Technology and the Revenge of Unintended Consequences*. New York: Alfred A. Knopf.

Trevino, Linda Klebe, and Katherine Nelson. (1999). *Managing Business Ethics*, 2nd edition. New York: John Wiley. Excellent holistic, practical approach to business ethics.

Weiss, Joseph W. (1998). *Business Ethics: A Stakeholder and Issues Management Approach*, 2nd edition. New York: Dryden.

Werhane, Patricia H., ed. (2000). *Business Ethics Quarterly* 10(1). Special tenth anniversary edition. Leading figures in the field of business ethics take a retrospective look at the field.

BUTLER, SAMUEL

Samuel Butler (1835–1902) was born in Nottinghamshire, England, on December 4. He was an early critic of evolutionary theory and was among the first to raise philosophical questions about human-machine relations. After being educated at Cambridge University Butler decided to forgo an anticipated ordination and moved to New Zealand to become a sheep rancher (1859–1864). There he read the biologist Charles Darwin's (1809–1882) *On the Origin of Species* (1859), whose theory of evolution became an obsession. Butler died in London on June 18.

At first Butler was convinced by the theories of Darwin; the two corresponded, and Butler became close friends with Darwin's son, Frances. Upon returning to England, Butler was initially a staunch defender of evolution. As a contribution to that defense he began a book to supplement Darwin's theory by elucidating the role of habit in relation to inheritance. However, while doing research Butler discovered the theory of the inheritance of acquired characteristics of Jean Baptiste de Lamarck (1744–1829) as well as the biologist St. George Jackson Mivart's (1827–1900) critique of natural selection, *Genesis of Species* (1871). Now that he was convinced that Darwin was wrong, Butler's book, *Life and Habit* (1878), became an attack. It was followed by a series of other critiques that did not have wide influence: *Evolution, Old and New* (1879), *Unconscious Memory* (1880), and *Luck, or Cunning?* (1887).

Best known in the early 2000s for his novel *The Way of All Flesh* (published posthumously in 1903), Butler achieved literary and financial success during his life from two satirical novels that often are described as Swiftian: *Erewhon* (1872) and its sequel *Erewhon Revisited* (1900). Those works, which originated in an essay titled "Darwin among the Machines" (1863) and continued his lifelong preoccupation with evolution, are of particular interest in regard to the ethics of technology.

The books whose titles are the word *nowhere* spelled backward envision a dystopian society in which machine development has been limited consciously and severely. In the first novel an unnamed narrator accidentally visits Erewhon, a land ruled by philosophers and prophets who equate morality with beauty and health and illness with crime. In Chapters 23 to 25, collectively called "The Book of the Machines," the narrator (whose name, Higgs, is revealed in the continuation) reads a treatise that considers the possible evolution of machine consciousness and details the Erewhonian revolution that led to the prohibition of machines to prevent their domination of the human race. The author argues that the rapid evolution of "higher machines" will lead to their consciousness if steps are not taken "to nip the mischief in the bud and to forbid them further progress."

The narrative further speculates on the nature of consciousness and offers a prescient description of modern DNA testing, anticipating a time when it may "be possible, by examining a single hair with a powerful microscope, to know whether its owner could be insulted with impunity." There is also a linking of machine consciousness with miniaturization and a consideration of whether human life may be merely a step in machine evolution. Chapter 23 concludes:

> We cannot calculate on any corresponding advance in man's intellectual or physical powers which shall be a set-off against the far greater development which seems in store for the machines. Some people may say that man's moral influence will suffice to rule them; but I cannot think it will ever be safe to repose much trust in the moral sense of any machine.

Selections from "The Book of Machines" have been reprinted frequently and often are used to initiate discussions of issues that remain fundamental to the ethics of technology.

JAMES A. LYNCH

SEE ALSO *Utopia and Dystopia*.

BIBLIOGRAPHY

Breuer, Hans-Peter. (1975). "Samuel Butler's 'Book of the Machines' and the Argument from Design." *Modern Philosophy* 72: 365–383. Discusses Butler's reading of Darwin's theories.

Butler, Samuel. (1970). *Erewhon,* ed. Peter Mudford. New York: Viking. A standard reprint.

Pauly, Philip. (1982). "Samuel Butler and his Darwinian Critics." *Victorian Studies* 25: 161–180. A history of the rift between Butler and Darwin.

C

CANADIAN PERSPECTIVES

Canada, by landmass the largest country in North America, is the smallest in population, at just over 32 million inhabitants. Despite this relatively small population, Canada has made a number of distinctive contributions to discussions of science, technology, and ethics. Among these is, notably, the Genomics, Ethics, Economics, Environment, Law, and Society (GE^{3}LS, pronounced *gels*) program, part of Genome Canada, that has supported more than seventy investigators and as many graduate students to investigate issues related to genomics research. As the name indicates, the goal is to promote social context research and education related to new developments in genetics.

General Background

While many would argue that ethical, economic, and social aspects have always been embedded in the management of science in Canada, these have not always been present in a formal sense. In earlier years companies, governments, and scientific researchers often consulted, in an ad hoc fashion, with social scientists and humanists about the impacts of their plans. In the 1970s, however, the demand for formal review arose (e.g., in environmental assessments, which frequently considered socioeconomic impact statements) at the same time as the supply of social scientists expanded and new university research institutes and degree programs related to applied ethics, human rights, environmental economics, risk studies, and science, technology and society (STS) studies were introduced.

The professional and academic efforts to investigate, consider, and implement ethical, economic, environmental, legal, and social studies related to genomics and other life-science research in Canada evolved in tandem with related efforts in the United States. Many of the researchers now leading GE^{3}LS teams previously participated in the Ethical, Legal, and Social Implications (ELSI) program initiated in 1990 by the Human Genome Project (HGP), which was based in the U.S. Department of Energy and the U.S. National Institutes of Health (NIH). The combined ELSI efforts constituted the largest bioethics program in the world and as such has been internationally influential, especially in Canada.

The Canadian efforts became more organized once the demand began to become more formal. Perhaps the first significant requirement for comprehensive social science analysis arose in the context of the evolving environmental legislation in the provinces and at the federal level. This culminated with the passage of the new Canadian Environmental Protection Act (CEPA) in 1992, which required assessment of any environmental effect on health, socioeconomic conditions, physical and cultural heritage, and aboriginal, historical, archaeological, paleontological, and architectural interests.

Shortly thereafter research into the human and various plant, animal, and microbial genomes accelerated. The scientific research efforts surrounding genomics is aimed at decoding all of the genetic information of an organism. This revolutionary research has given rise to a number of social, ethical, legal, and environmental issues.

Specific Initiatives

At about the same time, two independent processes arose to address the need for more social, ethical, legal, economic, and environmental review of Canadian science. One emerged from political discussions, the other from the research community.

In 1983 the federal government adopted its first Canadian Biotechnology Strategy, with an informal group of representatives from industry, consumer groups, and academia providing recommendations to the Canadian Minister of Industry. In 1998 the government concluded that if Canada were to become a leader in biotechnology research, it would need an advisory body with a wider membership base in order to examine and reflect on the changing role of science in society. This led, in 1999, to the establishment of the Canadian Biotechnology Advisory Committee (CBAC) as a part of a renewed Canadian Biotechnology Strategy. The CBAC consists of up to twenty members appointed for three-year terms, and is supported by an executive director with a small staff. Its mandate is to provide comprehensive advice on current policy issues associated with the ethical, legal, social, regulatory, economic, scientific, environmental and health aspects of biotechnology and to provide Canadians with easy-to-understand information and opportunities to voice their views. It is the CBAC that provides both a market for GE^3LS studies and a conduit for promoting the results to a broader audience.

In 1998 the nation's three peer-reviewed granting councils—the Social Sciences and Humanities Research Council, the Natural Sciences and Engineering Research Council, and the Canadian Institute of Health Research—released a tri-council policy statement titled "Ethical Conduct for Research Involving Humans." This statement laid out a series of policies related to confidentiality, consent, balance between benefits and harms, and respect for human dignity and the vulnerable. Universities, public labs, and industry responded by developing internal processes to conform to these ethical standards for both new and ongoing research.

In 2001 the three councils created an Interagency Advisory Panel on Research Ethics to support the development and evolution of collaborative ethics research following the 1998 statement. The advisory panel, composed of twelve volunteer members whose backgrounds span several disciplines including the social sciences, natural sciences, law, and commerce, meets regularly to examine and recommend policies related to council practices for life-science research. Once the direction was set, most national research efforts conformed and adopted ethical and socioeconomic reviews as a formal part of their structure.

The Canadian Networks of Centers of Excellence (NCE) program, started in 1990 by Industry Canada and the three granting councils to fund long-term discovery research networks involving industry, academia, and government, initially had little or no role for socio-ethical review. Once the tri-council guidelines related to research ethics involving humans were developed, however, the NCE program incorporated them into their projects and, in the competition round completed in 2002, formally included a GE^3LS research component and incorporated dedicated funding for GE^3LS programs. For example, the Advanced Food and Materials Network that began in 2002 spends C$22.2 million and involves eighty-eight investigators; C$3.5 million of the budget goes to GE^3LS studies, which fund eighteen investigators.

The single largest public investment in GE^3LS has been through Genome Canada. In the first two rounds of competition (in 2001 and 2003), Genome Canada funded five GE^3LS projects (one each in British Columbia, the Prairies, and Quebec and two in Ontario) and supported one GE^3LS investigation in a science project (related to potatoes). Those six projects had a total budget of more than C$16 million (equal to about 8% of the total investment of more than C$600 million by Genome Canada) and involved more than seventy investigators and at least as many graduate students. In 2005 the third competition for projects was underway and Genome Canada solicited dedicated GE^3LS projects and instructed all science projects to incorporate GE^3LS components. A brief review of a number of science projects suggests project proponents intend to invest on average 1 to 3 percent of their total requested funds in GE^3LS activities.

PETER W. B. PHILLIPS

BIBLIOGRAPHY

INTERNET RESOURCES

Canadian Biotechnology Advisory Committee (CBAC). Available from http://cbac-cccb.ca/epic/internet/incbac-cccb.nsf/en/Home. The home page of the CBAC.

Interagency Advisory Panel on Research Ethics. Available from http://www.pre.ethics.gc.ca/english/policystatement/policystatement.cfm. This site contains the tri-council policy statement, "Ethical Conduct for Research Involving Humans," first issued in 1998 and revised in 2000 and 2002.

CANCER

During the twentieth century wealthy countries underwent a transition in mortality from acute, infectious diseases such as pneumonia to chronic diseases such as cancer. By the late twentieth century the lifetime risk of a person receiving a cancer diagnosis in the United States had climbed above one-in-three. The quest for an elusive "cure" for cancer became a policy imperative, and by the first decade of the twenty-first century U.S. government expenditures on cancer research had reached three billion dollars per year. Notwithstanding decades of heavy research funding, advances in long-term survival for many of the common types of cancer have remained insignificant, and critics have charged that research funding has been too narrowly focused.

Etiologies

The ancient Greeks and Romans understood cancer and other diseases in terms of the bodily humors of phlegm, blood, black bile, and yellow bile (Rather 1978). When the humors were out of balance, such as an excess of black bile in the case of cancer, a disease could erupt. Similar humoral approaches characterized other Old World medical systems, such as the traditional medicines of east and south Asia. Although the rise of scientific biology displaced humoral thinking from the medical sciences, humoral approaches to disease can still be found in some *complementary and alternative medicine* (CAM) approaches to cancer, such as macrobiotic, Ayurvedic, and other traditional Asian medical systems, as well as in general notions of *rebalancing* the body. Ancient physicians also identified diet and trauma as two possible environmental sources of cancer, and those ideas continue to be relevant to thinking on the etiology (causes) of cancer in the early-twenty-first century.

By the beginning of the twentieth century medical researchers were pursuing diverse approaches to cancer etiology. In the wake of the bacteriological revolution, many researchers thought that cancer was an infectious, bacterial disease. Although bacterial theories and therapies were on the wane by the 1920s, throughout the twentieth century a marginal network of researchers kept the approach alive, and they developed dietary and vaccine-based therapies (Hess 1997). At the end of the twentieth century, bacteria were gaining some general recognition as a risk factor for digestive tract cancers. Viral oncology, which had a peak of popularity during the 1960s, had also won general acceptance for viruses as the cause of some human and animal cancers.

At a popular level, laypeople in early-twentieth-century Western countries frequently believed that trauma was a significant cause of cancer (Clow 2001), and the belief is still widespread in some countries. The medical profession recognized a related risk factor of tissue irritation from sources such as tobacco or childbirth. The interest in tissue irritation gradually developed into research programs on chemical carcinogenesis. In the eighteenth century the relationship between creosote tar and scrotal cancer in chimney sweeps had been identified. By the end of the twentieth century, a wide range of chemicals, as well as some forms of electromagnetic radiation, were acknowledged as risk factors, including especially the carcinogens in cigarette smoke.

At the beginning of the twentieth century, some medical researchers also drew attention to the role of internal biological processes in cancer etiology. One theory assumed that embryonic cells remained embedded in differentiated tissues and that they could develop into cancer under some conditions. The theory did not win widespread acceptance, but therapies based on enzymes and other dietary modifications continued as part of the field of CAM cancer care. Furthermore the theory drew attention to the role of growth hormones in cancer, which became part of mainstream cancer research. By the middle decades of the twentieth century, research programs were also emerging on the role of sex hormones in some cancers.

Another development during the twentieth century was research on inherited susceptibility to cancer, which developed from longstanding beliefs about heredity and cancer. Animal experiments in the early decades of the twentieth century confirmed the role of heredity, and by the late-twentieth century it became clear that some types of inherited gene variations (alleles) carried very high risk for some types of cancer, such as the BRCA1 and BRCA2 genes for breast cancer. However, epidemiologists at the end of the twentieth century generally believed that heredity explained only a minor percentage of the variation in the aggregate incidence of cancer and in its growth in incidence.

The development of molecular biology in the second half of the twentieth century allowed a synthesis of various risk factors (for example viruses, chemical carcinogens, radiation) at the molecular level of genetic damage and the expression of genes related to cancer (oncogenes and tumor suppressor genes). However, heredity as a risk factor needs to be distinguished from the understanding of carcinogenesis at a molecular level. Epidemiologists have increasingly given priority to environmental and lifestyle factors, of which diet and exposure to carcinogenic chemicals are generally seen as the central risk factors. In the early-twenty-first century, other recognized risk factors include reproductive behavior, obesity, viral infection, and excessive exposure to sunlight.

Ethics in the Clinical Setting

Most discussions of ethics and cancer focus on the doctor-patient relationship and the various types of ethical problems that emerge in cancer diagnosis and treatment (Angelos 1999). A key issue involves the communication of information to the patient. In some countries physicians have historically informed family members of the diagnosis but have concealed the diagnosis from the patient, even if the patient asks for the information. The practice appears to be changing, but other questions remain. For example, should a physician inform the patient of the diagnosis and/or prognosis, even if the patient asks not to be informed? Likewise should a clinician volunteer statistical information about prognosis even when only more general information is requested?

A related but in a sense inverted problem involves the disclosure to kin of a known genetic mutation that is related to cancer, such as the BRCA1/2 mutation. Patients who undergo such testing often do not expect to benefit personally from it, but they hope that the information will be helpful to kin. As a result, questions have been raised about informed consent regarding the autonomy of the patients who undergo testing, who may feel compelled by responsibility toward kin as a reason for undertaking the testing, as well as the autonomy of kin, who may not want to know such information or may fear genetic discrimination (Hallowell et al. 2003).

A second issue in the doctor-patient relationship involves the ethics of physician reactions to decisions by patients to withdraw from treatment. Sometimes patients decide that the side effects of conventional treatments, such as chemotherapy, are too severe in comparison with the potential benefits (long-term remission) for their particular type of cancer. Patients may combine the decision to withdraw from treatment with a decision to opt for a CAM treatment, but sometimes they simply forego chemotherapy for reasons other than pursuing a successful treatment. For example, patients may decide that there is no hope for recovery and that they are ready to die, or they may feel healthy and may want to work until they no longer can. However oncologists may not recognize nonmedical reasons as *good reasons* for refusing treatment, or they may reject the patient's assessment of the relative risks and benefits of various options, and consequently a communication gap may emerge when oncologists refuse to continue to monitor patients who refuse treatment (Huijer and Leeuwen 2000).

When parents make similar decisions for children, the cases can end in bitter conflicts. In some cases doctors have called in state agencies to take children away from their parents and forcibly deliver conventional therapies. Presumably some calculation of the benefits and risks of both the proposed conventional therapy (including no treatment) and the alternative treatment option (including no treatment) pursued by the parents inform decisions about whether to support the parents or take their child away. As a result, in some cases doctors may support the parents' decision. For example, a child was diagnosed with a type of brain tumor for which conventional therapies offered no possibility of cure. The parents decided to try antineoplastons, an experimental therapy that had only limited supporting evidence at the time but held some risk associated with the insertion of an intravenous catheter. In this case the doctors and hospital opted to insert the catheter and follow the patient, but they also informed the parents of their skepticism that the therapy would be beneficial (Jackson 1994).

Ethics and Research Funding

Ethical issues have also emerged around the politics of funding. One key area has been research funding on chemical carcinogenesis. For years, evidence that smoking is a substantial risk factor for lung cancer (as well as some other types of cancer) was suppressed, and epidemiologists who sought funds for and produced evidence on the role of smoking faced a long battle for recognition. In the early-twenty-first century a younger generation of epidemiologists faces a similar battle to gain acceptance for claims that military and industrial pollution is a major risk factor (Davis and Webster 2002). Historically researchers who have attempted to document risks from industrial pollutants such as ionizing radiation have faced suppression, and industry support groups also have produced scientific dissensus by funding studies that questioned the risks associated with industrial pollutants (Proctor 1995).

In addition to the politics of funding for research on etiology, ethical issues also have emerged around funding choices for research that evaluates or develops therapies. In the early twentieth century surgery was the only mainstream therapy for cancer, but radium-based therapies gained currency by the 1920s, and chemotherapy emerged after World War II. Surgeons and physicians who owned radium or advocated chemotherapy actively opposed the vaccine-oriented therapies developed by researchers who adopted immunological or biological approaches (Hess 1997). Similar suppression has been documented for nutritional therapies and a range of other CAM approaches to cancer (Moss 1995).

As cancer treatment developed during the twentieth century, medical subspecialties and cancer-related treatment industries opposed radical changes in treatment that threatened to undercut the profits of surgery, radiation therapy, and patented drugs. Although biological/immunological therapies for cancer (such as the use of interleukins and drugs that block the formation of blood vessels) are gaining ground in the early-twenty-first century, those developments take place through the mechanism of patented drug development. Researchers who investigate therapies that rely on unpatented products derived from plant or animal substances have been unable to obtain the level of private sector investment that is necessary to become competitors in the field of cancer therapy, which after the early 1960s involved a very costly drug approval process. As a result, a wide range of potentially lifesaving therapies has remained underinvestigated. Public funding agencies in the United States and other countries that could have stepped in to provide research funding for orphaned, unpatented therapies did not do so until the late-twentieth century, and even then the funding remained very minimal. (The term "orphaned" refers to therapies that lack sufficient research funding to be brought to market, because private firms cannot recuperate research costs in future sales due to lack of patentability or size of market.)

Another way in which research on unpatented products can hit a dead end is due to the way that the ethics of clinical trials has developed. Ethicists have argued in favor of *equipoise*, that is, the condition that study and treatment arms in a clinical trial have equal risk/benefit profiles. As a result, in cancer research placebo controls are rarely used; instead an experimental treatment is compared to the treatment standard. Frequently the experimental treatment is the standard treatment plus an additional drug. The standard of equipoise protects patients with life-threatening diseases from research that would put them at risk of receiving completely inefficacious treatment. However because funding is absent to generate preliminary human data, unpatented therapies can be locked in a limbo that prevents head-to-head testing against standard therapies. In this way ethical considerations at one level (patient rights) can negatively impact ethical considerations at another level (investigation of orphaned or unpatented therapies).

In short, significant ethical issues remain unaddressed regarding research funding for both etiology and treatment. Industrial interests external to cancer research and treatment, such as industries that generate significant pollution with suspected carcinogens, have opposed research that might lead to costly changes in materials or production processes. Likewise industrial interests internal to cancer research and treatment, such as medical subspecialties and the pharmaceutical/biotechnology industries, have opposed research that might open the door to competition from unpatented products. After decades of publicly supported research that have followed President Nixon's declaration of the war on cancer in 1971, for many patients therapeutic options remain limited and long-term prognosis remains dismal.

DAVID HESS

SEE ALSO *Death and Dying; Health and Disease; Medical Ethics.*

BIBLIOGRAPHY

Angelos, Peter. (1999). *Ethical Issues in Cancer Patient Care*. Dordrecht, The Netherlands: Kluwer. Good survey of the bedside ethical dimensions of conventional cancer care.

Clow, Barbara. (2001). *Negotiating Disease*. Montreal McGill-Queen's University Press. Survey of popular and academic understandings of cancer etiology in the twentieth-century.

Davis, Devra Lee, and Pamela Webster. (2002). "Epidemiology and Science: The Social Context of Science." *Annals of the American Academy of Political and Social Science* 584(13): 13–34. Example of the younger generation of epidemiologists that is developing the case for environmental etiologies.

Hallowell, Nina; Foster, C.; Eeles, R., et al. (2003). "Balancing Autonomy and Responsibility: The Ethics of Generating and Disclosing Genetic Information. *Journal of Medical Ethics* 29(2): 74–79. A leading journal for those interested in medical ethics.

Hess, David. (1997). *Can Bacteria Cause Cancer?* New York: New York University Press. A multidisciplinary analysis of the history of one type of alternative theory and therapy for cancer, analysis of its suppression, evaluation of the evidence, and discussion of policy remedies.

Huijer, Marli, and Evert van Leeuwen. (2000). "Personal Values and Cancer Treatment Refusal." *Journal of Medical Ethics* 26(5): 358–362.

Jackson, Jennifer. (1994). "Unproven Treatment in Childhood Oncology: How Far Should Pediatricians Co-Operate? Commentary." *Journal of Medical Ethics* 20: 77–79.

Moss, Ralph. (1995). *The Cancer Industry*. Brooklyn, NY: Equinox Press. Classic study of the suppression of alternative cancer therapies and researchers.

Proctor, Robert. (1995). *Cancer Wars*. New York: Basic Books. Review of research controversies surrounding environmental etiologies of cancer.

Rather, L. J. (1978). *The Genesis of Cancer: A Study of the History of Ideas*. Baltimore, MD: Johns Hopkins University Press. Examples the early theories of cancer.

CAPITALISM

Capitalism is both a special kind of self-organizing system for structuring economic activity and a historical movement in support of such a system. Its first full development is generally taken to have occurred in the late-eighteenth and early-nineteenth centuries in England, but its ideals of private property and open markets have been variously manifested and defended since. Capitalism is also coupled to a distinctive ethical view of the world, linked closely with developments in modern science and technology, and a source of challenges to other alternative ethical and political perspectives.

Historical Origins

The root of the abstract noun capitalism is the Latin *capitalis*, from *caput*, meaning head, from the hypothetical Indo-European *qap-ut*, by which cattle (another related term) are counted and thus in many preindustrial societies wealth measured. A popular but mistaken belief views capitalism as a transcultural phenomenon that "only needs to be released from its chains—for instance, from the fetters of feudalism—to be allowed to grow and mature" (Wood 2002). In reality, however, capitalism depends on special cultural conditions, including ethical commitments to the primacy of the individual and the importance of material welfare.

The political economist Adam Smith (1723–1790), who is often taken to be the father of modern capitalism, analyzes the accumulation of *capital* promoted by free markets and the productive efficiencies of increased divisions of labor. But the resulting economic order is what he calls a *system of natural liberty*. Even the extended critique of political economy found in the work of Karl Marx (1818–1883) prefers the more concrete *das Kapital* and *der Kapitalist* over *der Kapitalismus;* Marx's opposition is to the *capitalist production system* not capitalism. The English word capitalism first appears in print in British novelist William Makepeace Thackeray's *The Newcomes* (serial publication, 1854). It was left to later economists such as Werner Sombart (*Modern Capitalism* [1902]) and Max Weber (*The Protestant Ethic* and *Spirit of Capitalism* [1904]) to make capitalism as economic system and political ideology the center of debate.

As Weber, Sombart, and others make clear, capitalism as an economic system is closely associated with but not precisely the same as a market system. Free markets are possible on small scales, but capitalism presumes larger-scale industrial enterprises resting on both modern technology and a legal system that gives corporations the status of a person, thus creating a buffer between corporate and personal wealth and responsibility. Capitalism describes an economic system in which property resources are privately owned, but in a form not identical with individual wealth, with interactions between the supply and the demand for goods and services used to direct and coordinate economic activities. Once provided with a legal structure of private ownership enforced by the state and open markets, capitalism is self-organizing as if by means of what Smith once called an *invisible hand*. The result, it is claimed, is efficiency in two forms: technological (producing a given amount of goods with the minimum amount of resources) and allocative (distributing resources in the best way possible).

Science, Technology, and Capitalism

The role of science and technology in well-functioning capitalist economies is essential to their success. Continuing economic growth helps promote acceptance of inequalities, with such growth depending on increases in worker productivity, which is in turn supported by improvements in technology. Unfettered movement of capital, or access to capital, helps spur investment in research and development. This investment leads to scientific discovery and technological innovation, albeit sporadically.

It is also important to note that the free movement that is associated with capital and labor under capitalism has been more or less closely coupled with democratic politics. Indeed defenders of capitalism such as Michael Novak (1982) have argued that *democratic capitalism* must be distinguished from all attempts at centralized state control of science, technology, and capital.

However the relation between science, technology, and capitalism is two-sided. Not only does capitalism tend to promote science and technology, but science and technology have been argued to promote capitalism. Joel Mokyr's broad overview of economic and technological progress (1990) and of science and wealth (2002) place as much stress on how inventors and scientists have contributed to capitalism as how capitalists have funded technology and science. According to Mokyr, the development of systematic means for knowledge production and invention, and their institutionalization, went hand in hand with the development of systematic or industrial means of material production.

Scientists such as Michael Polanyi (1951) take this argument one step further and argue that the organization of science provides a model for democratic capitalism. It is in the scientific community that equality finds its strongest exemplar, and that the free flow of knowledge together with division of labor leads to an expansive production of knowledge that can serve as positive influence on and support for economics and politics.

At the same time the costs of some scientific and technological projects have on occasion been beyond the means of private capital formations. Historically states, not private corporations, have been required to pioneer public water systems, nuclear energy, major advances in airplane propulsion and design, cancer research, space exploration, the Internet, and decoding of the human genome. But it is mostly democratic capitalist economies that have provided the tax base and public support for such large-scale, big science efforts without measurable costs in consumer welfare—in the hopes that such expensive research and development projects would eventually contribute to greater public benefit.

For Mokyr, the roots of twentieth-century prosperity were the capitalist industrial revolutions of the nineteenth century, which were precipitated in part by the scientific revolution and Enlightenment of the seventeenth and eighteenth centuries. "To create a world in which 'useful' knowledge was indeed *used* with an aggressiveness and single-mindedness that no other society had experienced before was the unique Western way that created the modern material world" (Mokyr 2002, p. 297). Moreover in an increasingly knowledge-driven economy, scientists and engineers are themselves more often becoming entrepreneurial capitalists. The opportunities not just for profit but for conflicts of interest and other failures in professional ethics are nevertheless not to be minimized.

An Ethical Kaleidoscope

One key question imposed on policymakers in capitalist systems concerns the justice of those inequalities that capitalism promotes, and whether there might be appropriate remedies for such inequalities or alternative, more equitable systems of production. Capitalists typically argue both that property rights are grounded in human rights and that some level of inequality is beneficial to all because it stimulates productivity. Beyond social justice are other issues of professional ethics and cultural conflict that also deserve acknowledgement.

SOCIAL JUSTICE. The historical development of social justice issues can be traced to the classic period of the Industrial Revolution in England (c. 1750–1850). Social critics of the associated economic individualism among capitalists argued for an alternative of social solidarity among the workers and for some degree of common ownership of the means of production. Although specific mechanisms varied, a general term for this alternative is *socialism*.

The ideal of socialism, like capitalism, is a theoretical construct—a fiction. The spectrum of economic systems is bracketed by capitalism and socialism, but all economies in the early twenty-first century are in fact mixed, that is, lie somewhere in between these two extremes. On the capitalist end, economic individualism and the right to property are paramount, leading sometimes to major social inequalities. On the socialist end, communal ownership and collectivist values play a significant role, often leading to bureaucratic inertia. The historical response to capitalist failures has been state intervention, and to socialist shortcomings privatization.

THREE CONTINUING CRITICISMS. The issue of social justice has led to three general criticisms of basic assumptions of capitalist systems. The first basic assumption is that profits serve as the driving force for social as well as economic actions. If profits are not present, individuals will not have any incentive to act. But this view of humans as calculating, optimizing individuals may promote morally objectionable behavior. Defenders of capitalism respond that the profit motive is simply a reality of human nature (although the scientific evidence for this is at best ambiguous), appeal to the virtues of freedom of choice, and express faith in the ability of nongovernmental institutions to develop ethical protocols for behavior among individuals.

A second basic assumption is the sanctity of individual property rights. The criticism is that property itself is a kind of social fiction that in too strong a form may easily undermine equity or the collective good. In response, property rights are defended as basic human rights. Strong property rights are further argued ultimately to promote a productivity that benefits all, even though it may selectively benefit some more than others. An expanding pie gives even those with small pieces more to eat.

A third basic assumption is the value of free markets in both goods and services (the output market) and in the factors of production (the input market). Insofar as the input market is focused on material resources, liquid capital (money), and fixed capital (plant and machinery), this assumption is challenged only by environmentalists who argue that some natural resources may be undervalued. But the free market in labor input has a tendency, others argue, to treat humans as commodities. An unregulated labor market may lead to the violation of basic human rights—rights that, in other contexts, capitalism purports best to serve. The degree to which a society protects workers from the vagaries of the labor market is one strong measure of the influence of the socialist end of the capitalism-socialism spectrum.

The second and third assumptions—that capitalist systems have well-defined private property rights and input-output distributions guided by free markets—depend on ideal conditions that are unlikely to obtain fully in the real world. When property rights are weak or prices provide unreliable signals to market participants, a capitalist system may fail to realize its potential for good. In this regard, economists have identified four types of market failures under capitalism: (a) excessive market power where individual buyers or sellers have significant control over output, price, or both; (b) externalities where one economic agent imposes costs or benefits on another without the latter's knowledge or consent; (c) public goods where markets are either nonexistent or the good will be underproduced because there is little or no incentive for private property owners to provide a good that others can use without paying for it; and (d) asymmetric or incomplete information where either the buyer or the seller lacks sufficient information to make a free and rational decision.

Failures (b), (c), and (d) offer special challenges for science and technology in capitalist economic systems. Scientists and engineers almost always know more than others about what they may be providing by way of productive inputs or outputs. In many instances scientific research and technological development take place at the leading edge of economic activity where there is not yet and may never be any market sufficient to support it. And certainly the requirements of free and informed consent in human subject research can dramatically illustrate asymmetries in information between scientists and nonscientist participants.

CULTURAL CONTRADICTIONS. Finally there are ethical issues associated with what sociologist Daniel Bell has termed *The Cultural Contradictions of Capitalism* (1976). According to Bell, contemporary society can be organized into three distinct realms: the technoeconomic structure, the polity, and culture. The technoeconomic order is concerned with the production of material goods and services; the polity with social justice, the proper use of force, and the regulation of conflict; and culture with the meaning of human existence as expressed in various imaginative forms. At any one historical period each further exhibits distinctive norms and follows its own rhythm of change, with complex interactions that may be mutually reinforcing or subtly undermining. From the perspective of this framework, one of the general challenges of capitalist modernity is the way in which drives for change in the technoeconomic structure threaten to undermine traditions of cultural meaning on which all social orders ultimately rest.

In the contemporary capitalist world the three realms are ruled by antagonistic principles: competitive efficiency for the capitalist economy, liberty and equality in the polity, and self-realization or self-expression in culture. Bell's particular argument is that not only are there tensions between the contemporary norms (which he interprets somewhat differently) operative in each of these three realms, but also within the modernist, self-expressive culture itself. Together such antagonisms may destabilize the whole social order or particular regions within it. Certainly between the special cultures of science and technology and the general culture of self-expression yoked to capitalist productivity there are tensions that threaten the stability of science, for example, when scientists hype their results or shape them to fit economic interests. The globalization of capitalism, as a carrier of science, technology, and particular cultural values, no doubt provides further opportunities for cultural conflicts.

WILLARD DELAVAN
CARL MITCHAM

SEE ALSO *Conservatism; Critical Social Theory; Economics and Ethics; Market Theory; Marx, Karl; Smith, Adam; Work.*

BIBLIOGRAPHY

Bell, Daniel. (1996). *The Cultural Contradictions of Capitalism,* 20th anniversary edition. New York: Basic Books. First published in 1976.

Berger, Peter L. (1986). *The Capitalist Revolution*. New York: Basic Books. Sociologist Peter Berger maintains that capitalism transforms all aspects of social being and that capitalism provides the most successful mechanism yet devised for improving the material wealth of humankind. He provides a provocative set of testable hypotheses about the relationship between the new capitalism and human values.

Heilbronner, Robert. (1993). *Twenty-First Century Capitalism*. New York: W. W. Norton. A fascinating extension of lectures examining the relationship between capitalism and the notion of progress encompassing capitalism as both political and social system and its future potential for fostering economic growth.

Hutton, William, and Anthony Giddens, eds. (2000). *Global Capitalism*. New York: Free Press. Explores the impact of globalization on capitalism. It is a rich source of new perspectives on the new capitalism, its connection to social cohesion and justice, and comparative economic and political systems.

Mokyr, Joel. (1990). *The Lever of Riches: Technological Creativity and Economic Progress*. New York: Oxford University Press.

Mokyr, Joel. (2002). *The Gifts of Athena: Historical Origins of the Knowledge Economy*. Princeton, NJ: Princeton University Press.

Novak, Michael. (1982). *The Spirit of Democratic Capitalism*. New York: Simon and Schuster.

Polanyi, Michael. (1951). *The Logic of Liberty: Reflections and Rejoinders*. Chicago: University of Chicago Press.

Schumpeter, Joseph A. (1950). *Capitalism, Socialism, and Democracy*. New York: Harper & Row.

Soto, Hernando de. (2000). *The Mystery of Capital*. New York: Basic Books.

Wood, Ellen Meiksins. (2002). *The Origin of Capitalism: A Longer View*. New York: Verso.

CARE

SEE *Ethics of Care*.

CARSON, RACHEL

For post-World War II America, scientist and writer Rachel Louise Carson (1907–1964), born in Springdale, Pennsylvania on May 27, popularized the idea that ethical discussions of science and technology should consider environmental concerns. Using the insights of ecology, Carson pointed out that humans and nature were inextricably, even physically connected; for example, they were subject to similar dangers from industrial chemicals in the environment. Therefore, Carson

Rachel Carson, 1907–1964. Carson was an American biologist and writer whose book *Silent Spring* aroused an apathetic public to the dangers of chemical pesticides. *(The Library of Congress.)*

argued, humans should try to respect rather than dominate nature. This argument culminated in her international bestseller, *Silent Spring* (1962), published shortly before her death from breast cancer on April 14.

Early Work and Writings

Raised in a rural but rapidly industrializing area of Pennsylvania, Carson attended Pennsylvania Women's College (now Chatham College) from 1925 to 1929, where she majored in biology. From 1929 to 1934 she attended Johns Hopkins, graduating with a master of science in zoology. Due to the Depression, Carson could not afford to stay in school and earn her Ph.D. Instead she found a job as an editor and science writer with the U.S. Fish and Wildlife Service. She worked there until 1952, when the international success of her second book, *The Sea Around Us* (1950), finally made it possible for her to quit and write full-time.

Carson's professional background gave her a strong grounding in the latest research from several different scientific disciplines. As well as editing the work of other scientists, her job was to synthesize and publicize scientific information for the public. In addition, before ecology became a well-known approach, Carson had embraced an ecological perspective. (Ecology is the science that studies the interactions of organisms in the natural world.) Her first book, *Under the Sea-Wind* (1941), traced the many complex layers of marine ecosystems. During her employment, Carson also became concerned with the impact of various new postwar technologies on the wildlife and environment—among them, the pesticide dichlorodiphenylthrichloroethane (DDT), a wartime technology released into the consumer market in 1945.

As Carson's career as a writer began to gather momentum, so did her ideas about science, technology, and the environment. Repeatedly she emphasized the need to educate the public about science. She also challenged the idea that "*science* is something that belongs in a separate compartment of its own, apart from everyday life" (Brooks 1972, p. 128). Carson's developing critique of science targeted restricted circles of experts who isolated their knowledge of the natural world from the public. Her next book, *The Edge of the Sea* (1955), strove to make scientific information about the seashore accessible to the general reader. She also encouraged her readers to engage in firsthand experience with the environment to give them a reference point for evaluating scientific knowledge and discoveries.

Silent Spring

The United States's development of the atomic bomb proved to be a crucial turning point in Carson's thinking about the interactions of humans and their environment, and the consequences of science and technology. As she remembered, the possibility of humans being able to destroy all life was so horrible that "I shut my mind—refused to acknowledge what I couldn't help seeing. But that does no good, and I have now opened my eyes and my mind. I may not like what I see, but it does no good to ignore it..." (Lear 1997, p. 310). Instead Carson faced man's destruction of his environment. In particular she focused on synthetic chemical pesticides.

In *Silent Spring* Carson argued that science and technology had largely ignored the environmental consequences of pesticides in disturbing the *balance of nature*. This metaphor referred to the ecological interactions of species in the natural world, and Carson showed how pesticides interrupted these complicated relations. The widespread use of persistent synthetic chemical pesticides endangered birds, wildlife, domestic livestock, and even humans. Residues from DDT, aldrin, dieldrin, heptachlor, and other chemicals contaminated most water, soil, and vegetation. The federal government had not only failed to protect citizens from these dangers, but by carrying out aerial spraying attacks on the fire ant and the gypsy moth, it had committed some of the worst offenses. Chemical dangers even penetrated suburbia, where people intensively sprayed their homes and gardens. Carson discussed both the immediate consequences for human health and the possible long-term hazards, including genetic damage and cancer. In particular she blamed scientific experts (economic entomologists and agronomists, among others) who supported the chemical-based technologies of industrialized agriculture. For Carson agribusiness epitomized the industrial mindset of man dominating nature for the interests of private economic gain.

Silent Spring resulted in an enormous public uproar. The book raised issues that extended far past the debate on pesticides. Ultimately it questioned how modern, industrialized society related to the natural world. Pesticides were but symptoms of the underlying problem: the idea that humans should dominate and control nature. Carson wrote that the "*control of nature* is a phrase conceived in arrogance, born of the Neanderthal age of biology and philosophy, when it was supposed that nature exists for the convenience of man" (Carson 1962, p. 297). However, many readers disagreed. Criticizing Carson's idea of the balance of nature as too static, they argued instead that nature was inherently unbalanced. Man had to use pesticides and dominate nature in order to ensure his own survival. In fact Carson's understanding of the balance of nature was complicated: The phrase implied stasis, but she also portrayed nature as an active entity capable of great change.

Altogether Carson put forth an environmental ethic based on the physical, ecological connections that existed between humans and their environment. She insisted that science and technology be evaluated according to this ecological standard, where humans and nature merged as one. Moreover as part of the fabric of life, humans had no right to put the entire biotic community at risk. By popularizing ecological ideas, Carson treated her readers as capable of understanding and participating in scientific debates. She also redefined calculations of risk: Decisions on environmentally hazardous technologies should take into account public environmental values as much as scientific findings of harm. Moreover scientists and industries should bear the burden to prove their products safe, rather than the public having to prove them dangerous.

In *Silent Spring,* Carson set the foundation of the environmental movement that began in the late-twentieth century. The insight that humans and nature were ecologically linked gave people new ways to conceive of environmental issues. The environment existed not only in the wilderness and the national parks, but in the immediate, intimate surroundings of home, garden, workplace, and even the health of the physical body. Carson also sparked the ongoing public debate about how to best consider environmental issues in making ethical decisions about science and technology. She was especially significant for her grassroots appeal—making everyday people aware of their role in preserving their environment.

MARIL HAZLETT

SEE ALSO *Agricultural Ethics; DDT; Ecology; Environmental Ethics; Environmentalism; Waste.*

BIBLIOGRAPHY

Brooks, Paul. (1972). *The House of Life: Rachel Carson at Work.* Boston: Houghton Mifflin. Brooks, Carson's editor, wrote this book after her death in order to shed some light on Carson's private life, her writing process, and the history of *Silent Spring.*

Carson, Rachel. (1962). *Silent Spring.* Boston: Houghton Mifflin. Details the dangers of the first generation of synthetic chemical pesticides produced in the postwar era.

Lear, Linda. (1997). *Rachel Carson: Witness for Nature.* New York: Henry Holt and Co. The definitive biography on the life of Rachel Carson.

CARTESIANISM

SEE *Descartes, René.*

CENTRAL EUROPEAN PERSPECTIVES

Although the countries of Central Europe (CE) have a long tradition of critical reflection on science and technology, this tradition was severely curtailed from World War II to the end of the Cold War. Only since the early 1990s have discussions emerged that might be described as contributing to bioethics, environmental ethics, computer ethics, and related fields of science, technology, and ethics. Other traditions of scholarship nevertheless have developed in ways that may be related to these fields, and deserve consideration, especially when placed within a larger historical and philosophical context.

Boundary Issues

CE has been defined according to different criteria. A variety of factors—geographic, religious, linguistic, strategic, ethnic, historical, sociopsychological, and developmental—have shaped the dividing lines of the lands located between Russia and the German-speaking countries. In some conceptions, even Russia and Germany were included. For centuries, it was the route by which conquering Central Asian tribes—Huns, Magyars, Tatars, and others—invaded Europe. It was also the path by which Western armies—those of Sweden's Gustavus Adolphus, Napoleon, and Hitler—attacked, attempting to expand east into the center of Russia. This region was an important strategic area called the Euro-Asian *heartland* or *pivot area.* Whoever controlled the territory was said to control the world, which is why CE was repeatedly subject to invasions from east and west. As a result of all these assaults and historical expansions, CE has the most complex ethnic makeup in Europe, peopled in many places by ethnic groups too small to constitute a separate nation-state.

Like Southern and Eastern Europe, CE has been slow, and reluctant, to embrace the Enlightenment as well as the Industrial Revolution; economic development and industrialization evolved more slowly and unevenly than in Western Europe. This may be explained in part by the longtime authority and spiritual power of religion in these countries. Together with other influences, this religious authority contributed to other than economic growth. The specific character of the so-called Slavic mentality generated by the different character of language and cultural heritage is being protected and rescued against the attempts of homogenization resulting from integration with the economically powerful European Union. The problem is very vital in public discussions on the advantages and disadvantages of European integration, and is a strong arguing point for Eurosceptics against Euroenthusiasts. The former oppose treating economic factor as the exclusive criterion of development. They point to the literary tradition of ironic or spiritual distance to terrestrial profits.

Differences between developed countries of the West and the developing CE countries of Poland, the Czech Republic, Slovakia, and Hungary disclose special problems. In the early-twenty-first century, the dynamic growth possible for these countries—sometimes called the Visegrad Group—as a result of having joined the European Economic Community (EEC) as well as the

North Atlantic Treaty Organization (NATO), has opened a new era in their relationship to science, technology, and ethics.

Science

Communist regimes attached great importance to scientific achievements, realizing that such accomplishments constituted a strong position in the Cold War. However the communist ideology, trumpeted in the media and developed in every sphere of public life, that elevated the character of the working class and peasants over that of *elites,* ultimately resulted in scientists being considered parasites, producing nothing of material social value. Such political attitudes fluctuated, being stronger at some times (until Stalin's death in 1953) than at others; nevertheless they had significant impact. Many inventive scholars who did not sign *loyalty declarations* were marginalized or persecuted. After 1968 some university professors, many of Jewish origin, left CE for the West to continue their research in more democratic conditions.

One of them, Leszek Kołakowski, gained international fame as a critic of Marxist theory. His thorough, three-volume monograph of Marxism is outstanding not only due to vast range of materials used in the narration but also due to its clear-sighted style. Kołakowski explains the phenomenon of Marxism and the reasons of its worldwide spreading. He locates the project of radical transformation of social relations on the wide background of history of thought, exposing in it millenarist and eschatological motifs. In such a perspective Marxism is suspected of being one more version of salvation, but a secular one. Kołakowski discusses not only the very conception of Marx but investigates its further history in different European countries, registering meanders of the evolution of the original project, caused by peculiarities of social contexts and processes in different European countries and elsewhere.

Some philosophers nevertheless remained in CE doing work that is directly relevant to the philosophical and ethical understanding of science. Among these are Tadeusz Kotarbinski (Poland) and Jan Patocka (Czech Republic). Their unique achievements, such as the theory of good work called *praxiology* fromulated by Kotarbinski or phenomenological reflection on history and role of technology by Patocka were the exemplary proofs that autonomous and efficient thought has been practiced even under the Soviet Union supremacy. Praxiology was developed in many European countries (such as Norway) as well as in the United States as important contribution to the theories of management and could be also considered as Polish contribution into philosophy of technology within which technology is defined mainly as multi-levels organization. Phenomenological accent on responsibility makes Patocka's considerations actual both at the time he was writing and at the present moment.

After the collapse of communism in 1989, the period of transition and transformation began. The role of science in these countries has been recovering after a totalitarian regime's controlling system. The infrastructure of scientific development is strongly connected to economic growth, which, previously, was not highly advanced. The end of the Cold War opened borders. International cooperation in different fields, especially in the hard sciences (physics, chemistry, and informatics), became more regular and was not ideologically controlled. The Polish Academy of Science became a member of the European Science Foundation in 1991, and scientists had an opportunity to take part in extensive international research programs. International conferences and meetings were organized in all fields, social sciences and the humanities included. The Czech Academy of Science underwent a radical reform in 1994. Social needs fueled research into the economic and legal questions connected to the privatization of socialized property; specialists began to examine critically whether pure liberalism could cope with transition problems, and investigated the role and impact of business ethics in that process.

Social consciousness, which under communism was soothed artificially and often deliberately misdirected, developed rapidly. The problematic character of scientific authority, of science in general, and the issues related to the incorporation of scientific discoveries into society became the substance of public debate as well as of scholarly research. Important works related to these topics discuss issues of science and the search for truth or science and democracy, with the argument that scientific development is central to the future. Nevertheless the growing consciousness of the dilemmas raised by scientific-technological advancement, either generally (for example, spiritual crisis of the contemporary world, technology and civil rights) or more specifically (such as creating quality cultures, or economic and social effects of the lack of adequate technology education) have become vital to the worldview of the CE nations.

Education

Central European University in Budapest, Charles University in Prague, and Warsaw University are representative of the new tendency to liberate education from ideological limits and conditioning. According to some studies, the entire educational system in postcommunist CE countries is undergoing fundamental change. The structure is making a successful transition from the radical-structuralist model that previously dominated to a functional-liberal paradigm.

The communist party ran a hierarchical and strongly centralized educational system. An elementary level of education was easily accessible to all members of society. Education served the needs of the dynamic, industrial society; it also immersed students in *scientific socialism* ideology. In the early-twenty-first century, curricula and teaching methods have undergone serious transformation.

According to some research carried by The World Bank Institute in 1997 on the quality of educational systems in CE countries, the process of decentralizing started and was developed. Comparison of experiences from Hungary, Poland, and the Czech Republic let the researchers expose the main problems and suggest solutions.

Economic underdevelopment makes full educational reform unachievable. In this context, the activity of Hungarian financier and philanthropist, George Soros, appears to be very important. He is a founder and a chairman of Open Society Institute (OSI) in New York and in Budapest and of the Soros foundations network. Promoting a free press and political pluralism in all the postcommunist countries, in spite of being accused and hindered by the authoritarian governments in Eastern European and Post-Soviet countries, he and his foundations are dedicated to building and maintaining the infrastructure and institutions of an open society. Through the global network of nongovernmental organizations (NGOs), he helps to support health programs, to fight discrimination of all sorts, and to promote democracy. In CE countries they help to replace the authoritarian model in education with the civic education style. Different steps and procedures are being introduced to democratize education system, to develop a new way for teachers to relate to their pupils. Financial support providing schools with necessary equipment such as computers, videocassettes, and CDs contributes much to achieving real transition in the education field.

Technology

Under communism, scientific achievements were treated as part of a *scientific-technological revolution* rather than as abstract or pure concepts. At universities and technical schools throughout the CE countries, the philosophy of technology developed first from the Marxist viewpoint (for example, Radovan Richta in Prague, Adam Schaff in Warsaw), and then in a more pragmatic and individualistic way (such as Ladislaus Tondl in Prague; Tadeusz Kotarbiński in Warsaw; Józef Bańka in Katowice, Poland). In general, however, technology has been a subject of systematic philosophical reflection only since the early 1990s.

Apart from comments and attempts to build on the work of established Western thinkers (Karl Jaspers, Hans Jonas, Martin Heidegger, Jacques Ellul, Jose Ortega y Gasset, and others), only a few independent projects for conceiving interrelations between technology and society have appeared in response to contemporary problems and social needs. Ladislav Tondl (Prague) identified different aspects of social control of technology and developed the concept of *delegated intelligence*, which enabled him to investigate the structure of subsystems in technology. Imre Hronszky (Budapest) distinguished technological paradigms and discussed communities in technological change. Józef Bańka (Katowice) studied mutual interactions of modern technology and human personality.

Bańka's research became the basis of a new, individual approach that developed into a philosophical concept called *eutyphronics*. Its main principle was the protection of humankind as it faces the dangers of technological civilization. Andrzej Kiepas and Lech Zacher (Warsaw), editors of the interdisciplinary magazine *Transformacje* (Transformations), which has published numerous articles devoted to that central issue, have been promoting Western European and U.S. traditions of technology assessment and their own original conceptions of it for years.

Ethics

Although CE is increasingly engaged with Western intellectual discussions, such standard fields of applied ethics as environmental ethics, business, computer ethics, and professional ethics in science and engineering have not yet become standard fields for research and discussion. Nevertheless, using such recognized classifications, one can note the following contributions.

Business Ethics

The transformation from planned to market economy in the CE countries is a test bed for applying economic theory and business ethics to an enormous historical transition in the economic and political system. Authors from the Czech Republic, Hungary, Poland,

and Slovakia have analyzed the economic, philosophical and political problems of the transition process. The education and training necessary to combat increasing corruption in public bureaucracies of CE countries are being examined. The transition to democratic institutions must include the participation of all sectors to enhance transparency and build long-term public trust. Anticorruption efforts, including structural and normative approaches to ethical controls, must be aligned with the core values unique to each country's ecology. Key shared values must include honesty, stewardship, respect for human dignity, and concern for others.

Along with the public debate involved in creating a democratic system, social concerns also focus on so-called postmoral spirituality in different areas. For example, Budapest University organized a workshop called Spirituality in Management in Hungary in 2001. Participants discussed spirituality as a search for meaning, which transcends material well-being. The workshop focused on the possible role of spirituality in renewing the contemporary management praxis.

Computer Ethics

Advances in computer and data communication technology have created new ethical issues. Startling advances in biotechnology and genetic engineering offer not only new cures but also open the possibility of modifying existing organisms. Throughout CE, schools dedicated to these technologies have introduced seminars to enhance awareness of the moral implications of working as an engineer or technologist. Engineering ethics, already developed worldwide, is being introduced in CE university curricula and written about in philosophical journals by such authors as Wojciech Gasparski and Andrzej Kiepas (Poland).

Environmental Ethics

Henryk Skolimowski is a leader in the discussion of environmental ethics. His concepts of *cosmocracy* as the next stage of democracy and ecological spirituality constitute an important contribution to the philosophy of technology. Instead of treating the world as a machine, he recommends referring to the world as to the sanctuary. He considers the human race as a guide to realize the eschatological purpose of the universe. The basis of his ethics, which is a practical application of eschatology, is the notion of responsibility of some overreligious, mythological character.

At present, CE focus in this area is on practical problems and their resolution. Technology transfer and technology forecasting make it necessary to consider the expected rate of technological advance and to adjust conditions—material infrastructure and social framework—to various applications in science and technology.

Assessment

In comparison to Western Europe where, as a result of the Enlightenment, the separation of church from government has become the rule, in CE religion retains its importance and influence even in the public sphere. There are political-historical reasons for this situation. In Poland the church was, during the communist period, the center of opposition to the government, shaping opinions and helping to organize resistance to the political regime. Debates among those representing Marxist, atheist, and Roman Catholic views brought ethical problems connected to the scientific-technical revolution to the attention of the public. The vast range of new ethical conflicts and problems are very often still immersed in more general moral worldview religiously or even mythically inspired. Coexistence of these traits with the commonsensical, pragmatic attitude seems to some extent to be politically and socially conditioned. The election of Karol Wojtyła, a Pole, as pope contributed to strengthening the public resolve to reject communism. The great strike organized by the Solidarity movement in Poland in 1980 was the first in a chain of events, which included the fall of the Wall in Berlin in 1989, that culminated in the collapse of the Soviet Union in 1991, ending the communist era. The difficult period of transformation had begun.

MARIA KOSTYSZAK

SEE ALSO *Communism; German Perspectives; Marxism.*

BIBLIOGRAPHY

Bokajło, Wiesław, and Kazimierz Dziubka, eds. (2003). *Unia Europejska: Leksykon integracji* [European union: Lexicon of integration]. Wrocław, Poland: Publishing House "Europa." In each of six chapters there are short encyclopeadic articles devoted to main cultural, legal, social, economic and political issues connected with the process of European integration. Such entries as "National Minority," "Freedom of Belief and Conscience," "Napoleonian Visions of Europe," "Euroregions," "Civil Society," and many others are developed in their conceptual, historical and organizational dimensions.

Davies, Norman. (1997). *Europe: A History*. London: Pimlico. A comprehensive study of genesis, directions of development and the present shape of Europe conceived as a differentiated but integral mixture of nations, interests and complex forces. Some reviewers criticized the book for a somewhat undue emphasis on Poland-Lithuania and Eastern European affairs in general, and for his biased opinions of the Holocaust and the other genocides in modern Eastern Europe. In spite of that, a valuable source.

Gorzelak, Grzegorz; Eva Ehrlich; Lubomir Faltan; and Michal Illmer. (2001). *Central Europe in Transition: Towards EU Membership*. Warsaw: Scholar Wydawnictwo Naukowe [Scientific publishing house "Scholar"]. The transformation process in four countries: Czech Republic, Hungary, Poland and Slovakia in the decade of the 1990s is shown in four major domains: economy; socio-political process; education, science and technology; and the regional dimension of transformation. Prepared by the international team who made the evaluation of development scenarios—political, social and cultural aspects of system changes towards democracy, its institutional and mental obstacles.

Hartman, Jan. (2003). *Short Studies in Bioethics*. Kraków: Jagiellonian University Press. A collection of articles and speeches delivered during European conferences concerning the most vital problems of bioethics in CE countries.

Kaase, Max; Vera Sparschuh; and Agnieszka Wenninger, eds. (2002). *Three Social Science Disciplines in Central and Eastern Europe: Handbook on Economics, Political Science and Sociology (1989–2001)*. Berlin, Bonn, and Budapest: Social Science Information Center and Collegium Budapest. This volume documents the development of economics, political science and sociology in Central and Eastern Europe EU accession countries from 1989 to 2001, with a special emphasis on research. A CD-ROM enclosed in the handbook presents an overview on Central and Eastern European institutions in the respective countries relevant for economics, political sciences, and sociology (about 700 institutions). The CD-ROM enables direct access to the database INEastE in the Internet.

Koczanowicz, Leszek. (1997). "Memory of Politics and Politics of Memory: Reflections on the Construction of the Past in Post-totalitarian Poland." *Studies in East European Thought* 49: 259–270. The article concerns the democratic debate on the communist past in Poland that was carried on the basis of the two models of constructing the past. One was founded on Jaspers's theory of values; the other, dialogical one, conceived the past as the area to be socially negotiated.

Richta, Radovan. (1963). *Člověk a technika v revoluci našich dnů* [Man and technology in the revolution of our day]. Prague: Spolecnost pro síreni politických a vedeckých znalostí. This groundbreaking work did much to bring the concept of technology into the forefront of philosophical thought during the 1960s.

Skolimowski, Henryk. (1981). *Eco-philosophy: Designing New Tactics for Living*. Boston: M. Boyars.

Skolimowski, Henryk. (1992). *Living Philosophy: Eco-philosophy as a Tree of Life*. London and New York: Arkana. This and the preceding title represent two positions presenting basic principles of environmental ethics appealing to the attitude of deep caring about all segments of the surrounding world.

Szkudlarek, Tomasz. (1998). "Television as Adult Pedagogy: Learning Consumerism, Dreaming Democracy." In *Adult Education and Democratic Citizenship*, ed. Agnieszka Bron, John Field, and Ewa Kurantowicz. Kraków: IMPULS. The article provides an analysis of a monthly portion of the news and commercials blocks from Polish television. That case study shows tendencies in informational policy. Viewing contemporary education as the process of defining and re-defining individual and collective identities in constructing and re-constructing the social, the author points to the role media play in the process of production and understanding values.

Tjeldvoll, Arild. (1993). "Edukacja w Europie środkowo-wschodniej. Przemiany paradygmatu radykalno-strukturalistycznego na funkcjonalno-liberalny" [Education in Central-Eastern Europe. Transformation of a radical-structuralist paradigm into a functional-liberal one), trans A. Dąbrowska and B. Jarzynka. *Edukacja* [Education] 1993, no. 1, 13–33.

INTERNET RESOURCE

Slavonic and East European Review. Available at http://www.ingentaconnect.com/content/mhra/see/2004/00000082/00000003.

CFCS

SEE *Montreal Protocol*.

CHALLENGER ACCIDENT

SEE *Space Shuttle Challenger* and *Columbia* Accidents.

CHANGE AND DEVELOPMENT

• • •

Although it generally is acknowledged that change characterizes many aspects of human life and the larger world and is associated especially closely with science and technology and their influence on society, this phenomenon is not easy to define. One puzzling issue concerns how an object can be one thing, then change, and still remain the same object (that has undergone change). How should such a relationship, which implies both noncontinuity and continuity, be distinguished from replacement? A common response to is to argue that in change there is some development or growth: A thing has immanent within it a feature that over time (through change) is made manifest. The application of this biological notion to scientific, technological, economic, political, or ethical change remains fundamentally problematic and may best be approached through comparisons and in historical terms.

Enlightenment Origins: Change in Science as Progress

Early forms of the interrelated ideas of change and development were expressed in various instances of premodern (European and non-European) thought. Aristotle's *On Coming to Be and Passing Away* is the first systematic discussion of change. However, it was only in association with the scientific revolution of the 1600s and the Enlightenment of the 1700s that change became a theme for systematic articulation and gave rise to a concept of change as progress that has implications for science, technology, and ethics. The scientific revolution was understood by its proponents as a decisive progress in knowledge. Modern science claims as well as strives to represent a truer picture of nature than all previous sciences. In part, this knowledge depends on a more accurate understanding of development and change in the natural world.

The idea that human agency can be understood as social in origin and that all humans have the capacity to change their individual and collective destinies through the deployment of reason to combat tyranny, ignorance, superstition, and material deprivation was an important hallmark of European Enlightenment thinking. The notion that science can explain everything in nature, with the resulting knowledge being available to promote human progress, became the hallmark of modern rationalism and the social sciences. The first systematic compilation of scientific and technological knowledge to this end is contained in Denis Diderot's (1712–1784) *Encyclopédie* (1751–1772).

Armed with their ardent faith in the rationality of scientific methods and their ability to dissect and attack prevailing religious, social, political, and economic practices, many of the followers of the Enlightenment believed in and acted on the possibility of liberty, equality, and the pursuit of happiness for all humanity. Studies of the evolution of human societies gave rise to the notion of modernization as a way to change cultural patterns and social hierarchies and divisions.

The idea of progress through change became ingrained in intellectual thought and social and political action. Imaginative thinkers of modernization such as Auguste Comte (1798–1857), Henri Saint-Simon (1760–1825), and Robert Owen (1771–1858) claimed that the creative application of science and technology in industrial processes could unleash an economy of abundance that could bring an end to the pervasive poverty of the majority of the population in European societies. This progressive vision prevailed despite skepticism on the part of political economists such as Thomas Malthus (1766–1834) that poverty and want could not be eradicated because of unsupportable increases in the human population.

The Nineteenth Century and Beyond

The notion of society as organic in nature and societal progress as an evolutionary process became entrenched in modernization theory in the nineteenth century after the publication of Charles Darwin's (1809–1882) *On the Origin of Species* (1859). Karl Marx's (1818–1883) theorizing of civilizational development in teleological terms so that human history could be read as a dialectical process determined by the specific technological artifacts that are shaped by social forces and relations of production often was associated with Darwin's theory of evolution. Although Marx developed his views well before the *Origin of the Species* was published, Marx certainly thought that his views and Darwin's were compatible. However, the Darwinian theory of natural selection and "survival of the fittest" (a term coined by Herbert Spencer [1830–1903]) was used to justify "both a rugged economic individualism at home and a ruthless collective imperialism abroad" (McNeill 1963, p. 830).

Over the course of the 1800s the idea of progress became the basic ideology of scientific, technological, and economic change in Europe and North America. However, two basic theories about how to promote such progressive change emerged. One was that it was the result of spontaneous order arising from multiple individual sources, none of which has such order consciously in mind (as with Adam Smith's "invisible guiding hand" that operates in market economics); the other was that change requires some kind of central monitor to make sure it serves true human interests and thus becomes progress (by means of planning or some kind of social democratic control).

After World War II: Change as Development

The post–World War II idea of progress through science and technology beyond European and North American shores became the focus of modernization project. The extension of the notion of progress through science and technological industrialization to other nations and later into the colonies of imperial powers came to be known as development. Development as an autonomous practice within what is known as the Third World began in earnest after the World War II with the onset of decolonization. The modernization project implemented through different economic development models began in former colonies at the behest of the United Nations and the World Bank during the 1950s and afterward. The common denominator of those development models was modern technology, the rapid infusion of which was expected to materialize through its transfer from industrialized nations. The modernization project considered foreign aid in capital and technology to be vital for development.

The basic assumption of modernization projects is convergence, an important ontological premise of the Enlightenment: The world is on a Eurocentric path of economic and social change and democratic political dispensation; the West arrived there first, and the rest of the world is expected to catch up eventually. It is axiomatic in modernization theory that "traditional" societies can be transformed through a concerted project of economic development that can be achieved by changing the means of economic production by transforming archaic social structures that lack the incentives for and entrepreneurial spirit of rapid technological innovation. By formulating and implementing the "right" package of policies, the state and other agents of economic power can induce technological change, which is equated to a problem-solving activity. This minimalist, though very effective, model became the heuristic basis for economic development projects. However, this meta-model of modernization and the ensuing universalist narrative of change and development are being challenged by postcolonial and postmodern theorists and deep ecologists for various reasons.

It is important to note that beyond this pervasive notion of economic change and development, there are economists who believe that unleashing the invisible hands of free markets is the "natural" route to economic change and growth. Following this intellectual tradition from Adam Smith to Friedrich Hayek to Peter Bauer, they claim that progress comes from "spontaneous order," not from centrally planned rational design. One of the most influential development theorists of this genre was U.S. presidential adviser Walt W. Rostow (1956, 1960), who distinguished five states of development: (1) traditional society, (2) preconditions for takeoff, (3) takeoff, (4) drive to maturity, and (5) high mass consumption. In this schema, development started in Western Europe and then in North America and Japan and finally the winds of economic change reaches the developing world. It was such orthodox visions of development thinking that became the hallmark of development assistance spearheaded by the World Bank and other aid agencies, until more recently.

Unalloyed faith in scientific and technological knowledge as the most important resource for development was entrenched in all theories of modernization until the 1960s. It generally was agreed that more than capital and labor—the traditional factors of production—it was knowledge manifested as ideas, information, innovation, and technology that would increase productivity, and consequently, the income and wealth of nations.

Criticisms of the Model

However, the unprecedented material progress that the West had experienced as a result of advances in science and technology was challenged when the unintended consequences of controlling and using nature became apparent and problematic. Rachel Carson's (1962) *Silent Spring* brought public attention to the excesses of industrialization in the form of pollution and irreversible environmental changes. The moral qualms that many scientists and intellectuals felt about uncritically pushing the frontiers of scientific knowledge became a matter of serious ethical reflection on the uses and abuses of scientific research. The destruction of Hiroshima and Nagasaki by atom bombs and the invention of recombinant DNA technique added impetus to the notion that the creators of knowledge also bear ethical and moral responsibilities for the application of science and technology, which until that time was thought to be a force for good for all humans. Ulrich Beck (1998), employing a constructivist theoretical framework of self-reflexivity, claims that scientific and technological advances are leading to global risk societies.

The idea that the future of modern industrial civilizations is at risk if the manner and direction of industrialization and economic growth are not reformulated became an important point of discussion among many policy makers, scientists, and public intellectuals after the publication of the *Silent Spring* and the Club of Rome study titled *The Limits to Growth* (Meadows et al. 1972). Through a system-dynamics modeling of global production and consumption patterns, Meadows and associates claimed that the world would run out of food, minerals, and living space as a result of unsustainable population growth, industrialization, and pollution. The alleged inappropriateness of modern technology for the development of the Third World was forcefully argued by E. F. Schumacher (1973) in *Small Is Beautiful*.

Ironically, the advances in science and technology that originally had disproved Malthus's claim that unchecked human procreation would lead to pestilence and famine were presented by many modern neo-Malthusians as the new danger that humans faced. It is a fact that humans are confronted with global environment changes such as global warming, tropical deforestation, industrial pollution, and the proliferation of weapons of mass destruction. However, advances in science and technology are not the reasons for these problems, which are caused by the misuse of science and technology and the domination of the world by unenlightened political, religious, and economic ideologies.

Potential Answers

Advances in science and technology were able to unravel many of the myths of limits to growth and theories concerning unsustainable human population growth. Innovations in agriculture, industry, health, and habitat were shown to be capable of solving many of the problems of food scarcity, disease, and inhospitable living conditions. It became apparent that the difficulties faced by the world's poor are not a production problem any longer but are due to inequitable distribution of resources and denial of access to the opportunities for better living conditions as a result of failed development policies.

New information and communications technologies helped bring about the latest phase of economic, cultural, and political globalization. Recent advances in biotechnology, materials engineering, and communications and information technologies in tandem with globalization are promised to unleash a "new economy" that is predicted to bring prosperity and democracy to all people. However, the benefits of globalization may be a double-edged sword. Although untold wealth is created for a select few connected to the "network society," most people have not yet seen tangible benefits. The globalization of culture and the growth of economic markets are potent forces that threaten to complete the homogenization of cultures and the living patterns of many unique communities and social arrangements.

The ethical consequences of recent advances in molecular biology and genome science are predicted to be much more intractable than all earlier ethical questions concerning science and technology in the industrial age. Cloning, embryonic stem cell research, nanotechnology, biosynthesized and "intelligent" robots, bioengineered organs and tissues, and pervasive computing and human-computer interfaces are going to have a profound effect on the concept of what is "human." The increasingly tenuous divide that has existed between humans and nature will be removed forever. Because humans are now in a position to control their own evolution and because of the tenuous state of the idea of "human nature," the moral challenge will be to construct a collective "human identity" based on political notions such as equality, liberty, and the right to live a dignified life without fear, pain, hunger, and religious and political repression.

The "posthuman future" made possible by the coming biotech revolution (Fukuyama 2002) will allow people to construct the sort of "human essence" they want to preserve. However, questions of what exactly this "essence" is made up of and who can decide these issues and in what manner will be so complex and intractable that no advances in science and technology will be able to answer these questions.

Despite general skepticism in the industrialized countries that further advances in science and technology are the key to continued material well-being, the promise of modern science and technology to improve the material conditions poor people in the developing world is still largely unrealized. Advances in certain domains of science are still needed to conquer deadly diseases and improve the living conditions of billions of people. Unfortunately, funding for recent biomedical and biotechnological advances has been used to improve the dietary practices and treat the diseases that afflict rich people. Diseases such as malaria, tuberculosis, and AIDS that ravage hundreds of millions of poor people in the tropics have not yet received serious attention from the scientific establishment and funding agencies.

In a world riven by unfair social, political, and economic dispensations brought on by untenable religious and nationalistic prejudices in both the East and the West the only hope for a sane world is to rely on the critical rationality of modern science that many believers in the Enlightenment embraced. Science and technology face some crucial ethical dilemmas. Although there is no justification for funding scientific research and technological innovation to enhance the wealth of already rich people, many aspects of existing knowledge and technology could be deployed to liberate billions of people from poverty and deprivation.

Besides playing a direct instrumental role in advancing the material conditions of living, science and technology can be deployed to advance the cause of freedom that humans need to foster development and change. Scientific and technological knowledge is an important resource for advancing the cause of "development as freedom" (Sen 1999). Although scientific knowledge and technological artifacts have bestowed many good things on humanity and have paved the way for progressive change and development, they also have caused serious ethical dilemmas.

The idea behind change and development can be traced to the Enlightenment-driven notion of modernization, which entails two important principles. First, it favors the use of science and technology for human emancipation from wants and regressive social relations as well as inhospitable natural conditions. Second, it offers humans the possibility of becoming autonomous agents so that they can not only take charge of their own destinies but also self-consciously construct and change their identities.

GOVINDAN PARAYIL

SEE ALSO *Cultural Lag; Development Ethics; Progress; Sustainability and Sustainable Development.*

BIBLIOGRAPHY

Beck, Ulrich. (1998). *World Risk Society*. Malden, MA: Polity Press.

Carson, Rachel (1962). *Silent Spring*. Greenwhich, CT: Fawcett Crest Books.

Cowen, Michael P., and Robert W. Shenton. (1996). *Doctrines of Development*. London: Routledge.

Fukuyama, Francis. (2002). *Our Posthuman Future: Consequences of the Biotechnology Revolution*. London: Profile Books.

McNeill, William H. (1963). *The Rise of the West: A History of the Human Community*. New York: New American Library.

Meadows, Donella H.; Dennis I. Meadows; Jorgen Randers; and William W. Behrens III. (1972). *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind* London: Earth Island Ltd.

Mokyr, Joel. (1990). *The Lever of Riches: Technological Creativity and Economic Progress*. New York: Oxford University Press.

Parayil, Govindan. (1999). *Conceptualizing Technological Change: Theoretical and Empirical Explorations*. Lanham, MD: Rowman and Littlefield.

Parayil, Govindan. (2003). "Mapping Technological Trajectories of the Green Revolution and the Gene Revolution." *Research Policy* 32(6): 971–990.

Peet, Richard, with Elaine Hartwick. (1999). *Theories of Development*. New York: Guilford Press.

Rostow, Walt W. (1956). "The Take-Off into Self-Sustained Growth." *Economic Journal* 50(4): 150–200.

Rostow, Walt W. (1960). *The Stages of Economic Growth: A Non-Communist Manifesto*. New York: Cambridge University Press.

Rothschild, Emma. (2001). *Economic Sentiments: Adam Smith, Condorcet and the Enlightenment*. Cambridge, MA: Harvard University Press.

Schumacher, Ernst Friedrich. (1973). *Small is Beautiful: Economics as If People Mattered*. London: Blond & Briggs.

Sen, Amartya. (1999). *Development as Freedom*. New York: Anchor Books.

CHAOS

SEE *Complexity and Chaos*.

CHEMICAL WEAPONS

Chemical Weapons (CWs) constitute a major but often under appreciated ethical and political challenge for science and technology. The following entry examines this challenge by describing the character of CWs, the history of their use, and efforts of ethical and political control.

Chemical Weapons: What Are They?

Definitions of *chemical warfare* and *chemical weapon* have changed over time. History is replete with examples of chemicals being employed either to kill individuals, for example, murder or assassination, or larger numbers during warfare, such as the use of *Greek Fire* (a mixture of petroleum, pitch, sulfur, and resins) during at least two sieges of Constantinople (673 and 718 C.E.) However the twenty-first-century understanding of CWs is based on a better scientific appreciation of the underlying chemical and biological processes involved, which began to take shape during the nineteenth century.

Knowledge of how the toxic properties of chemicals could be employed as a method of warfare evolved in conjunction with the industrial and scientific infrastructure that brought about the large-scale production of chemicals. Such an infrastructure provided equipment, production protocols, and analytical techniques from the chemical industry and its research laboratories for CW purposes. Prior to such developments chemical warfare was essentially poisoning by persons who had little or no understanding of how such *weapons* functioned.

The internationally accepted definition of chemical weapons is that contained in the 1993 Chemical Weapons Convention (CWC), which states that such weapons consist of one or more of three elements: (a) toxic chemicals and their precursors (the chemicals used in the synthesis of the toxic chemicals) when intended for warfare; (b) munitions and devices specifically designed to cause harm or death through the use of such toxic chemicals; or (c) any equipment specifically designed to be used directly in connection with such chemicals, munitions, and devices.

Note the presence of a chemical in munitions does not automatically make them CWs. Weapons containing napalm and white phosphorus, for example, are not CWs because their primary effect depends on the incendiary properties of these chemicals and not their toxicity. The CWC definition of CWs contains a *general purpose criterion* (GPC) that bans the production and use of all toxic chemicals except for peaceful purposes.

The GPC is the principal mechanism by which technological and scientific developments can be taken into account by the Organisation for the Prohibition of Chemical Weapons (OPCW), which implements the CWC. The CWC definition of CWs is also phrased to ensure that bulk CW storage containers, and binary or other multi-component systems are covered by the convention.

Finally, toxins—the highly toxic chemical byproducts produced by certain types of living organisms—are covered by both the 1972 Biological and Toxin Weapons Convention (BTWC) and the CWC. Thus the use of a toxin as a *method of warfare* or for *hostile purposes* may be legally defined as both chemical and biological warfare.

Although CWs are, together with nuclear, biological, and radiological weapons, often referred to as *weapons of mass destruction,* they vary widely in terms of effect and lethality. While some CW agents are highly dangerous (i.e., toxic), others were developed to be used as incapacitatants (e.g., BZ or 3-quinuclydinyl benzilate, a hallucinogenic drug).

In terms of killing power, CW agents are not in the same category as nuclear weapons and some biological warfare agents. A fuel-air explosive, or thermobaric device, is generally more lethal (and predictable) than a comparable payload of CW agents. Comparisons are further complicated if one considers low-yield nuclear warheads, such as those being developed for use as part of deep-penetrating munitions, or *bunker busters*. Such weapons could be used in a manner that results in the deaths of only those people located inside a targeted, deeply buried and/or hardened facility.

Finally, LD50 (the amount of agent required to cause 50 percent of those targeted to die) figures do not reflect practical problems associated with the delivery to target of CW agents. The estimated amounts of agent required to effectively contaminate a given area help to illustrate such problems and, therefore, the actual threat posed to individuals by CW agents in the field.

Great attention has been given to the development of firing tables for various types of munitions and agents. For example, a U.S. Army manual estimates that approximately twenty-seven kilograms must be used to achieve a single casualty among protected troops. It has also been estimated that four metric tons of the organophosphorus nerve agent VX would be required to contaminate effectively a six-square-kilometer area. The equivalent figures for CWs employed in enclosed, urban areas, are generally somewhat lower. Additional uncertainties are caused by problems associated with extrapolating research data from various test animals to humans and extrapolating data involving the use of simulants, rather than actual CW agents, particularly in field tests.

CW agents may be divided according to their principal physiological effects: blister or vesicant, blood, choking, incapacitating, nerve, tear gas, and vomiting agents. Vesicants cause skin blisters and can cause severe damage to the eyes, throat, and lungs. Life-threatening infections in the trachea and lungs may result. Lewisite (L), nitrogen mustards (HN-1, HN-2, HN-3), sulfur mustard (H, HD), and phosgene oxime (CX) are examples of blister agents. Their primary purpose is to cause mass casualties requiring intensive, long-term treatment, rather than death. Those exposed may also suffer long-term health problems, such as cancer.

Blood agents, such as arsine (SA), cyanogen chloride (CK), and hydrogen cyanide (AC), inhibit cytochrome oxidase, an enzyme needed to allow oxygen to be transferred from the blood to body tissue and, in the case of significant exposure, rapidly become fatal.

Choking agents, such as chlorine, diphosgene (DP), and phosgene (CG), interfere with breathing. Phosgene and diphosgene interfere with transfer of oxygen via the lung's alveoli sacks. Symptoms of phosgene poisoning do not become apparent for several hours. In addition the chances for survival are a function of physical exertion. The more strenuously victims exert themselves physically after exposure, the more likely they are to die. Complete rest and oxygen treatment are recommended.

Incapacitating agents are designed to induce physical disability or mental disorientation. LSD (a form of lysergic acid) and BZ (3-quinuclidinyl benzilate) are two examples. The United States investigated the potential military uses of LSD. It also weaponized BZ, which can cause constipation, headaches, hallucinations, and a slowing of mental thought processes.

The principal nerve agents, sarin (GB), cyclosarin (GF), soman (GD), tabun (GA) and V-agents, are all organophosphorus compounds that inhibit an enzyme responsible for breaking down acetylcholine, a neurotransmitter. Nerve agents may be inhaled or absorbed through the skin. Symptoms include drooling, dilated pinhead pupils, headache, involuntary defecation, and a runny nose. Death is caused by cardiac arrest or respiratory failure.

Tear gases, such as chloroacetephenone (CN) and O-chlorobenzalmalonitrile (CS), cause irritation of the skin and uncontrolled tearing. Although these are designed to be used as non-lethal, riot control agents, their employment can result in death or injuries if improperly used in enclosed areas or for extended periods of time that results in high levels of exposure.

Although vomiting agents, such as adamsite (DM), diphenylchloroarsine (DA), and diphenylcyanoarsine (DC), have been used for riot control purposes, in the early twenty-first century they are generally considered too toxic for this purpose. All three agents have become obsolete as CWs against an opponent using modern protective equipment. Diphenylchloroarsine and diphenylcyanoarsine, which are in the form of a powder at normal ambient temperatures, were used as *mask breakers* during World War I and by the Japanese in China (1937–1945). The particles were able to penetrate the filters used at the time and could induce a soldier to break the seal of his mask allowing a more toxic agent such as phosgene to take effect. Diphenylchloroarsine and diphenylcyanoarsine were also mixed with sulfur mustard to lower the freezing temperature of the mustard and thus allow the mixture to be used at lower ambient temperatures.

History of Chemical Weapon Use

The first use of a chemical for lethal effect in modern times occurred on April 22, 1915, when the German army released approximately 180 tons of liquid chlorine at Ypres, Belgium, resulting in the deaths of an estimated 5,000 Algerian, Canadian, and French soldiers. The widest variety of chemical compounds developed and used on a large-scale are found among the CW agents produced during this conflict. At least forty different compounds were weaponized. But the most significant development was the production of sulfur mustard. This was first used at the second battle of Ypres in 1917 and, by the end of the war, had become known as the *king of war gases* due to the very large number of casualties resulting from its use. An estimated 1.45 billion shells were fired during the war, of which approximately 66 million contained CW-fill. Approximately 3,500 to 4,000 World War I-era shells were still being recovered annually in Europe during the 1990s, mostly in Belgium and France, of which about 10 to 20 percent are CWs.

Following the widespread use of CWs during World War I, countries with significant military capabilities or security concerns were compelled to consider threats that known or yet-to-be-discovered toxic chemicals might pose, particularly if delivered against vulnerable urban areas by aircraft (or balloons). During World War II, even larger stocks of CWs were produced and stockpiled than in World War I. Despite their widespread availability, however, CWs were, in general, not used during World War II. Most of the stockpiled CWs were either destroyed or disposed of by sea dumping at the end of the war. Their residue is the source of an old CW problem that continues to occur in a number of countries worldwide.

Military establishments have generally been reluctant to embrace chemical weapons, partly out of moral considerations. The use of CWs has generally gone against military codes of conduct. Their use was also generally viewed as an unnecessary complicating factor in military planning and practice operations. This was because of an inability to reliably predict lethal or casualty-causing effects. CW agents may quickly degrade or be dissipated by environmental factors such as rain, heat, and wind. Care must also be taken to ensure that the explosive charge for a CW munition can effectively disperse the agent, without destroying too much of the agent in the process. Aerosol platforms, mainly slow, low-flying aircraft, are also vulnerable to attack. Finally, modern protective clothing, if properly used and maintained, is generally effective against known CW agents.

There have been allegations of the use of CWs during most major armed conflicts in the twentieth century. Many allegations are unproven and appear to be false. This is partly due to deliberate misinformation, information indicating that an opponent possesses CWs or is pursuing a CW program, and the fact that participants may mistake toxic fumes generated during battle as CWs (for instance, fumes generated from the detonation of high explosives). From the early 1980s to the early 1990s, the United Nations Secretary-General investigated allegations of the use of chemical and biological weapon agents in Africa, Armenia, Iran, Iraq, and southeast Asia. The authority of the Secretary-General remains in effect. However if the alleged use were with CWs, the CWC would almost certainly take legal precedence. As previously noted, however, toxins are covered by both the BTWC and the CWC.

CW agents were used by British forces intervening in Russia's Civil War in 1919 (for example, adamsite), by Spain in Morocco in 1924 to 1927 (sulfur mustard), by Italian forces in Abyssinia in 1935 to 1940 (sulfur mustard, phosgene, phenyldichlorarsine), by Japanese forces in Manchuria in 1937 to 1945 (lewisite, diphenyl cyanoarsine, sulfur mustard), by Egypt in the Yemen civil war in 1963 to 1967 (sulfur mustard and phosgene), and by Iraq against Iran in 1982 to 1988 (cyclosarin, sulfur mustard, sarin, and tabun). The use of tear gas by U.S. forces as part of combat operations in Vietnam (to clear tunnel systems, for example) is also generally considered to be an instance of chemical warfare. The CWC forbids the use of riot control agents as a method of warfare. The use of tear gases as part of combat operations is therefore prohibited.

During the Iran-Iraq War (1980–1988), Iraq used CWs, including sulfur mustard and nerve agents (cyclosarin, sarin, tabun) extensively against Iran and its own Kurdish population. Although allegations have been made that Iran used CWs against Iraq, they have not been conclusively proven. By contrast, investigative teams sent to the region during the war by the U.N. Secretary-General conclusively proved Iraqi use of CWs. Iran is a party to the CWC and has declared a past production capability, but has not declared a CW stockpile.

Following the 1991 Persian Gulf War, the U.N. Security Council adopted resolution 687 of 1991 which, *inter alia,* required Iraq to end its CW program and destroy its CW stockpiles. The resolution also established the U.N. Special Commission on Iraq (UNSCOM) to verify the destruction and dismantlement of prohibited weapons and associated programs. (The International Atomic Energy Agency, or IAEA, was given primary responsibility for overseeing the nuclear weapon disarmament of the country.) The principal CW agents produced by Iraq were cyclosarin, sarin, sulfur mustard, and tabun, while the main unresolved CW issue was the nature and extent of Iraq's VX program. Iraq claimed that it had never weaponized VX and had only produced limited, pilot plant-scale quantities of the agent (2–3 metric tons of poor quality material). UNSCOM disputed this claim. UNSCOM inspectors left Iraq in late 1998, as a consequence of a dispute partly based on whether UNSCOM inspectors should be allowed unrestricted access to so-called presidential sites, with the VX issue still unresolved. In December 1999, UNSCOM was replaced by the United Nations Monitoring, Verification and Inspection Commission (UNMOVIC) (U.N. Security Council resolution 1284 of 1999). UNMOVIC conducted its first inspections of Iraq on November 27, 2002, partly under the terms of UN Security Council resolution 1441 of 2002, which deplored Iraq's failure to fully disclose all aspects of its prohibited programs, including with respect to CWs. In describing the nature of Iraqi cooperation with UNMOVIC inspectors, the UNMOVIC Executive Chairman made a distinction between *substance* and *process*. While Iraq did provide immediate access to all requested sites, its active and full cooperation was questioned. Another major unresolved CW issue was the failure by Iraq to account for approximately 6,500 munitions filled with about 1,000 metric tons of chemical agent. As of September 10, 2003, there were no reports of any CWs having been recovered by the U.S.-U.K.-led coalition forces that entered Iraq in March 2003.

The most significant use of CWs by a non-state actor was carried out by the Japanese-based religious cult Aum Shinrikyo. The first major lethal attack occurred in June 1994 when cult members vented sarin vapor from a specially modified van at night in Matsumoto, Japan, outside the homes of three judges who were then involved in a legal case involving the organization. Seven people died and approximately 300 were injured as a result. The incident was not immediately recognized as a CW attack and the police investigation was indecisive and poorly coordinated.

The second attack occurred in March 1995 when group members released sarin in the Tokyo subway. As a result, twelve people died, while approximately 500 people required medical attention or hospitalization. Approximately 5,500 people were examined. In this case, the means of attack and the identity of the perpetrators were quickly determined and the police carried out mass arrests and widespread searches of properties owned by the cult.

At the time, the group had assets worth an estimated 1 billion U.S. dollars. A number of cult members had masters and doctorate degrees in the natural sciences, including chemistry. Despite these factors, Aum Shinrikyo technical ability in creating chemical (and biological) warfare agents was limited. The sarin produced, for example, was unstable and of low purity. Safety precautions during testing and production were poor and a number of cult members were poisoned as a result. In 2004 the cult's founder and head, Chizuo

Matsumoto (a.k.a. "Shoko Asahara" or "bright light"), was sentenced to death.

Attempt at Ethical and Political Control

Agreements regarding CWs include the International Declaration Concerning the Laws and Customs of War (Brussels Conference, 1874); the Acts signed at the First International Peace Conference, Annex to the Convention (The Hague 1899); the Acts signed at the Second International Peace Conference, Annex to the Convention (The Hague 1907); the Treaty of Peace with Germany (also known as the Treaty of Versailles 1919); and the Treaty of Washington of 1922 Relating to the Use of Submarines and Noxious Gases in Warfare (Washington, DC 1922).

A more significant international legal instrument was the Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare, the well-known Geneva Protocol of 1925. The Geneva Protocol did not, however, prevent the stockpiling of CWs and many of the major powers attached conditions to their instruments of ratification (such as, that a state would not consider itself bound by treaty obligations if first attacked with CWs or if involved in a military conflict with states not party to the Protocol or military coalitions which included one or more states not Party to the Protocol).

Since 1993, however, the main international legal instrument dealing with CWs is the CWC. Treaty negotiations began in 1968 within the framework of the U.N. Eighteen-Nation Committee on Disarmament (the present-day Conference on Disarmament).

The CWC is implemented by the OPCW, based in The Hague, Netherlands. The OPCW consists of three parts: The Conference of the States Parties (CSP), the Executive Council (EC), and the Technical Secretariat (TS). The CSP is composed of all member states. It is the highest decision-making body and meets in regular session once each year. The EC is a representative body composed of forty-one members that represent five regional groups (Africa, Asia, Eastern Europe, Latin America and the Caribbean), and Western Europe and other states. Its main task is to oversee operational aspects of treaty implementation. It meets in regular session three to four times each year. Special sessions of the CSP and EC may be convened if a request (made by one or more parties) to convene is supported by at least one-third of the members. A special session of the EC would be convened, for example, if CWs were used. The TS is responsible for the practical implementation of the OPCW, including the processing of annual declarations submitted to the OPCW by the parties and the carrying out of on-site inspections. It has a staff of approximately 485, including about 200 inspectors. The OPCW's budget for 2003 was 68,562,966 euros.

As of July 7, 2003, 153 countries had ratified or acceded to the CWC, while twenty-five countries had signed but not ratified the convention and sixteen countries had neither signed nor ratified the convention. The OPCW's budget for 2004 was 73,153,390 euros. As of March 31, 2004, 161 countries had acceded to the CWC, while twenty countries had signed but not acceded the convention and twelve countries had neither signed nor acceded to the convention. Most of the non-member states are located in Africa or the Middle East, including Iraq, Israel, Egypt, and Syria. Many Arab countries have linked their accession to the CWC to Israel's becoming party to the 1972 Non-Proliferation Treaty (in doing so, Israel would have to demonstrate that it does not possess nuclear weapons). India, Iran, and Pakistan are parties to the CWC.

There are three principal types of inspections under the CWC: routine inspections, challenge inspections, and investigations of alleged use of CWs. CW-related facilities, including CW destruction facilities and facilities that use small quantities of agent for protective purposes, must be declared and are subject to routine on-site inspections. Part of the chemical industry, which processes, produces, or consumes certain chemicals above certain thresholds must also be declared and are subject to inspection. Thus far there have been no challenge inspections or investigations of alleged CW use. The CWC regime has provided a forum in which the parties can consider the contents of each others' declarations and pursue informally further clarification through informal consultations.

The CWC requires that all state parties declare whether they have produced CWs at any time since January 1, 1946. As of March 2004, twelve parties (Bosnia and Herzegovina, China, France, India, Iran, Japan, Libya, South Korea, Russia, the United Kingdom, the United States, and the former Yugoslavia (now Serbia and Montenegro) had declared sixty-four CW production facilities or sites. As of the same date ten parties (Australia, Belgium, Canada, France, Germany, Italy, Japan, Slovenia, the United Kingdom, and the United States) had declared possessing *old* CWs (defined as CWs produced before 1925, or between 1925 and January 1, 1946, and which have been determined not to be usable) and three parties (China, Italy and Panama) have declared having *abandoned* CWs (defined as CWs abandoned by a state on the territory of another state without the permission of the latter).

The CWC is a cooperative regime designed to allow member states to demonstrate their treaty compliance to each other. For such inspections to be completely successful, inspected states must cooperate. If they do not, inspectors should nevertheless be able to acquire some useful information or results. At a minimum, the inspection should serve to provide sufficient information to enable the EC and CSP to formally decide on issues of compliance (for instance, non-cooperation). Under the terms of the CWC, inspected parties may invoke *managed access* provisions to protect sensitive information, including sensitive information about its chemical industry and information sensitive for national security reasons. The burden of satisfying the compliance concern nevertheless lies with the inspected party.

UNSCOM and UNMOVIC, by contrast, were provided mandates that were established as part of an agreement to end military hostilities between Iraq and U.N.-sanctioned, international coalition forces. As such UNSCOM and UNMOVIC were to be provided with unrestricted, immediate access to all requested sites. Their work was also backed by the implicit (or explicit) threat of military action and economic sanctions. If a case of continued, fundamental non-compliance with the CWC were to occur, the OPCW would refer the matter to the U.N. Security Council and U.N. General Assembly for their consideration and action.

Current and Future Trends and Challenges

In the early twenty-first century there is an increased emphasis on ensuring that non-state actors, such as terrorist groups, do not acquire or use CWs. Much of this effort is of a law enforcement or intelligence nature and thus classified or otherwise not openly discussed. There has also been an increased emphasis on harmonizing and strengthening export control regulations and preparing emergency response and management. This is reflected in increased efforts by the OPCW to achieve better uniformity in the collection and reporting of information to the organization, including on the transfers of certain chemicals that appear in the CWC Annex on Chemicals. The OPCW is also implementing a "plan of action" to ensure that the parties have established effective national implementing legislation. The plan has the active political support and engagement of the members.

A number of factors complicate the confirmation or verification of non-production of CWs in chemical industry facilities. In the late twentieth and early twenty-first centuries there was a shift in the size and flexibility of many chemical industry facilities, away from big (e.g., petrochemical) plants that produce large volumes of a limited number of chemicals using a dedicated production method and toward small facilities capable of manufacturing a wide variety of specialized chemicals to order on short notice using smaller, less polluting and more easily reconfigured equipment for different productions routes.

Twenty-first century scientific capabilities also caused a blurring of the distinction between *chemical* and *biological* processes. Many biological substances that could not previously be synthetically manufactured may be *chemically engineered* through such advanced technology. Most biological warfare agents could, in fact, be viewed as chemicals because their action is biochemical in nature and because the derivation of many biological agents involves manufacturing processes—as opposed, for example, to the extraction of substances from naturally occurring organisms. Finally, the manner in which new toxic chemicals are developed and synthesized has been revolutionized through, for example, advances in combinatorial and computational chemistry and microarray processing technologies.

Complete security against CWs will not be achieved. In view of human, financial, and other resource limitations, the approach taken to identify and respond to possible risks posed by CWs should be carefully considered and balanced. The effectiveness of national and international laws against the development and use of CWs is dependent on the amount of attention and resources countries elect to devote to the matter. Any decisions taken with regard to protecting against CWs should be based on the recommendations and experience of CW technical specialists.

JOHN HART

SEE ALSO *Biological Weapons; Just War; Military Ethics; Terrorism; Weapons of Mass Destruction.*

BIBLIOGRAPHY

Dando, Malcolm. (2001). *The New Biological Weapons: Threat, Proliferation, and Control.* Boulder, CO; Lynne Rienner.

Sidell, Frederick R.; Ernest T. Takafuji; and David Franz, eds. (1997). *Medical Aspects of Chemical and Biological Warfare.* Washington, DC: Borden Institute.

Lundin, S. Johan, ed. (1988). *Non-Production by Industry of Chemical-Warfare Agents: Technical Verification under a Chemical Weapons Convention*. Oxford: Oxford University Press.

Lundin, S. Johan, ed. (1991). *Verification of Dual-Use Chemicals under the Chemical Weapons Convention: The Case of Thiodiglycol*. Oxford: Oxford University Press.

Pechura, Constance M., and David P. Rall, eds. (1993). *Veterans at Risk: The Health Effects of Mustard Gas and Lewisite*. Washington, DC: National Academy Press.

Stockholm International Peace Research Institute. (1971–1975). *The Problem of Chemical and Biological Warfare*. 6 vols. Stockholm: Almqvist & Wiksell.

Trapp, Ralf. (1993). *Verification under the Chemical Weapons Convention: On-Site Inspection in Chemical Industry Facilities*. Oxford: Oxford University Press.

Tu, Anthony T. (2002). *Chemical Terrorism: Horrors in Tokyo Subway and Matsumoto City*. Fort Collins, CO: Alaken, Inc.

INTERNET RESOURCES

Organisation for the Prohibition of Chemical Weapons. Available from http://www.opcw.org.

United Nations Monitoring, Verification and Inspection Commission. (2003). "Unresolved Disarmament Issues: Iraq's Proscribed Weapons Programmes." UNMOVIC working document. Available from http://www.unmovic.org under heading "Cluster Document."

CHEMISTRY

After physics, chemistry is often considered the paradigmatic modern science. The ethical issues associated with chemistry and chemical technologies have nevertheless been more diffuse and less systematically identified than those related to either physics or biology, although the ethical issues associated with chemistry—from worker and consumer safety to environmental pollution, in both public and private contexts, in peace and war—are as broadly present in daily life as those in any other science. The very proliferation of chemistry into analytical chemistry, biochemistry, geochemistry, inorganic and organic chemistry, physical chemistry—not to mention atmospheric, computational, electro-, polymer, and other forms of chemistry—emphasizes the ubiquitousness of this particular science, its technological dimensions, and thus its range of potential ethical and political engagements.

Historical Emergence

The history of chemistry may be divided into three periods: (1) alchemy (from the beginnings of Muslim and Christian knowledge of the subject until the seventeenth century), (2) classical modern chemistry (from the middle of the seventeenth century until the middle of the nineteenth), and (3) theory-based chemistry (twentieth and twenty-first centuries). According to such interpreters as Mircea Eliade and Carl Jung, alchemy was as much a psychological or spiritual practice as a physical one, involving more esoteric religious discipline than a positive science. But at the beginning of the thirteenth century, alchemists such as Roger Bacon, Albertus Magnus, and Ramon Llull, in association with the late medieval desacralization of nature, argued for an ethical shift toward the discovery of new methods and products that had this-worldly value. Thus, the Swiss Theophrastus Bombastus von Hohenheim (known as Paracelsus) dedicated his alchemical labors to the cure of sicknesses. According to him, salt, sulfur, and mercury in adequate proportions were a fountain of health for the human organism (the beginning of medical chemistry).

Standing at the transition from alchemy to chemistry as a positive science is the work of Robert Boyle (1627–1691). In *The Sceptical Chymist* he formulated the modern definition of an element as a substance that cannot be separated into simpler substances, and argued for empirical experimentation as well as the public sharing of scientific knowledge in ways that still define the scientific method. Yet he was a devout if dissenting Christian who saw his scientific studies as an extension of his spiritual life. Boyle also helped found the Royal Society (officially chartered in 1662).

The great positive achievement of the classical modern period in chemistry, and one that became the basis for its transformation into a more theory-based science, was the periodic table. While the Frenchman Antoine-Laurent Lavoisier (1743–1794) advanced the understanding of chemical reactions, the Englishman John Dalton (1766–1844) developed atomic theory, and the Italian Amedeo Avogadro (1776–1856) analyzed relations between molecules and conditions of temperature and pressure (Avogadro's law)—thus creating an international republic of science with a distinctly if unspoken ethical structure. As empirical data accumulated about the properties of various substances, chemists began to consider schemas for classification according to their periodicity. The first was published in 1862, according to which properties repeated with each seven chemicals.

But the initial table mistakenly included some compounds among the elements, and it was the Russian Dmitri Mendeleyev (1834–1907) who created the periodic table as we now know it. Mendeleyev discovered patterns in the properties and atomic weights of halogens and some alkaline metals, similarities in such series as those of chlorine-potassium-calcium (Cl-K-Ca) and iodine-cesium-barium (I-Cs-Ba), and organized the elements according to chemical characteristics and physical properties in order of ascending atomic weight, as published in *On the Relationship of the Properties of the Elements to Their Atomic Weights* (1869).

Nevertheless, no one had yet definitively determined some atomic weights, which caused a few errors. Mendeleyev discovered he had to resituate seventeen elements according to their properties and ignore previously given atomic weights. Furthermore, he left spaces for possible new elements, given that none of those yet identified suited the properties assigned to those spaces. He thus predicted the existence of new elements such as aluminum, boron, and silicon—ten in all, of which seven were eventually confirmed.

The periodic table prepared the way for major advances in both chemical theory and practice. With regard to theory, in the early twentieth century Linus Pauling (1901–1994) employed quantum mechanics to conceptualize subatomic structures at the foundation of the orders reflected in the periodic table. This theoretical achievement at once enhanced the control of chemical processes and increased the ability to design new compounds. With regard to practice, the periodic table effectively predicted the possibility of a whole series of transuranic elements that were experimentally created by Glenn Seaborg (1912–1999). In both instances these newfound powers raised ethical and public policy questions that have been further promoted by the interdisciplinary expansion of chemistry into engineering and biology.

Industrial Chemistry and War

Starting in the eighteenth century—even prior to its theoretical enhancement—chemistry more than any other science contributed to industrial development. Just as Lavoisier is considered a founder of classic modern chemistry as a positive science, his contemporary, Nicolas Leblanc (1742–1806), who developed a process for obtaining soda (sodium carbonate) from sea salt, is credited with founding industrial chemistry. Before Leblanc France depended on foreign imports for the sodium carbonate central to its glass, soap, paper, and related industries. Leblanc's alternative, subsequently improved by the Belgian Ernest Solvay (1838–1922), was thus a major contribution to French industrial independence.

After sodium carbonate, the development of industries to produce nitrogen and fertilizers dominated applied chemical research during the nineteenth century. As contributors to such achievements, the Englishman Humphry Davy (1778–1829) and the German Justus von Liebig (1803–1873) illustrate a special combination of humanitarianism and nationalism. Davy, for instance, along with pioneering work in electrochemistry, invented the miner's safety lamp and promoted improvements in the British agricultural, tanning, and mineralogical industries. Liebig, as a professor of chemistry, pioneered the laboratory as a method of instruction and helped make Germany the world leader in chemical education and research. He also virtually created the field of organic chemistry, which he applied especially to increase German agricultural productivity.

In another contribution to industrial chemistry, the Swedish chemist Alfred Nobel stabilized nitroglycerin in 1866 to make possible the fabrication of new and powerful explosives for military use. Such fabrication, along with the "dye wars" of the late nineteenth and early twentieth centuries, intensified relations between chemistry and national interests, which in turn challenged chemists to reflect on their ethical obligations. It was certainly some such reflection that led Nobel to use the profits from his own chemical industries to establish prizes in honor of "those who, during the preceding year, shall have conferred the greatest benefit to mankind" in the areas of physics, chemistry, physiology or medicine, literature, and peace.

At the Second Battle of Ypres, France (now Belgium), in April 1915, the negative potential of chemistry was nevertheless manifest as never before when chlorine gas was employed for the first time in "chemical warfare." (The term is somewhat anomalous, because gunpowder and all explosives are also chemical products.) In this the physical chemist Fritz Haber (1868–1934) provides a provocative case study. Having previously succeeded in developing a means for synthesizing ammonia from atmospheric nitrogen and hydrogen for industrial and agricultural uses, Haber at the outbreak of World War I placed his laboratory in service of the German government and worked to advance the national cause. One result was his advocacy for the use of chlorine gas at Ypres. But after the war, even though he was awarded the Nobel Prize in chemistry for his prewar work on ammonia synthesis, he remained isolated from the international scientific community. Feeling responsible for the German war debt, he even tried to develop a process to extract gold from seawater. But when Adolf Hitler came to power

Haber's Jewish heritage forced him to flee the country, and he died in exile.

Another feature of industrial chemistry was the creation of large-scale corporations. National efforts to promote self-sufficiency in various chemicals contributed first to overproduction in such basics as fertilizers and dyes, and then to a series of national mergers and consolidations: This produced IG Farben in Germany in 1925 (creating the largest chemical manufacturer in the world), Imperial Chemical Industries (ICI) in England in 1926, and a DuPont–ICI alliance in the United States in 1929. The chemical industry as much as any other anticipated the kind of competition and transnational relations characteristic of the dynamics of globalization—which likewise presents special ethical challenges.

The Chemical World

Despite its contributions to warfare, the primary connotation for chemistry has been, in the words of the long-time DuPont slogan (1939–1999), "Better Things for Better Living . . . through Chemistry" (the "through chemistry" was dropped in the 1980s). This vision of chemistry as a primary contributor to better living rests on the creation of a host of substitutes for traditional goods and the creation of new ones. Among substitutes, the most prominent have included first synthetic dyes and then synthetic rubber.

Among new products, plastics and pharmaceutical drugs have played major roles. Synthetic rubber and plastics are outgrowths of the huge development of polymer chemistry and discoveries of ways to use petroleum to create multiple enhancements of or substitutes for traditional materials: Formica (1910s) for wood and stone, Bakelite (patented 1907, but not widely used until the 1920s) for wood and glass, nylon (1930s) for fiber, and more. Complementing a wealth of pharmaceuticals are cosmetics, cleaning compounds, lubricants, and pesticides. From the 1960s there eventually emerged green or environmental chemistry and industrial ecology, with the concept of sustainability coming to play a significant role in chemical research and development. From the 1970s on, research and development also turned toward the design of functional materials, that is, materials fabricated according to the necessities of specific industrial sectors: reinforced plastics for the aerospace, electronics, and automobile industries; silicon for information technology hardware; and more.

In recognition of the chemical world and its pervasive transformation of the world, the American Chemical Society (ACS, founded 1876) undertook in the 1980s to publish a new kind of high school textbook, *Chemistry in the Community* (1988). Through this project professional chemists sought to communicate to those students who were not likely to become science majors some of the lifeworld significance of modern chemistry. The book was thus structured around community issues that had a significant chemical component more than around basic concepts and principles in chemistry itself. It was an effort to exercise professional responsibility in educating the public about the chemical world in which everyone now lived.

Ethical Issues and Responses

Against this historical profile one can identify two distinct chemistry-related ethical issues: those associated with military use and those related to commercial development—that is, the introduction into the world of increasing numbers of chemical compounds not otherwise found there. It is also possible to distinguish two kinds of response: institutional and individual.

With regard to military use, the institutional response has been the practice of military deterrence and development of a chemical weapons convention. The World War I use of chemical weapons was followed by the World War II avoidance of chemical weapons, no doubt in part because possession by all parties led to deterrence. The most dramatic use of chemical weapons since has been by what are sometimes called "rogue states" such as Iraq in the 1980s. The Chemical Weapons Convention (CWC) that entered into force in 1997 is implemented by the Organization for the Prohibition of Chemical Weapons located in The Hague, Netherlands. CWC state party signatories agree to ban the production, acquisition, stockpiling, transfer, and use of chemical weapons.

At the individual level, some activist organizations of scientists such as the Federation of American Scientists or International Pugwash have lobbied for limitations on the development and proliferation of chemical weapons, and in some instances called on chemical scientists and engineers to exercise professional responsibilities by not contributing to related research and development projects. One issue that has not been extensively addressed at either the institutional or individual level, although it has been discussed among scientific professionals concerned with professional responsibility, is the development of nonlethal chemical weapons, that is, weapons that do not kill but only incapacitate.

With regard to the commercial proliferation of chemicals, many governments have development institutional mechanisms for the assessment and regulation of chemicals consumed directly by the public or introduced more generally into the environment. One good example comes from the European Union (EU). According to a regulatory regime established in 1981 (Directive 67/548) all new chemicals manufactured in amounts of 10 kilograms or more must be registered and tested for health and environmental risks, but the more than 100,000 substances on the market at that time were exempted from this process. Because of testing expenses, this meant that innovation and chemical replacement was discouraged, in many instances leaving known dangerous chemicals in place.

In response the EU has proposed a policy reform called the Registration, Evaluation, and Authorisation of Chemicals (REACH) system. Under the new REACH regulatory regime, the manufacture or importation of any chemical in the amount of 1 metric ton or more must be registered in a central database. The registration must include relevant information regarding properties, uses, and safe handling procedures, with a new European Chemicals Agency being charged to review the database and to supplement existing data with other relevant information. No testing is required in the absence of suspected health or environmental dangers. (It may be noted that there is no similar regulatory process in the United States. In fact the U.S. government, along with U.S. chemical producers, have lobbied against REACH, which they argue will negatively affect most goods exported to the EU.)

At the international level, in 2000 negotiations were completed on the Stockholm Convention on Persistent Organic Pollutants (POPs). With 122 negotiating countries represented, the POPs treaty aims to eliminate or severely restrict production and use of nine pesticides, polychlorinated biphenyls (PCBs), and their by-products. The treaty also requires national action plans for its implementation as well as the management and reduction of chemical wastes, while providing funding for the participation of developing countries. According to POPs, trade in the covered chemicals is allowed only for purposes of environmentally sound disposal or in other limited circumstances. The "dirty dozen" substances covered by the treaty are aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, hexachlorobenzene (HCB), mirex, toxaphene, PCBs and their by-products, dioxins, and furans. The treaty includes methods to add new chemicals. Although signed in May 2001, as of 2005 the treaty awaits ratification in the U.S. Senate. Also relevant in the international context is the Globally Harmonized System for chemical classification and labeling that was adopted by Agenda 21 (1992) and is administered by the United Nations Economic Commission for Europe.

At the same time, the pernicious consequences of some chemical substances has led to the creation of a nongovernmental program called Responsible Care, initiated in 1985 by the Canadian Chemical Producers Association and then adopted three years later by the American Chemistry Council (then called the Chemical Manufacturers Association). In 1990 it was also adopted by the Synthetic Organic Chemical Manufacturers Association. Responsible Care is an industry-administered program to certify company compliance with management standards that promote reduced emissions, worker safety, industrial security, product stewardship, public accountability, and research and development. Internationally, Responsible Care is administered by the Brussels-based International Council of Chemical Associations. One stimulus to the creation of the Responsible Care program was no doubt the 1984 chemical accident in Bhopal, India.

One other individual initiative is that of the professional codes of ethics developed by chemists. As a pioneer, the American Chemical Society requires that all professional chemists recognize their obligations to the public, to colleagues, and to science. Building on its federal charter (1937) and "The Chemist's Creed" (1965), the current "Chemist's Code of Conduct" (1994) itemizes nine basic responsibilities to the public, chemistry itself, the profession, employers, employees, students, associates, clients, and the environment. More specifically, with regard to the profession, chemists must strive for the responsible recording and reporting of scientific data, be aware of conflicts of interest and handle them properly, and avoid ethical misconduct defined as fabrication, falsification, and plagiarism. With regard to the public, chemists have obligations both "to serve the public interest and welfare and to further knowledge of science." Indeed, with regard to science, chemists should assure that their work is "thorough, accurate, and . . . unbiased in design, implementation, and presentation."

The STS of Chemistry

The self-presentation of chemistry in its code of conduct and in its work of public education nevertheless raises some more general ethical and public policy issues. Insofar as the chemistry community might take applying chemistry and public science education as the primary ways to serve the public interest, a science, technology, and society (STS) assessment, with chemistry as the leading science, would be appropriate. STS studies in general have highlighted the importance of citizen participation in science and technology decision-making and of public debate appealing to science and technology. One framework that promotes recognition of such interactions is the concept of "post-normal science," defined as issue-driven science in which facts are uncertain, values disputed, but decisions urgent (Funtowicz and Ravetz 1990). Post-normal science calls for broader public education, of a conceptual and philosophical as well as an ethical sort, to manage the science–civil society relationship. In this sense the *Chemistry in the Community* model, with its stress on public problems related to chemistry, is insufficient.

From a philosophical, historical, and chemical education perspective, however, there exists a different but complementary agenda. The philosophy of chemistry, understood as a subdiscipline of the philosophy of science, has been taking shape since the mid-1980s (van Brakel 2000). Its agenda, dominated by the question of whether chemistry can be reduced to physics, has been enlarged to included classic conceptual issues in the philosophy of science (the character of representations and the structure of laws and explanations) as well as debates about ethical, aesthetic, and even sociocultural implications of chemistry. The principal periodicals dealing with such discussions are *Hyle: International Journal for Philosophy of Chemistry* (1995–present) and *Foundations of Chemistry: Philosophical, Historical, Educational, and Interdisciplinary Studies of Chemistry* (1999–present), the latter being the journal of the International Society for the Philosophy of Chemistry. Also relevant are some issues from the early 2000s (for instance, the Vol. 81, numbers 6 and 9 [2004], and the Vol. 82, number 2 [2005]) of the much older issues of the much older *Journal of Chemical Education* (1924–present).

In *Hyle* especially analyses of ethical issues have transcended particular chemical results in order to address questions that underlie all debates about regulation, responsible management, professional codes, or individual conduct. The ethics of chemistry includes questions concerning relations between the chemical community and society—that is, the importance of the particular values of chemists as such and their relation to general social values. This fundamental question can be approached from two directions: one being that of the professional community, the other being that of society. The former treats issues such as the status of the professional codes of conduct of chemical societies, the relation of a putative moral ideal to the specific ethical norms of chemistry, the moral or amoral character of chemical research, and the links that can be found between methodological values and moral values. The latter asks whether chemists have specific kinds of responsibility and duties to the society, or society any responsibility to the science of chemistry. It reflects on what lessons if any might be drawn from the positive and negative effects of chemical research (drugs, increased economic development, weapons, pollution). The responses from both perspectives will, of course, have implications for how the ethics of chemistry should be included within university curricula: as part of the methods of the science, as a technological application, or as a societal framework.

JUAN BAUTISTA BENGOETXEA
TRANSLATED BY JAMES A. LYNCH

SEE ALSO *Chemical Weapons; Environmental Ethics.*

BIBLIOGRAPHY

American Chemical Society. (1988). *Chemistry in the Community*. Dubuque, IA: Kendall/Hunt. 2nd edition, 1993. 3rd edition, 1998. 4th edition, New York: Freeman, 2002. A high-school level textbook structured around community issues related to chemistry rather than chemical concepts.

American Chemical Society. (1994). *Chemistry in Context: Applying Chemistry to Society*. Dubuque, IA: William C. Brown. 2nd edition, 1997. 3rd edition, Boston: McGraw-Hill, 2000. 4th edition, 2003. This is the college-level offspring of *Chemistry in the Community*.

Bensaude-Vincent, Bernadette, and Isabelle Stengers. (1996). *A History of Chemistry*, trans. Deborah van Dam. Cambridge, MA: Harvard University Press. A social and cultural history, originally published, 1993.

Eliade, Mircea. (1971). *The Forge and the Crucible: The Origins and Structures of Alchemy*, trans. Stephen Corrin. New York: Harper and Row. Originally published, 1956.

Funtowicz, Silvio O., and Jerome R. Ravetz. (1990). *Uncertainty and Quality in Science for Policy*. Dordrecht, Netherlands: Kluwer Academic.

Meyer-Thurow, Georg. (1982). "The Industrialization of Invention: A Case Study from the German Chemical Industry." *Isis* 73(268): 363–381.

Schummer, Joachim, ed. (2001). "Ethics of Chemistry." Special issue, *Hyle* 7(2): 83–167. Includes five articles on "Ethics and Science" (Giuseppe Del Re), "Ethics of Chemical Synthesis" (Joachim Schummer), "Handling Proliferation" (Pierre Laszlo), "Gifts and Commodities in Chemistry" (Jeffrey Kovac), and "The Technological Transfer Dilemma" (Brian P. Coppola). A second special issue, from 2002, on the same theme, *Hyle* 8(1): 3–48, includes three more articles: "'Pathological Science' Is Not Scientific Misconduct (Nor Is It Pathological)" (Henry H. Bauer), "Do the Professional Ethics of Chemists and Engineers Differ?" (Michael Davis), and "The Future of Tertiary Chemical Education: A *Bildung* Focus?" (Kathrine K. Eriksen).

van Brakel, Jaap. (2000). *Philosophy of Chemistry*. Leuven, Belgium: Leuven University Press.

INTERNET RESOURCES

American Chemical Society. Available at http://www.chemistry.org.

Globally Harmonized System of Classification and Labeling of Chemicals (GHS). Available at http://www.unece.org/trans/danger/publi/ghs/ghs_welcome_e.html.

International Council of Chemical Associations (ICCA). Available at http://www.icca-chem.org.

HYLE: International Journal for Philosophy of Chemistry. Available at http://www.hyle.org/.

REACH (European Community: Registration, Evaluation and Authorization of Chemicals). Available at http://europa.eu.int/comm/enterprise/reach/.

CHERNOBYL

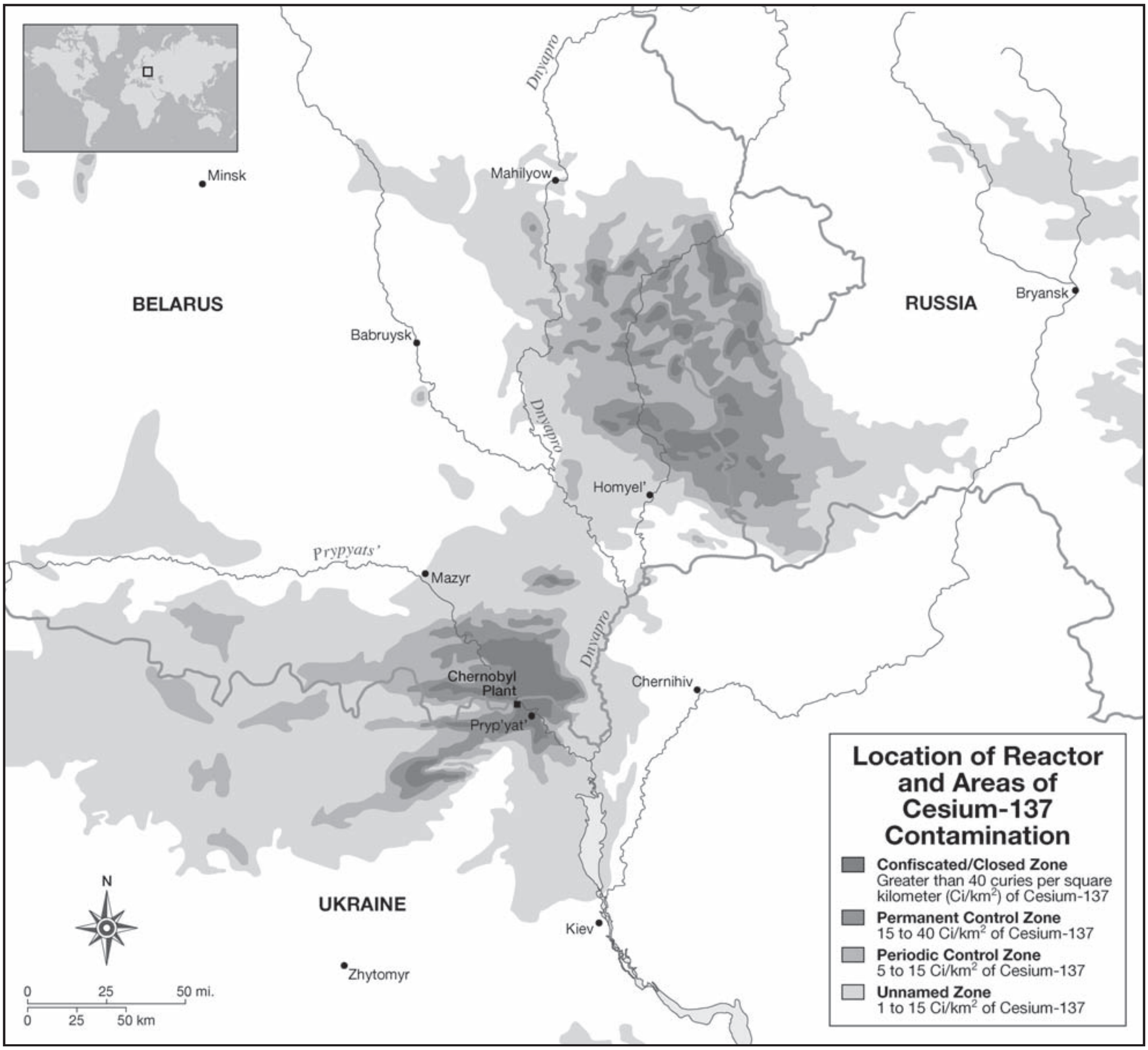
On April 26, 1986, a catastrophic accident occurred at the Chernobyl-4 reactor near the town of Pripyat, Ukraine, 100 kilometers northwest of Kiev. Figure 1 shows the reactor location and the regions of most intense radioactive contamination. The accident destroyed the reactor and released a large amount of radioactivity into the atmosphere, particularly radioactive iodine (I-131) and radioactive cesium (Cs-137), both of which have the potential to cause cancer. Thirty-one workers at the plant died within a few weeks, most of them from receiving lethal doses of radiation while putting out fires and responding to other emergencies.

Radiation fallout caused significant contamination in parts of Belarus, Russia, and the Ukraine, resulting in the resettlement of more than 350,000 people from 4,300 square kilometers. An approximate five- to ten-fold increase in thyroid cancer has been observed in children from Belarus, Russia, and Ukraine who received a large exposure to I-131. The economic impact has also been large, not only from the direct costs of accident cleanup, decontamination, and entombing the reactor, but also for lost agricultural production from the evacuated areas, and from regions throughout Europe where the radioactive fallout resulted in restrictions on eating certain foods and on limiting imports. Continued health monitoring over many years will be required for citizens who had lived in or are currently living in contaminated areas, and for cleanup workers who received significant doses of radiation.

At the time of the accident, the Chernobyl reactors were owned and operated by the Soviet Ministry of Power and Electrification. The reactor design was a unique Soviet design called an RBMK. A schematic diagram is shown in Figure 2. Like reactors in the United States, RBMK reactors use ordinary water to cool the fuel. Unlike U.S. reactors, which use water to slow down or moderate the neutrons produced in fission, the RBMK uses graphite as the moderator. In this case the water used for the coolant is actually a neutron absorber and reducing the density of the water increases the neutron production. In addition, the ratio of uranium isotopes U-235 to U-238 in the fuel is less in the RBMK than in U.S. reactors. The effect of these differences was that at low power operation, under the right conditions, the power in the RBMK could increase in an uncontrolled manner. Reactor designs that allow power increase in an uncontrolled manner are prohibited by regulation in the United States. The type of accident that occurred was unique to the Soviet-designed RBMK reactor. Another important difference is that Soviet reactors did not have a steel-lined, thick concrete-walled containment building like those in Western Europe, North America, and Asia, using instead an industrial-type building. This final difference had profound consequences.

The Accident

The accident occurred while the operators were conducting a test simulating loss of power at the plant. The goal was to determine if power from the spinning turbines could be used to operate the pumps while backup diesel generators were brought on line. In order to conduct the test, most of the safety systems that would have provided a safe shutdown were disconnected. A test of this type that disconnected the safety systems would never be allowed in the United States, Western Europe, or Asia. The test was to be conducted at about 25 percent power, but when the power level was reduced from 100 percent to 50 percent, the test was delayed for nine hours because the electricity was needed in Kiev. While the operators waited, a strong neutron-absorbing isotope, Xenon-135, built up in the reactor. The operators did not recognize this and did not incorporate the effect into the control computer. When the test resumed, the operators could not control the reduction of power because the Xenon-135 was absorbing neutrons needed for fission and consequent power production. To keep the reactor from shutting itself down, they pulled out most of the neutron-



Location of reactor and central spots of Cesium-137 contamination.

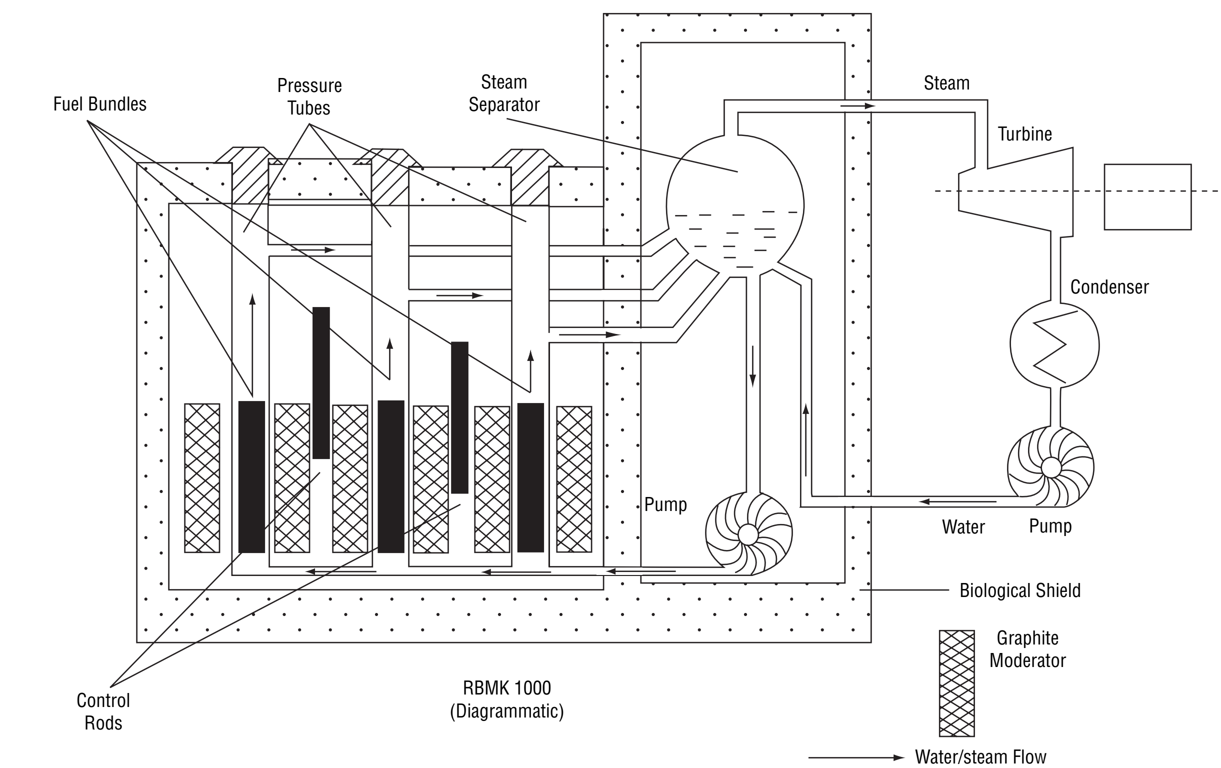
absorbing control rods that are used to control the reactor power. This was in violation of Soviet operating procedures. Unknown to the operators, they now found themselves operating under conditions where the reactor could increase in power in an uncontrolled manner.

When the operators continued the test procedure by turning off the water coolant pumps and re-inserting the slow-moving control rods, there was still enough power to cause the water to start boiling, thereby reducing the water density and increasing the neutron production. In addition, there were graphite tips on the bottom of the control rods that added moderator when the control rods were initially inserted, and this further increased neutron production. Instead of the power level decreasing, as the operators expected, it increased rapidly, reaching approximately one hundred times full power in just a few seconds. The increased power resulted in a massive steam buildup inside the reactor leading to an explosion.

A second explosion that followed shortly lifted the large top shield above the reactor, blew off the roof and walls of the building, and dispersed burning fuel and gra-

FIGURE 2

Schematic Diagram of the RBMK Reactor



SOURCE: Organisation for Economic Co-operation and Development, Nuclear Energy Agency (1995), p. 21

Schematic diagram of the RBMK reactor.

phite. The steel shield resettled at an angle, allowing air to enter the reactor and the argon gas that normally covers the reactor to escape. Contact with the air caused the hot graphite to ignite, propelling the volatile radioactive materials high up into the atmosphere. Firefighters who went to the room to put out the fires received a lethal dose of radiation. It took ten days to control the fire, and by that time 5 to 10 percent of the radioactive material in the core had been released to the atmosphere.

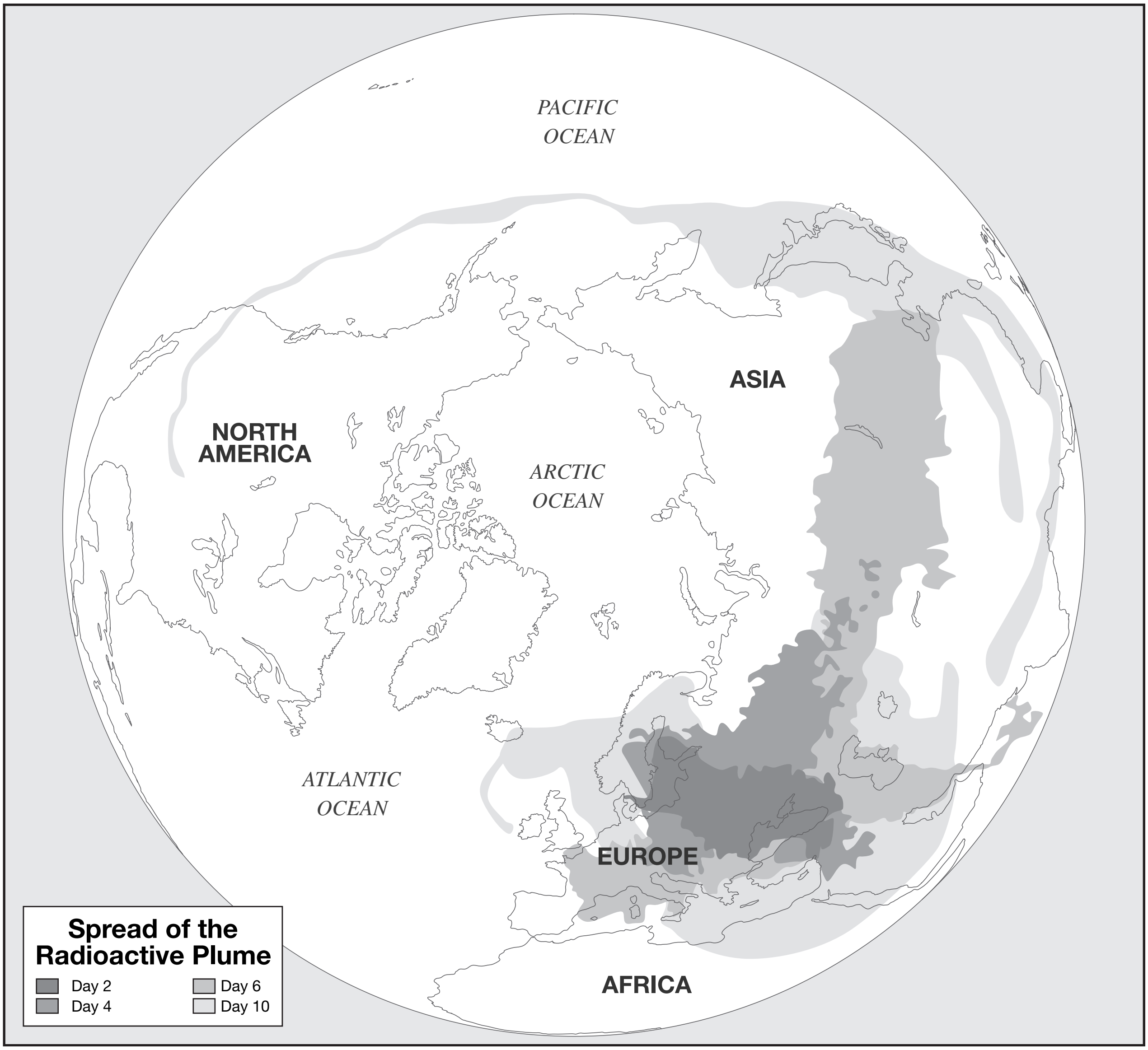
Evacuation and Health Effects

Evacuation of residents from the nearby town of Pripyat took place the following day, but evacuation from adjacent contaminated areas did not take place for several days, nor did the Soviet government quickly inform the residents or the world what had happened. The radiation release was first made public after the airborne radiation from the accident was detected in Sweden. In 1986 about 116,000 people were relocated from areas surrounding the reactor, and an additional 220,000 people from Belarus, the Russian Federation, and Ukraine were relocated after 1986.

The World Health Organization (WHO) has continually monitored those exposed to radiation, including the residents and 600,000 "liquidators" who came to clean up the accident. Two hundred thousand liquidators built a cooling system under the reactor and a shield building—commonly called the sarcophagus—around the damaged reactor. They received doses of 100 millisieverts (10 rem) or more, with 20,000 receiving doses of at least 250 millisieverts. For comparison, this is five times the U.S. total effective dose limit for radiation workers. Another 400,000 liquidators, who arrived after 1987, received much lower doses.

Extensive analyses of the public health effects from Chernobyl have been conducted by United Nations organizations including WHO. A comprehensive summary is available in a report by the United Nations Scientific Commission on the Effects of Atomic Radiation (UNSCEAR) published in 2000, which concludes that the

FIGURE 3



Spread of the radioactive plume over the Northern Hemisphere following the Chenrobyl accident.

only radiation-related effect to that date was an increase in thyroid cancer, largely in children. Through the years 1990–1998 there were about 1,800 cases of thyroid cancer in the contaminated areas of Belarus, Russia, and Ukraine in children 0–17 years old at the time of the accident. The majority of these were related to the accident.

Additional cases of thyroid cancer are expected in the future. Thyroid cancer is generally treatable if caught early. Nonetheless, ten deaths were reported as of 2000. It is not possible to make any accurate prediction about the number of deaths that will ultimately result, because there are no models that accurately predict deaths from low levels of radiation exposure. Many reports indicating much larger numbers of cancers and deaths from the Chernobyl accident were found in the UNSCEAR review to contain misinterpretations of data or use of unsubstantiated data.

While the heaviest radiation doses were received in Belarus, Russia, and Ukraine, the release of radioactivity from the Chernobyl reactor went high into the atmosphere and spread throughout Europe and then around the whole northern hemisphere. Figure 3 shows the dispersion of the radioactive cloud. The fallout in Europe varied considerably among the countries, depending on wind patterns and rain during the ten days the reactor was releasing radioactivity to the atmosphere. The largest doses were received in Poland, followed by Sweden, Germany, Italy, Finland, and Czechoslovakia. While such fallout caused great concern with the governments and the population, the doses received by the populations were relatively low, although there were some localized "hot spots."

Response and Lessons

Engineers from the former Soviet Union have made changes to all RBMK reactors to eliminate the possibility of repeating this type of accident. Nonetheless, in the West the RBMK is considered too unsafe to continue operation. All the Chernobyl units have been shut down. Other RBMK reactors outside Russia are being phased out of operation. However, the Russians still consider it a safe reactor and plan to continue operating all existing units. Plans to build new ones have been nevertheless cancelled.

In addition, the Soviet-designed water-cooled reactors, the VVER, built in the former Soviet Union and its satellite states, have either been shut down for inadequate safety features or modified to enhance safety. The United States and European countries have contributed millions of dollars in equipment and expertise to upgrade the safety of the existing reactors and their operation. The accident also stimulated the creation of the World Association of Nuclear Operations (WANO), whose goal is to improve safety in operations. WANO is an extension of the Institute for Nuclear Power Operations (INPO) that was formed after the accident at Three Mile Island in 1979 and was instrumental in improving safety in the operation of nuclear power plants in the United States.

While the design of the RBMK was flawed, a far greater problem was failures in human performance. How was it possible for the managers to allow the safety systems that would have prevented the accident to be disconnected during the test? How could all the control rods have been removed in violation of fundamental safety procedures? One answer is that written safety and accident response procedures actually did not exist in most RBMK control rooms before the accident. Furthermore, the operators were not trained to respond to different accident scenarios, and surely not to an accident that might occur during an experimental procedure. Importantly, there was no effective safety review of the proposed test. Moreover, the accident occurred in a society where secretiveness rather than openness was standard operating procedure, and this resulted in a lack of communication within the organization and with the public. After the accident, the Soviet government attempted to conceal it and the dangers posed to the local population and to the world.

Western nations learned the lessons of Three Mile Island, but states of the former Soviet Union did not. Specifically, they did not incorporate the fundamental lesson that safety is the most important responsibility of the operators, and that management from the top down must emphasize, encourage, and incorporate this thinking into plant operation. A culture that fosters "safety-first thinking" throughout the organization is necessary if nuclear power is to reach its potential to benefit humanity.

Since Chernobyl, nations of the former Soviet Union (FSU) have made significant improvements in both operations and design. Assistance from the United States and Europe led to the establishment of new training facilities, enhanced operator training, improved procedures for responding to accidents, and upgraded plant equipment. New Russian designs of the VVER type have added safety features and a containment building so they now meet safety standards used elsewhere in the world. There has been a change in management philosophy and an increased emphasis on operations safety. Regulatory agencies are improving in their capabilities. Nonetheless, the culture change needed to reach the safety standards of the United States and Western Europe will be a continuing challenge in the FSU countries.

The Chernobyl accident showed dramatically that an accident anywhere represents an accident everywhere, for it reflects on the ability of nuclear power to serve society as a trustworthy technology. This is a high standard and it raises the question: Can nations throughout the world that desire to use nuclear power maintain this level of attention to safety? Even though future reactors may be designed and built that prevent a catastrophic accident, it is important that an emphasis on a culture of safety be maintained. Ultimately it will reflect on the capacity of the world nuclear industry to serve civilization.

The accident was also global in the sense that radioactive fallout was present throughout the northern hemisphere and caused local contamination in many European countries that were not prepared for such an accident. The reactions of national authorities varied greatly on issues such as restrictions on consumption and marketing of foodstuffs. There was no uniformity in standards for implementation of protective actions. This could be especially disconcerting to the public in the border region when the nations on each side of the border took significantly different actions. National authorities sometimes used interpretations that responded to public fears rather than being based on sound science. This resulted in unnecessarily increasing public confusion and possibly public fears, and caused unnecessary government expense and economic loss. International efforts have been undertaken to produce more uniform regulations and criteria related to radiation accidents, and for emergency management of transnational accidents. Whether these efforts will be effective may not be known unless they are put to the test. In light of the level of terrorism that now exists in the world, and the possibility that biological and chemical agents can cross national boundaries as well as nuclear agents, it has become ever more critical that this type of emergency management be carefully developed and practiced. This could be one of the most important lessons from the Chernobyl accident.

EDWARD H. KLEVANS
DARRYL L. FARBER

SEE ALSO *Nuclear Ethics; Three-Mile Island.*

BIBLIOGRAPHY

Knief, Ronald Allen. (1992). *Nuclear Engineering: Theory and Technology of Commercial Nuclear Power,* 2nd ed. New York: Hemisphere. Nuclear engineering textbook with a good technical discussion of the RBMK reactor, the chronology of the accident, the causes of the accident, the effects of the accident, and comparisons with the Three Mile Island accident.

Medvedev, Grigori. (1991). *The Truth About Chernobyl,* trans. Evelyn Rossiter. New York: Basic Books. Written by a physicist who had been a chief engineer at Chernobyl and was an investigator of the accident; presents both background material and an intimate account of the events leading to the accident and the accident itself.

Organisation for Economic Co-operation and Development, Nuclear Energy Agency. (1995). *Chernobyl—Ten Years On: Radiological and Health Impact.* Paris: Nuclear Energy Agency, OECD. Covers radiation releases, dose estimates, health impacts, agricultural impacts, reactions of national authorities, and other issues.

INTERNET RESOURCES

Nuclear Regulatory Commission. (2000). “Fact Sheet on the Accident at the Chernobyl Nuclear Power Plant.” Available from http://www.nrc.gov. Briefly discusses the accident and presents information on the Nuclear Regulatory Commission’s post-accident activities to assist the Ukraine in dealing with the accident.

United Nations Scientific Commission on the Effects of Atomic Radiation (UNSCEAR). “Exposures and Effects of the Chernobyl Accident.” In Volume II of the *UNSCEAR 2000 Report.* Available from www.unscear.org/chernobyl.html. Comprehensive and authoritative report on the health effects of the Chernobyl accident with data through 1998.

World Nuclear Association. (2001). “Chernobyl.” Available from www.world-nuclear.org/info/chernobyl. (Go to Document inf07.) Site has a set of detailed and authoritative documents discussing many facets of the accident and its consequences. There are also maps of the area. Document inf07 describes the accident and its consequences in detail and gives direct access to three short reports on health effects from the accident.

CHINESE PERSPECTIVES

• • •

Overview
Engineering Ethics
Research Ethics

OVERVIEW

China is the oldest continuous civilization in the world and has produced a culture stretching back for millennia. For extended periods of time China led the world in science and technology. Yet traditional Chinese culture focused not on science and technology but on political-ethical issues. Traditional thinkers were more concerned with political morality and developing a centralized bureaucracy to run the country. Ethics was closely associated with politics, and the technical arts were subordinate to political considerations.

The Tradition

Confucianism formed the orthodoxy of premodern Chinese. Confucius (551–479 B.C.E.) himself stressed moral over material goods. He thus considered the technical arts as secondary to the ethical enterprise of living in harmony with the Way of Heaven. According to the Way, people have roles to play in society: the ruler to rule, ministers to administer, fathers to head families, and sons to serve as sons (*Analects*, 12:11). In the Confucian tradition, even acquiring material benefits was subordinate to living in accord with the Way, and technical fields such as agriculture, astronomy, mathematics, and medicine should serve the political needs of the country (Xi Zezong 2001). Though Confucians regarded the technical arts as the lesser way, specialists’ use of technology in the service of the people was often held up as an example of moral rectitude.

Daoism was also an important tradition of ancient China. The Daoist view of how the technical arts relate to ethics differed from the Confucian view. While Confucianism subordinated the technical arts to ethics, it did not oppose the special sciences and their results. In contrast, Daoism attributed social disturbances and moral decay in society to science and technology and rejected them outright. For example, Laozi (or Lao-tzu; sixth century B.C.E.), the founder of Daoism, thought that society was already technically too advanced, and that technical invention served only to alienate people from the natural order and destabilize society. He advocated rejecting technical knowledge and skills. According to Laozi, people should not use writing, machines, carriages, or ships. Zhuangzi (or Chuang-tzu; c. 369–c. 286 B.C.E.), another representative of Daoism, presented fables to suggest that the use of machines led individuals to act contrary to their nature.

Among the ancient schools of Chinese thought, only Mohism valued material goods for the benefit of society. This school held that moral value lies in benefiting the people. Mo Di (or Mo-tzu; fl. 476–390 B.C.E.), the founder of Mohism, regarded the technical arts as benefiting human society and proposed to develop them. Mohists even conducted scientific research and made contributions in the fields of geometry, mechanics, and optics. At the same time, Mo Di opposed the use of technology to wage unjust wars and to produce curios for the court (Zhu Yiting 2002).

These ancient philosophies provided the frameworks for traditional ethical thinking in China. A common feature of such philosophies is concern for people, but in a way different from modern ethical thinking: People are conceived in relation to the larger Way. Thus human good is not something that can be pursued scientifically or technologically for individuals in isolation from the cosmos.

For more than 2,000 years such philosophical attitudes predominated in China and influenced science and technology both directly and indirectly, as has been extensively examined not only in China but in the West as well (see Needham 1954–; Sivin 1995). Geoffrey Lloyd and Nathan Sivin (2002) agree that when the Chinese "thought about the universe, what intrigued them was its connection to sociopolitical order" (p. 235). They go on to contrast the emphasis on logical distinction and deductive rigor that separates Greek science from ethics and politics with Chinese efforts "to find and explore correspondences, resonances, interconnections" in ways that "favored the formation of syntheses unifying widely divergent fields of inquiry" (p. 250). Thus from the beginning, and even into the modern period, Chinese scholars pursued what in the West might now be termed synthetic, aesthetic, or interdisciplinary knowledge, which left them vulnerable to more empirical, confrontational ways of knowing and manipulating the world that developed in Europe after the Renaissance.

The Modern Era

The modern period in Chinese history began in the 1500s when European powers established colonies (the first being Macao, founded by Portugal in 1557) for purposes of developing trade. Over the course of the next 300 years, Chinese resources were progressively exploited by Western imperialist forces, culminating in the First Opium War (1839–1842), in which Great Britain fought to deny China the right even to prohibit the importation of an addictive drug that was undermining its social order.

In response to this humiliation and other calamities, there emerged a series of efforts at modernization such as the "self-strengthening movement," which sought to appropriate and adapt "Western learning," especially science and technology, for Chinese benefit. Western models were used to create special schools and factories. Leaders such as Yang Xingfo (1893–1933), who studied engineering and business in the United States and then promoted scientific management in China, and Ren Hongjuan (1886–1961), the founder of the Chinese Society of Science, put forward the idea of "saving the nation by science." Along with such efforts came the eventual overthrow of the Qing dynasty and the creation of the Republic of China in 1911—followed by war with Japan, civil war, and finally the establishment of the People's Republic of China (PRC) in 1949.

In the nearly thirty years from the founding of the PRC to 1978, when China began a policy of reform and opening up to the West, there was little academic research into ethics as related to science and technology. Ethics, as well as science and technology, were viewed through the prism of socialism. On the one hand, scientific socialism held that science and technology were revolutionary forces that drove historical advancement, which was the basis of their social value. On the other, more fundamental was class struggle, to which ethics, along with science and technology, should be subordinated. Intellectuals had to adhere to the party line and to be "both red and expert." During the Cultural Revolution (1966–1976), some aspects of natural science, such as the theory of relativity and modern cosmology, were even viewed as reactionary bourgeois ideas because of supposed antisocialist implications, and scientists in these fields were themselves criticized as reactionaries.

Since 1978, however, China has implemented policies of reform and opening up, and the government and people have come to view science and technology as a primary productive force. The government has implemented strategies for sustainably developing science, education, and the economy to modernize China. In this new intellectual climate, Chinese academics have begun to pay more attention to ethical questions related to science and technology. Their contributions can be broken down into four main categories.

Do Science and Technology Involve Ethical Problems?

One opinion holds that science seeks knowledge or truth and that as such it is a value-neutral cognitive activity devoid of ethical implications (Jin Wulun 2000). The opposite view is that knowledge creation in science and production through technology can involve ethics in any of three ways. First, insofar as scientists and engineers produce objective knowledge and skills, they must follow methodological guidelines, which include professional codes of ethics.

Second, the application of scientific knowledge and the technological manufacture of products may have both positive and negative impacts on the economy, society, and nature in a way that poses ethical problems. But because scientists cannot control how their research results are applied, and engineers cannot determine how their products are used, they are not professionally responsible for the consequences of their work. Only as consumers and citizens are they responsible.

Third, Gan Shaoping (2000) has argued that ethical issues are sometimes inherent in science and technology themselves. Modern science is no longer purely theoretical knowledge, and engineering is not simply design; both are practical activities with built-in purposes oriented toward special applications. Thus researchers cannot pursue science or engineering and ignore the ethical issues implicit in the application of their work.

Justice and Responsibility

The pursuit of science and technology poses ethical issues of justice and responsibility. The problem of justice appears in two forms. The first asks whether the distribution of scientific research resources among scientists, disciplines, and various social needs is just. The second asks whether the application of research results might unfairly favor some and create burdens or harm for others.

The problem of responsibility manifests itself in the human arrangements that science and technology require and make possible. With the ever-increasing power and impact of science and technology in human societies, human arrangements have increasingly replaced natural arrangements. Properly engineering these human arrangements is an ethical concern.

Moreover, with regard to both justice and responsibility, the activities of science and technology have become a global enterprise. The abuse and misuse of science and technology can threaten the entire human species and the habitability of the earth. Scientists and engineers—along with managers, politicians, and the rest of society—are now collectively responsible for how the development of science and technology affects the future of humankind (Zhu Baowei 2000).

Progress

Some scholars maintain that there exists what others have called a "cultural lag" between human ethical standards and scientific-technological progress. On this basis they argue for some limitations in the current uncontrolled growth of science and technology (Lu Feng 2002). Other scholars think that science is superior to ethics, and that ethics should thus conform to developments in science. Most scholars, however, think that there should be an interactive relationship among developments in science, technology, and ethics, and that this constitutes true progress. That is, the correctness of scientific and technological activity should not be judged just from some preconceived ethical standpoint; instead, ethical systems should themselves be rethought, corrected, and developed in light of and in association with science and technology (Li Deshun 2000).

Some scholars have also highlighted dilemmas that arise from interactions between new developments in science and technology and systems of ethical values. On the one hand, new developments in science and technology often bring about new worries in ethics; on the other, if these developments were forbidden, humanity might be deprived of major benefits. In response, it is suggested that a buffer (or soft-landing) mechanism should be introduced between new developments of science and technology and human systems of social values (Liu Dachun et al. 2000).

Ethical Disputes in Particular Hi-Tech Fields

Ethical concerns have come to the fore especially in relation to biotechnology, the environment, and the Internet.

BIOETHICS. In relation to biotechnology, He Zuoxiu, a famous theoretical physicist, argues that no work should be forbidden, not even human cloning (Piao Baoyi 2002) He criticizes bioscientists for caving in to the media and restricting such developments. Zhao Nanyuan, a scholar in the field of automation, further argues that Chinese moralists who simply repeat what foreigners say have become the mouthpiece in China for the antiscientific and antitechnological views of foreign religious zealots. At the same time, most scholars maintain that biotechnology should be pursued prudently because of the risks involved, and that humans should not be cloned because of the ethical and social problems that would arise from human reproductive cloning. The Ministry of Science and Technology and the Ministry of Public Health have firmly opposed human reproductive cloning.

ENVIRONMENTAL ETHICS. Some scholars accept arguments that animals, living things, and indeed the whole ecosystem have inherent value and some rights independent of their instrumental value for humans. Humans should preserve the environment, not only to enhance the well-being of humans and human posterity, but also to preserve the stability, prosperity, and beauty of ecosystems. Most Chinese philosophers, however, still adhere to an anthropocentric view that only humans have moral consciousness and can be morally responsible for their own behavior. Animals do not have rights. Whether holding anthropocentric or nonanthropocentric views, all agree that preserving the environment, reducing pollution, and maintaining biodiversity have long-term benefits.

NETWORK ETHICS. Information transmitted through the Internet may be true or false, healthy or pernicious. These issues have raised the most concern in the field of what is called “network ethics” (also called “computer ethics” or “information ethics” outside China). In addition, some research also focuses on the protection of intellectual property rights and individual privacy. Some scholars suggest that the anonymity of the Internet is the main cause for the ethical problems arising there, and that for this reason maintaining ethical behavior on the Internet ultimately depends on individual moral self-discipline (Wang Lujun 2000). The central government in the PRC also exercises some restrictions over Internet communication in accord with its concerns for social order.

Developments in the Early Twenty-First Century

Generally speaking, traditional Chinese culture, although emphasizing moral issues, has been relatively tolerant of science and technology. There is nothing like the trial of Galileo Galilei (1564–1642) or the rejection of evolution in Chinese history, except during the aberration of the Cultural Revolution.

In the early twenty-first century, China nevertheless lags behind Europe, the United States, Japan, and some other countries in its level of economic and technological development. There thus exists an urgent need to promote science and technology in China. Current studies of ethics in science and technology should thus include promoting the development of science and technology, especially with the aim of benefiting the most people (Chen Ying 2002).

China seeks to promote rapid yet safe and sustainable development of science and technology. This is reflected in an increasing commitment in the PRC to research and development: In 2003 China spent $15.56 billion in this area, an increase of 23.5 percent over that of the previous year. It actually supported more than half again as many researchers. Along with such increases in research support, the Ministry of Science and Technology has promoted efforts to establish ethical systems and adopt ethical codes, and has dealt seriously with issues of scientific misconduct. The China Association for Science and Technology has established a standing committee on morals in science. The Chinese Academy of Sciences and the Chinese Academy of Engineering have likewise adopted codes of behavior for academicians and have established related ethical systems.

In addition, education in the science, technology, and society (STS) studies field has actively cultivated research and teaching on ethics in science and technology. From 1984 to 2004 more than twenty centers or institutes for STS studies, including the Research Center for Science, Technology, and Society, and the Chinese Academy of Social Sciences, have been established. In 2004 Chinese universities have offered more than fifty courses of STS study. Moreover, there have been frequent international and national symposia, and many books and papers in the field have appeared (Yin Dengxiang 1997). STS studies in China seek to promote science and technology in a way that appreciates the ethical dimensions of these activities.

YIN DENGXIANG
LI SHIXIN

SEE ALSO *Buddhist Perspectives; Confucian Perspectives.*

BIBLIOGRAPHY

Chen Ying. (2002). "Keji lunli de genben yuanze: Wei zui da duoshu ren fuwu" [The basic principle for science and technology ethics: Serve the most people]. Paper presented at the Quanguo di si jie yingyong lunli yantaohui [Fourth National Symposium on Applied Ethics].

Gan Shaoping. (2000). "Keji lunli: Yige you zhengyi de keti" [Science and technology ethics: A hotly disputed topic]. *Zhexue dongtai* 10 5–8.

Jin Wulun. (2000). "Kexue yanjiu yu keji lunli" [Scientific research and science and technology ethics]. *Zhexue dongtai* 10 4–5.

Li Deshun. (2000). "Chen si keji lunli de tiaozhan" [Reflections on the challenge of science and technology ethics]. *Zhexue dongtai,* 10, 2–3.

Liu Dachun et al., ed. (2000). *Zai zhen yu shan zhi jian* [Between truth and good]. Beijing: Zhongguo shehui kexue chubanshe.

Lloyd, Geoffrey, and Nathan Sivin. (2002). *The Way and the Word: Science and Medicine in Early China and Greece.* New Haven, CT: Yale University Press. A comparison of the cosmology, science, and medicine of ancient China and Greece that relates conceptual differences to how intellectuals in the two civilizations earned their living, interacted with fellow inquirers, and were involved with structures of authority.

Lu Feng. (2002). "Keji jinbu yu daode jinbu" [Progress in science and technology and progress in morality]. Paper presented at the Quanguo di si jie yingyong lunli yantaohui [Fourth National Symposium on Applied Ethics].

Miller, H. Lyman. (1996). *Science and Dissent in Post-Mao China: The Politics of Knowledge.* Seattle: University of Washington Press. An examination of how scientific dissent led to a renewed liberal voice in China.

Needham, Joseph. (1954–). *Science and Civilisation in China.* 22 vols. to date (2004). Cambridge, UK: Cambridge University Press. A monumental work covering many fields of science in China.

Pourciau, Lester J. (2003). "The Ethics of Electronic Information in China and in Eastern Europe." In *Ethics and Electronic Information,* eds. Barbara Rockenbach and Tom Mendina. Jefferson, NC: McFarland.

Qiu Ren-Zong, ed. (2004). *Bioethics: Asian Perspectives.* Dordrecht, Netherlands: Kluwer Academic. Covers such topics as the intellectual foundation of Asian bioethics, bioethics and Asian culture, life and death, and euthanasia and end-of-life care in Asia.

Sivin, Nathan. (1995). *Science in Ancient China: Researches and Reflections.* Brookfield, VT: Variorum. Examines selected topics in astronomy, medicine, and the scientific revolution in China.

Suttmeier, Richard P. (1974). *Research and Revolution: Science Policy and Societal Change in China.* Lexington, MA: Lexington Books.

Unschuld, Paul U. (1979). *Medical Ethics in Imperial China: A Study in Historical Anthropology.* Berkeley and Los Angeles: University of California Press.

Wang Lujun. (2000). "Wangluo lunli wenti yanjiu zongshu" [Summary of studies on Internet ethical problems]. *Zhexue dongtai* 9.

Xi Zezong, ed. (2001). *Zhongguo kexue jishu sixiang shi: Kexue sixiang juan* [History of Chinese scientific and technical thought: Scientific thought]. Beijing: Kexue chubanshe.

Yin Dengxiang. (1997). *Shidai de huhuan: Kexue jishu yu shehui daolun* [The call of the times: An introduction to science, technology, and society]. Xi'an, China: Shan'xi renmin jiaoyu chubanshe.

Zhu Baowei. (2000). "Kexue jishu lunli: Gongzheng he zeren" [Science and technology ethics: Justice and obligation]. *Zhexue dongtai* 10, 9–11.

Zhu Yiting, ed. (2002). *Lunlixue da cidian* [Dictionary of ethics]. Shanghai: Shanghai cishu chubanshe.

INTERNET RESOURCES

Piao Baoyi. (2002). "Fandui 'fan kelong ren yundong'" [Against 'the movement of against cloning of people']. Available from http://www.people.com.cn/GB/kejiao/42/155/20020607/746960.html.

Zhao Nanyuan. "Minzhu, fazhi, lunli, and kexue: Zai kelong ren xianxiang de beihou" [Democracy, rule of law, ethics, and science: Behind the phenomenon of cloned people]. Available from http://www.oursci.org/magazine/200209/020920.htm.

ENGINEERING ETHICS

China has age-old traditions both in the practical sciences and technology and in ethics, but few studies link the two areas of endeavor. Traditional studies were limited to morality in the practice of medicine and doctrines that promoted harmony between humans and nature. From 1978, when China opened up to the outside world and began a program of reform, scholars in China started studying engineering ethics in the contemporary sense. In China, however, scholars more often talk of science and technology ethics and seldom use the term *engineering ethics.* Since 1978 research on ethics in science and technology has made considerable progress, going through three stages of development: the embryonic stage, the development stage, and the stage of a deepening appreciation of the issues involved.

The Embryonic Stage

During the Cultural Revolution (1966–1976) ethics was a prohibited topic. Scholars started writing about ethics only after 1978, when China began liberalizing. First came the translation of such key works as Rachel Carson's *Silent Spring* (in 1979), J. D. Bernal's *The Social Function of Science* (in 1982), and Donella H. Meadows and colleagues' *The Limits to Growth*. Such specialized volumes were complemented by more general works such as the reprinting of an important anthology of classic Western texts on ethics (Zhou Fucheng 1964) together with a critical biographical study of Western ethical philosophers (Zhou Fucheng 1987). During this period, Chinese scholars focused on the moral practices of Western scientists, using them in the construction of modern science and technology in China (see Xu Shaojin 1995).

Also about this time scholars began studying ethical issues related to specific technologies. One example is interest in environmental problems and ecological ethics, stimulated by the Carson and Meadows translations. As a forum for issues in the field of medical ethics, such as those involving test-tube babies and organ transplants, two new journals were created during the 1980s: *Medicine and Philosophy* (on the philosophy of medicine, published by the Chinese Academy of Medicine) and *Chinese Medical Ethics* (on medical ethics, published by Xinghua University). Relevant monographs include a book on the fundamental principles of medical ethics (Du Zhizheng 1985) that and another on bioethics (Qiu Renzong 1987).

Finally, some general works on ethics in science and technology also appeared: *The Ethics of Science and Technology* (Xu Shaojin 1989), *Essentials of Science and Technology Ethics* (Liu Fengrui 1989), and *Technological Ethics* (Huang and Chen 1989).

The Development Stage

New ethical problems brought about by modern science and technology gave rise to extensive scholarship in China, including frequent academic discussions and numerous publications. Among these was a debate, in the journal *Study of the Dialectics of Nature*, between two opposite views of the relation between humans and the ecosystem: anthropocentrism and ecocentrism. Many works concerned with environmental ethics appeared, among which were four books titled *Ecological Ethics* (Liu Xiangrong 1992, Li and Chen 1993, Ye Ping 1994, Yu Mochang 1999). Other books included *Environmental Ethics* (Li Peichao 1998), and *The Progress of Environmental Ethics* (Xu Songling 1999).

Issues in biomedical ethics also continued to be pursued. Zheng Zhenlu (1992) sought to unify medical and bioethics. Du Zhizheng (2000) undertook a more detailed criticism of the foundations of medical ethics alone.

The Stage of Deepening Appreciation

The beginning of the twenty-first century saw two notable trends in the area of science and technology ethics: Science and technology philosophers turned their attention toward ethics (for example Liu Dachun 2000, Zhou Changzhong 1999), and ethicists focused on science and technology. These two trends converged to form an intellectual climate in which scholars probed more deeply the theoretical and practical problems of science and technology ethics.

The greater attention that philosophers of science and technology gave to ethics aroused concern among scientists, technologists, and the general public about issues of ethical responsibility. Heated disputes about such basic questions as the ethics of human cloning made the study of science and technology ethics ever more important. The beginning of the century also witnessed an increase in exchanges and cooperation between Chinese and foreign scholars in science and technology ethics, especially in medical ethics and bioethics.

Between 2001 and 2003 many works appeared, including two books on general science and technology ethics (Fu Jing 2002, Li Qingzhen et al. 2003), one on engineering ethics (Xiao Ping 2001), a translation on information technology ethics (Spinello 2003), four books on medical ethics or bioethics (Chen and Qiu 2003, Li and Cai 2003, Li and Liu 2003, Qiu and Zhai 2003), and four works on ecological or environmental ethics (Lei Yi 2001, Fu Hua 2002, He Huaihong 2002a, 2002b).

In conclusion, although engineering ethics as such has not become a major theme in Chinese discussions, questions of the ethics of specific types of engineering—such as practiced in relation to the environment, medicine, or the Internet—have been increasingly discussed. In general engineering is seen as simply one aspect of science and technology, and analyzed accordingly. It is worth noting that Chinese perspectives on many of the issues mentioned here have also been increasingly considered in English-language studies, as is illustrated by Ole Döring (1999), Albert R. Jonsen (2000), and Lester J. Pourciau (2003).

LIU ZEYUAN

SEE ALSO *Engineering Ethics*.

BIBLIOGRAPHY

Bernal, J. D. (1982). *Kexue de shehui gongneng,* trans. Chen Tifang. Beijing: Shangwuyin shuguan. Originally published as *The Social Function of Science* (New York: Macmillan, 1939).

Carson, Rachel. (1979). *Jijing de chuntian,* trans. Lü Ruilan and Li Changsheng. Changchun, China: Jilin renmin chubanshe. Originally published as *Silent Spring* (Boston: Houghton Mifflin, 1962).

Chen Yuanfang and Qiu Renzong. (2003). *Shengwuyi yanjiu lunlixue* [Biomedical research ethics]. Beijing: Zhongguo xiehe yike daxue chubanshe.

Döring, Ole, ed. (1999). *Chinese Scientists and Responsibility: Ethical Issues of Human Genetics in Chinese and International Contexts.* Hamburg, Germany: Institut für Asienkunde.

Du Zhizheng. (2000). *Yixue lunlixue tanxin* [Probing medical ethics]. Zhengzhou, China: Henan yike daxue chubanshe.

Fu Hua. (2002). *Shengtai lunlixue tanjiu* [Probing ecological ethics]. Beijing: Huaxia chubanshe.

Fu Jing. (2002). *Keji lunlixue* [Science and technology ethics]. Chengdu, China: Xinan caijing daxue chubanshe.

He Huaihong. (2002a). *Huanjing lunlixue* [Environmental ethics]. Beijing: Gaodeng jiaoyu chubanshe.

He Huaihong. (2002b). *Shengtai lunlixue: Jingsheng ziyuan yu zhexue jichu* [Ecological ethics: Spiritual resources and philosophical foundations]. Shijiazhuang, China: Hebei daxue chubanshe.

Huang Linchu and Chen Aijuan. (1989). *Jishu lunlixue: Lilun yu xhixian* [Technological ethics: Theory and practice]. Xi'an, China: Xi'an jiaotong daxue chubanshe.

Jonsen, Albert R. (2000). "Medical Ethics of India and China." Chap. 3 in *A Short History of Medical Ethics.* New York: Oxford University Press.

Lei Yi. (2001). *Shengtai lunlixue* [Ecological ethics]. Xi'an, China: Shanxi renmin jiaoyu chubanshe.

Li Chunqiu and Chen Chunhua. (1993). *Shengtai lunlixue* [Ecological ethics]. Beijing: Kexue chubanshe.

Li Peichao. (1998). *Huanjing lunli* [Environmental ethics]. Beijing: Zuojia chubanshe.

Li Qingzhen et al. (2003). *Xiandai keji lunlixue* [Modern science and technology ethics]. Jinan, China: Shandong renmin chubanshe.

Li Runhua and Liu Yaoguang. (2003). *Yixue lunlixue* [Medical ethics]. Changsha, China: Zhongnan daxue chubanshe.

Li Yuzhen and Cai Jinhua. (2003). *Yixue yu shengming lunli* [Medicine and bioethics]. Beijing: Kexue chubanshe.

Liu Dachun. (2000). *Zai zhen yu shan zhi jian: Keji shidai de lunli wenti he daode jueze* [Between truth and good: Ethical problems and moral choice in the age of science and technology]. Beijing: Zhongguo shehui kexue chubanshe.

Liu Fengrui, ed. (1989). *Jianming keji lunlixue* [Essentials of science and technology ethics]. Beijing: Hangkong gongye chubanshe.

Liu Xiangrong. (1992). *Shengtai lunlixue* [Ecological ethics]. Changsha, China: Hunan shifan daxue chubanshe.

Pourciau, Lester J. (2003). "The Ethics of Electronic Information in China and in Eastern Europe." In *Ethics and Electronic Information,* ed. Barbara Rockenbach and Tom Mendina. Jefferson, NC: McFarland.

Qiu Renzong. (1987). *Shengming lunlixue* [Bioethics]. Shanghai: Shanghai renmin chubanshe. For an English introduction to this author's work see *Bioethics: Asian Perspectives*, ed. Qiu Renzong (Dordrecht, Netherlands: Kluwer Academic, 2004).

Qiu Renzong and Zhai Xiaomei. (2003). *Shengming lunlixue jiaocheng* [A course on bioethics]. Beijing: Zhongguo xiehe yike daxue chubanshe.

Spinello, Richard A. (2003). *Xinxi he jisuanji lunli anli yanjiu,* trans. Wu Hexin and Zhang De. Beijing: Kexue jishu wenxian chubanshe. Originally published as *Case Studies in Information and Computer Ethics* (Upper Saddle River, NJ: Prentice Hall, 1997).

Xiao Ping. (2001). *Gongcheng lunlixue* [Engineering ethics]. Beijing: Zhongguo tiedao chubanshe.

Xu Shaojin. (1989). *Keji lunlixue* [The ethics of science and technology]. Shanghai: Shanghai renmin chubanshe.

Xu Shaojin. (1995). *Xifang keji lunli xixiang shi* [The history of Western science and technology ethics]. Nanjing, China: Jiangsu jiaoyu chubanshe.

Xu Songling. (1999). *Huanjing lunlixue jinzhan: Pinglun yu chanshu* [The progress of environmental ethics: Comment and exposition]. Beijing: Shehui kexue wenxian chubanshe.

Ye Ping. (1994). *Shengtai lunlixue* [Ecological ethics]. Harbin, China: Dongbei linye daxue chubanshe.

Yu Mochang. (1999). *Shengtai lunlixue* [Ecological ethics]. Beijing: Shoudu shifan daxue chubanshe.

Zheng Zhenlu. (1992). *Yixue daode yu shengming lunli* [Medical morals and bioethics]. Shanghai: Huadong shifan daxue chubanshe.

Zhou Changzhong. (1999). *Puluomixiusi hai shi fushide: Keji shehui de lunlixue* [Prometheus or Faust: Ethics in scientific and technological society]. Wuhan, China: Hubei jiaoyu chubanshe.

Zhou Fucheng. (1964). *Xifang lunlixue mingzhu xuanji* [Selections of famous Western works on ethics]. Beijing: Shangwuyin shuguan. Reissued in 1987.

Zhou Fucheng. (1987). *Xifang zhuming lunlixue jia ping zhuan* [Critical biographies of well-known Western moralists]. Shanghai: Shanghai renmin chubanshe.

RESEARCH ETHICS

In China discussions about research integrity occur in the context of studies of the interaction among science, technology, and society (STS). Such discussions are concerned not only with identifying various types of misconduct in scientific and technological research but also with the institutional reasons for such misconduct in management systems and social culture. In these contexts, scholars suggest measures to counter such misconduct. Their discussions focus mainly on three aspects of STS interactions as follows.

Definition and Prevention of Academic Misconduct

Fan Hongye (1982, 1994), a historian of science, defines "misconduct" according to international standards as fabrication, falsification, or plagiarism to acquire recognition from scientific associations and societies for scientific research. This includes the fabrication or falsification of experimental data, unacknowledged use of others' research, and falsified reports of research results. This definition is generally accepted in academic circles throughout China.

Scholarly work on ethics in science began to develop in the 1980s. Fan's *The Falsification of Scientific Results* appeared in Chinese in 1982. William J. Broad and Nicholas Wade's 1982 book *Betrayers of the Truth* was translated into Chinese in 1988. Xu Shaojin published a monograph in Chinese entitled *The Ethics of Science and Technology* the following year.

As a result of such heightened awareness, since 1990 there have been many reports and criticisms of instances in which researchers, teachers, or graduate students falsified data or plagiarized others' data, such as the Hu Liming (a doctor and professor in Huadong University of Technology) plagiarizing case in 1997, and the Wang Mingming (a professor in Beijing University) plagiarizing case in 2002. Some scholars have pointed out that deficiencies in the system for managing scientific research lead to such misconduct. Others have suggested new laws, regulations, and rules governing scientific and technological research or improvements in systems of research management.

The Social Responsibilities of Scientists and Engineers

A central academic concern in China at the beginning of the twenty-first century is what kind of social responsibilities scientists and engineers should assume. Many scholars have noted that with increased academic freedom in China since the 1980s, scientists have more liberty to determine their research activities. If researchers do not exercise self-discipline and a high sense of responsibility, their research may adversely affect society. Zou Chenglu and Hu Qiheng, members of the Chinese Academy of Sciences, have argued this position, which has attracted much attention.

In 2002 the Chinese Academy of Sciences formulated and published "Self-Disciplining Standards of Scientific Integrity for Members of the Chinese Academy of Sciences," a statement of principles for protecting society, promoting science, and maintaining scientific integrity. Such Chinese works as those by Li Hanlin (1987) and Zhang Huaxia (1999) have analyzed the social responsibilities of scientists and engineers, and proposed measures to guard against weak moral discipline and lack of responsibility. Because of the complex nature of modern science and technology, society has little choice but to rely on technical experts to be responsible in their work.

Dissent as an Ideal in Chinese History

Research is most productive when academic dissent is possible. Academic debate is deeply rooted in Chinese history (though, it should be admitted, so is its opposite, authoritarianism). In the Spring and Autumn period (770–476 B.C.E.) and the Warring States period (475–221 B.C.E.), it was said that a hundred schools of thought contended. (That was before the first emperor of the Qin dynasty, who reigned China from 221 to 210 B.C.E., burned books and unified thought.) At other bright points in history, scholars such as Sima Qian (c. 145–c. 85 B.C.E.), Zhu Xi (1130–1200), and Wang Fuzhi (1619–1692) affirmed the truth, persuaded others by reason, and rejected political suppression of thought.

In 1956 Mao Zedong revived the principle of a hundred schools contending during the hundred flowers campaign. Though in the Soviet Union Trofim Denisovich Lysenko, from 1948 to 1953, successfully led a campaign to repress Mendelian genetics as antisocialist, biologists in China held a symposium on genetics in 1956 in Qingdao, where opposing parties objectively discussed biological research. Unfortunately, by mid-1957 some scholar criticism had been leveled against the leadership of Communist Party, with the result that Mao called a halt to the hundred flowers campaign and suppressed further criticism.

After 1978, when China opened up to the outside world, the pendulum again swung back, and China became an increasingly free and open society. At the beginning of the twenty-first century Chinese researchers enjoy considerable academic freedom. Indeed, the nation has again entered an age when a hundred flowers bloom together and a hundred schools of thought contend.

WANG QIAN

SEE ALSO *Research Ethics.*

BIBLIOGRAPHY

Broad, William J., and Nicholas Wade. (1988). *Beipan zhenli de renmen,* trans. Zhu Jinning and Fang Yuzhen. Beijing: Kexue chubanshe. Originally published as *Betrayers of the Truth—Fraud and Deceit in the Halls of Science* (New York: Simon and Schuster, 1982).

Chinese Academy of Sciences. (2001). "Zhongguo kexue yuan xue bu kexue daode jianshe zuotanhui jiyao" [Summary of a symposium on establishing standards of scientific integrity of Academic Department of the Chinese Academy of Sciences]. *Zhongguo kexue yuan yuankan* 5: 325–326.

Chinese Academy of Sciences. (2002). "Zhongguo kexue yuan yuanshi kexue daode zilü zhunze" [Self-disciplining standards of scientific integrity for members of the Chinese Academy of Sciences]. *Zhongguo kexue yuan yuankan* 1: 2.

Fan Hongye. (1982). *Kexue yeji de bianwei* [The falsification of scientific results]. Shanghai: Shanghai renmin chubanshe.

Fan Hongye. (1994). "Keyan zuowei xingwei ji qi bianshi yu fangfan" [Recognizing and preventing the falsification of scientific research]. *Ziran bianzhengfa tongxun* 1: 25–33.

Hu Qiheng. (1999). "Kexue de zeren yu daode: Yige zhide zhongshi de wenti" [Responsibility and integrity of science: A question worthy of attention]. *Xuehui* 11: 16.

Hu Qiheng. (2000). "Kexue daode bu rong hushi" [Scientific integrity cannot be neglected]. *Zhongguo gaige* 1: 21.

Li Bocong. (2000). "Daode huhuan he daode yueshu" [Moral appeal and moral restraint]. *Kexue dui shehui de yingxiang* 3: 49–50.

Li Hanlin. (1987). *Kexue shehuixue* [Sociology of science]. Beijing: Zhongguo shehui kexue chubanshe.

Li Hongfang. (2000). "Jinnian kexue yuegui wenti yanjiu pingshu" [A review of recent misconduct in science]. *Kexue daobao* 3: 16–18.

Li Peishan. (2000). "Ezhi kexue daode lunluo de jidian qianjian" [Several suggestions for preventing the loss of scientific integrity]. *Ziran bianzhengfa tongxun* 2: 10–11.

Li Peishan, and Xue Pangao. (1996). "Shi Yingwen wenti, haishi kexue daode wenti?" [Is it a problem of understanding English or a problem of scientific integrity?]. *Ziran bianzhengfa tongxun* 4: 74–80.

Li Qingzhen, Su Fuzhong, and An Weifu. (2003). *Xiandai keji lunlixue* [The ethics of modern science and technology]. Jinan, China: Shandong renmin chubanshe.

Liu Fengrui, ed. (1989). *Jianming keji lunlixue* [Essentials of science and technology ethics]. Beijing: Hangkong gongye chubanshe.

Ministry of Science and Technology, Ministry of Education, Chinese Academy of Sciences, Chinese Academy of Engineering and China Association for Science and Technology. (1999). "Guanyu keji gongzuozhe xingwei zhunze de ruogan yijian" [Several opinions on standards of behavior for scientists and technologists]. *Keji yu falü* 4: 3–4.

Shi Yumin. (1994). "Lun kexue huodong zhong de yuegui" [On misconduct in scientific activities]. *Kexue guanli yanjiu* 2: 6–14.

Wang Feng. (1999). "Chaoxi: Bu jinjin shi daode wenti, geng shi weifa xingwei" [Plagiarism: Not just an ethical matter, but an illegal act]. *Keyan guanli* 2: 68–73.

Wang Feng. (2002). "Kexue bu duan xingwei ji qi chengyin pouxi" [Misconduct in science and an analysis of contributing factors]. *Kexue xue yanjiu* 1: 11–16.

Xu Shaojin. (1989). *Keji lunlixue* [The ethics of science and technology]. Shanghai: Shanghai renmin chubanshe.

Yan Bing, and Song Ziliang. (1997). "Kexue zuowei yu daode jiaohua" [Forgery in scientific research and moral instruction]. *Kexue xue yanjiu* 1: 57–62.

Yan Bing, and Song Ziliang. (1999). "Kexue zuowei yu shehui tiaokong" [Forgery in scientific research and social control of it]. *Kexue xue yanjiu* 1: 16–24.

Yang Yusheng. (2002). "Xueshu fubai, xueshu guifan yu xueshu lunli: Guanyu gaoxiao xueshu daode jianshe de ruogan wenti" [Academic misconduct, academic standards, and academic ethics: Several problems for establishing academic standards in higher education]. *Shehui kexue luntan* 6: 28–34.

Yang Yusheng. (2002). "Xueshu piaoqie xianxiang: Women ying you de guanzhu yu fansi" [Academic plagiarism: What we should pay attention to and reflect on]. *Shehui kexue luntan* 4: 24–29.

Zhang Huaxia. (1999). *Xiandai kexue yu lunli shijie* [Modern science and the world of ethics]. Changsha, China: Hunan jiaoyu chubanshe.

Zhou Guangzhao. (1994). "Zai Zhongguo kexue yuan diqici yuanshi dahui shang de gongzuo baogao" [Working report of the seventh conference of members of the Chinese Academy of Sciences]. *Zhongguo kexue yuan yuankan* 3: 196–202.

Zou Chenglu. (2002). "Kexuejia yu kexue yanjiu daode" [Scientists and scientific research integrity]. *Minzhu yu kexue* 1: 10–12.

Zou Chenglu, Shen Sanjiong, Wu Min, and Li Lin. (1991). "Zai lun kexue daode" [On scientific integrity, part 2]. *Zhongguo kexue bao,* 25 October 1991.

CHOICE BEHAVIOR

The ability to make a choice, as opposed to being told what to do, or given only a single option, has been shown to have positive effects (Deci and Ryan 1985). People are more internally motivated and perform better on tasks they have chosen, and they also are more satisfied with their choices and feel more in control. However as decisions become more difficult for decision makers, these benefits begin to disappear. When people face difficult decisions, they experience more anxiety, anticipate potential regret, and are more likely to postpone the decision, relegate it to another person, or avoid making it altogether (Schwartz 2004). In addition after making a difficult decision people are likely to be dissatisfied, and feel less confident that the *right* choice was made. These phenomena have obvious ethical implications for a society in which science and technology are often valued because of their ability to enhance choices.

A number of factors increase the difficulty of a decision. Situations that require decision makers to contrast unattractive options, make large tradeoffs, or compare large numbers of items make decisions difficult, as do those where accountability to others or a lack of information lead to anticipated regret or fear of blame. Increasing the number of options available increases the number of tradeoffs that must be made between desirable attributes of those options. This increases the effort required of the decision maker and induces more severe psychological consequences, which leads decision makers to rely on less of the available information, and to use simplified decision rules, which in turn make mistakes more likely. This result has been found to hold true not only for consumer purchasing decisions, but also for selecting retirement and health insurance plans, and choosing medical treatments (both by patients and doctors) (Schwartz 2004).

In addition to changes in the decision process, researchers have demonstrated effects on decision outcomes. More specifically when the choice involves potential tasks or activities, more options can lead to the decision maker feeling less motivated and performing more poorly on the chosen task. For example, researchers offered students either thirty topic options for an extra credit essay or six options, and found that when students had thirty options to choose from, fewer students chose to write an essay, and the quality of the essays written was worse.

Importantly experts do not appear to be immune to the effects of decision difficulty (Shanteau, Weiss, Thomas, and Pounds 2003). Whereas experts are often able to consider more of the available information, the only experts who appear uniquely equipped to make decisions are those in fields such as physics and mathematics where rules exist for reaching solutions, relative levels of certainty exist, and there are opportunities to learn from feedback. Experts in fields where there are not explicit rules or equations for solving problems (for example, clinical psychologists, legislators, advertising executives) have been found to use simplified decision rules and be affected by the psychological effects of tradeoffs. However the accountability that comes with being an expert has been shown, in many situations, to increase a decision maker's search effort and the complexity of decision strategies (Lerner and Tetlock 2003).

Unfortunately experts and novices alike are commonly unaware of the influences that decision difficulty has on their behavior. People often believe they want more choice options, yet those options make them less happy, and they often want to give such options away once they have them (Schwartz 2004). For example, 65 percent of healthy people say that they would want to choose their own medical treatment if they were to get cancer, whereas among people with cancer only 12 percent want to choose their own treatment. When not actually facing it, people do not realize the difficulty of the decision and the emotional consequences they will face when they have to bear the responsibility of deciding. Likewise as experts make decisions, particularly those concerning outcomes for other individuals, they need to take into consideration both their own cognitive abilities and limitations—in particular, the effects of decision difficulty that they might not be aware of—as well as the abilities and limitations of the individuals who will be affected. For example, legislators deciding not to make changes to an existing program may indicate decision aversion in response to the difficulty that comes from accountability; similarly creating a program that gives more options to the affected citizens (such as giving workers options for investing social security savings) may result from the desire to shift the responsibility of making wise choices to the other party. Whereas the people affected might even think they want the options, if the options leave them with difficult decisions that are undesirable, providing the choice might prove to be a disservice.

ELIZABETH J. MULLIGAN
ERIC D. CLAUS

SEE ALSO *Decision Theory; Psychology.*

BIBLIOGRAPHY

Deci, Edward L., and Richard M. Ryan. (1985). *Intrinsic Motivation and Self-Determination in Human Behavior*. New York: Plenum Press.

Lerner, Jennifer S., and Philip E. Tetlock. (2003). "Bridging Individual, Interpersonal, and Institutional Approaches to Judgment and Decision Making: The Impact of Accountability on Cognitive Bias." In *Emerging Perspectives on Judgment and Decision Research*, ed. Sandra L. Schneider and James Shanteau. Cambridge, UK: Cambridge University Press.

Schwartz, Barry. (2004). *The Paradox of Choice: Why More Is Less*. New York: Ecco. Provides a very thorough, yet accessible, account of research findings on decision making that illuminates the problems that arise when decision makers encounter increasing numbers of options and/or lack information needed to make a decision.

Shanteau, James; David J. Weiss; Rickey P. Thomas; and Julia Pounds. (2003). "How Can You Tell If Someone Is an Expert? Performance-Based Assessment of Expertise." In *Emerging Perspectives on Judgment and Decision Research*, ed. Sandra L. Schneider and James Shanteau. Cambridge, UK: Cambridge University Press.

CHOICE THEORY

SEE *Rational Choice Theory*.

CHRISTIAN PERSPECTIVES

Contemporary Assessments of Science
Contemporary Assessments of Technology
Historical Traditions

CONTEMPORARY ASSESSMENTS OF SCIENCE

The relationship between science and Christianity is often portrayed as one of perpetual conflict. Although controversies such as that between the science of evolution and claims for religious creationism or intelligent design theory lend credence to this popular perception, the actual relationship is more complex. Indeed, since the Scientific Revolution of the seventeenth and eighteenth centuries and the Industrial Revolution of the nineteenth century, theologians have spent considerable effort just trying to sort out alternatives. Two great contributors to this effort were the German historian of Christianity Ernst Troeltsch (1865–1923) and the American theologian H. Richard Niebuhr (1894–1962). Niebuhr, for instance, distinguishes five basic relationships between Christ and culture: Christ as opposed to culture, as in agreement with culture, as above culture, as paradoxically related to culture, and as transformer of culture. Insofar as science is a kind of culture, these same five types can be found manifest in the Christianity–science relationship. Indeed, in a contemporary adaptation of Niebuhr, Ian G. Barbour (1990) develops a typology of four possible relationships that can serve here as a convenient framework.

Conflict

Barbour contends that this option represents a relatively small group of highly vocal protagonists whom he labels scientific materialists and biblical literalists. Within this schema, materialists use science to discredit religious faith, whereas literalists use religion to dictate the purview and course of scientific investigation.

Scientific materialists assert that science offers the only reliable route to knowledge, and that matter and energy are the fundamental realities of the universe. Drawing heavily on logical positivism, they argue that only verifiable or falsifiable statements have cognitive value. Consequently, religious beliefs are dismissed as meaningless, emotive statements because theological claims can be neither verified nor falsified. Examples of influential scientific materialists include Jacques Monod (1972), Edward O. Wilson (1978), and Richard Dawkins (1986).

Biblical literalists insist that scripture reveals the fundamental truth of the universe as God's creation. Although the Bible does not offer a detailed description of how God brought the universe into existence, it does disclose an underlying intelligent design as unbiased observations of nature confirm. Any so-called scientific evidence to the contrary should be attacked as false, incomplete, or mistaken. Moreover, because God is a supernatural being, divine or miraculous acts are not subject to the principles of verifiability or falsifiability in order to determine their truth. Consequently, given the supernatural origins of the universe, revelation provides the most trustworthy knowledge about ultimate realities.

The difference between materialists and literalists is most pronounced in their conflicting claims on human nature. Materialists argue that human behavior can be best explained as the emergent outcome of a blind evolutionary process. Human values and social mores are thereby the result of adaptive behavioral strategies that gave *Homo sapiens* and predecessors a survival advantage over time. Any moral difference separating humans from other animals is one of degree, not kind. Literalists retort that human beings were specially created by God. Unlike animals, humans possess souls that enable them to have fellowship with God, and the ability to perceive and obey God's moral commands as disclosed in Scripture. Thus human life has a uniquely sacred quality that is fixed rather than malleable. These contending claims over human nature are in turn often reflected in the


Christianity
More than 25% of population, including Andorra, Antigua and Barbuda, Barbados, Cape Verde, Dominica, Grenada, Kiribati, Liechtenstein, Malta, Marshall Islands, Mauritius, Micronesia, Monaco, Nauru, Palau, Samoa, San Marino, São Tomé, Seychelles, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Tonga, Tuvalu, Vatican City (not shown); The Bahamas, Jamaica, Luxembourg, Solomon Islands, Vanuatu (shown)
5–25% of population, including Singapore (not shown); Brunei (shown)
Less than 5% of population
©2005 Thomson Gale

acrimonious "culture wars" fought over such contentious issues as abortion, embryonic stem cell research, and euthanasia.

Independence

One strategy for avoiding conflict between science and religion is to insist on a rigorous separation and mutual honoring of their respective disciplinary boundaries. Science and religion are discrete and autonomous domains of inquiry that do not overlap. Given this détente, science confines itself to questions of *what*, while religion focuses on issues of *why*. Science offers empirical descriptions of physical reality while religion interprets the meaning of human existence by employing theological and moral precepts.

Christian theologians use a variety of methodologies in maintaining their independent sphere of inquiry. Karl Barth and his followers, for example, insist that history rather than nature is the domain of God's activities. It is through God's covenant with Israel, and the life, death, and resurrection of Jesus Christ that God reveals the divine plan for creation. In this respect, the Bible is held in high regard but is not interpreted literally. Consequently, naturalistic explanations of the origin of the universe do not contradict the biblical creation stories because both accounts are offered in delineated and noncompetitive modes of discourse. Moreover, an evolutionary description of human origins is unproblematic because God is revealed in the historical category of human culture rather than the natural category of biology. Similar approaches have been developed by Langdon Gilkey (1965) and Thomas F. Torrance (1969).

Science and theology do not conflict because of their highly disparate objects of inquiry and respective methodologies. They represent differing languages or linguistic constructs that cannot be easily translated into each other's categories. Although mutual independence promotes a peaceful relationship between science and religion, the price is that both appear to be describing two unrelated worlds rather than a common or single reality.

Dialogue

One way of overcoming this artificial division is to promote a dialogue between science and religion. There are two levels at which this dialogue may be pursued. First, both scientists and theologians encounter questions or make discoveries that cannot be easily confined within their respective disciplinary boundaries. Scientific research, for instance, may disclose a natural beauty and elegance inspiring a response of awe and wonder, while theologians are driven to find rational connections between human history and its underlying natural foundations. These transdisciplinary insights raise the prospect that although science and religion invoke two incompatible languages, they are nonetheless making correlative claims. Ernan McMullin (1998), for example, contends that although the big bang theory does not prove the Christian doctrine of creation, there is an implicit consonance suggesting that the universe is dependent upon God. More explicitly, Karl Rahner (1978) contends that Christian anthropology is compatible with evolutionary theory because it is through the emergence of spirit within matter that God has brought into being a creature with the capabilities of self-transcendence and divine fellowship.

The second level of dialogue focuses on the methodological parallels between science and religion. Wolfhart Pannenberg (1976), for instance, contends that theological doctrines are equivalent to scientific hypotheses that can be tested against universal rational criteria. The principal difference between science and theology is that the latter is concerned about reality as a whole, and given its unfinished and unpredictable character is not subject to as rigorous disciplinary scrutiny. In a similar vein, Alister E. McGrath (2003) argues that theological doctrines should be thought of as theories about nature and reality, whose truthfulness should be tested by rigorous theological and philosophical criteria. Other writers, such as Janice Martin Soskice (1985), Barbour (1990), and Mary Gerhart and Allan Russell (1984) insist that the dichotomy between "objective" science and "subjective" religion is false and misleading. Scientific research is itself theory-laden rather than neutral, and scientists often resort to intuition and analogies in constructing their theories. Similarly, theologians use theory-laden models and metaphors to investigate and describe religious experience. The work of both scientists and theologians may therefore be assessed in terms of coherence, comprehensiveness, and fruitfulness, thereby acquiring a common form of knowledge that Michael Polyani asserts is personal but not merely subjective. Consequently, the models and metaphors employed respectively by science and theology may prove mutually enriching in investigating the origin and nature of the universe in general and those of human beings in particular.

Integration

Although the dialogue approach promotes a closer relationship between science and religion than that offered by the independence model, the resulting conversation tends to be cursory given the focus on methodological issues. A number of writers assert that in order to correct the incomplete character of this dialogue, the content of science and religion needs to be integrated. Following Barbour, there are three prominent ways for pursuing such integration, which he identifies as natural theology, theology of nature, and systematic synthesis.

Natural theology is based on the premise that the order and intelligibility of the universe suggests an underlying purpose or design. This is especially the case with respect to the emergence of life, which proponents claim implies a natural teleology; that is, the evolution of the universe is itself oriented toward an emergent intelligence. Religious experience and revelation confirm this basic scientific insight. Consequently, natural theological arguments often begin with science in order to construct subsequent religious claims. Richard Swinburne (2004), for instance, contends that given all the available scientific evidence, it is more probable than not that a deity or creator exists. A variety of authors have also invoked the anthropic principle, claiming that the universe appears to be "fine-tuned" for the emergence of life. Freeman Dyson (1979) claims that although the anthropic principle does not prove God's existence, the universe's architecture is consistent with a structure in which something like a mind plays a dominant role. More expansively, Simon Conway Morris (2003) contends that evolution is not a random process, and that the emergence of human life was inevitable given the rare physical conditions of planet Earth.

A theology of nature approach starts with traditional religious claims and reformulates them in light of contemporary science. Arthur Peacocke (1993), for example, explicates a pantheistic understanding of God to account for the necessity of randomness and chance in God's created order. It is through natural processes as disclosed by science that God participates in the ongoing creation of the universe. In this respect, Peacocke asserts that God is in the world but the world in also in God, and he uses the analogy of the universe as God's body and God as the universe's mind or soul to illustrate his argument. John Polkinghorne (1994) and Ted Peters (2000) have also undertaken similar reformulations, though with differing doctrinal emphases. More radically, Pierre Teilhard de Chardin (1964) offers a reinterpretation of Christian eschatology in which the evolution of self-conscious and intelligent life is being drawn toward an "Omega Point" of a single, universal consciousness.

Other writers advocate a systematic synthesis of science and religion resulting in an all-embracing metaphysics. The process philosophers Alfred North Whitehead (1978/1929) and Charles Hartshorne (1967) are leading examples of this approach. Both reject traditional doctrines of divine omnipotence in favor of a persuasive God, thereby accounting for the necessity of freedom, chance, and suffering in the world. Creation is an incomplete process, and God encourages its self-creation and completion, thereby allowing humans to exhibit genuine freedom and novelty within malleable natural structures. More modestly, James Gustafson (1981) and Charles Birch and John B. Cobb Jr. (1981) use scientific and religious principles to develop a nonanthropocentric ethic in which nature and nonhuman life-forms are valued in respect to God rather than for their usefulness to humans. In formulating their respective ethics, they draw heavily on the biological and environmental sciences. Philip Hefner (1993) has also used a variety of sciences in pursuing a thorough and systematic recasting of theological anthropology. Humans are the products of genetic and cultural information to such a degree that technological civilization has become their natural habitat. Humans have therefore emerged as created cocreators, who in partnership with God are responsible for the eventual fate of creation.

Assessment

There is thus no such thing as *the* Christian assessment of contemporary science. Rather, there is a wide range of assessments reflecting denominational and doctrinal differences, as well as the diversities of contemporary culture. Moreover, the typologies employed should not be construed as rigid categories but as markers within a highly fluid range of options. This is in keeping with the fact that the various relationships between science and religion are themselves subject to frequent reevaluation and revision in response to rapid developments in scientific, theological, and philosophical inquires.

It might also be noted that Barbour's typology has been criticized for a failure to take revelation seriously enough or as containing a built-in bias toward integration. Certainly there is a sense in which, from Barbour's perspective, integration appears to be the highest type of relationship between science and Christian theology.

BRENT WATERS

SEE ALSO *Anglo-Catholic Cultural Criticism; Evolution-Creationism Debate; Natural Law.*

BIBLIOGRAPHY

Barbour, Ian G. (1990). *Religion in an Age of Science*. San Francisco: Harper and Row. An extensive summary and overview of various relationships between modern science and religion.

Birch, Charles, and John B. Cobb Jr. (1981). *The Liberation of Life*. Cambridge, UK: Cambridge University Press. A theistic interpretation of human evolution from the perspectives of a leading ecologist and process theologian.

Dawkins, Richard. (1986). *The Blind Watchmaker*. New York: Norton. A materialist and contemporary Darwinian account of nature.

Dyson, Freeman. (1979). *Disturbing the Universe*. New York: Harper and Row. A philosophical reflection by a leading scientist on the meaning of recent and anticipated scientific and technological advances.

Gerhart, Mary, and Russell, Allan. (1984). *Metaphoric Process: The Creation of Scientific and Religious Meaning*. Fort Worth: Texas Christian University Press. An inquiry into the similarities and differences between religious and scientific ways of knowing.

Gilkey, Langdon. (1965 [1959]). Maker of Heaven and Earth: A Study of the Christian Doctrine of Creation. Garden City, NY: Anchor Books. A contemporary Protestant theological treatise on the Christian doctrine of creation in light of modern science.

Gustafson, James M. (1981). *Ethics From A Theocentric Perspective*, Vol. 1: *Theology and Ethics*. Chicago and London: University of Chicago Press. A leading Protestant theologian argues that ethics should be theopocentric (God-centered) rather than anthropocentric (human-centered).

Hartshone, Charles. (1967). A Natural Theology for Our Time. La Salle, IL: Open Court. A concise exposition on the primary themes of process philosophy and theology.

Hefner, Philip. (1993). *The Human Factor: Evolution, Culture, and Religion*. Minneapolis, MN: Fortress Press. Argues that advances in biological cultural evolution disclose humans as god's created co-creators.

McGrath, Alister E. (2001). *A Scientific Theology*, Vol. 1: *Nature*. Grand Rapids, MI: Eerdmans. Contends that from the perspective of Christian theology, nature should be regarded as creation.

McGrath, Alister E. (2002). *A Scientific Theology*, Vol. 2: *Reality*. Grand Rapids, MI: Eerdmans. Argues that creation can only be properly understood from a critical realist vantage point.

McGrath, Alister E. (2003). *A Scientific Theology*, Vol. 3: *Theory*. Grand Rapids, MI: Eerdmans. Contends that theological doctrines constructed from a critical realist perspective are similar to scientific theories that can be tested through the employment of various criteria.

Mcmullin, Ernan. (1998). "Cosmic Purpose and the Contingency of Human Evolution." *Theology Today* 55(3): 389–414. Examines the relevance of recent advances in cosmology for Christian theology.

Monod, Jacques. (1972). *Chance and Necessity*, trans. Austryn Wainhouse. New York: Vintage Books. A philosophical interpretation of biology from an evolutionary and materialist perspective.

Morris, Simon Conway. (2003). *Life's Solution: Inevitable Humans in a Lonely Universe*. Cambridge, UK: Cambridge University Press. Argues that the evolution of life is not radically open-ended but is convergent, and thereby limited to a restricted range of outcomes.

Pannenberg, Wolfhart. (1976). *Theology and the Philosophy of Science*, trans. Francis McDonagh. Philadelphia: Westminster Press. A highly detailed investigation into the relation between systematic theology and philosophy of science.

Peacocke, Arthur. (1993). *Theology for a Scientific Age*, rev. edition. Minneapolis, MN: Fortress Press. Crafts a concept of God that is intended to be compatible with contemporary scientific perspectives.

Peters, Ted. (2000). *God—the World's Future: Systematic Theology for a New Era*. Minneapolis, MN: Fortress Press. The author reconstructs a wide range of traditional Christian doctrines in response to new scientific theories and developments in postmodern philosophy.

Polkinghorne, John. (1994). *The Faith of a Physicist: Reflections of a Bottom-Up Thinker: The Gifford Lectures for 1993–4*. Princeton, NJ: Princeton University Press. An interpretation of Christian belief in light of new developments in physics, with an emphasis on natural theology, and the relationship between faith and reason.

Price, Daniel J. (2002). *Karl Barth's Anthropology in Light of Modern Thought*. Grand Rapids, MI: Eerdmans. A critical and detailed assessment of Barth's theological anthropology.

Rahner, Karl. (1978). *Foundations of Christian Faith*, trans. William V. Dych. New York: Seabury Press. General reflections on the relationship between science and religion by one of the twentieth century's leading Catholic theologians.

Soskice, Janet Martin. (1985). *Metaphor and Religious Language*. Oxford: Clarendon Press. A comparative study of religious and scientific forms of discourse.

Swinburne, Richard. (2004). *The Existence of God*, 2nd edition. Oxford: Clarendon Press. A highly detailed philosophical argument for the existence of God.

Teilhard de Chardin, Pierre. (1964). *The Future of Man*, trans. Norman Denny. London: Collins. A collection of highly speculative essays on the future course of human evolution.

Torrance, Thomas F. (1969). *Theological Science*. London: Oxford University Press. A philosophical and theological inquiry into the relationship between science and religion by a leading Protestant theologian.

Whitehead, Alfred North. (1978 [1929]). *Process and Reality*. New York: Free Press. A highly detailed account of the principal themes of process philosophy by its leading proponent.

Wilson, Edward O. (1978). *On Human Nature*. Cambridge, MA: Harvard University Press. An overview of the principal claims and methodologies of sociobiology.

CONTEMPORARY ASSESSMENTS OF TECHNOLOGY

Insofar as Christianity, like any religion, is a way of life as much or more than a system of thinking, its relations to modern technology are even more problematic than those with science. The Christian life aspires to provide guidance for daily behavior, from the saying of prayers to charitable care for others. When Jesus of Nazareth was asked about the most fundamental commandments (not ideas), he answered that they were "to love the Lord your God . . . and your neighbor as yourself" (*Luke* 10:27). And when asked who is the neighbor, he answered not with a theoretical discourse but the parable of the Good Samaritan (*Luke* 10:30–37). The most fundamental question for Christianity is the degree to which technology is or is not a way to practice love of one's neighbor.

The Origins of Technology

The historical fact is that modern technology arose within the context of a Christian culture. This has led to numerous debates about the degree to which Christianity has itself contributed to this origin. The most radical position is that of the historian Lynn White Jr. (1967) who has argued at length that the roots of technology in its distinctly modern form lie in Christian theology as it developed in the Latin West.

White's chief contention is that Christian theology, particularly the teaching of human dominion over creation, is the primary culprit underlying the environmental crises of the late twentieth centuries. In exercising this dominion humans have developed and deployed various technologies in an irresponsible manner, leading to ecological instability.

Although White's thesis has been subjected to subsequent criticism noting his failure to take into account the attending biblical emphasis on stewardship, which blunts the more egregious forms of exploitation he deplores, he nonetheless identifies a dilemma regarding a Christian moral assessment of technology per se. If on the one hand, technology is a valuable instrument humans use in exercising their dominion and stewardship, then it is inherently good. If on the other hand, technology is used in an exploitive and environmentally destructive manner thereby distorting human dominion and stewardship, then it is inherently evil. Various Christian theologians have adopted one or the other of these options, as well as a range of alternative assessments between these two extremes.

This historico-theological debate easily invites further analysis of the spectrum of theological attitudes toward technology. Drawing on a typology developed by Ian G. Barbour (1993), it is convenient to classify these basic attitudes as those of optimism, pessimism, and contextualism.

Christian Optimism

The first approach, optimism, perceives technology as a liberating force. Optimists contend that technology has been a singularly effective means for improving the quality of human life by overcoming a series of natural, social, and psychological constraints. This impressive accomplishment has been achieved by enabling higher living standards, improved health care, an expanded range of individual lifestyles, greater leisure, and rapid communication. Moreover, there is no compelling reason to believe that technological development will not continue this progressive trend in the foreseeable future.

Pierre Teilhard de Chardin (Teilhard, 1964) offers an expansive vision in which technology is used by humans to determine their own destiny as a species. Current technical interventions are prompting the evolution of a global spiritual consciousness, and Teilhard foresees the day when humans will no longer be discrete organisms. Subsequent theologians in this category draw heavily on the works of such futurists as Daniel Bell, R. Buckminster Fuller, Herman Kahn, and Alvin Toffler. Harvey Cox (1965), for instance, praises technology for rescuing humans from the tyranny of tradition, thereby expanding the range of their freedom and creativity. Philip Hefner (1993, 2003) portrays it as a principal mechanism for humans to fulfill their calling as God's created co-creators. In general, optimists tend to regard technology as a means for humans to better display the divine image they bear, or to more effectively express a love of neighbor.

Critics charge that optimists too easily disregard the costs and risks of technological development; unintended consequences and catastrophic accidents can and do occur. In addition, the large-scale technologies advocated by most optimists concentrate economic and political power in the hands of the few, which is inherently antidemocratic. Most importantly, the emergence of a technological age has alienated humans from nature, and is unsustainable because it is consuming natural resources and destroying ecologies at voracious rates that will eventually threaten human welfare. Confidence in unlimited technological development is more an unorthodox than an orthodox leap of faith. In the words of Jacques Ellul (1964), it is a non-Pascalian wager on human power, not the existence of God.

In reply, optimists contend their reliance on technology is justified. History is a relatively accurate indicator of future trends, and the path of technological development has an impressive track record. Whatever problems may exist presently or in the future can be solved through rational policies governing further technological development.

Christian Pessimism

The second type, pessimism, is the polar opposite of the first because it views technology as a grave threat, a consequence of living in a fallen creation. Pessimists perceive the emerging technological society as a place of unrelenting uniformity and conformity that undermines individual freedom. They decry a narrow understanding of efficiency leading to numbing specialization and social fragmentation. Moreover, the process of developing and maintaining various technological projects is inherently alienating; genuine communities are displaced by functional and manipulative relationships. More menacingly, technology takes on a life of its own that is not easily subjected to human control.

Ellul is the dominant figure here. His principal thesis is that society now comprises a series of interdependent ensembles of economic, political, and psychological techniques. More troubling, these ensembles are merging into a singular, comprehensive, and autonomous technique that resists, if not defies, meaningful human participation or control. In short, modern technological development is totalitarian and dehumanizing. A number of other writers have either expanded on or formulated similar arguments. George Grant (1986), for example, contends that modern technology embodies Friedrich Nietzsche's will to power, resulting in an unrelenting desire to master nature and human nature.

This fixation on mastery creates two related moral problems: First, technology is the means of the powerful to assert their will over the weak, and second, rather than enabling human flourishing, technical efficiency becomes a standard to which human behavior must conform. As a consequence, basic notions of truth, beauty, goodness, and justice become profoundly disfigured and corrupted in a technological age. Albert Borgmann (2003), for instance, argues that the principal values underlying technological development distort normative patterns of human interaction. The fast-food industry has transformed the art of dining into a quick meal on the run. What is lost in the process is a rich set of cooperative practices involving the careful preparation of the meal, its leisurely consumption, and accompanying conversation. This loss in turn has a detrimental effect on the quality of life for individuals, families, and communities. It should be noted that although pessimists are certainly not sanguine about the future, neither are they without hope. For instance, Grant and Borgmann assert, respectively, that a recovery of Platonic principles and Christian moral convictions, and the employment of key focal practices can at least mitigate the ill effects of a technological society.

Critics charge pessimists with such a high level of abstraction that their ensuing analysis diverts rather than focuses attention on the ethical issues at stake. They grant technology a deterministic power that cannot be challenged; the outcomes of technological development will, by definition, always be evil or at least menacing. This conclusion is unwarranted because pessimists have concocted a self-fulfilling prophecy instead of demonstrating an inherent inevitability. This is reflected in their failure to make any discrimination among discrete technologies, and how their development has varied within different cultural settings. More importantly, pessimists refuse to entertain the possibility that technology can be redirected in ways that strengthen rather than corrode the values they commend. More control over the direction of technological development can be exerted than they are willing to admit.

In response, pessimists insist that their level of abstraction is no less than that employed by optimists. Consequently, the resulting analysis in behalf of progressive technological development serves to confuse rather than clarify the ethical issues in question. Moreover, the contention that technology can be easily redirected to serve human values is naive, because it fails to recognize the extent to which the purported values have been deformed by a pervasive technical rationality, thereby rendering them unsuitable as a moral rudder.

Contextualism

The third type, contextualism, occupies the middle space between the previous two. Rejecting the generalizations of both optimists and pessimists are those who claim that technology is an ambivalent instrument of power that can be used for good or evil purposes in varying socioeconomic contexts. Consequently, contextualists contend that through a combination of social, political, and economic reforms, technological development can be redirected toward more just and humane goals.

Given their heavy emphasis on reform, contextualists devote a great deal of attention to issues involving regulatory policies. Victor C. Ferkiss (1969, 1974), for instance, argues that existing political structures can redirect technological development, but that this requires two prior steps. First, technology must be directed away from generating private wealth (for example, corporate profit) and toward promoting the common good (such as the environment). Second, a rampant individualism that diminishes the common good must be tempered with more decentralized, inclusive, and participatory decision-making processes. Roger Shinn (1982) agrees with the pessimists that various technologies form an interlocking structure that tends to concentrate and centralize economic and political power, but he argues that citizens can marshal sufficient pressure to garner greater democratic control.

Barbour places himself in the contextual camp because he believes it embodies a biblical perspective that combines the ideal of social justice with a realistic assessment of self-interested power. Contextualists seek the practical application of moral convictions that direct technology toward meeting basic human needs, and this goal is best accomplished by creating more distributive economic systems, implementing widely participatory and democratic regulation, and developing appropriately scaled and sustainable technologies.

As might be expected, optimists and pessimists offer differing criticisms of this middle position. Optimists contend that the reforms envisioned by contextualists would serve only to retard economic growth. Without sufficient incentives for return on investment little innovation or technical progress will be achieved, even on the modest scale envisioned. The net effect would be to amplify the very injustice and suffering of the disadvantaged groups the contextualists purportedly wish to serve. Pessimists dismiss reform as little more than a rearguard action that may slow the pace but will not change the direction of technological development. Once enacted, reforms will be subsumed within a more encompassing framework of techniques, thereby rendering them ineffectual. There is scant evidence that the course of modern technological development has been redirected once it has achieved sufficient momentum. In reply, contextualists argue that the dire predictions of optimists and pessimists cannot be known in advance. The only way to test the validity of reform is its implementation in order to judge the failure or efficacy of actual results.

Illustrative Issue: Energy

Although this typology identifies three basic approaches for assessing technology, the question remains: What difference do these approaches make in respect to specific ethical issues and religious life? Consider two illustrative case studies. First, since the 1960s environmental issues have commanded public attention. Focusing on the related issue of energy allows for a more clear focus on the arguments originating in the categories outlined above. In each instance a dominant theological doctrine or theme underlying these arguments is also identified.

Optimists assert that the so-called energy crisis is greatly exaggerated. There is admittedly a finite limit to fossil fuels, but new and more plentiful sources, such as hydrogen and nuclear power, can be developed. The adverse impact on the environment caused by steadily increasing energy consumption has also been overstated. Automobile and power plant emissions have already been reduced through the use of more efficient technologies, and the development of new fuels promises even cleaner sources of energy. Individuals do not need to forsake their affluent lifestyles as claimed by many environmentalists. Rather, what is needed are economic incentives and investment opportunities that promote rapid technological development to ensure plentiful and relatively cheap sources of energy.

The principal theological justification of this position is an underlying *anthropocentrism*. Human benefit is the measure for determining whether certain acts are good or evil, a belief stemming from the biblical mandate that humans have been given dominion over creation. Consequently, humans may exploit natural resources to improve the quality of their lives, and the standard used to evaluate this improvement is predominantly materialistic.

The optimists' energy manifesto merely confirms the worse fears of the pessimists. On the one hand, hope is being placed largely on unproven technologies with unknown risks. The entire enterprise could prove disastrous. On the other, even if successful the envisioned programs would centralize political and economic power even more, thereby exacerbating the gap between rich and poor, and further eroding the already fragile bonds of various communities. This is but another ploy for tightening the grip of an autonomous technological system already beyond democratic control.

The primary religious imagery informing this perspective may be described as *theopocentric*. The morality of certain acts is judged in relation to God's will or commands. Moreover, nature is not a storehouse of raw material waiting to be exploited, but part of God's creation, and should be honored as such. Consequently, natural limits should shape normative patterns of both individual lives and communal life. This may require adopting far simpler lives of restricted mobility and reduced consumption of material goods, but such is the price, as well as the joy, of being God's faithful and obedient servants.

Contextualists claim that pessimists and optimists proffer, respectively, a mistaken diagnosis and remedy. Technology per se is neither the problem nor the solution. The real issue at stake is the purposes that various technologies serve. The generation and delivery of energy should be directed primarily toward meeting needs rather than wants. This means that a combination of renewable and nonrenewable sources of energy should be developed, and the delivery mechanisms scaled down, decentralized, and subjected to participatory and democratic control. These reforms admittedly require adopting less mobile and consumptive lifestyles, but not a wholesale rejection of technology as feared by the optimists. In addition, greater democratic participation and less hectic lives may also promote the kind of human relationships and communities advocated by the pessimists.

The principal theological theme informing the contextualist approach is *stewardship*. Humans do not own the earth and may not do with it what they wish. They are instead entrusted by God to oversee its care. Because humans are accountable to God, there are certain normative convictions inherent to the role they have been called to perform. Consequently, there are limits to the extent to which natural resources should be exploited, but this does not mean that technology should be rejected because its appropriate use can assist humans to be good and faithful stewards.

Illustrative Issue: Biotechnology

Although Barbour's typology helps to identify differing ethical assessments of and theological perspectives on technology, the analysis is confined principally to mediating a perceived dualistic relationship between nature and human culture. But are the three approaches still illuminating when technology is used to bridge or even eliminate the nature–culture distinction? This question is prompted by anticipated developments in biotechnology, artificial intelligence, robotics, and nanotechnology. The most promising advances presumably involve the complementary approaches of designing sophisticated machines that emulate biological processes, while at the same time engineering biological organisms. Such an approach blurs the line separating the natural from the artificial. In practical terms, this implies a gradual merging of humans with their technology. Presumably this will occur initially through the introduction of more effective prosthetics (for example, optical implants to relieve blindness), but these therapeutic interventions could be used to enhance normal functions (such as telescopic or night vision). Some writers, such as Rodney A. Brooks (2002), Hans Moravec (1988, 1999), and Ray Kurzweil (1999), predict that this merging will prove so beneficial and complete that someday humans will be more like software than hardware. Minds will be uploaded into computers and then downloaded into organically engineered, robotic or virtual substrata. Yet how would Christians assess the prospect of an emerging technoculture populated by a new species of "technosapiens"?

Technological optimists and pessimists have an apparently easy time answering this question. Optimists presumably support these envisioned advances. Alleviating suffering and extending longevity, to say nothing of the virtual immortality predicted by bold visionaries, would certainly benefit humankind. Against the assertion that developing technosapiens negates the anthropocentric base of the optimists' moral stance, it can be maintained that the possibility that humans might evolve into a superior species is not ruled out in principle. Natural selection, which is slow paced and indifferent to human well-being, is being replaced by a more efficient and purposeful form of selection that favors human flourishing. Moreover, the quintessential characteristic of the human mind will be preserved and amplified in technosapiens. This emphasis upon a technologically enhanced human could in turn enable the emergence of the kind of global and spiritual consciousness envisioned by Teilhard de Chardin.

Pessimists are appalled by the prospect of a technoculture because it is little more than thin veneer disguising a death wish for the human species. On the one hand, no one can foresee the potentially lethal consequences of the proposed technological developments. Pessimists echo the concerns of Bill Joy (2000) and others, who contend that these new technologies could very easily run amok, leading to the extinction of *Homo sapiens*. On the other hand, if the project proves successful, the emergence of posthumans nonetheless signals the end of human life. Individuals are formed within a series of relationships that are experienced in and mediated through organic bodies. To ignore this embodied quality is also to reject what it means to be human. Asserting their underlying theopocentric stance, the pessimists contend that humankind is a unique creature bearing the image of God. Bearing that image faithfully requires that the vulnerable and mortal nature of embodied existence be accepted and honored as a gift instead of despised as a burden to be escaped. Any presumption that humans can improve or perfect themselves is an idolatry predicated upon and ending in death.

It is difficult to determine how contextualists might assess the emergence of a technoculture. First, contextualists tend to use conceptual frameworks that may not be applicable in an emerging technoculture. How, for instance, are concepts of scale, sustainability, participation, and identifying risks and benefits applicable to the interests of posthumans? The reformist agenda promotes a responsive rather than proactive ethic, one more suited to redirecting rather than charting a new course of technological development.

Second, the dualism presupposed in the underlying theological rationale of stewardship is severely eroded if not rendered unintelligible. The role of the steward is to somehow protect nature or creation from what are judged to be unwarranted intrusions by human culture. Yet the force driving the technology in question itself collapses the boundaries separating these categories. Recovering a role for the steward in the context of an emerging technoculture would require making normative claims about nature or humankind. Such a maneuver, however, would also presumably entail moving closer to either the optimist or pessimist camp, thereby forsaking the middle ground.

Assessment

To ponder the prospect of an emerging technoculture populated by technosapiens is admittedly highly speculative. If history is a reliable guide, many, if not most, prognostications about this future will prove mistaken. Moreover, the immodest predictions about digitized beings enjoying their immortality within the friendly confines of virtual reality can be easily dismissed as science fiction posing as science. Such a casual dismissal, however, should be resisted. Again, if the past is any guide, the wildest dreams of many scientists and inventors that never came true, nonetheless sparked the imagination of previous generations to form a culture, for good or ill, intricately dependent upon an evolving technology. Even if none of the predictions about a technoculture and technosapiens prove true, the speculation itself reveals how humans are coming to perceive themselves and their future. This imaginative enterprise in turn poses a crucial question: In light of humankind's technological potential, what does it mean to be human? And more importantly, should the question be answered in terms of an essential feature (mind or body), or function (stewardship), or some combination? Answering these questions requires both critical *and* constructive engagement, and given the unprecedented transformative power these new technologies embody this will also require creating new categories which go beyond either optimism or pessimism. The Christian theological tradition can offer both critical constructive resources for answering these questions, and hopefully its contribution will help forge an ethic to guide the future course of technological development.

BRENT WATERS

SEE ALSO *Ellul, Jacques; Kierkegaard, Søren; Nietzsche, Friedrich.*

BIBLIOGRAPHY

Barbour, Ian G. (1993). *Ethics in an Age of Technology*. San Francisco: HarperSanFrancisco. An overview of historical and contemporary ethical assessments of technologies from various religious perspectives.

Borgmann, Albert. (1984). *Technology and the Character of Contemporary Life: A Philosophical Inquiry*. Chicago: University of Chicago Press. A detailed and in-depth analysis of how technology shapes modern social structures and institutions.

Borgmann, Albert. (2003). *Power Failure: Christianity in the Culture of Technology*. Grand Rapids, MI: Brazos Press. A critical and constructive assessment of the emerging technoculture from an overtly Christian philosophical perspective.

Brooks, Rodney A. (2002). *Flesh and Machines: How Robots Will Change Us*. New York: Pantheon. A leader in the field of robotics argues that human nature contains key features that are essentially mechanistic, especially in respect to artificial intelligence.

Cole-Turner, Ronald. (1993). *The New Genesis: Theology and the Genetic Revolution*. Louisville, KY: Westminster/John Knox Press. Argues that Christian theology needs to be reformulated in light of recent advances in genetics and biotechnology.

Cox, Harvey. (1965). *The Secular City: Secularization and Urbanization in Theological Perspective*. New York: Macmillan.

Deane-Drummond, Celia. (1997). *Theology and Biotechnology: Implications for a New Science*. London: Geoffrey Chapman. An introductory overview of issues theological issues raised by recent developments in biotechnology.

Deane-Drummond, Celia, and Bronislaw Szerszynski, eds. (2003). *Re-Ordering Nature: Theology, Society, and the New Genetics*. London: T and T Clark. A collection of essays by theologians and scientists examining a range of ethical issues related to genetic research.

Ellul, Jacques. (1964). *The Technological Society*, trans. John Wilkinson. New York: Knopf. A wide ranging critique of the social and political influence of modern technology.

Ferkiss, Victor C. (1969). *Technological Man: The Myth and the Reality*. New York: Braziller. Argues that modern political philosophy must be formulated in light of technology as the most influential formative social and economic force.

Ferkiss, Victor C. (1974). *The Future of Technological Civilization*. New York: Braziller. A philosophical argument in behalf of "ecological humanism."

Fern, Richard L. (2002). *Nature, God, and Humanity: Envisioning an Ethics of Nature*. Cambridge, UK: Cambridge University Press. Argues that a Christian solution that places a higher premium on the inherent value of nature needs to be developed in response to the environmental crisis.

Grant, George. (1986). *Technology and Justice*. Notre Dame, IN: University of Notre Dame Press. A highly critical assessment of the destructive nature of modern technological development.

Gustafson, James M. (1996). *Intersections: Science, Theology, and Ethics*. Cleveland, OH: Pilgrim Press. A series of theological reflections on the cultural and religious meaning of modern technological development.

Hefner, Philip. (1993). *The Human Factor: Evolution, Culture, and Religion*. Minneapolis, MN: Fortress Press. A theological apology for the human as God's created co-creator.

Hefner, Philip. (2003). *Technology and Human Becoming*. Minneapolis, MN: Fortress Press. A religious reflection on the prospect and potential benefit of humans becoming cyborgs.

Heidegger, Martin. (1977). *The Question Concerning Technology, and Other Essays*, trans. William Lovitt. New York: Harper and Row. Argues that technology is enfolding humanity within its own rationality and destiny.

Herzfeld, Noreen L. (2002). *In Our Image: Artificial Intelligence and the Human Spirit*. Minneapolis, MN: Fortress Press. Written by a computer scientist; the central contention is that various approaches to research in artificial intelligence reveals corresponding assumptions regarding the central aspects of human nature.

Houston, Graham. (1998). *Virtual Morality: Christian Ethics in the Computer Age*. Leicester, UK: Apollos. Proposes that Christian theology can provide basic moral principles for governing behavior within the growing virtual domain of cyberspace.

Kurzweil, Ray. (1999). *The Age of Spiritual Machines: When Computers Exceed Human Intelligence*. New York: Viking. Argues that in the twenty-first century computer intelligence will become superior to that of humans, and that humans in turn will be forced to merge with computers in order to survive.

Mitcham, Carl, and Jim Grote, eds. (1984). *Theology and Technology: Essays in Christian Analysis and Exegesis*. Lanham, MD: University Press of America. A collection of essays assessing the theological and religious significance of modern technology.

Moravec, Hans. (1988). *Mind Children: The Future of Robot and Human Intelligence*. Cambridge, MA: Harvard University Press. A highly speculative essay on future developments in which artificial life will emerge as earth's most highly evolved species.

Moravec, Hans. (1999). *Robot: Mere Machine to Transcendent Mind*. New York: Oxford University Press. A description of anticipated developments in robotics and artificial intelligence that will pave the way for humankind's "mind children" described in his previous book.

Pullinger, David. (2001). *Information Technology and Cyberspace: Extra-Connected Living*. London: Darton Longman and Todd. Examines such issues as privacy and community in light of the Christian teaching on love of neighbor in a world being shaped by communication technology.

Schultze, Quentin J. (2002). *Habits of the High-Tech Heart: Living Virtuously in the Information Age*. Grand Rapids, MI: Baker Books. Discusses, from a Christian perspective, how people can be virtuous in a high-tech world.

Schuurman, Egbert. (1995). *Perspectives on Technology and Culture*, trans. John H. Kok. Sioux Center, IA: Dordt College Press. A critical analysis of technology's historic and scientific background in contemporary culture.

Shinn, Roger. (1982). *Forced Options: Social Decisions for the 21st Century*. San Francisco: Harper & Row. A leading Christian social ethicist examines a wide range of issues related to science, technology and society.

Teilhard de Chardin, Pierre. (2004 [1964]). *The Future of Man*, trans. Norman Denny. London: Collins; New York: Image Books/Doubleday. A collection of highly speculative essays on the future course of human evolution.

White, Lynn, Jr. (1967). "The Historical Roots of our Ecological Crisis." *Science* 155(3767): 1203–1207.

INTERNET RESOURCE

Joy, Bill. (2000). "Why The Future Doesn't Need Us." *Wired* 8(4): April. Available from http://www.wired.com/wired/archive/8.04/joy.html. Argues that research in biotechnology, artificial intelligence, robotics and nanotechnology should be regulated, and in some instances prohibited, because they pose a threat to human survival.

HISTORICAL TRADITIONS

The relation between science, technology, and Christianity has been subjected to varying interpretations. A popular impression inherited from the Enlightenment of the eighteenth century is that the relationship is one of perpetual conflict. Science is opposed to religious belief and, by focusing on material phenomena, diverts attention from spiritual concerns. In reaction, some scholars contend that Christian theology provided the intellectual foundations for modern science and technology. Because nature was not sacred it was open to investigation and manipulation, activities that improved the human condition and were therefore compatible with Christian convictions. In distinction from both these analyses, other theologians contend that the relationship is characterized by neither hostility nor affinity. Science and religion represent two different forms of inquiry and discourse, and technology consists of neutral instruments that can be used for either good or evil purposes. These varying interpretations are reflected in the historical development of this relationship, which in turn informs contemporary assessments.

Premodern Christian Attitudes toward Nature, Science, and Technology

Early Christian interpretation of Scripture reflects ambiguous appraisals of activities associated with science and technology. Work, for example, is both extolled as a sacred vocation and portrayed as punishment for Adam's original sin. The grandeur and beauty of creation that humans cannot fully understand and master is juxtaposed with a dominion that they are called by God to exert over a world that is often inimical to their welfare, a mandate that can be accomplished only with the aid of tools and artifacts. There is, in short, no obvious endorsement or condemnation of what is now called science (*episteme* and *logos*) and technology (*techne*) in the Bible.

As recorded in the Gospels, Jesus of Nazareth often alluded to nature in his parables and, except for the last week in Jerusalem before his crucifixion, confined his ministry largely to the countryside. Care should be taken, however, not to read too much into such general observations. It is not clear if these allusions imply a positive view of nature or if Jesus employed familiar scenes for his predominantly rural audience; nor should his death be construed as a blanket condemnation of urban life. Jesus, after all, was also a carpenter (*tekton*).

In contrast, Paul makes few references to nature, and spent his ministry almost entirely in cities along the Mediterranean. Moreover, he thanked God for the mobility and safety afforded by Roman roads and ships that assisted his missionary work. Caution dictates, however, against concluding that Paul valued human artifacts more highly than nature. Although he appreciates the ability to transform natural resources into useful tools, Paul also offers the enigmatic vision of creation groaning in futility awaiting its salvation, implying that nature has an intrinsic value and will be included in God's final redemptive act (*Romans* 8:18–25).

This ambiguity extends into the patristic period (the first few centuries C.E.). Although Tertullian (c. 155 or 160–after 220 C.E.), for instance, admits that natural philosophy may disclose some of the workings of creation, he insists that the knowledge revealed in Scripture is of far greater importance. The former deals only with temporal matters, whereas the latter is focused on eternity. The science of Athens has nothing significant to add to the faith of Jerusalem. Gregory of Nazianzus (c. 330–c. 389) was more open to what Athens offered, using the science of his day to expound the creation stories found in Genesis. But he too concludes that mystical experience is superior to natural knowledge.

Augustine of Hippo (354–430) likewise insisted that revelation was superior to unaided reason, but he exhibited, to a greater extent than previous theologians, an appreciation of natural philosophy. He rebuked fellow Christians who were uninformed about the natural workings of the world that were well known to educated unbelievers, complaining that their ignorance brought the faith into disrepute. Moreover, Augustine argued that because the world is God's good creation, the material aspects of life should not be despised. In contrast to Greek philosophy, the physical world is not a place of vulgar necessity in which the craft of artisans is inherently inferior to contemplative pursuits. Augustine praised human intellect and ingenuity, singling out achievements in such areas as agriculture, architecture, navigation, communication, medicine, military weaponry, and the arts (*City of God*, Book XXII, Chapter 24).

Interest in science and technology waxed and waned among subsequent generations of theologians. It was with the recovery of Aristotle (384–322 B.C.E.) by scholastic theologians that attention gathered momentum. This is particularly the case in the synthesis of Augustinian and Aristotelian themes by Thomas Aquinas (1225–1274). Thomas argued that reason and revelation do not contradict each other, and grace perfects rather than negates nature. Knowledge about the world complements and amplifies religious belief.

The recovery of Aristotle also transformed the medieval university. Alongside the faculties of theology, law, and medicine, the arts and sciences grew in prestige and intellectual rigor. Inevitable tensions arose as rediscovered texts in Greek mathematics, physics, and astronomy were refined and elaborated upon, but a great deal of latitude was given to scientific inquiry so long as it did not challenge directly the church's core theological teachings.

Modern Christian Attitudes toward Science and Technology

Tension nevertheless grew more intense as scientists gained greater confidence in their methods of investigation. Galileo Galilei (1564–1642), for example, was tried and convicted of heresy because his defense of a heliocentric universe displaced the earth from its central position. More importantly, this shift from the center to the periphery implied that humankind could no longer regard itself as the apex of creation. The case of Galileo, however, is not representative of the relation between Catholicism and science throughout the sixteenth and seventeenth centuries. Many Catholics, such as Marin Mersenne (1588–1648), René Descartes (1596–1650), and Pierre Gassendi (1592–1655), made important contributions to science during this period.

Protestants, however, tended to view science and technology in a more accommodating manner. The ordering of creation was subject to God's providential governance, which though at times inscrutable was ultimately intelligible. Scientific inquiry could disclose the workings of divine providence, and scientists were thereby encouraged to explore the created order. Many Protestants, for example, were influential members of the Royal Society. This framework led scientists such as Johannes Kepler (1571–1630), Isaac Newton (1642–1727), and Robert Boyle (1627–1691) to investigate nature with relative freedom, leading to numerous important discoveries. More significantly, many discoveries contributed to inventive developments in commerce and industry.

The Enlightenment and its aftermath placed severe strains on this Protestant framework. The problem was primarily philosophical. A number of philosophers claimed that the physical world could be described in naturalistic terms independently from theistic beliefs. Initially, many theologians invoked science as an ally in defending traditional doctrines against deist and atheist attacks. Natural theology in particular drew heavily upon science to argue that nature had been designed by a creator. The image of a watch and watchmaker was often used as a popular analogy. Yet the analogy required appeal to consistent laws of nature rather than an inscrutable divine providence to account for the rational ordering of the universe. Significantly, scientists could appeal to these same laws without attributing their legislation to the God of the Bible and Christian dogma.

Both theologians and scientists referred to nature in increasingly mechanistic terms. This in part reflected the rapid proliferation of inventions and other technological innovations associated with scientific discoveries. A growing knowledge of natural laws could be applied to improving the quality of human life by constructing more effective tools and artifacts. Progress thus displaced providence as the dominant conceptual framework for charting the course and destiny of human history. This progressive ideology introduced a tacit division of labor in which nature was a realm studied by science, whereas spiritual and moral concerns fell within ecclesiastical purview. Conflict was avoided so long as neither party crossed these jurisdictional boundaries.

In the nineteenth century this tacit division began to unravel. Charles Darwin's *The Descent of Man* (1871) implied that even human nature could be explicated in naturalistic categories. Natural selection and not the presence of a soul shaped human behavior. In short, there was no longer a unique sphere that Christianity could claim as its own. It should not be assumed, however, that the ensuing battle lines were drawn evenly or predictably. Darwin had both his scientific critics and religious defenders, and it is arguable that new forms of biblical criticism (before Darwin) and Freudian psychology (after him) presented more severe challenges to traditional Christian beliefs than evolution.

Christianity in the Industrial Revolution

Nevertheless, Darwinian evolution influenced later developments in ethics and social theory related to the rapid industrialization of the late nineteenth and early twentieth centuries. The image of nature red in tooth and claw captured both public and intellectual attention. Social Darwinists, such as Herbert Spencer (1820–1903) and William Graham Sumner (1840–1910), contended that what was true in nature was also true in society, namely, that competition over scarce resources promoted a strong and vibrant human race. Moreover, science and technology were key factors in ensuring the survival of the fittest. This was readily apparent in the economic realm, where the rapid development of new industrial, transportation, and communication technologies offered competitive advantages.

Although the Industrial Revolution generated unprecedented wealth and created new markets and employment opportunities, the ensuing economic benefits were unevenly distributed. Factory workers were usually underpaid and overworked, and endured dangerous working conditions. Rapidly growing cities suffered from overcrowded tenements, inadequate sanitation, stifling pollution, widespread poverty, and violent crime. These deplorable conditions inspired mounting social unrest. In defense of industrialization it was often argued that these conditions were regrettable but necessary in the short term, and would eventually be remedied through greater economic growth driven by technological innovation. Workers must be patient, for any attempt to redistribute wealth along socialistic lines would serve only to derail the necessary competition that would eventually provide greater material comfort to a wider range of people, especially those devoted to thrift and hard work.

Religious responses to industrialization and its accompanying ethical issues were far from uniform. Proponents of the gospel of wealth maintained that economic competition was not incompatible with biblical and Christian teaching. Indeed, the accumulation of wealth promoted a philanthropic spirit as demonstrated in the largesse of such industrialists as Andrew Carnegie (1835–1919) and John D. Rockefeller (1839–1937). Critics countered that the plight of workers was patently unjust and dehumanizing. Laborers were little more than commodities exploited by owners driven by monopolistic greed instead of genuine competition. In response, the Social Gospel movement, drawing especially on the works of Walter Rauschenbusch (1861–1918), advocated workers' rights, the formation of labor unions, large public expenditures to improve urban life, antitrust legislation, and at times more radical proposals for public ownership of various industries.

What was at stake in these disputes was purportedly the progressive trajectory and destiny of history. Although various protagonists tried to wrap themselves in the mantel of progress, the perception of science and technology as the twin engines driving the steady improvement of human life made a powerful public impression. This impression was reinforced by the publication of John William Draper's *The History of the Conflict between Religion and Science* (1874) and Andrew Dickson White's *A History of the Warfare of Science with Theology in Christendom* (1896), both of which portrayed a perpetual battle between science and religion. The popularity of these books helped create a public perception that the progressive forces of science and technology were once again struggling against their old foes of religion and superstition. Although the myth of perpetual warfare is a modern invention, it continues to influence popular perceptions. As other entries demonstrate, however, contemporary Christian assessments of science and technology are more varied and nuanced than the myth admits.

BRENT WATERS

SEE ALSO *Augustine; Natural Law; Thomas Aquinas.*

BIBLIOGRAPHY

Augustine of Hippo. (1984). *Concerning the City of God against the Pagans*, trans. Henry Bettenson. London: Penguin Books. A classic theological interpretation of human history and destiny in light of the Christian doctrines of providence and eschatology.

Basalla, George. (1988). *The Evolution of Technology*. Cambridge, UK: Cambridge University Press. A historical and philosophical overview of technological innovation and its influence on cultural development.

Brooke, John Hedley. (1991). *Science and Religion: Some Historical Perspectives*. Cambridge, UK: Cambridge University Press. A series of in-depth essays examining a broad range of historical events shaping the relationship between science and religion.

Kasson, John F. (1976). *Civilizing the Machine: Technology and Republican Values in America, 1776–1900*. New York: Penguin. A critical overview of industrialization in nineteenth century America.

Manuel, Frank E. (1983). *The Changing of the Gods*. Hanover, NH: University Press of New England. A historical overview of the rise of deism and atheism in the enlightenment.

Nisbet, Robert. (1980). *History of the Idea of Progress*. New York: Basic. A philosophical inquiry tracing the idea of progress through its stages of historical development.

Rauschenbusch, Walter. (1997 [1917]). *A Theology for the Social Gospel*. Louisville, KY: Westminster John Knox Press. A treatise offering a biblical and theological foundation for the social gospel by the movement's leading proponent.

Tennant, F. R. (1928–1930). *Philosophical Theology*. 2 vols. Cambridge, UK: Cambridge University Press. A systematic attempt to reconcile key Christian doctrines with leading scientific theories of the late nineteenth and early twentieth centuries.

Turner, James. (1985). *Without God, without Creed: The Origins of Unbelief in America*. Baltimore: Johns Hopkins University Press. An in-depth analysis of the rise of atheism in the nineteenth and early twentieth centuries.

CICERO'S CREED

Lawyer, author, statesman, and scholar Marcus Tullius Cicero (106–43 B.C.E.) is considered Rome's greatest orator. His philosophical writings are impressive. In vocabulary alone, Cicero gave Rome the words *quality*, *individual*, *moral*, *definition*, *comprehension*, and *infinity* (Everitt 2001). Also attributed to him is Cicero's Creed, called the oldest statement of engineering ethics specifically, "Salus populi suprema est lex," or "the safety of the public shall be the[ir] highest law" (Broome 1986), which is comparable in stature to medicine's "primum non nocere" ("first, do no harm," attributed to Hippocrates, but found in his *Epidemics* rather than his *Oath*). Varying versions of Cicero's Creed have been incorporated into each of the major engineering professional organizations' codes (Martin and Schinzinger 2005). As such, it has served as a common reference point for contemporary engineers navigating the moral boundaries of their work.

As with "first, do no harm," however, the practicality of applying Cicero's Creed came into question during the 1980s. Just as the new field of bioethics scrutinized how physicians made ethical decisions and asked what role (if any) the public had in this process (Veatch 1981), three contending criticisms challenged Cicero's Creed. The contractarian code denied any implied or explicit contract between engineers and the public and posited that social contracts were "abstract, arbitrary, and absent of authority." The only operative contract was one between professional engineers and their employers. The personal-judgment imperative maintained that the interests of business and government never conflict with the interests of the public. Engineers, de facto, then represent the public in their safety decisions. The third criticism defined engineering as consisting of "theories for changing the physical world before all relevant scientific facts are in." Hence, engineering could never be totally risk-free or absolutely safe (Broome 1986).

Rosa Pinkus, et al. (1997) incorporated these disparate views into a framework for gauging the ethical practice of both the individual and the organization. It consists of three principles: competence, responsibility, and Cicero's Creed II. Adding specificity to the historic code, Cicero's Creed II suggests that the "ethical engineer should be cognizant of, sensitive to, and strive to avoid the potential for harm and opt for doing good." Operationalizing this implies understanding the risk and failure characteristics of the product or process at hand. Further, "the ethical organization manages technology so as not to betray the public trust," thus introducing the concept of stewardship for public resources that embodied the intent of Cicero's original ethic. Hence, the ethical engineer must have the "competence" to assess risk and should exercise the "responsibility" to communicate it when it is known.

The longevity of Cicero's Creed is a tribute to the rhetorical power and wisdom of its originator. When Cicero coined the phrase, "the safety of the people shall be their highest law," rather than engineers, he was referring to newly appointed "praetors, judges, and consuls" who were, in turn, directed to decide civil cases in the Roman Empire. However, as noted by Harris, Pritchard, and Rabins (2004, p. 12), it was not until 1947, when the engineers' council for professional development issued the first major code proclaiming that engineers "will have due regard for the safety and health of the public." Until then, engineers were to consider the protection of their clients or employers interests as their highest professional obligation.

Hence one can conjecture that around this time some engineers began to refer to the safety of the public as "Cicero's Creed." Perhaps it was first used in a popular speech or article and caught on as a professional ethic. Mistaken context aside, when balanced within the cost and schedule of completing a project, Cicero's Creed can provide direction for weighing the competing ethical demands that are built into the profession of engineering.

ROSA L. PINKUS
LARRY J. SHUMAN
HARVEY WOLFE

SEE ALSO *Codes of Ethics; Engineering Ethics.*

BIBLIOGRAPHY

Broome, Taft H., Jr. (1986). "Ethics: The Slippery Ethics of Engineering." *Washington Post,* December 28, p. D3.

Cicero, M. T. *De Legibus* III, trans. C.W. Keyes. Cambridge, MA: Harvard University Press.

Everitt, Anthony. (2001). *Cicero: The Life and Times of Rome's Greatest Politician.* New York: Random House.

Harris, Charles E., Jr.; Michael S. Pritchard; and Michael J. Rabins. (2004). *Engineering Ethics: Concepts and Cases.* Belmont, CA: Thomson Wadsworth.

Martin, Mike W., and Roland Schinzinger. (2005). *Ethics in Engineering,* 4th ed. Boston: McGraw-Hill.

Pinkus, Rosa Lynn; Larry J. Shuman; Norman P. Hummon; and Harvey Wolfe. (1997). *Engineering Ethics: Balancing Cost, Schedule, and Risk—Lessons Learned from the Space Shuttle.* Cambridge, UK: Cambridge University Press.

Veatch, Robert A. (1981). *A Theory of Medical Ethics.* New York: Basic Books.

INTERNET RESOURCE

Augustine, Norman R. (2002). "Ethics and the Second Law of Thermodynamics." *The Bridge* 32(3). Available from http://www.nae.edu.

CITIZENSHIP

Citizenship is the status of being a legally recognized member of a nation-state or other political community, possessing rights such as voting and owing duties such as jury service. In democratic thought, citizens generally are expected to be more actively involved and influential than citizens of authoritarian political systems. By joining environmental organizations, writing letters to government officials, working as volunteers, and otherwise affecting civic life, millions of citizens have helped bring about improvements in environmental policy, AIDS-HIV treatment, civilian nuclear power, genetically modified foods, and other technological endeavors.

In the city-state of ancient Athens, members of the *demos* participated directly in public debates and governmental choices, a time-consuming responsibility and honor—but only for the minority of the adult population who were not females, slaves, or otherwise excluded. When democracy was reinvented on the scale of the nation-state in Western Europe and the United States, citizenship extended only to property-owning males. Although such legal constraints have been abolished, the affluent and well educated continue to participate at higher rates, donate more money to candidates, and speak and write more persuasively. Women are underrepresented in political life due to the legacy of being hindered in "their access to full citizenship (including their capacity to speak and write freely, to acquire education, or to run for political office)" (Kessler-Harris 2001, p. 3–4). Ethnic minorities are disadvantaged almost everywhere.

New Citizenship Problematics

Challenges for citizenship now arise from globalization and the erosion of national sovereignty. The governmental unit one should identify with—the city of Paris, the nation of France, the European Union, or humanity most generally—is no longer clear (Balibar 2004). Because technological innovation emerges primarily in the affluent nations, moreover, those who reside elsewhere—a majority of humanity—in some respects are not citizens of the technological world order. Transnational citizenship seems increasingly sensible, therefore, yet institutions for it are weak.

Citizenship also becomes less salient when technological choices occur via the economy more than via government. Business executives exercise primary discretion over job creation, quality of work life, and new technological products, and computerized transactions in a few financial centers such as London affect monetary matters worldwide (Dean 2003). The privileged position of business extends to ordinary politics, where industry executives marshal unrivaled expertise, enjoy easy access to public officials, and have ample funds for lobbying and for legal challenges to government regulations (Lindblom and Woodhouse 1993).

In contrast, most adults work in semiauthoritarian organizations and exert little influence over whether technological innovations are used to make jobs more interesting, or to displace and down-skill those affected. Workers may learn a more general lesson: Don't expect to be full citizens whose opinions are valued and influential. Industrial democracy in the former Yugoslavia, codetermination laws in Scandinavia, and other experiments in economic democracy have not been widely emulated (Dahl 1985).

To the extent that ordinary people do participate in economic-technological choices, it is via consumer purchasing or *market voting*. Thus new homes in the United States grew from 800 to 2,300 square feet from 1950 to 2000, affecting energy usage, environmental despoliation, and even the level of envy. Consumer-citizens catalyzed global proliferation of a high-consumption lifestyle including air conditioning, television, and leisure travel—thereby distributing endocrine-disrupting chemicals throughout the biosphere, causing the extinction of several thousand languages and traditional cultures, endangering myriad species, and increasing rates of psychological depression.

The Challenge of Technoscientific Expertise

Another difficulty confronting citizenship is that technical knowledge increasingly required for informed discussion. When a U.S. congressional committee considered tax credits to help professional cleaners switch away from the dangerous solvent perchloroethylene in 1999, not a single citizen or public interest group wrote, phoned, or visited: Hardly anyone understood the problem of toxic air pollution from professional cleaning. Technologists do not themselves control governments, but expertise complexifies and effectively restricts participation in governance (Laird 1993).

A subtle way this occurs is that technoscientists accelerate innovation to a pace that government regulators, interest groups, and the attentive public cannot match. Roboticists, developers of esoteric weapons, biomedical researchers, nanotechnologists, and others ride a juggernaut fundamentally altering everyday life worldwide. If representative processes do not apply to technologists—most of whom are upper-middle-class males from the European Union, Japan, and the United States—and if there is insufficient time for deliberation, what meaning does citizenship have?

For all the shortcomings of traditional democratic procedures, that realm at least has competing parties, electoral campaigns, interest groups, and other forms of public inquiry, advocacy, deliberation, and dissent. Consumer-citizens enjoy none of these advantages—for example, shoppers rarely hear informed, conflicting views about environmental and other public consequences of products they purchase. Should citizenship be extended to the technological-economic sphere? To do so might require a set of citizen rights and obligations to "reconcile democracy . . . with the right of innovators to innovate . . . (and) to reconcile technology's unlimited potentials for human benefit and ennoblement with its unlimited potentials for human injury, tyrannization, and degradation" (Frankenfeld 1992, p. 462). Citizens arguably deserve relevant information, informed consent, and a limit on endangerment; and they presumably should embrace a corresponding duty to learn enough to exercise informed judgment.

In the early twenty-first century, technoscientists often proceed without obtaining informed consent, publics are mostly quiescent, and decision-making processes are not designed for timely deliberation. Extensive political research and development would be required to develop new mechanisms for holding technoscientific-economic *representatives* accountable, while organizing intermediary institutions to assist citizens in gaining requisite knowledge and shouldering other burdens of responsible participation.

There are a few encouraging signs: Some European political parties now require that women occupy 50 percent of elected offices, international norms and governance mechanisms may be emerging, and small-scale experiments with consensus conferences and other participatory innovations are gaining credibility. Nevertheless *no innovation without representation* is a long way from becoming the twenty-first-century equivalent of American colonists' cries against taxation without representation; there are formidable obstacles to an ethically defensible citizenship for wisely governing technoscientific trajectories and for fairly distributing rights and duties in a technological civilization.

E. J. WOODHOUSE

SEE ALSO *Civil Society; Consensus Conferences; Democracy; Expertise.*

BIBLIOGRAPHY

Balibar, Etienne. (2004). *We, the People of Europe?: Reflections on Transnational Citizenship.* Princeton, NJ: Princeton University Press.

Beiner, Ronald, ed. (1994). *Theorizing Citizenship.* Albany: State University of New York Press. Widely cited text that nevertheless fails to theorize the problems that science and technology pose for citizenship.

Dahl, Robert A. (1985). *A Preface to Economic Democracy.* Berkeley: University of California Press.

Dean, Kathryn. (2003). *Capitalism and Citizenship: The Impossible Partnership.* New York: Routledge.

Frankenfeld, Phillip J. (1992). "Technological Citizenship: A Normative Framework for Risk Studies." *Science, Technology, & Human Values* 17: 459–484.

Kessler-Harris, Alice. (2001). *In Pursuit of Equity: Women, Men, and the Quest for Economic Citizenship in 20th-Century America.* New York: Oxford University Press.

Laird, Frank N. (1990). "Technocracy Revisited." *Industrial Crisis Quarterly* 4: 49–61.

Lindblom, Charles E., and Edward J. Woodhouse. (1993). *The Policy-Making Process*, 3rd edition. Englewood Cliffs, NJ: Prentice Hall.

Lister, Ruth. (2003). *Citizenship: Feminist Perspectives*, 2nd edition. New York: New York University Press. Analyzes gender and citizenship in terms going beyond women's participation.

CIVIL SOCIETY

Civil society refers to the sphere of human activity outside government, the market economy, and the family. It includes communities, churches, voluntary associations, philanthropic organizations, and social movements. Civil society potentially constitutes a venue for reasoned discussion that bridges social differences, empowers participation in public life, and encourages deliberation concerning ethical issues pertaining to science and technology.

Development and Problems

Derived from Aristotle and applied to the modern nation-state by eighteenth-century liberal reformers, the concept of civil society came to be so closely associated with bourgeois economic and political life that Karl Marx distrusted the idea. Neo-Marxists came to endorse a public arena independent of state- or party-controlled communication, however, and contemporary social scientists generally view intermediary associations as conducive to stable democracy. As civic disengagement became widespread in the 1970s and thereafter, coupled with globalization, deregulation of industry, and the rise of new social movements, the idea of *building social capital* by strengthening nongovernmental organizations (NGOs) and other social institutions that *make democ-*

racy work seemed attractive to many social thinkers and activists, especially in the former Soviet sphere and in Latin America.

Defining the boundaries of civil society proves difficult, however. Publicly funded educational institutions catalyze research and discussion, yet are part of government. Most mass media are profit-making businesses; yet civic life depends on these institutions for informed inquiry. Conversely, some not-for-profit organizations such as hospitals are hard to distinguish from private businesses. Quakers and Unitarians may think deeply about social justice, but other religious groups turn away from social problems. So where exactly *is* civil society?

Also problematic is the idea of a venue/network where people with public-regarding values interact to produce outcomes endorsed by progressive social forces—saving the Mediterranean, stopping abusive labor practices, bringing AIDS drugs to Africa. However the Heritage Foundation and the Hoover Institution helped conservative Republicans create reform agendas that progressives perceive as exacerbating social differences and disempowering non-elites. Yet those research institutions clearly belong to the system of organized social inquiry and discourse. Perhaps, then, civil society belongs to no particular ideological camp, but can be mobilized by one's allies or opponents in the service of both good and ill.

A third difficulty is that most nongovernmental organizations are not altogether *public*. The American Association for the Advancement of Science (AAAS) lobbies government for taxpayer subsidies for well-paid scientists, with much research arguably serving scientists' hobbies more than the public good. Auto and chemical workers' unions focus on higher wages for current members rather than on fairer income distribution or on innovating technologically to improve the quality of work life for all. And if admission to a not-for-profit science museum costs more than seeing a Hollywood film, in what sense is the museum a *public* institution?

Fourth, governments and corporations dominate technological decisions, relegating civil society to the periphery of innovations in robotics, nanotechnology, weaponry, computers, pharmaceuticals, electronics, transport, chemicals, and agriculture. There are too many businesses for the few NGOs to watch, and government officials usually side with business. Thus, although Consumers Union and Mothers Against Drunk Driving (MADD) make modest contributions to transportation safety, they are no match for investment tax credits to industry, trust funds for building highways, and billions spent marketing new cars.

Achievements and Limitations

Nevertheless, NGOs have been influential on aspects of environmental policy, including technological changes such as catalytic converters on cars, scrubbers on electric power plants, and support for renewable energy. The environmental movement has enrolled millions of people in opposing hazardous waste dumping, fighting installation of polluting facilities, and lobbying for tighter regulations. Health social movements have tilted medical care toward AIDS prevention and treatment. Although quite important, these are exceptions to the rule, and the rule is that civil society organizations participate in only a small fraction of technoscientific choices, rarely winning a large fraction of what they seek.

Such inherent disadvantages are magnified by elite dominance over fundamental ideas circulating within civil society. From clergy and nobles of centuries past to contemporary scientific spokespersons, government officials, and business executives, elites sometimes reinforce myths that limit critical inquiry and thoughtful deliberation concerning science, technology, and ethics. Such myths include, among many others:

- That technoscience benefits all more or less equally, even though poorer persons and countries obviously are less able to purchase innovations;
- That research and development should proceed quite rapidly, despite the fact that humans learn and react rather slowly to the many unintended consequences of technology;
- That inherited economic and political institutions need not be fundamentally reconsidered, despite new organizational challenges involved in governing technological civilization.

It is of course rare to find societies where the dominant myths do not serve the interests of powerful organizations, affluent people, and experts themselves (Lindblom and Woodhouse 1993).

Perhaps the clearest connection between technological innovation and civil society is that television has displaced political conversation and other leisure activities, because "more television watching means less of virtually every form of civic participation and social involvement" (Putnam 2000, p. 228). Television maximalists lack time for civic engagement; the medium encourages individuation—as epitomized by the ubiquity of television sets in children's bedrooms; and an emphasis on individual rather than collective failings discourages viewers from trying to ameliorate social problems. Cell phones and email have been used in organizing public protests and even toppling a few governments, but cyberspace generally has not lived up to the hopes of early advocates as a space for public inquiry.

Capacities for public thought and action would be stronger in a commendable technological civilization, where civil society might function closer to the *ideal speech situation* envisioned by Jürgen Habermas. One of the most important changes would be to reduce the domination of public discourse by those with governmental, business, media, religious, and scientific authority; this would allow organizations and spokespersons to champion many more facets of many more issues than now occurs. Another important change, now partially under way, would be the evolution of an international civil society capable of reining in the worst practices of national governments, multinational corporations, and the global communities of technoscientists. Third, civil society participants would need to pay far more attention to ethical and policy issues pertaining to science and technology.

Overall, then, civil society advocates from Alexis de Toqueville to Michael Walzer surely are correct in recognizing that *social capital* plays an important role in building a society worth living in. Civil society plays an indispensable role in focusing, channeling, and helping to improve the quality of public thought: When anti-environmentalists win public office, for example, they cannot reverse most policies because pro-environmental discourse has become so widespread. Advocacy organizations play important roles in raising questions about the conduct of science and technology, and strengthening civil society probably is a necessary condition for a wiser, fairer technological civilization. However a balanced understanding of civil society must include recognition that it is difficult to conceptualize, is relatively weak compared with market and state, and possibly has been undermined as much as strengthened by the rise of global science and by recent technological developments.

E. J. WOODHOUSE

SEE ALSO *Citizenship; Liberalism; Nongovernmental Organizations.*

BIBLIOGRAPHY

Breyman, Steve. (2001). *Why Movements Matter: The West German Peace Movement and U.S. Arms Control Policy.* Albany: State University of New York Press. Argues that social movements are responsible for much of what works well in technological civilization.

Cohen, Jean L., and Andrew Arato. (1992). *Civil Society and Political Theory.* Cambridge, MA: MIT Press. One of the most sophisticated analyses of the relationship between civil society and democratic government.

Ehrenberg, John. (1999). *Civil Society: The Critical History of an Idea.* New York: New York University Press. Places contemporary discussions in a historical context going back to Plato's concern that ambition, greed, and other private concerns would undermine public order.

Habermas, Jürgen. (1981). *The Theory of Communicative Action.* Boston, MA: Beacon Press. A classic perspective from a later version of critical theory.

Kaldor, Mary. (2003). *Global Civil Society: An Answer to War.* Cambridge, UK: Polity Press. Proposes that civil society could become an antidote to the war-making propensities of nation states.

Kaviraj, Sudipta, and Sunil Khilnani, eds. (2001). *Civil Society: History and Possibilities.* Cambridge, UK: Cambridge University Press, 2001. Learned essays on European civil society and its possible futures, but under-emphasizing science and technology.

Keane, John. (2003). *Global Civil Society?* Cambridge, UK: Cambridge University Press. Argues that new democratic ways of living in a stronger global civil society are the key combating "turbocapitalism."

Lindblom, Charles E., and Edward J. Woodhouse. (1993). *The Policy-Making Process,* 3rd edition. Englewood Cliffs, NJ: Prentice Hall. Traces shortcomings in governmental policy to weaknesses in civil society, including "circularity" in public discourse whereby citizens tend to ask for no more than what business and governmental elites find it convenient to provide.

Nyhart, Lynn K., and Thomas H. Broman, eds. (2002). *Osiris,* Vol. 17: *Science and Civil Society.* Chicago: University of Chicago Press.

Putnam, Robert D. (1993). *Making Democracy Work: Civic Traditions in Modern Italy.* Princeton, NJ: Princeton University Press. Demonstrates the importance of civic life to democracy via careful study of the public sphere in many Italian communities.

Putnam, Robert D. (2000). *Bowling Alone: The Collapse and Revival of American Community.* New York: Simon and Schuster. One of the most thorough empirical studies of declining participation in community life.

Walzer, Michael, ed. (1997). *Toward a Global Civil Society.* New York: Berghahn Books. A leading political philosopher's interpretation of globalization and the prospects for a planet-wide civil society.

CLASS

Social inequalities are ancient, but the concept of class evolved only in the nineteenth century with the increasing division of labor accompanying industrialization. Karl Marx (1818–1883) sometimes wrote as if there were just two distinct, inherently antagonistic classes—the bourgeoisie owning the means of production, and the proletariat working for them. Class structures actually were more complex than that even in prerevolutionary Europe, and are all the more so in a global technological civilization. Class is thus a special form of inequality tied to the development of modern science and technology; it is of ethical significance because the costs and benefits of innovation tend to be distributed along class lines.

Sociology of Class

Sociologists studying class tend to categorize households by the male breadwinner's occupation. John H. Goldthorpe (1987) uses eleven categories ranging from professionals, administrators, and corporate managers at the top, to small proprietors, farmers, and personal service workers in the middle, to unskilled manual and agricultural workers near the bottom. Using this and other measures, it becomes apparent that there is substantial variation in distribution of what Max Weber called life chances: The United States has much greater income inequality than most other affluent nations, and low-income American families have worse access to health care, education, and other desired social outcomes (Lareau 2003, Hofrichter 2003). Intergenerational social mobility turns out to be poor just about everywhere, however, with the odds of a middle-class child remaining in that class as an adult about fifteen times greater than the chances of a working-class child moving into the middle class (Marshall et al. 1997).

Increasing participation of women in the workforce means that spouses may work in different job categories, which makes the above classification scheme harder to apply. Two-income households can afford different lifestyles than single-income households, moreover, so categorizing by occupation has become less meaningful. Parents' education may matter more than their occupations in determining a family's Internet usage, leisure activities, nutrition and health, and aspirations for children's futures. More fundamentally, conventional depictions of social class capture rather poorly the creative destruction that technological innovation brings, creating new types of careers while undermining older occupations. The winners celebrate, but several hundred million worldwide have been displaced from farms, factories, and other workplaces in the past generation at considerable personal and social cost.

Likewise being reconstructed over time are the everyday lives of various social strata. At the beginning of the twenty-first century, the affluent enjoy transportation, communication, medical care, food, and leisure opportunities superior to what has previously been available to anyone. Even persons of comparatively modest means have access to television, refrigeration, T-shirts, plastic bags, and other manufactured artifacts. Their shared participation in a *consumer class* may be a more salient social fact than their occupational or even income differences. Because people's realities are substantially structured in relationship with material things, class warfare arguably has become less a conflict among classes than one between the consumer class and the planet.

International Dimensions

Older understandings of class are challenged as well by international stratification. Most of the affluent live in the northern hemisphere, and a *working-class* household in Europe or Japan is well above average for the world as a whole—and may include a comfortable dwelling, reliable electricity, convenient mass transit or automobile, and government-funded medical care. Peasant farmers and stably employed urban dwellers in poor countries have far less access to technological benefits, and yet they are well above the billion or more persons living in absolute poverty.

Possibly on the lowest rung of the ladder are those who speak one of the 3,000 languages likely to become extinct in the twenty-first century. For example, in 2003 the Danish Supreme Court turned down the final appeal of 150,000 indigenous peoples forcibly expelled from their ancestral lands in northern Greenland during the Cold War to make way for a U.S. missile base. "The Inuit will, in all likelihood, join other indigenous peoples globally whose language, culture, and presence are no longer with us" (Lynge 2002, p. 103).

Thus conventional depictions of social class are too *nice*, and fail to convey the raw power and powerlessness that often accompany technologies deployed in contexts of socioeconomic inequality. Large dams that flooded villages while failing to deliver the promised irrigation benefits displaced millions. Millions more have been dislocated, maimed, or killed in civil wars fought with helicopter gun ships and automatic weapons. Subsistence farming was undermined by the imposition of export-oriented monocultures and European and North American *scientific* agricultural methods. International financial markets enabled by computerized data processing have caused ruinous fluctuations in local currencies. Toxic wastes and environmentally hazardous manufacturing processes have been transferred to poor countries (Clapp 2001).

Even within affluent societies, technological bads tend to follow class lines. As environmental justice advocates point out, those with less capacity to buy their way out or to organize politically often get stuck living near noisy factories, polluted waterways, traffic noise and exhaust fumes, hazardous waste dumps, landfills, and other noxious facilities (Bullard 2000). Those with less power in the labor market often find themselves disadvantaged by technological changes in the workplace (Wyatt et al. 2000)

The Future of Class

In sum, an adequate understanding of social class requires dealing with the ugly realities of power, gross international inequalities, post-industrial socioeconomic issues going well beyond occupational stratification, consumers as a new kind of class, and upheavals in work roles and lifestyles associated with technological innovation. The technoscientists' predicament is that their findings and innovations enter a highly stratified world; although few technologists might be comfortable acknowledging it, in effect they work for some social classes much more than for others. Class consciousness has long been weak in the United States, and has diminished even in European social democracies; many social observers speak as if inequality were unimportant. Yet the pervasive, harmful effects of inequalities are well documented, and one need not return to simplistic notions of a ruling class in order to think that ethically charged questions about who gets what deserve the same careful attention accorded to technical aspects of innovation.

E. J. WOODHOUSE

SEE ALSO *Affluence; Citizenship; Marxism; Money; Race; Work.*

BIBLIOGRAPHY

Bullard, Robert D. (2000). *Dumping in Dixie: Race, Class, and Environmental Quality*, 3rd edition. Boulder, CO: Westview Press.

Clapp, Jennifer. (2001). *Toxic Exports: The Transfer of Hazardous Wastes from Rich to Poor Countries*. Ithaca, NY: Cornell University Press.

Gibson-Graham, J. K.; Stephen A. Resnick; and Richard D. Wolff, eds. (2000). *Class and Its Others*. Minneapolis: University of Minnesota Press. A feminist, cultural studies approach to the subject of class.

Goldthorpe, John H. (1987). *Social Mobility and Class Structure in Modern Britain*, 2nd edition. Oxford: Clarendon Press.

Hofrichter, Richard, ed. (2003). *Health and Social Justice: Politics, Ideology, and Inequity in the Distribution of Disease*. San Francisco: Jossey-Bass.

Lareau, Annette. (2003). *Unequal Childhoods: Class, Race, and Family Life*. Berkeley: University of California Press.

Lynge, Aqqaluk. (2002). *The Right to Return: 50 Years of Struggle by Relocated Inughuit in Greenland*. Nuuk, Greenland: Forgalet Atuagkat.

Marshall, Gordon; Adam Swift; and Stephen Roberts. (1997). *Against the Odds?: Social Class and Social Justice in Industrial Societies*. New York: Oxford University Press.

Wyatt, Sally; Flis Henwood; Nod Miller; and Peter Senker, eds. (2000). *Technology and In/equality: Questioning the Information Society*. New York: Routledge.

CLINICAL TRIALS

Clinical trials are systematic investigations on human subjects testing the safety and efficacy of novel medical interventions, including drug, surgical, or behavioral treatments. Conventionally clinical trials are divided into four types or *phases*. In a phase I clinical trial, typically involving tens of subjects, a novel procedure is tested for the first time in human beings and data is collected on safety. In a phase II trial, which may involve hundreds of patients, evidence is sought that a novel intervention has a therapeutic effect on the disease of interest. In a phase III clinical trial, often involving thousands of patients, the novel intervention is compared to a standard intervention or placebo. In a phase IV trial, called a post-marketing study, information is collected on the long-term safety and efficacy of the intervention from patients receiving the intervention in clinical practice and measured against a control treatment. The rigorous evaluation of novel medical interventions in clinical trials is a foundation of evidence-based medicine.

Historical Development

The randomized clinical trial is one of the most important advances in medicine in the twentieth century. Prior to its development, treatments were adopted on the basis of the publication of a series of cases in which their use had proved helpful. Due to numerous sources of potential bias, including variation in expertise from one clinician to the next, and the selection of patients more likely to recover for inclusion in the study, case series often led to misleading results. Clinicians were faced with numerous treatments from which to choose, and little evidentiary basis upon which to ground a choice. For example, Richard Doll, a well-known British clinical trialist, described how at the start of his research into the treatment of peptic ulcer in 1948, he was able to list purported treatments beginning with each letter of the alphabet.

In clinical trials until mid-twentieth century, two treatments for comparison were allocated to alternating patients. This method was flawed by the fact that physicians could anticipate the treatment assignment, and thereby select which treatment a particular patient would receive by changing the patient's position in the queue. It was not until mid-century that R.A. Fisher's allocation strategy using random numbers, developed in 1926 for agricultural experiments, was used in clinical trials. Allocation using random numbers countered bias in selection and provided statisticians with an estimate of random error, a key component of modern statistical analysis. The first clinical trial to randomly allocate treatments to patients using random numbers was the United Kingdom Medical Research Council (MRC) whooping cough immunization trial initiated in 1946. The better-known MRC streptomycin trial in tuberculosis started a few months later, but published its results before the whooping cough trial in 1948.

Since the mid-twentieth century, the clinical trial has undergone a dramatic increase in use for the evaluation of the safety and efficacy of novel medical interventions. A variety of social and political factors supported this trend. The period following the Second World War witnessed an unprecedented public investment in health research. In 1945, the United States National Institutes of Health budgetary appropriation was $700,000; in 1970 its appropriation was $1.5 billion. Drugs regulation underwent significant changes in this period as well. From 1938 to 1962, the U.S. Food and Drug Administration (FDA) was only empowered to require that new drugs be tested for safety. Following on the heels of the thalidomide tragedy, in which hundreds of infants were born with congenital malformations after exposure to thalidomide in utero, legislative reform dramatically increased the FDA's power. The 1962 Kefauver-Harris Act expanded the FDA's mandate to test new drugs for both safety and efficacy.

The testing of new drugs for safety and efficacy in clinical trials occurs in an increasingly international environment. Cooperation among drugs regulators and manufacturers seeks to standardize the conduct of clinical trials and their review by drugs regulators. The International Conference on Harmonization *Good Clinical Practice* guidelines are a key instantiation of this effort. The protection of human subjects in research is similarly seen as a matter of global concern. Perhaps the most influential ethics document in the international forum is the World Medical Association's *Declaration of Helsinki*. The declaration requires that clinical trials be reviewed by appropriately constituted research ethics committees; research be free of misconduct; the consent of human subjects be obtained; study participation pose a favorable balance of benefits to harms; and subjects be selected equitably.

Ethical Issues

Some of the most important ethical challenges of clinical trials stem from conflicting duties of the physician-researcher. Physicians have fiduciary obligations to patients, including a duty to provide competent personal care. Researchers, by contrast, have obligations to science and society, including duties to provide treatment as prescribed in the trial protocol, ensure that patients comply with treatment, and encourage them to stay in the study. Given that these duties may conflict, the central moral question of the clinical trial is: When may physicians legitimately offer patients enrollment in a clinical trial? While a variety of answers have been provided to this question, the most widely accepted is that of clinical equipoise. According to clinical equipoise, physicians may legitimately offer patients enrollment in a clinical trial only if the medical interventions within the study are consistent with competent medical care. More formally, it requires that at the start of the study there exists a state of honest, professional disagreement as to the preferred treatment. The consequences of clinical equipoise for the design of clinical trials are far reaching.

Two issues in respect to the design of clinical trials have dominated research ethics literature since the 1990s. The first is the proper role of placebo controls in the new drug approval process in developed countries. Drug regulatory agencies in developed countries, such as the FDA, have long required that new drugs prove superior to placebos in at least two clinical trials before licensure. The practice in the United States is rooted in legislation that requires the FDA to ensure new drugs are efficacious, that is, that they have some effect in treating the condition of interest, but generally restricts its ability to demand evidence of comparative effectiveness. According to clinical equipoise, placebo-controlled clinical trials are unproblematic when there is no proven treatment for the condition of interest.

Criticism has focused on the use of placebo controls in clinical trials testing novel interventions for treatable medical conditions, such as severe depression and schizophrenia. The use of placebos in these cases is impermissible, because no competent physician would fail to offer a patient treatment and, accordingly, clinical equipoise is violated.

The 2002 revision of the Declaration of Helsinki sets aside this fundamental moral requirement, and for the first time permits the use of a placebo control when "compelling and scientifically sound methodological reasons" exist. This change seems to violate a core provision of the declaration requiring that "[i]n medical research on human subjects, considerations related to the well-being of the human subject should take precedence over the interests of science and society." Whether there are in fact *scientifically sound methodological reasons* to prefer a placebo control over a standard treatment control remains an open question.

The second clinical trial design issue to receive considerable attention in the literature is the choice of control treatment in clinical trials of new and affordable treatments for developing countries. Disagreement was originally sparked by clinical trials testing the efficacy of short-course zidovudine against placebos for the prevention of transmission of HIV from mother to child. Critics of the clinical trials pointed to the existence of an effective prevention regimen called ACTG 076 used in developed countries. Denying subjects in the clinical trials conducted in developing countries access to this prevention regimen, they claimed, constitutes an ethical double standard between developed and developing countries.

Proponents of the clinical trials countered that the ACTG 076 regimen is not suited to administration in many developing countries and the cost is prohibitive. Changes in international regulation have tended to entrench rather than resolve the dispute. The Declaration of Helsinki proscribes placebo controlled trials in developing countries when effective treatment exists in developed countries saying that "[t]he benefits, risks, burdens and effectiveness of a new method should be tested against those of the best current prophylactic, diagnostic, and therapeutic methods." Yet the "International Ethical Guidelines for Biomedical Research Involving Human Subjects" permit placebo controlled trials under these circumstances provided the clinical trial is "responsive to the health needs of the population from which the research subjects are recruited and there [is] assurance that, if it proves to be safe and effective, it will be made reasonably available to that population."

OPEN QUESTIONS. The interface between the ethics and science of clinical trials is replete with challenging questions yet to be addressed adequately. What ought the role be for adaptive designs, for instance, clinical trials in which the probability of being assigned to one treatment or another is dynamic in an attempt to minimize the number of subjects who receive the treatment that turns out to be inferior? Can alternative medical treatments be evaluated rigorously in clinical trials? Alternative practitioners may claim that alternative treatments cannot be removed from a holistic treatment context, a substantial obstacle to the rigorous assessment of the treatment's efficacy. How will pharmacogenetic testing impact the conduct of clinical trials? Proponents of pharmacogenetics suggest that identification by genetic testing of those likely to respond to treatments and those likely to suffer adverse events would increase the efficiency and safety of clinical trials. Critics wonder if the gains from such testing will be as large as promised and what impact it will have on the generalizability of clinical trial results.

While ethical issues in the design of clinical trials are the subject of ongoing scholarship, ethical aspects of the conduct and reporting of clinical trials are relatively ignored. As clinical trials accumulate data on outcomes, disparities may emerge between the treatments in the clinical trial raising questions as to whether the trial ought to be stopped early. It is generally agreed that when clinical trials use outcome measures of mortality or serious morbidity an independent data monitoring committee should be established to periodically review accumulating data. A satisfactory moral framework to guide the decisions of data monitoring committees has yet to be developed.

Ethical issues in the reporting of clinical trial results also deserve attention. If researchers fail to report the results of a negative clinical trial, subjects in the trial were exposed to risk for naught and the problem of publication bias is compounded. While this seems problematic intuitively, a moral basis for an obligation to publicize clinical trial results has yet to be articulated.

CHARLES WEIJER

SEE ALSO *Complementary and Alternative Medicine; Drugs; Human Subjects Research.*

BIBLIOGRAPHY

Angell, Marcia. (1997). "The Ethics of Clinical Research in the Third World." *New England Journal of Medicine* 337: 847–849. A stinging critique of placebo controlled clinical trials testing the efficacy of short course zidovudine in the prevention of perinatal transmission of HIV in developing countries.

Crouch, Robert, and John Arras. (1998). "AZT Trials and Tribulations." *Hastings Center Report* 28(6): 26–34. A sober response to Marcia Angell's critique.

Doll, Richard. (1998). "Controlled trials: The 1948 Watershed." *British Medical Journal* 317: 1217-1220. A historical review of changes to clinical trials at mid-century by one of the central figures in its development.

Emanuel, Ezekiel; Robert Crouch; John Arras; et al., eds. (2003). *Ethical and Regulatory Aspects of Clinical Research: Readings and Commentary*. Baltimore, MD: Johns Hopkins University Press. The definitive collection of readings in the ethics of human experimentation.

Miller, Paul, and Charles Weijer. (2003). "Rehabilitating Equipoise." *Kennedy Institute of Ethics Journal* 13: 93–118. A philosophical piece examining the conflicting duties of physician and researcher, and how these conflicts might be resolved.

Piantadosi, Steve. (1997). *Clinical Trials: A Methodologic Perspective*. New York: John Wiley & Sons. An authoritative methodological resource for the design of clinical trials.

INTERNET RESOURCES

Council for International Organizations of Medical Sciences. "International Ethical Guidelines for Biomedical Research Involving Human Subjects." Available from http://www.cioms.ch/frame_guidelines_nov_2002.htm. Guidelines for the conduct of research in resource-poor nations.

National Placebo Working Committee. "National Placebo Initiative: Draft Report of the National Placebo Working Committee." Canadian Institutes of Health Research. Available from http://www.cihr-irsc.gc.ca/e/services/pdf_19320.htm. A thorough document setting out the scientific, ethical, legal, and policy case for and against the widespread use of placebo controls in clinical trials.

World Medical Association. "Declaration of Helsinki." Available from http://www.wma.net/e/policy/b3.htm. The most influential international statement of moral standards for the conduct of clinical research.

CODES OF ETHICS

A code of ethics may appear in disciplines such as engineering, science, and technology under several other names: professional principles, rules of conduct, ethical guidelines, and so on. However denominated, a code of ethics can be placed in one of three categories: (1) *professional*, such as the Chemist's Code of Conduct of the American Chemical Society, applying to all the members of a certain profession (chemists) and only to them; (2) *organizational*, such as the Code of Ethics of the Institute of Electrical and Electronic Engineers, applying to members of the technical or scientific society that has enacted it and only to them or, in the case of the code of ethics of a university or industrial laboratory, only to a certain class of the enacting organization's employees; (3) *institutional*, such as the Computer Ethics Institute's Ten Commandments of Computer Ethics, applying to anyone involved in a certain activity (in this case, using a computer).

Codes of ethics may include ordinary moral rules ("Do not steal" or "Treat others fairly"). Codes of ethics may be enacted into law. For example, some codes (such as the engineer's code of ethics in Chile) have the status of domestic administrative law. Other codes, such as the "Nuremberg Code" on human experimentation, have become part of both international law and the general domestic law of many countries. Nonetheless, a code of ethics is never simply a matter of law or ordinary morality. To call a document a code of *ethics* is to make a claim for it one does not make when one claims that the document in question is a statute or statement of ordinary morality.

The Meaning of Codes

The word *code* comes from Latin. Originally it referred to any wooden board, then to boards covered with wax that were used to write on, and then to any book (*codex*). That was the sense it had when first applied to the book-length systemization of Roman statutes that the Emperor Justinian enacted in 529 C.E. Justinian's *Code* differed from an ordinary compilation of law in one important respect: He had the legal authority to make his compilation law, replacing all that preceded it.

Since that time, any document similar to Justinian's *Code* could be called a code. Sometimes the analogy with Justinian's *Code* is quite close (as it is, for example, for the *Code Napoleon*). Sometimes it is not. For example, computer code is code in a rather distant sense: Although the rules are presented systematically, computer code is written for machines, not for humans.

An important feature of Justinian's compilation is that it was written. Could a code be *unwritten*? Certainly there are unwritten laws. However, because the point of codification is to give law (and by analogy any similar system of guidance) an explicit and authoritative formulation, an unwritten code would seem not to be a code at all. There are nonetheless at least two ways in which codes can be unwritten. First, a code that is not in writing may have an authoritative *oral* formulation. Second, an unformulated code may be so obvious to those familiar with the practice that the code need only be formulated to be accepted. Although some parts of engineering or science may have a few rules unwritten in one or both of these senses, no large discipline or organization seems to have enough of those rules to constitute an unwritten code. In a world in which so much changes so quickly, how can individuals separated by education, experience, and distance reach agreement on much without putting that agreement in writing?

The Meaning of Ethics

The term *ethics* has at least four senses. In one, it is a synonym for ordinary morality, the universal standards of conduct that apply to moral agents simply because they are moral agents. Etymology justifies this sense. The root of the word *ethics* (*ēthos*) is the Greek word for "habit" (or "character"), just as the root of the word *morality* (*mores*) is the Latin word for that concept. Etymologically, *ethics* and *morality* are twins (as are *ethic* and *morale*). In this sense of the term, codes of ethics are systematic statements of ordinary morality; there is no point in speaking of ethics rather than morality.

In at least three other senses, however, ethics differs from morality. In one, ethics consists of the standards of conduct that moral agents *should* follow (*critical morality*); morality, in contrast, consists of the standards that moral agents generally do follow (*positive morality*). Ethics in this sense is very close to its root *mores*; it can refer to unethical acts in the first sense of *ethics*. What some believe is morally right (slavery, forced female circumcision, and the like) can be morally wrong. Morality in this sense has a plural: There can be as many moral*ities* as there are moral agents. Nonetheless, ethics in this sense can be a standard that is common to everyone. This second sense of ethics is, then, as irrelevant to the purposes here as is the first. Codes of ethics generally contain some rules ordinary morality does not.

Sometimes ethics is contrasted with morality in another way: Morality consists of the standards that every moral agent should follow. Morality is a universal minimum, the standard of moral right and wrong. Ethics, in contrast, is concerned with moral good, with whatever is beyond the moral minimum. This is another sense that seems not to fit codes of ethics. First, this ethics of the good is still universal, applying outside professions, technical societies, and institutions as well as within them. Second, codes of ethics in fact consist largely of *requirements*, the right way to conduct oneself rather than just a good way. Any sense of ethics that excludes requirements cannot be the sense relevant to codes of ethics.

The term *ethics* can be used in a fourth sense to refer to the morally permissible standards of conduct that govern the members of a group simply because they are members of that group. In this sense, research ethics is for people in research and no one else, engineering ethics is for engineers and no one else, and so on. Ethics in this sense is relative even though morality is not; like law and custom, it can vary from place to place, group to group, and time to time.

Though relative, ethics (in this sense) is not mere mores. It must (by definition) set a standard that is at least morally permissible. There can be no thieves' ethics or Nazi ethics, except with quotes around the word to signal an analogical or perverted use. Because ethics in this fourth sense must both be morally permissible and apply to members of a group simply because of their membership, it must demand more than law, market, and ordinary morality otherwise would. It must set a "higher" or "special" standard.

The Meaning of Codes of Ethics

A code of ethics, though not a mere restatement or application of ordinary morality, can be morally binding on those to whom it applies; that is, it can impose new moral obligations or requirements. How is this possible? Some codes of ethics are morally binding in part because they require an oath, a promise, or other "external sanction" (for example, one's signature on a contract that makes accepting an employer's code of ethics a condition of one's employment). In general, though, codes of ethics are binding in the way the rules of a morally permissible game are binding on those who voluntarily participate. The sanction is "internal" to the practice. When a person voluntarily claims the benefits of a code of ethics—for example, the special trust others place in those whom the code binds—by claiming to be a member of the relevant group ("I am an engineer"), that person has a moral obligation, an obligation of fairness, to do what the code says. Because law applies to its subjects whether they wish it to or not, law cannot bind in the way a code of ethics (a voluntary practice) can. Because a code of ethics applies only to voluntary participants in a special practice, not everyone, a code, if it is generally followed, can create trust beyond what ordinary moral conduct can. It can create a special moral environment. So, for example, if engineers generally "issue public statements only in an objective and truthful manner [including] all relevant and pertinent information" (as the Code of Ethics of the National Society of Professional Engineers requires), their public statements will generally (and justifiably) be trusted in a way those of politicians, lobbyists, and even ordinary private citizens would not be. Engineers will therefore have a moral obligation to do as required to preserve that trust. They will have a special moral obligation to provide all relevant and pertinent information even when others do not have such an obligation.

Attempts have been made to distinguish between short, general, or uncontroversial codes (code of ethics) and longer, more detailed, or more controversial ones (code of conduct, guidelines, and the like). Although this type of distinction may occasionally be useful in practice, it is hard to defend in theory. A typical code of conduct is as much a special standard as a typical code of ethics is, except when the code of ethics, being a mere restatement of morality, is just a moral code. Codes of conduct are also generally as morally binding as other codes of ethics. Sometimes, as in the Code of Ethics and Professional Conduct of the Association of Computing Machinery, the code does not even distinguish between the two.

Attempts have also been made to distinguish between (hard and fast) "rules" and mere "guidelines". Rules are then said to be typical of law, to allow only for submission or defiance, and therefore to interfere with moral autonomy. Guidelines, in contrast, are said to be typical of ethics, to require interpretation rather than "mindless submission", and therefore to preserve moral autonomy. In fact, all rules, including statutes, require interpretation (rather than mindless submission). In this respect, all rules are mere guidelines. There is, then, no reason why a code of ethics, understood as rules, should interfere with moral autonomy—or, at least, no reason why it should interfere any more than a promise or obligation of fairness does. On the other hand, "guidelines" such as those in ACM's Code often have the same mandatory form as other rules. They function as a commentary on the code rather than as a distinct document.

Uses and Design of Codes of Ethics

Codes of ethics have at least five uses: First and most important, a code of ethics can establish special standards of conduct in cases in which experience has shown that common sense is not adequate. Second, a code of ethics, being an authoritative formulation of the rules that govern a practice, can help those new to the practice learn how to act. Third, a code can remind those with considerable experience of what they might otherwise forget. Fourth, a code can provide a framework for settling disputes even among persons with considerable experience. Fifth, a code can help those outside the group ("the public") understand what they may justifiably expect of those in the group.

A code of ethics can also be used to justify discipline, legal liability, or other forms of external accountability, but such uses threaten to turn the code into something like law. Even when a code of ethics has been enacted into law, obedience to it must rely in large part on conscience or there is no point in describing it as a code of *ethics* (rather than just another legal requirement).Therefore, to object to a code of ethics that it cannot be enforced in the way laws generally are is to confuse ethics with law.

Some writers have claimed that a code of ethics must have a certain content (something more specific than "a higher standard"), for example, that any "true professional code" must have a provision giving special prominence to the public interest. For some professions, such as engineering, the claim is plausible. Engineers have long agreed that the public health, safety, and welfare should be "paramount" in their professional work. But for other professions, such as mathematics, the claim is much less plausible. The Ethical Guidelines of the American Mathematical Society commit mathematicians to mathematical truth, whether in the public interest or not. Many other scientific professions have a similar commitment to truth rather than the public interest as such. There can be no moral objection to such a failure to emphasize the public interest so long as the code does not require or allow anything ordinary morality forbids.

Because codes of ethics have no necessary content, they have no necessary structure or design. So, for example, the Software Engineering Code of Ethics divides its requirements into eight major categories (Public, Client and Employer, Product, Judgment, Management, Profession, Colleagues, and Self); the Codes of Ethics of the Australian Computer Society divides its requirements into six (Priorities, Competence, Honesty, Social Implications, Professional Development, and Computing Profession); and other codes have adopted other divisions, some similar to these and some quite different. About all that can usefully be said about the structure of codes of ethics generally, is that the structure should help ordinary users understand the code as a whole and to find what in particular they need.

MICHAEL DAVIS

SEE ALSO *Accountability in Research; Cicero's Creed; Engineering Ethics; Profession and Professionalism; Sociological Ethics.*

BIBLIOGRAPHY

Anderson, Ronald E. (1994). "The ACM Code of Ethics: History, Process, and Implications." In *Social Issues in Computing: Putting Computing in Its Place,* ed. Chuck Huff and Thomas Finhold. New York: McGraw-Hill. An excellent (and rare) description of the writing of a code of ethics in a major technological organization (with lots of details about the give-and-take involved).

Baker, Robert B.; Linda L. Manuel; Arthur L. Caplan; and Stephen R. Latham, eds. (1999). *The American Medical Ethics Revolution: How the AMA's Code of Ethics Has Transformed Physicians' Relationship to Patients, Professionals, and Society.* Baltimore: Johns Hopkins University Press. An excellent resource for understanding the writing of what is (arguably) the first code of ethics governing a technological profession.

Berleur, Jacques, and Marie d'Udekem-Gevers. (2001). "Codes of Ethics: Conduct for Computer Societies: The Experience of IFIP". In *Technology and Ethics: A European Quest for Responsible Engineering,* ed. Philippe Goujon and Bertrand Hériard Dubreuil. Leuven, Belgium: Peeters. Describes the failure of a major international organization to adopt a code of ethics, apparently because of worries about enforceability.

Coady, Margaret, and Sidney Block, eds. (1996). *Codes of Ethics in the Professions.* Carlton South, Victoria, Australia: Melbourne University Press. A good collection of essays providing a benchmark for current philosophical understanding of codes of ethics in professions.

Davis, Michael. (2002). *Profession, Code, and Ethics.* Aldershot, UK: Ashgate. A major challenge to the current philosophical (and sociological) understanding of professions, with engineering (along with law and police) as one of the three major professions studied.

Ladd, John. (1980). "The Quest for a Code of Professional Ethics: An Intellectual and Moral Confusion." In *AAAS Professional Ethics Project: Professional Ethics Activities in the Scientific and Engineering Societies,* ed. Rosemary Chalk, Mark S. Frankel, and Sallie B. Chafer. Washington, DC: American Association for the Advancement of Science. A classic challenge to the very idea of a code of ethics.

Luegenbiehl, Heinz. (1983). "Codes of Ethics and the Moral Education of Engineers." *Business and Professional Ethics Journal* 2: 41–61. An important work on the educational uses of codes of ethics, as well as the classic statement of the distinction between rules and guidelines.

INTERNET RESOURCE

Center for the Study of Ethics in the Professions, Illinois Institute of Technology. "Codes of Ethics Online." Available at http://www.iit.edu/departments/csep/PublicWWW/codes. An enormous collection of codes of ethics, by far the largest available online. All codes cited here can be found at this site.

COLONIALISM AND POSTCOLONIALISM

Colonialism, understood provisionally as the European annexation and administration of lands and populations in the Americas, Africa, and Asia, has been intertwined with science, technology, and ethics since the Renaissance. Certainly one prelude to colonial expansion was the European acquisition of military and navigational technologies superior to those found in other continents. But the colonial experience also had a formative impact on the nascent European science, because it permitted the region's scholars to come into contact with new environments and data and provided access to alternative systems of knowledge developed by other cultures. In fact, the requirement of controlling and cataloging colonial populations and resources led to the creation of new disciplines in the social sciences, such as ethnography, linguistics, and archaeology. Moreover, this impact has continued to the early twenty-first century, as a new scientific discipline, ecology, has found inspiration in the practices of non-western precolonial cultures and on the nineteenth century British and French "colonial conservationism" that attempted to deal with the degradation caused by the exploitation of recently acquired environments was "able to foresee, with remarkable precision, the apparently unmanageable environmental problems of today"(Grove 1995, p. 12).

Indeed, colonialism had an indirect, though profound, impact on European culture. In reaction to the frequently genocidal military tactics used by Europeans and the exploitation of indigenous populations that characterized the administration of colonies, few, if any, other historical events did more to promote the extension of ethics into the political, social, and legal spheres. In politics, such central contemporary concepts as human rights, representative democracy, and socialism developed, at least in part, as reactions to the brutality of the process of colonization and to the contact with non-European cultures and their political systems. Moreover, colonialism, by transferring enormous amounts of gold and silver from the Americas to Europe during the sixteenth and seventeenth centuries, thereby permitting the development of a money economy, may be seen as a factor that contributed to the development of capitalism, and the science that studies it, economics. The European colonization of Africa, the Americas, and Asia is thus one of the founding experiences of modernity, its impact felt on every aspect of contemporary life, even in countries that did not embark on colonial adventures.

Conceptual Issues

Despite its importance, however, any attempt to define colonialism in a manner that goes beyond the mere recounting of a set of historical facts runs into a series of conceptual problems. The difficulty in defining colonialism and related concepts—such as imperialism, anticolonialism, neocolonialism, or even postcolonialism—is that they can be interpreted as linked to social phenomena existing since antiquity throughout the world. Yet, it is customary to see colonialism as bounded, on the one hand, by a European expansion that began in the fifteenth century with the Portuguese and Spanish forays into Africa and the Americas, and, on the other, by the decolonization of Asia and Africa, a process that concluded in 1975 with the independence of the last Portuguese dominions, Mozambique and Angola. Although the United Nations reported that, as of 2003, there were still sixteen "non-self-governing territories," colonialism, as customarily defined, is no longer at the core of the world economy, and the impetus for self-governance, while not fully realized, concerns smaller populations and areas.

These temporal boundaries are justified by a central difference between classical and modern empires. In the latter, colonization was characterized not only by the conquest of a territory and its population, or by the extraction of monetary, human, or material resources, as was the case in antiquity, but also by a thorough restructuring of the colonial economy for the benefit of the economic interests of the metropolis. The securing of raw materials to be used exclusively by imperial industries or the restrictions placed on the production of goods in the colonies in order to transform them into exclusive markets for metropolitan products are examples of such restructuring.

In addition to reshaping economic structures, modern colonialism also attempted to change the cultures of the populations conquered. The successful catechization of Latin America in the sixteenth century, despite the frequently syncretic character of the resulting religion (that is, its being a combination of originally Amerindian and European beliefs), is a case in point. In fact, this cultural change was often a prerequisite for the economic exploitation of the acquired territories, because traditional labor patterns and economic structures had to be transformed according to the economic requirements of European industries and settlers. Colonialism's practical emphasis on the modification of the cultures of the conquered populations and the concomitant resistance of the latter, as well as the unavoidable hybrid identities generated by this encounter, have become key objects of study for contemporary theorists.

But the difficulties to be found in conceptually delimiting colonialism remain implicit in such a description. The most obvious problem is that processes of colonization and decolonization are not discrete and chronological. In fact, the first postcolonial societies in the Americas arose before the second wave of European imperialist expansion crested in the nineteenth century. Furthermore, as José Carlos Mariátegui (1894–1930) noted in the 1920s, colonial practices, institutions, and ideologies did not disappear with formal independence, but frequently constituted the bases on which the new nations were built. Thus it becomes possible to talk of an internal colonialism present in politically independent nations in which cultural, racial, ethnic, religious, linguistic, or caste differences form the basis for the institutionalized economic exploitation of one group by another. Then, moreover, there is the unique case of the United States: a postcolonial society that itself became a full-fledged colonial power in the second half of the nineteenth century through the annexation of Puerto Rico, the Philippines, and Hawaii, and that in the twentieth century helped establish new patterns of international domination and unequal resource flows. Given this inequality, it is possible to argue that current international economic structures and relationships among different national and regional economies constitute a continuation and development of colonialism rather than its abolition.

Imperial Differences

Critics have questioned the validity of the chronology proposed above by distinguishing Spanish and Portuguese colonialism, on one side, and the later French and British empires, on another. Unlike the more fully capitalist British or French colonial regimes, the earlier Iberian empires were frequently mercantilist and precapitalist, even medieval. While the former restructured the new colonies' economies so as to propel metropolitan capitalist growth, the latter colonial enterprises were based mainly on the acquisition or extraction of directly marketable resources, such as gold or spices, and on the taxation of native and settler populations as direct sources of income. From this perspective, colonialism as a fully modern capitalist undertaking must be differentiated from earlier Iberian empire building. In fact, critics have argued that terms such as colonialism, imperialism, or postcolonial "evince the history of British colonial/imperial involvement with Ireland, India, and South Africa" and that their use leads to the "(mis)-understanding and (mis)labeling of the so-called colonial American situation" (Klor de Alva 1995, p. 264). Thus mainstream analyses of colonialism would be applicable only to the European empires built in Asia and Africa during the eighteenth and particularly the nineteenth centuries.

A concept frequently used to separate earlier Iberian and later colonialisms is that of imperialism. In 1917 V. I. Lenin (1870–1924), arguably the most influential critic of imperialism, claimed that it constituted "the monopoly stage of capitalism." For him, colonial expansion responded to the needs of monopolistic finance capital, which he believed to be the hegemonic sector in a modern economy, to find a "guarantee against all contingencies in the struggle against competitors" by ensuring access to markets and resources (Lenin 1977, p. 260). Because Lenin saw finance capital as firmly national, imperialism necessarily led to war as the colonial powers attempted to acquire "precapitalist" areas, to forcibly take over each other's colonies, or even to try to gain access to the natural resources located in Europe. (World War I was Lenin's prime example of how the hegemony of financial monopoly capital invariably led to war.)

Critics have noted, however, that one can free Lenin's arguments from his national, political, and military framework. In this way it becomes possible to speak of a U.S. imperialism that is no longer based on the formal possession of colonies, as Harry Magdoff (1969) first argued; or of a neocolonialism in which "First World" nations use international economic, political, and cultural structures and institutions to maintain their political and economic control over nominally independent nations, as the Ghanaian independence leader Kwame Nkrumah (1909–1972) proposed in 1965. In their 2000 book, *Empire,* Michael Hardt and Antonio Negri have taken this loosening of the ties between economic relations and the national sphere to its ultimate conclusion. For them, globalization has led to the creation of a true empire of capital in which unequal flows of resources are organized by means of a "decentered and deterritorializing apparatus of rule" that no longer has a geographically defined direction (Hardt and Negri 2000, p. xii). While inequality is seen as probably growing, the concept of imperialism, based on notions of metropolises and colonies, and its dependency theory derivation of center and periphery, is, therefore, obsolete.

Paradoxically, this postmodern interpretation of empire has been proposed at precisely the moment when the United States has acquired unparalleled economic, military, and technological superiority, and has claimed the right to use military force to achieve its goals, exercising this "right" first in Afghanistan (2001) and then in Iraq (2003). Indeed, critics as well as supporters of contemporary U.S. foreign policy frequently describe it as imperial. Thus current discussions of imperialism and empire frequently attempt to elucidate the role played by the United States in international economic inequalities. For instance, Aijaz Ahmad argues "what we actually have is, finally, for the first time in history, a globalised empire of capital itself, in all its nakedness, in which the United States *imperium* plays the dominant role, financially, militarily, institutionally, ideologically" (Ahmad 2000, Internet page). Whether this new globalized capitalism is a dramatically new stage in capitalism that invalidates earlier analyses whether Marxist or not, as Hardt and Negri argue, or simply an intensification and elaboration of the basic traits of capitalism and imperialism, as analyzed by Marx and Lenin, as Ahmad and others propose, is a matter of disagreement.

The standard chronology of colonialism has also been put into question by arguments that in order to understand European colonization it is necessary to analyze its underlying discursive and ideological underpinnings. Thus in his 1978 book, *Orientalism,* arguably the foundational text of postcolonial studies, Edward Said (1935–2003) traces the construction of the "Orient" back to early modern and even Greek sources, analyzes its influence on the self-construction of the "West," and notes how this European production of knowledge affected colonialist practice in the region. From a related perspective, Nelson Manrique (1993) has emphasized the manner in which the mind-set formed by 700 years of contradictory interaction among Christians, Muslims, and Jews was transplanted by the Spanish conquistadors to very different American realities. According to these and related studies, the conventional chronology of European colonialism leads only to the distortion, even the mutilation, of history.

Given these difficulties in establishing a clearly bounded definition of colonialism and related terms, these must be seen as constituting a semantic field in which conceptual boundaries blur into one other, and in which historical frameworks, though necessary, necessarily break down.. But underlying the semantic field there exists a continuum of unequal and exploitative economic, social, and political phenomena that impacts directly on the relationships among science and technology, and has ethical consequences that have yet to be fully explored.

Colonialism as Turning Point

Iberian colonialism nevertheless signaled a turning point in world history. Not only did European power and culture begin its process of expansion and imposition throughout lands and populations unknown by the West, but also new unequal flows of resources favoring colonial powers were for the first time established on a planetary scale. British and French colonialism, even contemporary international trade relations, are subsequent, capitalist developments within this unequal planetary framework. Furthermore, the pivotal role played by the Iberian empires is evidenced by the way they developed two of the central institutions characteristic of eighteenth- and nineteenth-century colonialism and beyond, slavery and the plantation system, as well as the ultimate ideological basis on which colonialism would be built: racism. As the Spanish philosopher Juan Ginés de Sepúlveda (1490?–1572 or 1573) argued, the colonization of the Americas and the exploitation of the Amerindians was justified by the fact that these were "as inferior to Spaniards as children are to adults and women to men ... and there being between them [Amerindians and Spaniards] as much difference as there is between ... monkeys and men" (Sepúlveda 1951 [1547], p. 33). Although miscegenation (the mixing of races) was more frequent in Iberian colonies than in those of France or England, it was the product of necessity, given the limited number of women who traveled with the conquistadors, and was not incompatible with the development of intricate racial hierarchies that became legacies of the Spanish and Portuguese empires. Indeed, the scientific racialism of the nineteenth century would ground a similar discourse, not on philosophical and religious reasons, as Sepúlveda did, but on (pseudo)scientific ones.

Colonialism is thus more than a set of institutions or practices that permit the establishment and maintenance of unequal economic exchanges among regions or countries. Underlying colonial economic relations and institutions are evolving beliefs or ideologies that make possible the permanence and reproduction of colonialism. For instance, the Spanish conquistadors saw even their most brutal actions justified by their role in spreading the Catholic religion. It is reported that Hernán Cortés (1485–1547), the conqueror of Mexico, claimed that "the main reason why we came ... is to praise and preach the faith of Christ, even if together with this we can achieve honor and profit" (Zavala 1972, p. 25). In a similar vein, the British and French empires found their justification in supposedly bringing civilization to "primitive" regions of the world.

Western culture is thus permeated by pseudo-rational justifications of racial hierarchies, which would seem to ground colonialism on nature. Even the usually skeptical David Hume (1711–1776) accepts colonial racial hierarchies when he states "the Negroes and in general all other species of men (for there are four or five different kinds) to be naturally inferior to the whites. There never was a civilized nation of any other complexion than white, nor even any individual eminent either in action or speculation" ("Of National Characters," *Philosophical Works III*, p. 228). Writing about "Locke, Hume, and empiricism," Said has argued "that there is an explicit connection in these classic writers between their philosophic doctrines [and] racial theory, justifications of slavery [and] arguments for colonial exploitation" (Said 1978, p. 13). Other canonic names are easily added to that of Hume, and many other disciplines to that of philosophy, from evolutionary biology—which, despite the misgivings of Charles Darwin (1809–1882), ended up applying its notions of competition to humanity—to historical linguistics, which helped provide a pseudoscientific basis for racist celebration of the so-called Aryan race.

Anticolonialism

Yet just as colonialism found occasional supporters among its subjects in the Americas, Africa, and Asia, European reaction to colonialism was not homogeneous. There was an important streak of anticolonial thought and action in Europe as long as colonies existed, and this too left an imprint on Western thought. Indeed, colonialism not only permeated Western culture, it also established the framework within which anticolonialist thought and action frequently developed. Because of the central role played by Catholicism in the justification of Spanish expansion, the anticolonialist reaction in sixteenth-century Spain used the intellectual tools provided by the church. Thus Bartolomé de Las Casas (1474–1566), the greatest critic of the Spanish conquest, used Biblical exegesis, scholastic philosophy, canonic law, historiography, and his own and others' eyewitness accounts to convince the Spanish court and the church of the humanity of the Native American populations and to achieve partial recognition of their rights. In fact, the arguments of Las Casas and other like-minded contemporary critics of colonialism, such as Francisco de Vitoria (c. 1486–1546), are the seeds from which contemporary notions of human rights and international law have sprung. But Las Casas did not deny the need to evangelize Native Americans or fail to acknowledge the sovereignty of the Spanish monarchy over them, even as he vindicated their right to self-government and to be treated as human beings.

Even texts produced in the Americas that are generally taken to be expressions of indigenous cultures, such as the anonymous seventeenth-century compilation of Meso-American myths, the *Popol Vuh,* or the Andean chronicler Felipe Guaman Poma de Ayala's *El primer nueva corónica y buen gobierno* (The first new chronicle and good government), also finished in the early seventeenth century, were intellectually framed by Catholicism. While the *Popol Vuh* uses Latin script to reconstruct the Mayan hieroglyphic books destroyed during the Spanish catechization, and can, therefore, be considered an act of absolute resistance to the Spanish conquest, its anonymous author describes the text as written "in Christendom." Although Guaman Poma de Ayala's very title implies criticism of Spanish rule, it is a hybrid text in which traditional Andean structures, such as the *hanan/hurin* (upper/masculine–lower/feminine) binary, are maintained while acknowledging Catholicism and incorporating into its narrative idiosyncratic versions of biblical stories.

This dependence on European thought, even on some of the basic presuppositions of colonialism itself, will be continued by most oppositional movements and texts produced after the first moment of resistance to European invasion. For instance, while for Lenin imperialism is rooted in the nation and in national capital, anti-imperial movements will likewise be national movements struggling to achieve independence. If the spread of "civilization" is seen in the nineteenth century as validating colonial expansion, the Cuban anticolonial activist, revolutionary, and scholar José Martí (1853–1895), in his classic essay, "Our America," proposed the establishment of the "American University," in which a decolonized curriculum would, for example, privilege the Incas and not the Greeks as the foundation of culture. Even the appeal of Mahatma Gandhi (1869–1948) to nonviolence as the basis of the struggle against colonial oppression, while rooted in his reading of the *Bhagavad Gita,* is also a reinterpretation of principles first proposed by David Henry Thoreau (1817–1862) and developed by Leo Tolstoy (1828–1910), with whom the great Indian leader corresponded.

A similar appropriation and modification of Western discourse can be found in twentieth-century anticolonialism's relationship with Marxism, even if in this case, as in that of nonviolence, it is an oppositional rather than a hegemonic one that is being used. Thus Mariátegui argued: "[Socialism] must be a heroic creation. We must give life to an Indo-American socialism reflecting our own reality and in our own language" (Mariátegui 1996, p. 89). And this attempt at translating Marxism into local cultural traditions was replicated throughout most of the colonial and neocolonial world, as authors as diverse as Ernesto "Che" Guevara (1928–1967), Amilcar Cabral (1921–1973), and Mao Zedong (1893–1976) attempted to create "socialisms" not only compatible with the social and cultural conditions of Latin America, Lusophone (Portuguese-speaking) Africa, and China, but also rooted in them. Precisely because of the importance given to local conditions, this anticolonial and nationalist Marxism was characterized by an emphasis on the cultural effects of political actions, and vice versa. Although not completely ignored, culture and nation did not play prominent positive roles in classic European revolutionary authors such as Karl Marx (1818–1883), Friedrich Engels (1820–1895), and Lenin. The subsequent preoccupation with culture is a link between anticolonial Marxism and postcolonialism, understood as a cultural and political critique of the surviving colonial and developing neocolonial structures and discourses.

Postcolonialism

But questions remain regarding postcolonialism. Is the *post* in *postcolonialism* merely a temporal marker? If so, all postindependence literary and critical production in all former colonies, regardless of whether they deal with or promote cultural and structural decolonization, would be postcolonial. Or is it a reference to those writings that attempt to deal with the aftermath of colonialism, with the social and cultural restructuring and healing necessary after the expulsion of the European colonists? In this case the novels of James Fenimore Cooper (1789–1851) and even those of Henry James (1843–1916), all of which, in one way or another, deal with the problem of establishing a U.S. identity distinct from those of England and Europe, could be classified as "postcolonial." In Latin America, several figures would qualify as postcolonial thinkers: the nineteenth-century polymath Andrés Bello (1781–1865), with his didactic poetry praising and, therefore, promoting "tropical agriculture," and his attempt at modifying Spanish orthography so as to reflect Spanish-American pronunciation; the Cuban scholar Fernando Ortiz (1881–1969), producer of pioneering studies of the cultural hybridity characteristic of the colonial and postcolonial experiences for which he coined the term *transculturation;* and, as well, the aforementioned Martí and Mariátegui, who among others, initiated in the region the systematic criticism of neocolonialism, internal colonialism, racism, and cultural dependence.

Or is the *post* in the term a not-so-implicit alignment with poststructuralism and postmodernism, that is with the antifoundational philosophies developed by, among others, Jacques Derrida (1930–2004), Gilles Deleuze (1925–1995) and Félix Guatari (1930–1992) and Michel Foucault (1926–1984)? If so, despite the existence of transitional figures such as Frantz Fanon, whose writings combine anti-colonial agitation, Marxism, French philosophy and psychoanalysis, postcolonialism could be seen as opposed to Marxist and non-Marxist anticolonialism and to mainstream attempts at understanding and undermining neocolonialism. From this antifoundational perspective, if the stress on cultural topics characteristic of anticolonial and postindependence fictional and theoretical texts establishes a connection with postcolonialism, their frequent essentialism, occasional blindness toward gender hierarchies, emphasis on politics and economics over constructions of subjectivity, make them at best flawed precursors. And from the point of view of scholars who claim to be developing the perspectives proposed by anticolonial theorists—Marxist or otherwise—postcolonialism can be interpreted as the direct application of theories developed in Europe and the United States that disregard earlier local theorizations and mediations.

Regardless of how one understands its relationship with anticolonial thought, this postcolonialism as exemplified by the works of Said, Homi K. Bhabha, and Gayatri Chakravorty Spivak, among others, has generated challenging analyses of the role of gender within colonial and postcolonial institutions, of the political implications of hybridity and diaspora, of racism, and of the importance of constructions of identity within colonial, neocolonial, and postcolonial situations. Moreover, it has permitted the extension of its analyses of subjectivity and of heterogeneous social groupings to the colonial archive, permitting the elaboration of innovative historical reconstructions that go beyond the obsession with facts and events of conventional historiography, or the frequently exclusive preoccupation with classes and economic structures characteristic of Marxism.

Assessment

The importance of the study of colonial and postcolonial structures and ideologies resides in the fact that contemporary international economic and cultural relations and realities, rather than being their negation, can be read as their continuation. In fact, contemporary American, African, and Asian national boundaries are part of the colonial inheritance. These borders, drawn according to purely administrative and political criteria by the imperial powers without taking into account cultural, ethnic, linguistic, or historical differences among the diverse populations thus brought together, have been a contributing factor to the ethnic and national violence that have plagued postcolonial areas.

But international economic inequality is the most egregious legacy of empire. The depth of this continuing disparity is such that, according to the Food and Agriculture Organization (FAO) of the United Nations, of the 842 million people classified as undernourished between 1999 and 2001, 798 million lived in postcolonial areas (FAO 2003). A similar inequality, though undeniably less dramatic in its immediate consequences, is present in the field of science and technology. For instance, Latin America holds only 0.2 percent of all patents (Castro Díaz-Balart and Rojas Pérez 2002, p. 331). While this is the direct result of the countries of the so-called developing world investing only 0.3 to 0.5 percent of their gross domestic product in the fields of science and technology—in contrast, "First World" countries set aside 2 to 5 percent for the same purpose (Castro Díaz-Balart and Rojas Pérez 2002)—it is also a consequence of the unequal manner in which the contemporary global economy is structured, which transforms scientific and technological research into a luxury. Moreover, this low investment in science and technology constitutes a contributing factor to the perpetuation of this international inequality (Castro Díaz-Balart and Rojas Pérez 2002). Furthermore, colonialism and the continuing global inequality it created can be seen as determining patterns of consumption of natural resources that have played a central role in past and current exploitation and destruction of colonial and postcolonial environments. For instance, Richard Tucker (2000) has noted that the United States, as a neocolonial power, has come "to be inseparably linked to the worldwide degradation of the biosphere" (p. 2). Thus the inheritance of colonialism, described by the constellation of heterogeneous terms postcolonialism, neocolonialism, or imperialism—in both its territorialized and deterritorialized conceptualizations—not only constitutes a central problematic in the fields of science and technology but also is at the core of the major ethical dilemmas faced by humanity in the early twenty-first century.

JUAN E. DE CASTRO

SEE ALSO *African Perspectives; Development Ethics; Globalism and Globalization; Industrial Revolution; Scientific Revolution.*

BIBLIOGRAPHY

Adas, Michael. (1989). *Machines as the Measure of Men: Science, Technology, and Ideologies of Western Dominance*. Ithaca, NY: Cornell University Press. A broad, comparative study of the history of European responses to the cultures of sub-Saharan Africa, India, and China that emphasizes the role played by western evaluations of technological differences.

Ahmad, Aijaz. (1992). *In Theory: Classes, Nations, Literatures*. London: Verso. Ahmad, an Indian poet and literary critic, provides a stringent critique of postcolonial theory and a defense of the continuing relevance of Marxist analysis to the understanding of colonial and neocolonial literatures, cultures, and politics.

Ahmad, Aijaz. (2000). "Globalisation: A Society of Aliens?" *Frontline* 17(20). Also available from http://www.frontlineonnet.com/fl1720/17200490.htm. In this article Ahmad provides a Marxist analysis of globalization.

Bello, Andrés. (1997). *Selected Writings of Andrés Bello*, trans. Frances M. López-Morillas. New York: Oxford University Press. This is a selection of essays and didactic poetry by the most influential nineteenth-century Spanish American intellectual of the independence and post-independence periods.

Bhabba, Homi K. (1994). *The Location of Culture*. London: Routledge. One of the key sources for the concept of hybridity in the humanities and social sciences. Bhabba analyzes the manner in which cultural mixture undermines colonial and postcolonial projects.

Cabral, Amilcar. (1979). *Unity and Struggle: Speeches and Writings*, trans. Michael Wolfers. New York: Monthly Review Press. In this collection of his writings, Cabral, the main leader of the struggle for the independence of Guinea-Bissau, provides sophisticated Marxist analyses of the roles played by culture and nationalism in anticolonial revolutions.

Brockway, Lucile H. (1979). *Science and Colonial Expansion: The Role of the British Royal Botanic Gardens*. New York: Academic Press. Arguably the foundational text in the new literature of case studies on the relationship between Western science and colonialism.

Castro Díaz-Balart, Fidel, and Hugo Rojas Pérez. (2002). "Globalization, Science and Development." *Perspectives on Global Development and Technology* 1(3/4): 322–339. A study of contemporary international inequalities in scientific research and their impact on development.

Fanon, Frantz. (1963). *The Wretched of the Earth*, trans. Constance Farrington. New York: Grove Press. Fanon, at the time deeply involved in the struggle for Algerian independence, applies insights from psychoanalysis, Sartrean existentialism, and Marxism to the colonial situation in Africa. Originally published in 1961.

Fanon, Frantz. (1967). *Black Skin, White Masks*, trans. Charles Lamm Markmann. New York: Grove Press. In this book, Fanon, a trained psychoanalyst, studies the influence of colonialism on black colonial subjects. Originally published in 1954.

Fishlock, Trevor. (2004). *Conquerors of Time: Exploration and Invention in the Age of Daring*. London: John Murray. Extended narrative stressing how technological inventiveness was often stimulated by problems encountered in colonial settings.

Food and Agriculture Organization (FAO) of the United Nations. (2003). *The State of Food Insecurity in The World*, 5th edition. Rome: Author.

Gandhi, Mahatma. (1983). *The Essential Gandhi*, ed. Louis Fischer. New York: Vintage Books. Useful collection of essays, speeches, and interviews by the spiritual leader of India's independence movement.

Grove, Richard H. (1995). *Green Imperialism: Colonial Expansion, Tropical Island Edens, and the Origins of Environmentalism, 1600–1860*. Cambridge, UK: Cambridge University Press. Argues that modern notions of ecology are heavily dependent on the colonial experience, and especially professional scientists working in the Dutch, French, and British colonies.

Guaman Poma De Ayala, Felipe. (1978 [1613]). *Letter to a King: A Peruvian Chief's Account of Life under the Incas and under Spanish Rule*, ed. and trans. Christopher Wentworth Dilke. New York: Dutton. Originally published in Spanish as El primer nueva corónica y buen gobierno [the first new chronicle and good government]. Written by a regional noble, this early seventeenth-century illustrated chronicle is not only the most thorough expression of the indigenous perspective on the conquest of Peru, but its 398 drawings provide an invaluable visual record of life during the first years of the colony.

Guevara, Ernesto "Che." (1997). *Che Guevara Reader*, ed. David Deutschmann. Melbourne: Ocean Press. Comprehensive selection of essays and speeches by the Argentine-born leader of the Cuban revolution who became the international symbol for anti-imperialist and anti-capitalist struggles.

Hardt, Michael, and Antonio Negri. (2000). *Empire*. Cambridge, MA: Harvard University Press. Influential attempt to apply poststructuralist theories to the analysis of contemporary international economic reality.

Johansen, Bruce E. (1982). *Forgotten Founders: Benjamin Franklin, the Iroquois, and the Rationale for the American Revolution*. Ipswich, MA: Gambit. Study of the influence of Iroquois political institutions on those of the United states.

Klor de Alva, Jorge. (1995). "The Postcolonization of the (Latin) American Experience: A Reconsideration of 'Colonialism,' 'Postcolonialism,' and 'Mestizaje.'" In *After Colonialism: Imperial Histories and Postcolonial Displacements*, ed. Gyan Prakash. Princeton, NJ: Princeton University Press. Analysis of the difficulties found in the application of postcolonial theory to the Latin American colonial experience.

Las Casas, Bartolomé de. (1992). *A Short Account of the Destruction of the Indies*, trans. Nigel Griffin. London: Penguin. Originally published in Spanish as *Brevísima relación de la destrucción de las Indias*, 1552. A devastating account of the genocide of the Amerindian by the Spanish conquistadors written by the foremost sixteenth-century defender of indigenous rights.

Lenin, Vladimir Illich. (1977). "Imperialism, the Highest Stage of Capitalism." In *Lenin: Collected Works*, Vol. 22.

Moscow: Progress Publishers. Originally published in German, 1917. Classic Marxist analysis of nineteenth-century and early-twentieth-century imperialism.

Loomba, Ania. (1998). *Colonialism-Postcolonialism.* London: Routledge. Careful introduction to the history of colonialism and its contemporary incarnations and to the different theoretical approaches to the topic.

Magdoff, Harry (1969). *The Age of Imperialism: How US Foreign Policy Works*. New York: Monthly Review Press. Collection of essays which analyze from an economic perspective how U.S. imperialism works.

Manrique, Nelson. (1993). *Vinieron los sarracenos: El universo mental de la conquista de América* [The Sarracens arrived: the mental universe of the conquest of America]. Lima: Desco. Well-documented reconstruction of the evolution of the "mental world" of medieval Spain that helped determine the attitudes and actions of the Spanish conquistadors in the New World.

Mao Zedong. (1970). *Mao Papers, Anthology and Bibliography*, ed. Jerome. Ch'en. London: Oxford University Press. Collection of some of the Chinese revolutionary's most influential essays and speeches.

Mariátegui, José Carlos. (1971). *Seven Interpretive Essays on Peruvian Reality*, trans. Marjory Urquidi. Austin: University of Texas Press. Originally published in Spanish, 1928. Foundational text of Latin American Marxism. It studies Peru's history, social and economic structures, and cultural topics from a heterodox perspective; also influenced by Georges Sorel, Friedrich Nietzsche, and Sigmund Freud.

Mariátegui, José Carlos. (1996). *The Heroic and Creative Meaning of Socialism*, ed. and trans. Michael Pearlman. Atlantic Highlands, NJ: Humanities Press. A collection of essays on cultural and political topics written by the Peruvian Marxist in the 1920s.

Martí, José. "Our America." (2002). In *José Martí: Selected Writings*, ed. and trans. Esther Allen. New York: Penguin. Originally published in Spanish as "Nuestra América," 1881. Influential anti-imperialist tract written by the great poet and martyr of Cuba's independence.

Nkrumah, Kwame. (1965). *Neo-Colonialism: The Last Stage of Imperialism.* London: Heinemann. Analysis of the manner in which political independence does not necessarily lead to economic independence.

Ortiz, Fernando. (1995). *Cuban Counterpoint: Tobacco and Sugar*, trans. Harriet de Onís. Durham, NC: Duke University Press. Originally published in Spanish in 1940. By means of a study of the histories of the tobacco and sugar industries in Cuba, Ortiz provides the foundational study of cultural contact in Cuban and the Caribbean.

Reingold, Nathan, and Marc Rothenberg, eds. (1987). *Scientific Colonialism: A Cross-Cultural Comparison.* Washington, DC: Smithsonian Institution Press. The proceedings of an Australian conference that studies the role played by colonialism in stimulating the development of Western science.

Said, Edward. (1978). *Orientalism*. New York: Pantheon. One of the foundational texts in postcolonial theory that studies the discursive formation of the notion of the Orient and its distorting effect on colonial and contemporary policies and analyses.

Sepúlveda, Juan Ginés de. (1951 1547]). *Demócrates segundo, o, De las justas causas de la guerra contra los indios* [The second democrates, or, of the just causes for the war against the Indians], ed. Ángel Losada. Madrid: Instituto Francisco de Vitoria. Justification of the conquest written by Las Casas's main ideological rival and one of Spain's foremost Rennaisance Aristotelians.

Spivak, Gayatri Chakravorty. (1996). *The Spivak Reader: Selected Works by Gayatri Chakravorty Spivak*, ed. Donna Landry and Gerald Mac Lean. New York: Routdledge. A collection of essays informed by postructuralism and feminism on postcolonial literature and history, as well as on other theoretical and cultural topics.

Tucker, Richard P. (2000). *Insatiable Appetite: The United States and the Ecological Degradation of the Tropical World.* Berkeley and Los Angeles: University of California Press. An extended analysis of the negative impact of the United States as a neocolonial power on the world's environment.

Tedlock, Dennis, trans. (1996). *Popol Vuh: The Mayan Book of the Dawn of Life*, rev. edition. New York: Simon and Schuster. A collection of Maya creation myths written shortly after the conquest by an anonymous indigenous author.

Young, Robert J. C. (2001). *Postcolonialism: An Historical Introduction*. Oxford: Blackwell. Good overview that emphasizes the links between anti-colonial and postcolonial theories.

Zavala, Silvio. (1972). *La filosofía política en la conquista de América* [Political philosophy in the conquest of America]. Mexico City: Fondo de Cultura Económica. Originally published in 1947. Analysis of the philosophical and political debates in Spain and the Americas on the rights of Amerindians that emphasizes their links to the development of modern notions of democracy and human rights.

INTERNET RESOURCES

Ahma, Aijaz. "Globalisation: A Society of Aliens." Available from http://www.flonnet.com/fl1720/17200490.htm.

Food and Agriculture Organization of the United Nations. "The State of Food Insecurity in the World 2003." Available from http://www.fao.org/DOCREP/006/J0083E/J0083E00.HTM/.

Guamán Poma de Ayala, Felipe. *El primer nueva corónica y buen gobierno* [The first new chronicle and good government]. Available from http://www.kb.dk/elib/mss/poma/.

United Nations. "The United Nations and Decolonization." Available from http://www.un.org/Depts/dpi/decolonization/main.htm.

COLUMBIA ACCIDENT

SEE *Space Shuttle Challenger* and *Columbia* Accidents.

COMMON HERITAGE OF MANKIND PRINCIPLE

The Common Heritage of Mankind Principle (CHP) as it was presented to the United Nations General Assembly in various declarations and treaties, and as it is understood in the early-twenty-first century, affirms that the natural resources of the deep seabed and of outer space are held in common by all nations, and should be distributed equitably for the benefit of all humankind. Specifically the CHP of the 1979 Treaty Governing the Activities of States on the Moon and Other Celestial Bodies (The Moon Treaty), refers to: the equitable sharing of outer space resources; the nonappropriation of *in-place* resources particularly with regard to outer space mining activities; and the institution of an *international regime* to supervise commercial activities in space.

The CHP was presented with the understanding that it was crucial to plan for future exploration and uses of these important regions in order to insure not only an equitable distribution of their natural resources, but to prevent conflicts among nations as have occurred during earlier eras of exploration. Proponents of the CHP believe the principle confers on a region the designation of *domino util* or beneficial domain that should be legally defined as *res communis humanitatis,* a common heritage that is not owned by any nation, but from which all nations may garner profits and benefits.

Early Usage

Notions designating global resources as the common property of humankind (*res communis*) are not new, particularly in relation to the oceans, but date back more than 400 years. During the great age of discovery in the fifteenth century, Spain and Portugal claimed sovereignty over the high seas in accordance with the Papal Bull of 1493. This Bull established the border between Portuguese and Spanish waters "by a meridian line running 100 leagues west of the Azores, through both poles." In the late 1500s, however, the Protestant, seafaring nations of England and Holland challenged these claims of exclusive sovereignty over the oceans. Elizabeth I, in 1577, specifically dismissed Spanish claims of sovereignty over the high seas by "declaring that the sea, like the air, was common to all mankind and that no nation could have title to it" (Schachter 1959, p. 10). This began the establishment of the principle of *freedom of the seas,* or open access and nonappropriation in maritime law, which later was seen as a positive-sum game that encourages the usage and development of ocean resources as well as international trade for the common interest of nations (DeSaussure 1989, p. 29).

Modern Applications

The International Geophysical Year (IGY) was a main motivating factor behind the development of contemporary legal notions concerning open access and common property as applied to new territories such as Antarctica, the deep seabed, and outer space. The international scientific investigations conducted during 1957 and 1958 were enormously successful, and created a new paradigm for international prestige through cooperation in quality scientific research. In fact, the collaborations forged during the IGY fostered the formation of a number of new international committees and agreements including the 1958 United Nations General Assembly Conference in Geneva on the Law of the Sea, which reaffirmed the freedom of the high seas and began negotiations concerning the natural resources of the continental shelf and deep seabed; the 1959 Antarctic Treaty; the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS); and ultimately the 1967 Outer Space Treaty containing the Common Benefit Principle (a modified *res communis*), which mandates that space exploration and the utilization of its resources be "for the benefit and in the interests of all countries."

The Law of the Sea and the Moon Treaty

During the late 1960s, the development of new technologies capable of taking commercial advantage of natural resources in the deep seabed and outer space, rendered the common benefit and nonappropriation clauses of earlier treaties obsolete. Ambassador Arvid Pardo of Malta introduced to the United Nations in 1967 a declaration related to the peaceful uses of the seabed and ocean floor that referred to these areas as a common heritage of humankind (Gorove 1972). According to Pardo, the CHP would establish "an administrative process whereby benefits derived from the resources of the [ocean] would be used for the common advantage of all peoples without regard to conditions of poverty or of wealth"; require supplementary programs of environmental protection to insure that the ocean's resources would be "passed on to succeeding generations"; and imply that the ocean and its resources "will be used exclusively for peaceful purposes" (Christol 1976, p. 44.) This declaration was accepted by the United Nations General Assembly without major criticism, and work began on the Declaration of Principles Governing the Sea-bed, the Ocean Floor, and the Subsoil Thereof, Beyond the Limits of National Jurisdiction, which was presented to the General Assembly in 1970.

The opening of outer space territories and resources to the possibility of commercial ventures also raised new questions with regard to the activities of states and private entities in outer space. The Common Benefit Principle of the 1967 Outer Space Treaty in combination with its nonappropriation clause in Article 2 left open certain questions concerning sovereignty and property rights in relation to permanent space stations, lunar stations, and astral and lunar mineral resources. The CHP was offered as a complementary principle that would fill these legal gaps by defining the nature and use status of outer space and its resources; clarifying the rights and obligations of states and private entities in relation to these resources; and providing regulatory guidelines that would reduce the monetary risks of commercial space ventures. In 1972 the United States made a formal presentation to the COPUOS committee working on the Moon Treaty draft advocating inclusion of the CHP into the treaty text.

Implications for Science and Technology

The possible implications of the CHP for advancement of science and technology can be found in the debate between First and Third World nations as to the effects the implementation of this principle might have on the commercial development of space resources and the technologies that access them.

As committee work on the Moon Treaty continued, controversy grew in the United States concerning the CHP and its implications for the development, use, and allocation of outer space resources. There was considerable debate on both the definition of what the equitable sharing of resources meant under the CHP, and whether or not that sharing included access to space technology. In particular, a swarm of small but powerful U.S. space interests, especially the L-5 Society, began to publicly protest against the treaty, and managed to challenge the original U.S. position in several important areas.

Consequently U.S. representatives began arguing that the implementation of the CHP, with its mandate for profit sharing through an international regime, would be a disincentive to capital investment by private enterprise in the development of space resources and technologies. In addition, the principle's affirmation of equitable sharing and open access to space resources and technologies would bring about static inefficiency in the development of these resources, resulting in fewer benefits being produced for all concerned. Finally the equitable sharing of space technologies would be a threat to national security, both undermining the economic base of the United States and supplying potentially unstable nations with technology that had possible dual-use military applications.

Third World nations argued that the CHP did not constitute a disincentive to space resource development because its provisions were designed to grant positive rights that would allow humankind to exploit the benefits of space resources for the first time (Cocca 1973). This was a clear improvement to the 1967 Outer Space Treaty that specifically excluded the possibility of appropriating these resources. In addition, the CHP authorizes an equitable, not an equal, sharing of profits, and contains a compromise clause that balances the distribution of benefits by taking into consideration both the needs of Third World countries, and the efforts put forth by the nations or entities developing these specific resources.

Third World nations also argued that the international regime, rather than obstructing the development of space resources, actually furnishes a system capable of facilitating cooperative space ventures between nations for the accessing of space resources. Moreover the mitigation of Third World underdevelopment and external dependency on the First World through the equitable sharing of outer space resources would in reality further international cooperation and reap greater economic benefits for all nations. In fact, economic research studies have recommended that "for the sake of American commercial competitiveness in space," the United States should maintain lenient policies in relation to international technology transfers and encourage the cooperative exchange of information among scientists from all nations as a means of accelerating technological innovation (Corson 1982, pp. 59–61).

Status and Assessment

The Moon Treaty, with its common heritage language, spent seven years in the COPUOS working committee before it was finally passed by consensus and sent to the UN General Assembly in 1979 for a vote, where it was adopted by all 152 member nations. However the Moon Treaty was subsequently ratified by only thirteen nations, and while it is technically in force in 2004, the lack of support by First World, spacefaring nations has undermined the treaty's inherent authority, and ultimately created a large and growing gap between the uses of space resources and technologies and the adequacy of the laws regulating them.

In the absence of an accepted system of international space law, nations have been turning to the formation of their own domestic law to furnish at least some legal guidance and security for the conduct of space activities (Goldman 1988, p. 85). Domestic space law, however, generates even more complex issues of compliance, particularly given the international nature of outer space and space activities. Questions regarding whose law will apply for joint space ventures such as the international space station, or in areas of liability for space accidents occurring between states, will be extremely troublesome to answer.

Yet the compromises that occurred during the laborious process of consensus in developing the Moon Treaty and the CHP were made to "assure developed and developing nations the opportunity to benefit from space activities" taking place within a commonly held region beyond national territorial boundaries (Jasentuliyana 1984, p. 4). The Moon Treaty offered an indispensable legal framework for maintaining international stability and clarifying the expectations of the international community, thereby reducing the potential for conflict, creating a safer investment climate for both government and private entities, and furnishing an organizational mechanism for cooperative commercial ventures in outer space (Jasentuliyana 1980, pp. 6–7; Goldman 1985, p. 85).

Consequently First World suspicions regarding the CHP and its mandate for the equitable sharing of space resources and technologies, along with the belief that open access, and/or cooperative ventures with *less qualified* Third World nations would lead to the inefficient development of these resources, ended an unprecedented era of international collaboration in scientific exploration, technological advancement, and the development of positive international law.

KIM ALAINE RATHMAN

SEE ALSO *Development Ethics; Space Exploration.*

BIBLIOGRAPHY

Christol, Carl. (1976). "The Legal Heritage of Mankind: Capturing an Illusive Concept and Applying it to World Needs." In *Proceedings of the XVIII Colloquium on the Law of Outer Space*. Paris: International Institute for Space Law.

Cocca, Aldo A. (1973). "The Principle of the *Common Heritage of All Mankind* as Applied to Natural Resources form Outer Space and Celestial Bodies." In *Proceedings of the XVIth Colloquium on the Law of Outer Space*. Paris: International Institute for Space Law.

Corson, Dale. (1982). *Scientific Communication and National Security*. Panel on Scientific Communication and National Security. Committee on Science, Engineering, and Public Policy. Washington, DC: National Academy Press.

DeSaussure, Hamilton. (1989). "Maritime and Space Law, Comparisons and Contrasts: An Oceanic View of Space Transport." In *Outer Space: Problems of Law and Policy*, ed. Glenn Reynolds and Robert Merges. Boulder, CO: Westview Press.

Goldman, Nathan. (1985). "The Moon Treaty: Reflections on the Proposed Moon Treaty, Space Law, and the Future." In *People in Pace: Policy Perspectives for a Star Wars Century*, ed. James Katz. New Brunswick, NJ: Transaction Books.

Goldman, Nathan. (1987). "Transition of Confusion in the Law of Outer Space." In *International Space Policy: Legal, Economic, and Strategic Options for the Twentieth Century and Beyond*, ed. Daniel Papp and John McIntyre. New York: Quorum Books.

Goldman, Nathan. (1988). *American Space Law, International and Domestic*. Ames: Iowa State University Press.

Gorove, Stephen. (1972). "The Concept of the *Common Heritage* of Mankind: A Political, Moral or Legal Innovation?" *San Diego Law Review* 9: 390–403.

Jasentuliyana, Nandasiri. (1980). "A United Nations Perspective of the Moon Agreement." Paper presented at the Seminar on the United Nations Moon Treaty, Center for Strategic and International Studies, Georgetown University, Washington, DC, February 19.

Jasentuliyana, Nandasiri. (1984). "Conditions Essential for the Peaceful Uses of Outer Space: The Moon Treaty," Paper presented at the symposium cosponsored by the United Nations and the International Institute of Space Law, Peace Palace, The Hague, Netherlands, March 12–15.

Jasentuliyana, Nandasiri, ed. (1992). *Space Law: Development and Scope*. Westport, CT: Praeger.

McDougall, Walter A. (1985). . . . *The Heavens and the Earth: A Political History of the Space Age*. New York: Basic Books.

Reynolds, Glenn, and Robert Merges, eds. (1989). *Outer Space: Problems of Law and Policy*. Boulder, CO: Westview Press.

Schachter, Oscar. (1959). "Who Owns the Universe?" In *Space Law: A Symposium*. Washington, DC: Government Printing Office. *Space Law: A Symposium* was prepared at the request of Honorable Lyndon B. Johnson, Chairman Special Committee on Space and Astronautics, U.S. Senate, 85th Congress, 2nd Session.

Vicas, Alex. (1980). "Efficiency, Equity and the Optimum Utilization of Outer Space as a Common Resource. *Annals of Air and Space Law* 5: 589–609.

COMMUNICATION ETHICS

Communication ethics is concerned primarily with human communication mediated by communications technologies, from print to radio, television, and other advanced electronic media. As such it assumes the importance of ethical responsibilities in direct or immediate communication, such as the obligation to speak truthfully, and seeks to reflect on how these carry over into the complex circumstances that arise with the development of communications science and technology. Because of the historical role played by reflection on ethics in relation to mass circulation print technologies in the form of newspapers during the first half of the twentieth century, communication ethics has its roots in journalism ethics. Because of the multiplicity of communications media during the last half of the twentieth century, the term *media ethics* is sometimes used as a synonym for communication ethics.

Contemporary Context

The communication technologies that produce and distribute information are an economic paradise. Massive multimedia conglomerates are at war for the trillions of dollars at stake—Pearson PLC in England, Bertlesmann in Germany, Microsoft and Disney in the United States, the Rupert Murdoch empire, and Sony of Japan. The business tycoons of these global companies do not specialize in hard goods, but control images, data, software, and ideas. Clusters of high-tech communication firms are re-mapping the planet. Previous geographical alignments organized by political power are being reordered in terms of electronic megasystems.

The revolution is not taking place in abstraction, outside of everyday affairs. Banking, the stock market, entertainment media, and the military represent the most advanced electronic communication systems. However the menagerie of fiber optics, supercomputer data, and satellite technology, although inescapably global, is local and personal as well. Television, CDs and CD-ROMs, DVDs and VCRs, online databases, rock music channels, PCs, video games, cellular telephones, and virtual reality—the electronic highway has become the everyday world of advanced industrial societies

Public life in the twenty-first century is being altered in complex ways through ubiquitous multimedia technologies, and ethics is essential for coming to grips with them. Language is indispensable to humanness and to the social order; therefore when human communication capacity is mediated in fundamentally different ways than before, the impact is substantial and far-reaching. Accounting for the social influence of media technologies is an historical and empirical task, but clearly the domain of communication ethics as well.

Communication as Symbol Making

The mainstream view in communication studies has been a mechanistic stimulus-response model rooted in empiricist science. However since the 1990s, communication theory has been complemented with an interpretive turn. From this perspective, human discourse and culture become fundamental, and language is the public agent through which identity is realized. Individuals are integrated into social units through symbol, myth, and metaphor. Communication is the creative process of building and reaffirming through symbols, with cultures the constructions that result. In a symbolic approach to communications, concepts are not isolated from their representations. The social and individual dimensions of language are a unified whole. Through the social nature of language, human beings integrate specific messages with the larger project of cultural formation.

Although not identical to that which they symbolize, symbols participate in their meaning. They share the significance of that to which they point. Symbols create what human beings call reality. Human identity embedded in representations matters to people. Thus worries about racism, sexism, and age discrimination in language are not marginal but central to socially responsible communication. The manner in which race, age, gender, class, disabilities, economic status, and ethnicity are represented symbolically influences the possibilities for a just sociopolitical order.

From a symbolic perspective, when symbols are mediated technologically, the changes in human life and culture must be understood historically and evaluated morally. Walter Ong (2002) calls this *technologizing the word*. Symbolic theory presumes that the history of communications is central to the history of civilization, that social change results from media transformations, that changes in symbolic forms alter the structure of consciousness.

The Canadian scholar Harold Innis (1951), for instance, studied the introduction of papyrus, the printing press, radio, and the telegraph—and documented a bias regarding space and time. Oral communication systems, he argued, are biased toward time, making time continuous while rendering space discontinuous. Print systems, by contrast, are biased toward space, making geography continuous and breaking time into distinct units.

Thus from the introduction of cuneiform writing to contemporary communication satellites and fiber optics, media technologies have attracted considerable attention—scholars in the symbolic tradition examining all significant shifts in technological form, associating with them alternations in culture and in perception. Within this paradigm of bias in communication systems, the intellectual challenge is to identify the distinguishing properties of particular media technologies such as books, cinema, and the Internet. As the physicist steps inside the world of atoms to understand them from the inside, so communications scholars, regarding television or magazines or billboards, must delve into their aesthetic properties in order to know them fundamentally and distinctively (McLuhan 1966).

As a minor premise, Innis (1952) argued that one form of communication tends to monopolize human knowledge and render other forms residual. Communications media never exist innocently and equally alongside one another. Elizabeth Eisenstein (1979), for example, documents the overriding significance of symbolic formation in her definitive work on the invention of printing. The printing press reformulated symbols at a historical watershed, fostering prescriptive truth and decentering papal authority by empowering the home and countryside with vernacular Bibles and Martin Luther's pamphlets. The ninth-century Carolingian and twelfth-century Gothic renascences were limited and transitory. The preservative power of Johannes Gutenberg's invention made the Renaissance permanent and total.

If oral cultures make time stand still, and print cultures foster empire and objectivism, the ongoing shift, from invention of the telegraph to early-twenty-first-century electronic culture, dislocates individuals from both space and history. It ruptures historical consciousness and pushes people into world citizenship, ill-equipped as they may be to accept that role. Without specific anchors in time and space, humans are ripe for electronic picking. Linear rationality facilitated by print is co-opted by mass media images. In sociological terms, the large-scale electronic media radically disconnect human beings from the mediating structures that serve as their everyday habitat—family, school, church, neighborhoods, and voluntary associations. Such primary groups lose their resonance.

The development of Internet technology marks another era of rapid growth and change in the media. Mass media technologies are converging into digital formats. Internet chat rooms, e-mail, multi-user domains (MUD), web-based publications, and the ability to hyperlink are producing new forms of human interaction. The 3-D virtual world is the innovative edge of these online technologies. In principle, interactive Internet technology gives people a voice and connects users directly without professionals or gatekeepers in between. Internet technologies can be democratic tools that serve people's everyday needs rather than those of special interest groups or the market.

Jacques Ellul developed the argument that technology is decisive in defining contemporary culture. Indeed not only productivity, but also economics, politics, and symbolic formations are dominated by the technological. In Ellul's (1969) framework, communications media represent the world of meaning in the technological system at large, the arena where the latter's character is most clearly exposed. Though exhibiting the structural elements of all technical artifacts, their particular identity as a technology inheres in their function as bearers of symbols. Information technologies thus incarnate the properties of technology while serving as agents for interpreting the meaning of the very phenomenon they embody.

Ellul calls communication systems the "innermost, and most elusive manifestation" of human technological activity (Ellul 1978, p. 216). All artifacts communicate meaning in some sense, but media instruments play this role exclusively. As the media sketch out the world, organize conversations, influence decisions, and impact self-identity, they do so with a technological cadence, massaging a technological rhythm and disposition into the human soul. With moral and social values disrupted and reoriented in the process, the ethics of communications technologies are an important arena for examining life in technological societies at present.

History of Communication Ethics

Historically communication ethics arose in conjunction with concerns related to print media, so that it requires work to extend the original developments to the more prominent digital technologies. Print news and the ethical standards for newspaper reporters were the first concerns of anything that could be called communication ethics. The harm that an unregulated press could do to society was first explicitly linked to ethical principles in North America and Europe during the 1890s, when critics began assessing journalism philosophically. These initial forays blossomed into the first systematic work in communication ethics during the 1920s in the United States. Four major books emerged from

America's heartland during that decade, their authors among a *Who's Who* of journalism luminaries: Nelson Crawford's *Ethics of Journalism* (1924), Leon Flint's *The Conscience of the Newspaper* (1925), William Gibbons's *Newspaper Ethics* (1926), and Albert Henning's *Ethics and Practices in Journalism* (1932). These authors understood ethics as a scholarly enterprise and left a permanent legacy. In Europe also several ethical issues emerged during the early-twentieth-century. Sensationalism was considered contrary to the public service role of the newspaper. Freebies and junkets, scourged by media critics as early as 1870, were treated more systematically in the context of rising business competition. Truthfulness as a moral principle was abstracted for the first time from the practice of accurately reporting facts. During this period, a platform for the free press/fair trial debate was created, though it was one-sided in promoting the rights of the press. Together they carved out much of the structure that dominates journalism ethics across Europe and North America in the early-twenty-first century, and with some nuances, in various regions around the world.

The intellectual roots of the democratic press were formed when print technology was the exclusive option. Most of the heavyweights in communication ethics in industrialized democracies demonstrate like predilections for news, and news in its literary rather than electronic broadcast form. Yet extensive research remains to be done on various aspects of the news business: declining readership among youth and in urban cultures, production practices, multiculturalism, the problematic status of objectivity, technological innovation, newspaper credibility, hiring practices, and others. Most of the perpetual issues in media ethics—invasion of privacy, conflict of interest, sensationalism, confidentiality of sources, and stereotyping—get their sharpest focus in a print context. Meanwhile newspapers outside the mainstream have scarcely been considered.

But the context has changed. Television is the primary source of news for most people and information radio remains vital. Even research that emphasizes the news function tackles cases and problems from broadcasting, the wire service agencies, and documentaries, in addition to everyday reporting. And beyond the daily paper, magazines and instant books are increasingly prominent. In a more dramatic trend, reporting is being removed from its pedestal and treated in the same way as other mass media functions. News is now being integrated with other aspects of the information system, that is, to persuade, to entertain, and to serve bureaucracy. In fact, practitioners of journalism, advertising, entertainment, and data management are often part of the same institutions and encounter other media functions directly in their work.

Arguably heads of media corporations should ideally come from a news background, and clearly the demands on news operations have never been more intense. But it is empirically true that the media's role in persuasion, entertainment, and digital transmission has also become pervasive, socially significant, and ethically charged—thus the burgeoning research in the ethics of public relations, organizations, face-to-face encounters, the music business and cinema, libraries, book publishing, confidentiality in computer storage, fiction, new media technologies, the mass-mediated sports industry, and more.

The dark side of ethical research into this expanding field is faddishness and fragmentation. However there is hope that the widening spectrum will open new insights and fresh approaches to the substantive issues. Deception and economic temptation are common in all mass-mediated communication. Sexism and racism are deep-seated everywhere. Reporters often fail to recognize sensationalism in the news until they confront the difference between gratuitous violence and realism in entertainment media. Invasion of privacy, easily excused in news, becomes an insufferable evil when government agencies access confidential information from data banks without permission. The challenge is to demonstrate how ongoing ethical quandaries can be fruitfully examined across a diverse range of media technologies and functions.

Ethical Issues

In outlining an agenda for communication ethics in terms of global media technologies rather than print journalism alone, several issues emerge as primary. Each can profit from the past, though several are new or have such dramatic intensity in the early twenty-first century that thinking rooted in the communication ethics of the first half of the twentieth century is no longer directly relevant. Meanwhile the electronic media have achieved some important successes. The Internet makes it possible for people who disagree with government policies to unite and protest against them. The Montreal Protocol and the Landmine Ban Treaty, for example, could not have happened without new media technologies. Television was the stimulus for humanitarian intervention in Somalia and prison reform in the U.S. military. Strengthening the media's role in democracy is important for communication ethics, while identifying the negative dimensions that are already obvious.

DISTRIBUTIVE JUSTICE. An ethics of distributive or social justice is mandatory for understanding the communications revolution. The mainstream view of social justice centers on fairness. As a formal concept, justice means "the consistent application of the same norms and rules to each and every member of the social cluster to which the norms and rules apply" (Heller 1987, p. 6). But in the more dynamic and multidimensional terms of distributive justice, the overriding question is accessibility. Just distribution of products and services means that media access ought to be allocated to everyone according to essential needs, regardless of income or geographical location. Comprehensive information ought to be ensured to all parties without discrimination.

In contrast, the standard conception among privately owned media is allocating to each according to ability to pay. The open marketplace of supply and demand determines who obtains the service. Consumers are considered at liberty to express their preferences and to select freely from a variety of competing goods and services. The assumption is that decisions about allocating the consumer's money belong to the consumer alone as a logical consequence of the right to exercise social values and property rights without coercion from others.

An ethics of justice where distribution is based on need offers a radical alternative to the conventional view. Fundamental human needs are related to survival or subsistence. They are not frivolous wants or individual whims or deserts. Agreement is rather uniform on a list of most human necessities: food, housing, clothing, safety, and medical care. Everyone is entitled without regard for individual success to that which permits them to live humanely.

The electronic superhighway is swiftly becoming indispensable. Communications networks make the global economy run, they provide access to agricultural and health care information, they organize world trade, they are the channels through which international and domestic political discussions flow, and through them people monitor war and peace. Therefore as a necessity of life in a global order, communication systems ought to be distributed impartially, regardless of income, race, religion, or merit.

What is most important about Internet technology is not so much the availability of the computing device or the Internet line, but rather the ability to make use of the device and conduit for meaningful social practices. Those who cannot read, who have never learned to use a computer, and who do not know the major languages of software and Internet content will have difficulty getting online, much less using the Internet productively.

There is no reasonable likelihood that need-based distribution will ever be fulfilled by the marketplace itself. Technological societies have high levels of computer penetration, and nonindustrial societies do not. Digital technology is disproportionately concentrated in the developed world, and under the principle of supply and demand there are no structural reasons for changing those disproportions. Even in wired societies, the existence of Internet technology does not guarantee it will reach its potential as a democratic medium. There is a direct correlation between per capita gross domestic product (GDP) and Internet distribution. The geography of the digital world is not fundamentally different from that of the off-line world. The history of the communications media indicates that existing political and economic patterns will prevail; inequities in society lead to inequities in technology.

In the digital age—rooted in computers, the Internet, fiber optics, and communication satellites—ideally all types of persons will use all types of media services for all types of audiences. Therefore the normative guideline ought to be universal access, based on need. And universal service is the Achilles' heel of new technologies driven by engineering and markets. As the economic disparity between rich and poor countries grows, an information underclass exacerbates the problem because information is an important pathway to equality. An ethics of justice requires that the approach to media institutions should be modeled after schools, which citizens in democracies accept as their common responsibility. Without intervention into the commercial system on behalf of distributive justice, the world will continue to be divided into the technologically elite and those without adequate means to participate.

CULTURAL DIVERSITY. Indigenous languages and ethnicity have come into their own in the early-twenty-first century. Sects and religious fundamentalists insist on recognition. Culture is more salient at present than countries. Muslim immigrants are the fastest-growing segment of the population in France and longstanding policies of assimilation are no longer credible. Thirty thousand Navajos live in Los Angeles isolated from their native nation and culture. The nomadic Fulani, searching for good pasture throughout sub-Saharan West Africa, are held together by clan fidelity, but their political future hangs in the balance. More than 30 percent of the information technicians working for the Microsoft Corporation in the United States come from India. In the early 1900s, 80 percent of immigrants to the United States were from Europe. Since the 1960s, the majority has come from Asia, Latin America, and developing countries in Africa. Rather than the melting pot of the last century, immigrants to the United States in the early-twenty-first century insist on maintaining their own cultures, religions, and languages. Identity politics has become dominant in world affairs since the Cold War, and ethnic self-consciousness is now considered essential to cultural vitality. As a result, social institutions such as the mass media are challenged to develop a healthy cultural pluralism instead of strident tribalism.

In order to integrate the new demands of cultural diversity into media practices and policies, an individualistic morality of rights must be modified by a social ethics of the common good. A commitment to cultural pluralism makes sense when the community is understood to be axiologically and ontologically superior to the individual. Human beings in this communitarian perspective do not disappear into the tribe, but their identity is constituted organically. Persons depend on and live through the social realm. Human beings are born into a sociocultural universe where values, moral commitments, and existential meanings are both presumed and negotiated. Thus in communitarian ethics, morally appropriate action intends community. Unless a person's freedom is used to help others flourish, that individual's well being is itself diminished.

Communitarianism as the basis for ethnic plurality moves media programming and organizations away from melting pot homogeneity and replaces it with the politics of recognition. The basic issue is whether democracies discriminate against their citizens in an unethical manner when major institutions fail to account for the identities of their members (Taylor et al. 1994). In what sense should the specific cultural and social features of African Americans, Asian Americans, Native Americans, Buddhists, Jews, the physically disabled, or children publicly matter? Should not public institutions insure only that democratic citizens share an equal right to political liberties and due process without regard to race, gender, or religion? Charles Taylor considers the issue of recognizing multicultural groups politically as among the most urgent and vexing on the democratic agenda. Beneath the rhetoric is a fundamental philosophical dispute that Taylor calls the *politics of recognition*. As he puts it, "Nonrecognition or miscrecognition can inflict harm, can be a form of oppression, imprisoning someone in a false, distorted, and reduced mode of being. Due recognition is not just a courtesy we own people. It is a vital human need" (Taylor et al. 1994, p. 26). This foundational issue regarding the character of cultural identity needs resolution for cultural pluralism to come into its own.

As one illustration of this framework, Robert Entman and Andrew Rojecki (2000) indicate how the race dimension of cultural pluralism ought to move forward in the media. Race in the early-twenty-first-century United States remains a preeminent issue, and Entman and Rojeck's research indicates a broad array of white racial sentiments toward African Americans as a group. They emphasize not the minority of outright racists but the perplexed majority. On a continuum from comity (acceptance) to ambivalence to animosity and finally racism, a complex ambivalence most frequently characterizes the majority. "Whites bring complicated combinations of assumptions, misinformation, emotional needs, experiences, and personality traits to their thinking about race" (Entman and Rojecki 2000, p. 21). They may believe, for example, that blacks face discrimination and merit aid, but argue against welfare spending out of a suspicion of government programs. Ambivalence means that the majority of whites do not necessarily harbor deep-seated fears or resentment, but become conflicted about the best strategies to follow and sometimes lose their patience with the slow progress of change.

Correcting white ignorance and dealing with ambiguities hold the most promise for the media. The reality is, however, that the media serve as resources for shading ambivalence off into animosity. There is little evidence that television or other popular media pull their viewers toward comity. The white majority mostly experiences "media images of Blacks on welfare, of Black violence on local news, and of crude behavior—open sexuality and insolence—in entertainment television.... The habits of local news—for example, the rituals in covering urban crime—facilitate the construction of menacing imagery" (Entmann and Rojecki 2000, p. 34). Thus the media do little to enhance racial understanding among the ambivalent majority most open to it. Unfortunately the media do not provide the information that this important swing group needs to move policy and institutions toward cultural pluralism.

VIOLENCE. Violence in television and film has been a major ethical issue for decades. Internet technology has complicated the problem with hate speech and cyberterrorism.

In the United States, for example, studies have shown that by high school graduation the average seventeen-year-old will have seen 18,000 murders in the movies and on television. From the horrific shootings at Columbine High School in 1999 to similar tragedies in other states and countries before and since, teenagers who slaughter their classmates and teachers, and then kill themselves, are linked by debate or research to the culture of violence in which they live. While the United States leads the world in the amount of violence on television, television programming in all parts of the globe contains a great deal of violence, including a high percentage of guns as weapons and indifference to brutality, with the terrible consequences only hinted at or not depicted at all (Potter 1999). Gun-related deaths in the United States have reached the level of a public health epidemic.

Meanwhile media industries and civil libertarians opposed to censorship claim that no direct effects from violent programming have been documented or proved. In fact, this argument against curtailing violence in the media has long been the most persistent and persuasive. However the no-effects conclusion is no longer credible. Evidence of a positive association between media violence and real violence has been accumulating for at least forty years. Analyses during the 1990s of literally hundreds of studies on media violence verify a causal link between televised violence and real-life aggression with some of the strongest effects among young children. Research conducted for the American Medical Association (AMA) and the National Centers for Disease Control and Prevention, and the results of the exhaustive National Television Violence Study (1994–1998) support the same conclusion (Wilson et al. 2002).

Based on a review of the research, James Potter (1999) concludes that there exist both immediate and extended consequences from televised violence—with the caveat that the effects process is highly complex. In the short term, fear and habituation occur, but increased aggressiveness toward others is strongly supported also. The same is true for effects over a longer period: Research shows that exposure to violence in the media is linked to long-term negative effects such as increased aggression, a worldview based on fear, and desensitization to violence.

Violence is a serious ethical issue because it violates the persons-as-ends principle. In Immanuel Kant's standard formulation, people must treat all other people as ends-in-themselves and never as means only. In Judeo-Christian agape and feminist relational ethics, violence contradicts Other-regarding care. On multiple grounds, the gratuitous cheapening of human life to expand ratings is a reprehensible mistreatment of human beings. From the persons-as-ends perspective, there is a special interest in the sexual violence so common in music video, horror movies (especially slasher films), pornographic literature, and video games. Sadistic, bloodthirsty torture in a sexual context is a particularly offensive form of dehumanization.

A new dimension of violence has emerged with hate speech on the Internet. In 1995, former Ku Klux Klan (KKK) leader Don Black established Stormfront, the first white supremacist Internet site. As access to the Internet became less expensive and creating web pages much simpler, the number of Internet sites and people visiting them grew exponentially. Mirroring this growth, Internet sites espousing various kinds of bigotry have multiplied dramatically, now numbering in the thousands. In the past, hate was promoted through crude graffiti and low quality pamphlets. Bulk mailings to even a few hundred people were difficult. But with the Internet, slick web sites devoted to hate are available to a potential audience of millions.

In the early-twenty-first century, though the KKK is more fragmented than at any time since World War II, its factions are using the Internet to revitalize the organization. The KKK sites maintain and defend the superiority of the white race, and warn against interracial marriage. Jews are vilified as Satan's people, and immigration is condemned as an uncontrolled plague. In addition, the number of Internet sites for the National Association for the Advancement of White People, founded by former KKK leader David Duke, has mushroomed and energized the so-called *Klan without robes*.

Numerous neo-Nazi Internet sites promote the anti-Semitic racism of Adolf Hitler, with the National Alliance being the most prominent Hitlerian organization in the United States. Jews are blamed for inflation, media brainwashing, and government corruption, with blacks depicted as criminals and rioters. A host of sites are devoted to Holocaust revisionism, denying the murder of Jews in World War II.

Internet sites of hate groups that claim religious legitimacy are flourishing as well. The Christian Identity site is virulently racist and anti-Semitic. The World Church of the Creator calls nonwhites physiologically subhuman. The site for White Aryan Resistance rails against the nonwhite birthrate. Other sites are anti-Catholic and anti-Muslim, or militantly anti-abortion.

Most organizations that monitor Internet hate activity do not advocate censorship. Education is seen as more effective than trying to silence bigots. With many moral problems in the media, some ethical theories are more appropriate than others, but hate speech on the Internet is contradicted by all major theories without exception. This across-the-board condemnation suggests that all personal, educational, and policy efforts to combat Internet hate speech are permissible, even mandatory, but obviously without the revenge and aggressiveness that contradict good ends.

Another kind of violence made possible by digital technology is cyberterrorism, that is, attacks on human targets abetted by machines and direct attacks on the telecommunications infrastructure. Financial transaction systems, electrical supply networks, military operations, police and emergency electronic devices, water purity management, air traffic control, and other essential services are vulnerable to computerized sabotage. All attempts at protecting societies through cybersecurity have tended to lead to increased surveillance, intrusions upon private data, and centralized government authority. High-level encryption technology is essential for protecting civil liberties and societies from terrorist attacks. Many security issues in advanced societies are still unclear and their resolution ill-defined. Should diagrams of nuclear power plants or city water systems, for example, be easily available to the public as they were before September 11, 2001? Resolving the conundrums requires as much open communication as possible, but the profusion of communication itself is sometimes counterproductive. In all aspects of cyberterrorism, a proactive citizenry and enlightened legislation are indispensable.

INVASION OF PRIVACY. Public opinion polls indicate that privacy is the premier issue in media ethics, at least in European and North American cultures. Intruding on privacy creates resentment and damages the credibility of the news media. But for all of the advances in privacy and tort law, ethicists consider legal definitions an inadequate foundation. How can the legally crucial difference between newsworthy material and gossip or voyeurism be reasonably determined?

Therefore while acknowledging legal distinctions and boundaries, the ethics of privacy is constructed from such moral principles as the dignity of persons and the redeeming social value of the information disclosed. Privacy is a moral good because it is a condition for developing a healthy sense of personhood. Violating it, therefore, violates human dignity. But privacy cannot be made absolute because people are cultural beings with responsibility in the social and political arena. People are individuals and therefore need privacy; people are social beings and therefore need public information about others. Because people are individuals, eliminating privacy would eliminate human existence as they know it; because people are social, elevating privacy to absolute status would likewise render human existence impossible. These considerations lead to the formal criterion that the intimate life space of individuals cannot be invaded without permission unless the revelation averts a public crisis or is of overriding public significance and all other means to deal with the issue have been exhausted.

From an ethical perspective, legal definitions of privacy beg several questions about the relationship between self and society. A legal right to privacy presumes a sharp line dividing an individual from the collective. An ethics of privacy prefers the richer connections between public and private advocated by social theorists since Alexis de Tocqueville, who have centered their analysis on a viable public life. While participating in theoretical debates over the nature of community, media ethicists have been applying moral principles to three areas: (a) the reporting of personal data on various social groups from innocent victims of tragedy to public officials to criminals; (b) protecting confidential information stored in computer data banks—medical, financial, library, educational, and personal records, for example, and (c) ubiquitous advertising that intrudes on our everyday activities.

Conclusion

The cosmopolitan reach of high-speed electronic technologies has made communication systems and institutions of global scope possible. Dealing with these new entities requires a technologically sophisticated, cross-cultural ethics commensurate with the worldwide reach of the media. In the process of identifying and responding to specific issues, communication and media ethics must make the questions raised by technology the central focus while repositioning them internationally. As true of professional ethics generally, communication ethics ought to become comparative in character. In place of its largely European and North American, gender-biased, and monocultural canon, media ethics of the future must be ecumenical, gender-inclusive, and multicultural.

A diversified comparative ethics, with a level playing field rooted in equal respect for all cultures, is by no means unproblematic and involves an act of faith. The claim that all cultures have something important to say to all human beings is an hypothesis that cannot be validated concretely. Yet it serves as an open horizon for moving comparative, transnational study forward in an interactive mode. Of the various types of applied and professional ethics, communication ethics has its roots most deeply in language, culture, and dialogue. In that sense, a multicultural style is required for its own authenticity.

CLIFFORD G. CHRISTIANS

SEE ALSO *Communications Regulatory Agenices; Computer Ethics; Computer Viruses/Infections; Ellul, Jacques; Journalism Ethics; Information Society; Internet; Networks; Rhetoric of Science and Technology; Science, Technology, and Literature.*

BIBLIOGRAPHY

Bertrand, Claude-Jean. (2000). *Media Ethics and Accountability Systems.* New Brunswick, NJ: Transaction.

Christians, Clifford. (2000). "An Intellectual History of Media Ethics." In *Media Ethics: Opening Social Dialogue,* ed. Bart Pattyn. Leeuven, Belgium: Peeters. Gives a detailed account of the development of media ethics during the twentieth century in North America and Europe.

Christians, Clifford, and Michael Traber. (1977). *Communication Ethics and Universal Values.* Thousand Oaks, CA: Sage. A common commitment to truth-telling, human dignity, and nonviolence is documented from thirteen countries on four continents.

Crawford, Nelson. (1924). *The Ethics of Journalism.* New York: Knopf.

Eisenstein, Elizabeth. (1979). *The Printing Press as an Agent of Change: Communications and Structural Transformations in Early-Modern Europe,* 2 vols. New York: Cambridge University Press.

Ellul, Jacques. (1969). *Propaganda: The Formation of Men's Attitudes,* trans. Konrad Kellen, and Jean Lerner. New York: Alfred A. Knopf. The mass media are described as agents of covert, sociological propaganda in contrast to overt, political propaganda.

Ellul, Jacques. (1978). "Symbolic Function, Technology and Society." *Journal of Social and Biological Structure* October: 207–218.

Entman, Robert, and Andrew Rojecki. (2000). *The Black Image in the White Mind: Media and Race in America.* Chicago: University of Chicago Press.

Flint, Leon Nelson. (1925). *The Conscience of the Newspaper.* New York: Appleton.

Gibbons, William Futhey. (1926). *Newspaper Ethics: A Discussion of Good Practice for Journalists.* Ann Arbor, MI: Edwards Bros.

Hamelink, Cees J. (2000). *The Ethics of Cyberspace.* Thousand Oaks, CA: Sage. Universal human rights as defined by the United Nations are presented as the standard for evaluating cyber technologies.

Heller, Agnes. (1987). *Beyond Justice.* Oxford: Basil Blackwell.

Henning, Albert F. (1932). *Ethics and Practices in Journalism.* New York: Long and Smith.

Innis, Harold. (1951). *The Bias of Communication.* Toronto: University of Toronto Press.

Innis, Harold. (1952). *Empire and Communication.* Toronto: University of Toronto Press.

Lester, Paul M., and Susan D. Ross, eds. (2003). *Images That Injure: Pictorial Stereotypes in the Media,* 2nd edition. Westport, CT: Greenwood.

Lyon, David. (2001). *Surveillance Society: Monitoring Everyday Life.* Philadelphia: Open University Press.

McLuhan, Marshall (1966). *Understanding Media: The Extensions of Man.* New York: McGraw Hill.

Ong, Walter J. (2002). *Orality and Literacy.* Florence, KY: Taylor and Francis Books. The psychological and sociological differences between oral and print societies are outlined historically.

Potter, W. James. (1999). *On Media Violence.* Thousand Oaks, CA: Sage Publications.

Taylor, Charles K.; Anthony Appiah; Jürgen Habermas, et al. (1994). *Multiculturalism: Examining the Politics of Recognition.* Princeton, NJ: Princeton University Press. Taylor argues that the need for a voice from various ethnic groups is one of democracy's most difficult challenges at present.

Wilson, Barbara; Stacy L. Smith; W. James Potter; et al. (2002). "Violence in Children's Programming: Assessing the Risks." *Journal of Communication* 52: 5–35.

COMMUNICATIONS REGULATORY AGENCIES

Human beings are animals that communicate intensively, and all communication systems, beginning with spoken and written languages, are regulated in at least informal ways. Most people feel that there are certain things that should not be said or written and that certain forms of speech and writing are appropriate for different contexts. However, with the development of physical communication systems such as the postal system and even more with that of the telegraph, telephone, radio, and television, regulation guided by ethical principles has become an increasingly prominent feature of those technologies. Ethical principles concerning content and access have created the foundation for regulation of communication systems. Concerns about content include privacy and anonymity, copyright, defamation, censorship, and profanity. Ethical issues relating to access include concerns about the availability of communication systems and control of content production.

Speech and Postal Systems

Law has been used to regulate the content of speech and writing since at least Roman jurisprudence, in which speakers were held liable for defamatory communication that caused injury to another party. The United Kingdom began regulation of defamation during the sixteenth and seventeenth centuries; this area of law was established in the United States after independence and is mirrored in other countries. Defamation law protects individuals from falsehoods that may cause economic or emotional harm and covers utterances in both speech (slander) and writing (libel). This principle of constrained communication extends to all media and their respective systems and has a lengthy judicial history in the United States and the United Kingdom (Jones 2003).

A number of ancient civilizations created courier services to deliver official documents and messages, with the earliest evidence of an organized infrastructure appearing in Egypt in 2000 B.C.E. From initially serving the government, a number of those systems were expanded to include public and private correspondence; that led to the almost complete control of postal services by nations by 1875. Regulation of those entities focused primarily on efficient administration.

However, by the middle of the twentieth century an expectation of privacy had made its way into many legal systems, including the Mexican constitution, U.S. and British law, and the European Convention on Human Rights. This principle restricts readership of mail to the addressee but generally is qualified to give states the ability to censor materials in the name of security; this explains the still widespread censorship of mail within military forces (Scheele 1970).

Toward the end of the twentieth century government-run monopolies on postal services began to compete again with private courier services. In response a number of government services, including the U.S. Postal Service, began to operate with more independence from the government. Ensuring complete access to the global postal network remains a key factor supporting government-run services as many small or hard to reach communities fear complete isolation in an entirely privately run system.

Telegraph and Telephone

The wire telegraph was invented by Samuel F. B. Morse (1791–1872) in 1835 and saw widespread deployment within ten years of its invention. Alexander Graham Bell (1847–1922) was granted a patent on the telephone in 1876, but that technology grew somewhat more slowly than did the telegraph, with the first transcontinental line in North America not being finished until 1915. In 1865 the International Telegraph Union was founded to support international interoperability of the telegraph system. That union was the first international body to regulate communications and attempted to allow easier communication across national boundaries. The union has expanded to include all telecommunications activities but does not address ethical issues involving content or access directly.

The telegraph initially was regulated in the United States through the Post Roads Act of 1866, which gave authority to the postmaster general to fix rates for telegrams sent by the government. Greater government involvement in the industry did not come until twenty-one years later, when the U.S. Congress passed the Interstate Commerce Act of 1887 to regulate railroads and laid the foundation for the regulation of common carriers within the United States. A common carrier is any transporter that offers services to the general public to transport goods. Court interpretation of common carriers to include communication services provided the legal authority for government to become more actively involved in the communications industry. The 1887 act was amended explicitly to include that extension of government jurisdiction to regulate telephone and telegraph companies by the Mann-Elkins Act of 1910. Regulation of telephone and telegraph was taken over by the Federal Communications Commission (FCC) at its inception in 1934.

Although some nations tried to regulate privately owned telephone and telegraph companies as the United States did, a number of others followed a model closer to that of the postal service and created nationalized phone utilities. In many countries, including the United States, regulators oversaw private companies with full or partial monopolies. Regardless of the details of the regulatory structure or the preference for government involvement or free market competition, each nation faced similar ethical questions.

Early regulation of the telegraph and telephone industries focused on improving interoperability between competing networks, allowing consumers to send messages to any recipient regardless of the network to which they subscribed. Regulators also attempted to ensure that telephone and telegraph companies charged consumers equally for the same service, thus supporting equal access to the system. Each regulatory regime also grappled with questions concerning the privacy and content of those transmissions. When can the state or an individual record or intercept those messages? In the United States third-party taping of conversations requires a court order, whereas rules for recording by parties to a conversation vary from state to state. As with the postal service, most nations have formulated some expectation for the privacy of telephone and telegraph messages.

Radio and Television

Concurrent with the initial development of the telephone and telegraph, research into wireless communications systems led to the creation of the first wireless telegraph by Guglielmo Marconi (1874–1937) in 1895. Maritime adoption of that technology for ship-to-ship and ship-to-shore communication spread rapidly and led to the Berlin International Radiotelegraphic Convention, a series of international conferences in Berlin in 1903 and 1906 and in London in 1912 to discuss radio telegraphy. Beyond determining SOS as the standard distress signal, the 1912 conference led directly to the U.S. Radio Act of 1912, which, along with the Mann-Elkins Act, became the foundation for the regulation of communication systems by the U.S. government.

Radio transmission of voice developed slowly during that period and remained closely tied to telephony. However, by 1920 radio broadcasting had begun in earnest with the November 2 broadcast of election returns by the Pittsburgh station KDKA. The early years of broadcast radio were marked by turmoil. Stations went on and off air, using a frequency and power of their choosing, resulting in widespread interference and confusion. The Radio Act of 1912 required stations to obtain a license from the U.S. Department of Commerce, although the department had no enforcement authority and issued licenses with little oversight. As a result Congress passed the Dill-White Radio Act of 1927, which established the Federal Radio Commission and granted it authority to assign and revoke broadcast licenses at particular powers and frequencies. The act also included provisions for the regulation of programs that exploited or misled the public; that allowed the commission to end broadcasts of fraudulent drug claims or religious scams.

Faced with a growing number of regulatory bodies responsible for communication, Congress created the Federal Communications Commission in the Communications Act of 1934 to take over all communication regulatory activities of the U.S. government. The U.S. regulatory structure stayed largely unchanged until the passage of the Telecommunications Act of 1996.

By the time of the creation of the FCC the television pioneers Vladimir Zworykin (1889–1982) and Philo Taylor Farnsworth (1906–1971) had succeeded in designing and producing all-electronic televisions and television broadcasting was beginning. By the mid-1930s over a dozen stations were broadcasting within the United States. As with radio, the FCC regulated the licensing, power, and frequency of new broadcasters to limit or eliminate interference and ensure that airways were used in the public interest. Television began to grow rapidly in the 1950s and 1960s, quickly reaching a large majority of the public. In the United States satellite and cable television entered the market in the late1970s, but its development was largely unregulated after the Cable Communications Act of 1984 removed much of FCC jurisdiction over those industries.

Although the telegraph and the telephone were accessible by a wide range of the public, broadcast radio and television were limited to a few stations that could broadcast without interference. As a result of the limited nature of broadcasting, governments created various methods to ensure programming in the public interest. In the United Kingdom owners of television sets are required to pay a license fee for partial funding of the government-sponsored British Broadcasting Corporation. In the United States the FCC requires broadcast stations to meet public interest requirements as terms for receiving a broadcasting license. In 1967 the Public Broadcasting Act created public television and radio stations in the United States and partially excluded them from FCC regulation. However, the FCC did act to revoke the license of the Alabama Educational Television network in 1975 because of its racist programming and hiring practices.

From the creation of the Federal Radio Commission to 1987 the FCC enforced a regulatory principal known as the Fairness Doctrine, which holds that stations are obligated to seek out issues of public importance and present contrasting points of view. During the presidency of Ronald Reagan (1980–1988) the FCC began to deregulate all the industries in its jurisdiction. Court cases in 1987 held that the Fairness Doctrine was not required by an act of Congress, allowing the FCC to rescind the policy. Two related rules requiring equal time for targets of personal attacks or political editorials to respond were removed in 2000. Advocates of the change argued that the growth in media outlets negated the need for the doctrine; opponents argued that broadcasters would attempt to further specific political and/or economic agendas to the detriment of the public at large. The Fairness Doctrine was a prime example of regulation of communication that was intended to benefit the public by influencing the content of broadcasts.

Regulators also grappled with control of the limited means of production in the broadcast industry. In light of the limited number of voices that can be brought to air, the distribution of those voices is an important ethical question. A poignant example of the perceived power of broadcasting was the capitulation of broadcasting companies in 1950s to the blacklisting of performers, writers, and directors for alleged leftist political leanings by the organization aware. In that case regulators at the FCC took no action, as they would later do in cases of race or gender discrimination.

Regulators often have attempted to limit ownership of multiple media outlets by single companies to maintain diversity, seeking a balance between preserving independent ownership and allowing free competition. Advances in technology also have changed the availability of the broadcast spectrum by decreasing the amount of interference between nearby stations. At the beginning of the twenty-first century the FCC examined the viability of low-power television and radio stations that would serve small areas and determined that those neighborhood broadcasters did not pose a significant risk of interference with established stations. However, legislation to grant the FCC authority to license those stations has not gotten support from the U.S. Congress.

Internet, Convergence, and the Information Society

The last two decades of the twentieth century saw tremendous growth in a number of new telecommunications fields, especially the worldwide network of computers now known as the Internet. The potential movement of traditional telephone, radio, and television communication to the Internet is known as convergence. The technological underpinning of the Internet makes no distinction between data as the data travel. E-mail, pirated video, and Internet telephony all move equally and without distinction. Data can be identified only by destination or origin. The transformation of all types of data (writing, speech and audio, pictures and video) to computer-based digital data has profound implications for all previous systems: Anyone with access to the Internet can transfer text, audio, or video around the globe and can compete with or avoid traditional communication systems.

Regulation in the new media has been minimal for the most part, with China being a striking exception. The easy accessibility of information on the Internet has led to concerns about the content being provided. The Chinese government regularly blocks content from outside the country and exerts strong control of the information posted within the country. In the United States some have found the availability of pornography to be repugnant and have pushed for greater control over content. In 1996 that desire led to the Communications Decency Act, which created stiff penalties for the distribution of pornographic works to minors; however, the act was struck down by courts as a violation of First Amendment freedom of speech rights.

In light of the growing importance of the Internet, access has become a vitally important question. Disparities between rich and poor individuals and nations in computer access have created a digital divide that has implications for the future growth and equality of those groups.

Assessment

Communication regulation helps define the limits of freedom of speech. Regulators set limits on the content of communication for a variety of reasons, including the protection of personal or secret information, a desire to limit false and misleading claims, and the encouragement of debate. Communication may have negative consequences for individuals, groups, or entire societies. Lessening these harms, however, can require sacrifices in terms of the privacy, anonymity, and freedom of individuals. Modern regulatory agencies must balance the rights of the individual broadcaster with the interests of society as a whole.

Coupled with the regulation of communication content, regulatory agencies also try to control access to communication technologies. Some technologies have a limited capacity for public use, such as radio and over-the-air television. Thus, access to those means of communication is a unique benefit that government has seen fit to control. Other technologies may have limited access because of economic inequities or limits to the physical interconnection of communication networks. Here too regulatory agencies have interfered with the market to promote access to the widest possible set of consumers.

The great power of communications systems as a persuasive force makes these determinations of appropriate content and access disputed issues. Changes in these systems affect millions of consumers and billions of dollars of economic activity. Regulatory agencies sit at the center of political and ethical debate over the appropriate use of these rapidly evolving technologies.

TIND SHEPPER RYEN

SEE ALSO *Communication Ethics; Internet; Radio; Science, Technology, and Law; Television.*

BIBLIOGRAPHY

Brennen, Linda L., and Victoria E. Johnson, eds. (2004). *Social, Ethical and Policy Implications of Information Technology*. Hershey, PA: Idea Group. A social science text on the ethical dimensions of IT communication

Hilliard, Robert L. (1991). *The Federal Communications Commission: A Primer*. Boston: Focal Press. A general guide to the commission's organization, decisions, and history

Jones, William K. (2003). *Insult to Injury: Libel, Slander, and Invasions of Privacy*. Boulder: University Press of Colorado. Provides a detailed history of libel cases within the United States

Jordana, Jacint, ed. (2002). *Governing Telecommunications and the New Information Society in Europe*. Cheltenham, UK: Edward Elgar. Detailed work on the structure of IT governance within the European Union

Levy, Brian, and Pablo T. Spiller, eds. (1996). *Regulations, Institutions, and Commitment: Comparative Studies of Telecommunications*. New York: Cambridge University Press. Describes telecommunication industries in a number of industrialized and developing countries, particularly in South America

Scheele, Carl H. (1970). *A Short History of the Mail Service*. Washington, DC: Smithsonian Institute Press. A detailed history of mail service, especially with in the United States

INTERNET RESOURCES

Federal Communications Commission History Project. (2004). Available from http://www.fcc.gov/omd/history.

COMMUNISM

The word Communism has been used in different senses by different authors, but from 1917 onward it was most readily associated with the type of political and economic system established in Russia and the other lands that became the Union of Soviet Socialist Republics (USSR). By the 1970s Communism in this sense of the term prevailed in Latvia, Lithuania, Estonia, and parts of Bessarabia, all of which were incorporated directly into the USSR, as well as in Mongolia, Poland, Hungary, Czechoslovakia, Bulgaria, Romania, Yugoslavia, Albania, East Germany, North Korea, China, Tibet, Cuba, Vietnam, Laos, and Cambodia. A number of other states, including Nicaragua, Granada, Afghanistan, Angola, Mozambique, and Ethiopia, were ruled by parties closely allied with the USSR, but whether they were full-fledged Communist states is open to debate. In addition, parties advocating the Soviet model of government formed in most other countries. These states and parties, although they used various names—workers, people's, democratic—were commonly referred to as Communist.

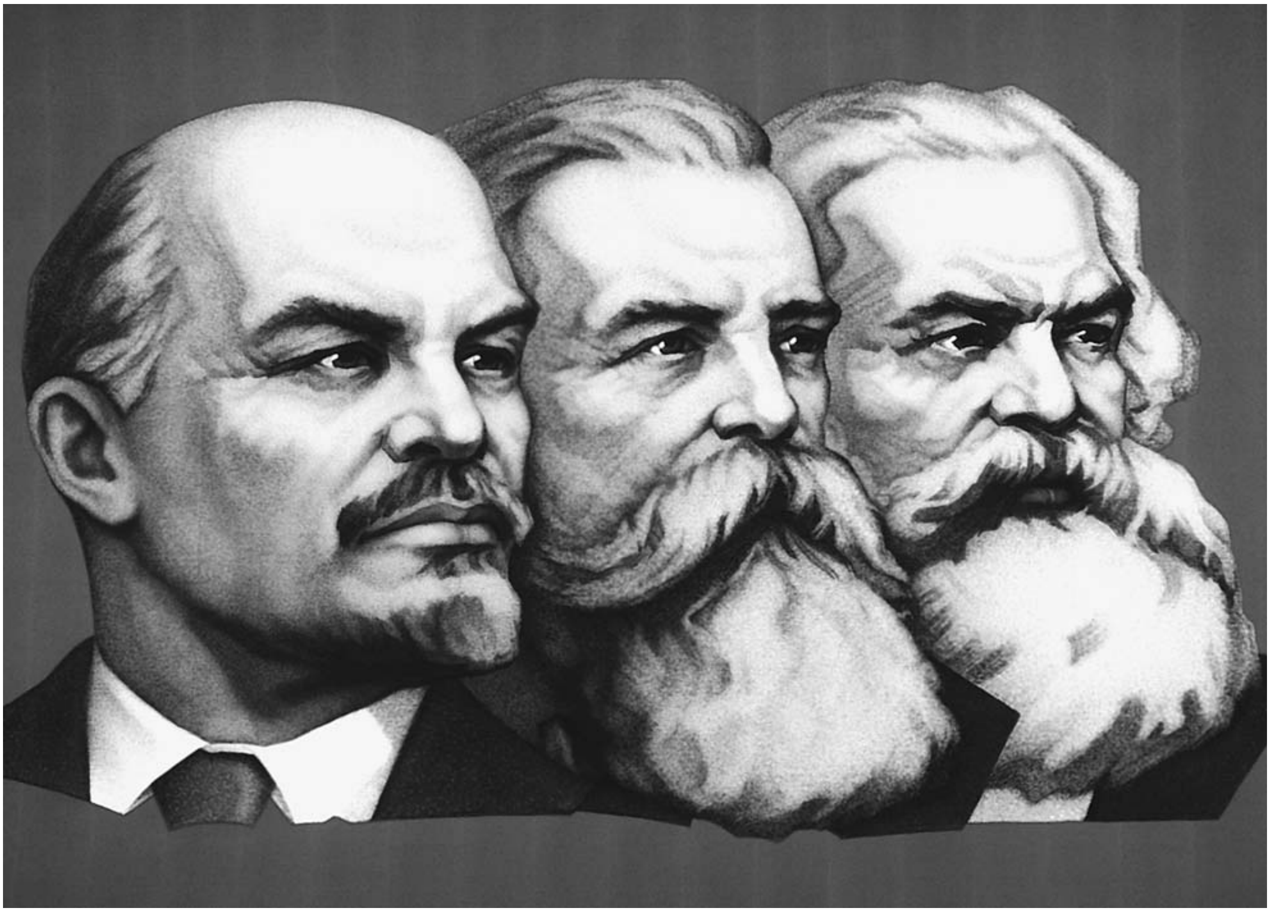
From its earliest period of development Communism made two important claims about its relation to science. The first was that it was itself a scientific theory. The second was that it put science and technology to greater benefit than any competitor political practice. Both claims were disputed by non-Communists.

Marxism-Leninism as Science

Although Communism was not alone among the various schools of socialism in tracing its roots to Marxism, Communists were the most emphatic in asserting the absolute validity of that doctrine. Under Vladimir I. Lenin (1870–1924), the founder of Communism, the scientific claims of Marxism were treated as undeniable dogma. Lenin wrote, "From the philosophy of Marxism, cast of one piece of steel, it is impossible to expunge a single basic premise, a single essential part, without deviating from objective truth, without falling into the arms of bourgeois-reactionary falsehood" (Lenin 1977, p. 326).

Lenin wrote these words years before he came to rule Russia. Once he took power, the dogmatic spirit they reflect was reinforced by the exigencies of revolutionary government. Lenin's party, first called Bolshevik and later Communist, was a small, elite group. In order to hold onto power its members saw they would have to suppress the opposition, and Lenin made no bones about this. Since he was confident that his party was the authentic representative of the proletariat, any opposition would inevitably reflect hostile class interests that deserved to be suppressed for the sake of human progress.

Thus did Lenin introduce the practice of silencing criticism or dissent. Under his heir, Joseph Stalin (1879–1953), and their disciples in other countries, such as China's Mao Zedong (1893–1976), Communism assiduously policed the expression of opinion, exacting draconian penalties against any deviation from party policy. All of this was accompanied by sweeping assertions of the scientific character of Marxist and Commu-



Banner depicting (left to right) Vladimir Lenin, Karl Marx, and Friedrich Engels. The three men can be thought of as the "fathers" of Communism. *(© Brian A. Vikander/Corbis.)*

nist doctrine, evidenced by the fact that almost any speech, book, essay, or paper required numerous citations from the texts of Marx, Engels, and Lenin. This semblance of scientific procedure was topped off by the claim that Communism was possessed of a unique form of philosophical reasoning called *dialectic* or *dialectical materialism* that somehow offered more penetrating insights than did conventional logic.

In the usage of Lenin and subsequent Communists, calling something science or scientific meant that something was true. To real scientists, the term has nearly the opposite meaning, connoting a search for truth in which all conclusions are provisional.

In the end even Communist leaders themselves acknowledged that the legacy they inherited was less one of science than dogma. In the USSR Mikhail Gorbachev, under the rubric *glasnost,* reversed the tradition initiated by Lenin and opened the way to freedom of speech. And in China Deng Xiaoping (1904–1997) sought to undo Mao's worship of doctrine, coining the slogan: "It does not matter if a cat is black or white as long as it catches mice."

If free inquiry and acceptance of the notion that all conclusions are subject to revision in the face of new evidence are the touchstones of science, then Communism presented an environment that was inimical to science. This went even a step further in China, where for a time Mao actively discouraged the reading of books and education other than practical training. Peasants, although harshly exploited in collective farms, were nonetheless held by Mao to be the repositories of revolutionary virtue, and urbanites that fell afoul of the regime were often exiled to the countryside to "learn from the peasants." During the Great Proletarian Cultural Revolution (1966–1977), schools were closed for years as teenagers were mobilized into perpetual street mobs in byzantine power struggles between rival party factions. All of this fierce anti-intellectualism, so at odds with traditional Chinese reverence for education, was justified as being egalitarian and antielitist. But such contempt for formal learning was also antiscientific.

Communist Achievements in Science and Technology

This is not to say that Communist societies were without their accomplishments in scientific fields. There were some, particularly in engineering and applied research. Great investments were made in military equipment and in other technologies such as space exploration that were part of a symbolic competition with the capitalist world. Moreover Communist regimes were disdainful or indifferent to *soft* fields of scholarship—the arts, humanities, and social sciences—so that the finest minds of these societies almost necessarily found their outlets in hard science or engineering.

In addition to discouraging free inquiry, Communist regimes sometimes intervened directly in scientific questions, most famously when Stalin directed Soviet biology to embrace the tenets of Trofim Denisovich Lysenko (1898–1976). Ironically, in light of Marx and Engels's belief that their theories were analogs to Darwin's, Lysenko was a Soviet scientist who dissented from a key tenet of Darwin's principle of natural selection. Lysenko believed that acquired, as opposed to inherited, traits could be passed on genetically. Because Stalin had a deep fondness for great projects of social engineering, the idea that one might alter life itself in this manner appealed greatly. For some years genetic research in the USSR was forced to devote itself to Lysenko's eventually discredited theories.

Through the concentration of material and human capital, Communist regimes competed effectively, albeit usually coming in second, in the fields of weaponry and space exploration. Sometimes what these endeavors lacked in fine-tuning they made up for in size—for example, less accurate missiles armed with larger warheads. Usually they competed a lot less well in technologies devoted to consumer goods. The lack of marketplace incentives to maintain or improve the quality of products, combined with the general dampening of innovation and the low priority given to economic planning involving consumer goods, resulted in a generally shoddy quality of merchandise. Popular discontent on this score was an important factor that eventually resulted in pressure for political change in China and the USSR.

The most singular episode in the history of technology under Communism was the Great Leap Forward (1957–1960), a program guided by Mao's conviction that a collective farm could produce industrial as well as agricultural goods and thereby become completely self-sufficient. In a fervent national campaign from which dissent was not tolerated, collectives began trying to produce industrial goods including that sine quo non of industry, steel. Mao announced that small *backyard* smelters could replace large steel mills. One of the many flaws in this theory was the absence of thought given to the question of material inputs for these smelters. Egged on and intimidated, peasants felt compelled to contribute not only scrap but whatever was available in existing tools and utensils, so that these might be melted down to make new steel. Little real steel was produced by this method, but many small tools and even cooking woks were sacrificed. Add to this the sacrifice of peasant labor diverted from the fields, and the result was a mass famine during the years 1959–1962 that most sinologists estimate took some 30 million or more lives.

Ethics: New Ends Justify Any Means

The large-scale loss of life under Communism in China, the USSR, and a few other places, notably Cambodia and North Korea, highlights the ethical issues raised by Communism. Although the facts of these cases were once hotly disputed, for the most part disputes ended when successor Communist rulers acknowledged the respective tragedies. That is, the deaths caused by Stalin's regime in the USSR were decried first by Nikita Khrushchev (1894–1971), then more fully by Gorbachev. The depredations of Pol Pot (1926–1998) were roundly denounced by the Communists who threw him out of power in Cambodia. And some of the carnage caused by Mao—that associated with the Great Proletarian Cultural Revolution—was recognized at least implicitly after Deng Xiaoping took the helm in China in 1978, although Mao was not directly blamed.

The needless deaths of large numbers of human beings would in itself seem to constitute a moral transgression of the highest order. And yet under Communism this was not deemed axiomatic. Communists asserted the moral standards that were traditional to Christianity (and in the East to Confucianism or other longstanding codes) were themselves expressive of the domination of the wealthy classes. As Lenin put it: "People always have been the foolish victims of deception and self-deception in politics, and they always will be until they have learned to seek out the *interests* of some class or other behind all moral, religious, political and social phrases, declarations and promises." (Lenin 1969).

Mao Zedong waves to the cheering crowd at Tiananmen Square in Beijing as they celebrate May Day, 1967. Mao was influenced by the writings of Marx and Lenin, but was also inescapably a Chinese nationalist. He believed that the communist revolution in China was distinct from all others because of the weight of its history and culture. *(Getty Images.)*

Therefore the proletariat would embody its own ethical standards. And these would be closely tied to the fulfillment of its mission to overthrow capitalism and usher in a new historical age. Communism would provide a fulfilling life for all people, and since society would no longer be divided by classes, it would make possible for the first time the emergence of truly universal moral principles.

Since so much is at stake in the triumph of the socialist revolution—nothing short of the achievement of humankind's ultimate destiny—everything must be put at the service of this goal. As Lenin wrote:

> "Our morality is entirely subordinated to the interests of the proletariat's class struggle. When people tell us about morality, we say: to a Communist all morality lies in conscious mass struggle against the exploiters. We do not believe in an eternal morality Communist morality is based on the struggle for the consolidation and completion of communism." (Lenin 1968).

In taking this approach, Lenin rested on a strong but nonetheless ambiguous tenet in Marxist theory. Marx and Engels asserted that all ideas spring from class roots, which suggests that no objective ethical standards exist. Yet their condemnation of capitalism drew its power from its implied moral terms. Marx and Engels often claimed that they had done no more than lay bare the laws of history, showing that capitalism was destined to be replaced by socialism. But if so, there was no reason to work for the advancement of socialism. In practice Marx and Engels worked with all the energy they could muster. They were as much activists as philosophers, and the only explanation for this, even if implicit, was that socialism was not only inevitable but also highly desirable—which implies some standard of good and bad.

At the same time, Marx also proclaimed that "Communism is the riddle of history solved." If indeed this is the case, then it is hard to take exception to Lenin's very instrumental approach to ethics, for nothing else could possibly take priority. The achievement of Communism would be the measure of all things.

A companion aspect of the view that all else must be subordinated to the fulfillment of the destiny of humankind as a whole is that any given individual's well being might be subordinated to this higher, collective good. As explained by Aleksandr F. Shishkin, author of the leading Soviet text on ethics, Communist morality teaches the individual "not to look upon himself as an end in himself." Rather "the new society cultivates the individual in such fashion as to cause him to see the fullness of human existence to lie in struggle for a common cause and to be able to resolve in favor of society any contradiction arising between the needs of society and his personal ambition" (Shishkin 1978, p. 88).

JOSHUA MURAVCHIK

SEE ALSO *Chinese Perspectives; Lysenko Case; Marxism; Marx, Karl; Russian Perspectives; Socialism.*

BIBLIOGRAPHY

DeGeorge, Richard T. (1969). *Soviet Ethics and Morality*. Ann Arbor: University of Michigan Press.

Graham, Loren R. (1972). *Science and Philosophy in the Soviet Union*. New York: Knopf.

Graham, Loren R. (1993). *Science in Russia and the Soviet Union: A Short History*. New York: Cambridge University Press.

Graham, Loren R., ed. (1990). *Science and the Soviet Social Order*. Cambridge, MA: Harvard University Press.

Heller, Mikhail, and Aleksandr M. Nekrich. (1986). *Utopia in Power: The History of the Soviet Union from 1917 to the Present*. New York: Summit.

Kamenka, Eugene. (1969). *Marxism and Ethics*. New York: St. Martin's Press.

Kolakowski, Leszek. (1979). *Main Currents of Marxism*. Oxford: Oxford University Press. The work consists of three volumes; see especially volumes I and III.

Lenin, Vladimir I. (1969). *Three Sources and Three Component Parts of Marxism*. Moscow: Progress Publishers. Originally published in 1913.

Lenin, Vladimir I. (1968). *The Tasks of the Youth Leagues*. Moscow: Progress Publishers.

Lenin, Vladimir I. (1977). "Materialism and Empirico-Criticism." In *Collected Works*, Vol. 14. Moscow: Progress Publishers.

Marx, Karl. (1978). "Economic and Philosophical Manuscripts of 1844." In *The Marx-Engels Reader*, ed. Robert C. Tucker. Text originally published in 1844.

Medvedev, Zhores A. (1978). *Soviet Science*. New York: Norton.

Pipes, Richard. (1993). *Russia under the Bolshevik Regime*. New York: Knopf.

Shishkin, Aleksandr F. (1978). "On Moral Values in the Contemporary World." *Soviet Studies in Philosophy* 17(1): 71–99.

COMMUNITARIANISM

Communitarianism is part of the neo romantic reaction to rationalism. It emphasizes moral and social values and the societal institutions that support them, especially community and its traditions, passions and beliefs, religion, and the habits of the heart. Communitarianism is not blind to facts and logic, the cool calculations of the rational mind, or the importance of science, technology, and economic progress. Nevertheless, it is concerned that such perspectives may override, if not ignore, other *human* considerations, to which communitarianism is attentive. For the same reasons, communitarianism seeks to balance concern for individual rights and liberty with concerns for the common good and community.

Definition and History

The term *communitarian* was first introduced in 1841, to mean "of, pertaining to, or characteristic of a community or communistic system; communitive." It was infrequently employed from then until the mid-twentieth century.

Several critics have argued that the concept of the community is of questionable value because it is so ill-defined. In *The Myth of Community Studies*, Margaret Stacey (1974) argues that the solution to this problem is to avoid the term altogether. In the same publication, Colin Bell and Howard Newby similarly point out, "There has never been a theory of community, nor even a satisfactory definition of what community is" (p. xliii).

Amitai Etzioni (1996) has nevertheless argued that community can be defined with reasonable precision. Community has two characteristics: first, a web of affect-laden relationships among a group of individuals, relationships that often crisscross and reinforce one another (as opposed to one-on-one relationships); and second, a measure of commitment to a set of shared history and identity—in short, a particular culture. David E. Pearson stated, "To earn the appellation 'community,' it seems to me, groups must be able to exert moral suasion and extract a measure of compliance from their members. That is, communities are necessarily, indeed by definition, coercive as well as moral, threatening their members with the stick of sanctions if they stray, offering them the carrot of certainty and stability if they don't" (Pearson 1995, p. 47)

Among early sociologists whose work is focused on communitarian issues (though they did not draw on the term) are Ferdinand Tönnies (1855–1936), especially his comparison of the *Gemeinschaft* and *Gessellschaft*; Emile Durkheim (1858–1917), particularly his studies of the socially integrating role of values and the relations between the society and the person; and George Herbert Mead (1863–1931) in his work on the self. Other early relevant sociological works are those of Robert E. Park, William Kornhauser, and Robert Nisbet.

While the term *communitarian* was coined in the mid-nineteenth century, ideas that are essentially communitarian appear much earlier. They are found in the Old and New Testaments, Catholic theology (for example, the emphasis on the Church as a community), more recently in socialist doctrine (for example, writing about early communes and workers' solidarity), and finally *subsidiarity*—the principle that the lowest level of authority capable of addressing an issue is the one best able to handle it. In essence, moral judgments are best made at the community level rather than from the higher governing bodies.

Balancing Liberty with the Common Good

In the 1980s, communitarianism was largely advanced by political theorists Charles Taylor, Michael Sandel, and Michael Walzer. They criticized liberalism for overlooking that people can have a strong attachment to their societies. They lamented liberalism's focus on individualistic self-interest.

Since that time, two main forms of communitarianism have emerged. Authoritarian communitarians, who typically concern themselves with Asian culture, argue that to maintain social harmony, individual rights and political liberties must be curtailed. Some emphasize the importance of the state to maintain social order (for instance, leaders and champions of the regimes in Singapore and Malaysia), and some focus on strong social bonds, morality, and traditional culture (as in Japan). Some Asian communitarians also hold that the West's notion of liberty actually amounts to anarchy, that strong economic growth requires limiting freedoms, and that the West uses its idea of legal and political rights to chastise other cultures.

In 1990 a new school of communitarianism developed. Among its leading scholars are political theorist William A. Galston, legal scholar Mary Ann Glendon, political scientist Thomas Spragens, Jr., writer Alan Ehrenhalt, and sociologists Philip Selznick, Robert Bellah and his associates, and Amitai Etzioni. The work of these authors laid the foundations in 1990 for the second form of communitarianism: responsive (democratic) communitarianism.

Responsive communitarianism assumes that societies have multiple and not wholly compatible needs, in contrast to philosophies built on one core principle, such as liberty. In communities, there is an irrepressible tension between exclusion and inclusion, and between civility and piety. Thus community is not a restful idea, a realm of peace and harmony. On the contrary, community members must recognize and deal with competing principles. Responsive communitarianism assumes that a good society is based on a balance between liberty and social order, and between particularistic (communal) and society-wide values and bonds. This school stresses the responsibilities that people have to their families, kin, communities, and societies. These exist above and beyond the universal rights that all individuals command, which is the main focus of liberalism.

While a carefully crafted balance between liberty and social order defines a generic concept of the good society, communitarians point out that the historical-social conditions of specific societies determine the rather different ways that a given society in a given era may need to change to attain the same balance. Thus, contemporary Japan requires much greater tolerance for individual rights, while in the American society excessive individualism needs to be curbed.

To achieve this balance, unlike laissez faire conservatives and welfare liberals who differ mainly with regard to the respective roles of the private sector and that of the state, communitarians are especially concerned with the third sector, that of civil society. They pay special attention to the ways that informal communal processes of persuasion and peer pressure foster social responsibilities for the common good.

Communitarians are also concerned with the relationship between the self and the community. Political theorists depict the self as "embedded," implying that the self is constrained by the community. Responsive communitarians stress that individuals who are well integrated into communities are better able to reason and act in responsible ways than are isolated individuals, but if social pressure to conform rises to high levels, it will undermine the individual self and therefore disrupt the balance.

This issue is reflected in questions that arise when associations of scientists and professions such as engineering address ethical and policy issues relevant to their work. Should the decisions involved, say whether or not to proceed with human cloning, be made by each scientist or by their informal communities or associations? And what role, if any, should the public and its elected representatives have in making these decisions? Closely related are similar questions such as to how to deal—and above all, who should deal—with instances of fraud in research, misappropriation of funds, and violations of security.

Communitarianism's Critics

Critics generally suggest that those who long for communities ignore the darker side of traditional communities. "In the new communitarian appeal to tradition, communities of 'mutual aid and memory,'" writes Linda McClain (1994), "there is a problematic inattention to the less attractive, unjust features of tradition" (p. 1029). Amy Gutmann (1985) pointedly remarks that communitarians "want us to live in Salem" (p. 319), a community of strong shared values that went so far as to accuse nonconformist members of witchcraft during the seventeenth century.

Communitarians counter that behind many of these criticisms lies an image of old, or total, communities, that are neither typical of modern society nor necessary for, or even compatible with, a communitarian society. Old communities (traditional villages) were geographically bounded and the only communities of which people were members. In effect, other than escaping into no-man's-land, often bandit territories, individuals had few opportunities for choosing their social attachments. In short, old communities had monopolistic power over their members.

New communities are often limited in scope and reach. Members of one residential community are often also members of other communities, for example work, ethnic, or religious ones. As a result, community members have multiple sources of attachments; if one community threatens to become overwhelming, individuals will tend to pull back and turn to another for their attachments. Thus, for example, if a person finds herself under high moral pressure at work to contribute to the United Way, to give blood, or to serve at a soup kitchen for the homeless, and these are lines of action she is not keen to follow, she may end up investing more of her energy in other communities—her writers' group, for instance, or her church. This multi-community membership protects the individuals from both moral oppression and ostracism.

Another criticism is that communities are authoritarian. Derek Phillips (1993), for instance, remarks, "[C]ommunitarian thinking … obliterates individual autonomy entirely and dissolves the self into whatever roles are imposed by one's position in society" (p. 183). As the political scientist Robert Booth Fowler (1991) puts it, critics "see talk of community as interfering with the necessary breaking down of dominant forces and cultures" (p. 142). Some critics mean by this that communities are totalistic, a point already covered. Others mean that they are dominated by power elites or have one group that forces others to abide by the values of those in power.

Communitarians find that this criticism has merit but is misdirected. There are communities both past and present that have been or still are authoritarian. The medieval phrase *Stadt Luft macht frei* ("the air of the cities frees") captures what the farmers of traditional villages must have felt when they first moved into cities at the beginning of the industrial era. (Poor working conditions and slums aside, being away from the stricter social codes of their families and villages seems to have given them a sense of freedom, which in some cases led to anarchic behavior.) Totalitarian communities exist in contemporary societies, such as North Korea. However, most contemporary communities, especially in communitarian societies, are not authoritarian even when they are defined by geography. Also, the relative ease of mobility means that people often choose which community to join and within which to live. Agnostics will not move into a Hasidic community in Brooklyn, and prejudiced whites will not move into a neighborhood dominated by the Nation of Islam.

Science and technology help open up societies and they promote relatively empirical, rational approaches to the world. New communications technologies, such as the Internet and satellite dishes, help undermine authoritarian regimes. However, no one should assume that on their own, these devices are capable of delivering a truly democratic state—especially when such technological advances are not accompanied by a proper change in values, as has been seen in Russia, Singapore, and China in the early twenty-first century.

Contemporary Issues

Communitarians have developed several specific concepts and policies that draw on their philosophy. They favor shoring up families, not traditional-authoritarian ones but peer marriages (in which mothers and fathers have equal rights and responsibilities). They fostered schools that provide character education rather than merely teach, but avoid religious indoctrinization. They developed notions of community justice, in which offenders, victims, and members of the community work together to find appropriate punishments and meaningful reconciliation. Communitarians favored devolution of state power, and the formation of communities of communities (within national societies and among nations), among many other policies.

Following the growing popularity of the concept of civic society, Etzioni (1999) argues that contemporary civic society is insufficient because it tends to be morally neutral on all matters other than the attributes that citizens need to make themselves into effective members of a civic society, for instance, the ability to think critically. In contrast, a good society seeks to promote a core of substantive values, and thus views some voluntary associations and social activities as more virtuous than others.

In the same vein, communitarians argue that while everyone's right to free speech should be respected, some speech—seen from the community's viewpoint is morally highly offensive and when children are exposed, damaging. For instance, the (legal) right to speak does not render verbal expressions of hate (morally) right.

Science has long been associated with rational thinking and in turn with secularism. Indeed, historically, science has often been considered antithetical to religion. However, communitarians are concerned with the moral fabric of society and they find religion one source of moral values. A communitarian may prefer to divide the issues people face among those that are subject to rational or scientific analysis and those that belong to a different sphere, reserved for belief. These include questions such as is there a god, why people are cast in this world born to die, what people owe their children and members of their community, among others.

Closely related is the question of a proper balance between the two *sectors*. Since the enlightenment, the sector of rationality (and within it science and technology) has increased dramatically in western societies. Communitarians ask whether in the process resources and time dedicated to the family, social and public life, culture, and spiritual and religious activities have been neglected.

While sociologists made numerous contributions to altered communitarian thinking, in turn communitarian philosophy has challenged sociology to face issues raised by cross-cultural moral judgments. Sociologists tend to treat all values as conceptually equal; thus, sociologists refer to racist Nazi beliefs and those of free societies by the same "neutral" term, calling both *values*. Communitarians instead use the term *virtue* to indicate that some values have a high moral standing because they are compatible with the good society, while other values are not and hence they are "aberrant" rather than virtuous.

AMITAI ETZIONI

SEE ALSO *Community; Durkheim, Émile; Liberalism; Libertarianism; Neoliberalism.*

BIBLIOGRAPHY

Bell, Daniel A. (2000). *East Meets West: Human Rights and Democracy in East Asia*. Princeton, NJ: Princeton University Press. Is liberal democracy universal? Daniel Bell explores this question with a look at Asian societies. Bell criticizes the "Asian values" perspectives, but finds that drawing on East Asian cultural traditions can create a model for political institutions that differs substantially from western-style democracy.

Bellah, Robert Neelly, ed. (1996). *Habits of the Heart: Individualism and Commitment in American Life*. Berkeley: University of California Press. Argues that democratic communities must focus on forces that humanize markets and government administrative powers.

Etzioni, Amitai. (1996). *The New Golden Rule*. New York: Basic Books. A foundational work of new communitarian theory. This book argues for the need to balance freedom with morality, and automony with community. It paves the way for a social order largely based on moral suasion rather than coercion.

Etzioni, Amitai. (1999). *The Limits of Privacy*. New York: Basic Books. An exploration of the right to privacy and the potentially negative impact it can have on public health and safety. Suggests criteria when privacy ought to yield and when it needs to be further extended. Case studies include sex offenders; HIV testing; medical records; ID cards; and encrypted communications.

Fowler, Robert Booth. (1991). *The Dance with Community: The Contemporary Debate in American Political Thought*. Lawrence, KS: University Press of Kansas.

Glendon, Mary Ann. (1993). *Rights Talk: The Impoverishment of Political Discourse*. New York: Free Press. Contends that the rise of the language of rights in Western discourse has stifled real discussion, debate, and even the liberties that it seeks to protect.

Gutmann, Amy. (1985). "Communitarian Critics of Liberalism" *Philosophy And Public Affairs* 14 (3): 308–322.

Kornhauser, William. (1959). *The Politics of Mass Society*. Glencoe, IL: The Free Press.

McClain, Linda C. (1994). "Rights and Irresponsibility" *Duke Law Journal* 43 (5): 989.

Nisbet, Robert. (1962). *Community and Power*. New York: Oxford University Press.

Pearson, David E. (1995). "Community and Sociology" *Society* 32 (5): 44–50.

Phillips, Derek L. (1993). *Looking Backward: A Critical Appraisal of Communitarian Thought*. Princeton, NJ: Princeton University Press.

Sandel, Michael. (1998). *Liberalism and the Limits of Justice*. Cambridge, UK: Cambridge University Press. Liberal societies try to avoid imposing value judgements on their members so that each individual is free to pursue the principles that meet with their interpretation of the good life. But do such principles exist? Sandel critiques this form of democratic liberalism.

Stacey, Margaret. (1974). "The Myth of Community Studies" In *Sociology of Community: A Collection of Readings*, ed. Colin Bell and Howard Newby. London: Frank Cass & Co.

INTERNET RESOURCES

The Communitarian Network. Available from http://www.gwu.edu/~ccps/index.html.

COMMUNITY

Community is a term with widely varying historical and current meanings in both specialized and everyday discourse. It also possesses several dimensions—ethical, political, social, ontological, psychological, and epistemological—many of which are relevant to discussions of science and technology.

Theorists generally consider community to be a good that, carried too far, may undermine its own moral and political values for those both within and outside it. Community is an important source of meaning in human lives, and it encompasses the sets of values, beliefs, and interpretative frameworks by which the world takes on meaning. Indeed, the scientific and technological enterprise is often described as dependent on the special values of a scientific or technical community (Merton 1942). Community, however, may also manifest itself in oppressive political forms that defy universal values, shared rights, or basic forms of well-being of certain members of a society in the name of community. Political forms of community such as nationalism or populist fascism, or Thomas Hobbes's or Jean-Jacques Rousseau's different versions of collective identity, may belie other human values such as individual liberty. Members of the scientific community have also sometimes ignored the rights of nonscientists or the larger social orders of which science is a part.

At a minimum, community is a set of shared goals or values perceived as good by those who participate in their formation or by those who belong to the heritage these shared values define. A qualitative sense of belonging therefore attends community, and a broader notion of community also includes common language, rituals, geographical territory, religion, historical memory, and ethnic identification.

Community versus Society

In 1887 the German sociologist Ferdinand Tönnies developed the distinction between community and society in terms of the informal, moral, familial bonds of traditional communal life and the formalized and impersonal, amoral, juridical, and administrative relations of industrial society. "Community" was taken to have an organic quality, whereas society was mechanistic in nature. The importance of this distinction relates to the sense of belonging in social relations and has applications for notions of citizenship, the legitimacy of political representation, ideas of the common good, and the meaning of public participation. "Society" corresponds to the "neutral" structural conditions of modern life. For better or worse, Tönnies's distinction has served to circumscribe much of the sociological, political, and moral meaning of community to this day. In contemporary political thought, for example, the distinction is manifested in terms of holistic communitarianism versus individualistic liberalism. While complex, these latter terms highlight the relative importance of participation in political life, whether the good is best articulated collectively or individually, and the extent to which institutions should choose between a fully embodied moral community and a minimally protective framework for individual liberties.

If one assumes that shared values and frameworks of belief are paramount in the legitimate governance of societies, Tönnies's distinction between community and society has also influenced modern science and technology in important ways. Twentieth-century critics of technology as varied as Martin Heidegger, Herbert Marcuse, Jacques Ellul, Ivan Illich, and early Jürgen Habermas maintain that the intrinsic qualities of communal life were slowly eroded by a postindustrial society of "technoscientific," instrumental emphasis on values of use and efficiency. Langdon Winner (1986) further argues that technological choices determine broader social and administrative structures and reframe the conditions of moral and political life, even though these choices remain beyond the scope of communities. In such views, modern society is an "organizational" society in which rationalizing "technoscientific" approaches to social organization root out the affective (emotional) characteristics of sociality and the bonds of community that Tönnies and others ascribe to community. Expert management replaces participation and communal frameworks of value as the main force of modern social and value formation. If moral value is rooted in community, then technical social management entails institutions that express a small set of values disguised as socially neutral instruments. Others argue, more specifically, that the global spread of modern technologies has served to destroy traditional cultures, communities, and economies and to undermine modern values such as sustainability (see, for example, Helena Norberg-Hodge's studies of Ladakh [1991]).

Scientific and Democratic Community

In contrast, John Dewey (1954 [1927]) and others argue that technological society, especially through new communications technologies, harbors the potential to revive local community. Similarly, Thomas C. Hilde (2004) suggests that the integration of modern technologies and science into the global formation of norms presents not only risks to traditional notions of community but also new possibilities. For Hilde this framework constitutes an "epistemic cosmopolitanism" capable of facilitating new forms of community.

The scientific sense of communal inquiry and of the production of knowledge is further developed by Peter M. Haas (1990) and others as "epistemic community." Epistemic communities are, according to Haas, scientists and others united by both causal explanations (of, for example, ecological damage) and shared values regarding which policies should emerge from scientific evidence.

If scientific inquiry always harbors the preferences of a broader community and social organization in which scientists work (Kuhn 1962, Longino 2002, Harding 1998), then the currently dominant utilitarian values enframe the broader technological/scientific project. This, in turn, constricts the range of values embodied in technical decisions that influence the shape of society and its future policy outcomes. If this basic thesis regarding the importation of value is correct, then both community and scientific inquiry merit further discernment of beneficial preferences from damaging ones, and in such cases deliberation may be better sought through the broader community. Scientific inquiry might then better serve to advance not only the knowledge of the broader community, but also its methods of inquiry.

THOMAS C. HILDE

SEE ALSO *Civil Society; Communitarianism.*

BIBLIOGRAPHY

Bauman, Zygmunt. (2001). *Community: Seeking Safety in an Insecure World.* Cambridge, UK: Polity Press.

Dewey, John. (1954 [1927]). *The Public and Its Problems.* Athens, OH: Swallow Press.

Feyerabend, Paul. (1993). *Against Method,* 3rd edition. London: Verso.

Haas, Peter M. (1990). *Saving the Mediterranean: The Politics of International Environmental Cooperation.* New York: Columbia University Press.

Habermas, Jürgen. (1987). *The Theory of Communicative Action,* Vol. 2: *Lifeworld and System,* trans. Thomas McCarthy. Boston: Beacon Press.

Harding, Sandra. (1998). *Is Science Multicultural? Postcolonialisms, Feminisms, and Epistemologies.* Bloomington: Indiana University Press.

Hilde, Thomas C. (2004). "The Cosmopolitan Project: Does the Internet Have a Global Public Face?" In *The Internet in Public Life,* ed. Verna V. Gehring. Lanham, MD: Rowman and Littlefield.

Kuhn, Thomas. (1962). *The Structure of Scientific Revolutions.* Chicago: University of Chicago Press.

Longino, Helen E. (2002). *The Fate of Knowledge.* Princeton, NJ: Princeton University Press.

Marcuse, Herbert. (1964). *One-Dimensional Man.* Boston: Beacon Press.

Merton, Robert K. (1942). "Science and Technology in a Democratic Order." *Journal of Legal and Political Sociology* 1: 115–126. Reprinted as "The Normative Structure of Science." In *The Sociology of Science: Theoretical and Empirical Investigations,* ed. Norman W. Storer. Chicago: University of Chicago Press, 1973.

Norberg-Hodge, Helena. (1991). *Ancient Futures: Learning from Ladakh.* San Francisco: Sierra Club Books.

Peirce, Charles S. 1992 (1868). "Some Consequences of Four Incapacities." In *The Essential Peirce,* Vol. 1, ed. Nathan Houser and Christian Kloesel. Bloomington: Indiana University Press.

Taylor, Charles. (1985). *Philosophical Papers,* Vol. 2: *Philosophy and the Human Sciences.* Cambridge, UK: Cambridge University Press.

Tönnies, Ferdinand. (1957 [1887]). *Community and Society.* New York: Harper and Row.

Winner, Langdon. (1986). *The Whale and the Reactor: A Search for Limits in an Age of High Technology.* Chicago: University of Chicago Press.

COMPLEMENTARY AND ALTERNATIVE MEDICINE

The term *alternative medicine* refers to therapies and diagnostic procedures that are used instead of those of conventional medicine, whereas *complementary medicine* refers to therapies and diagnostic procedures that are used in addition to those of conventional medicine. The same therapy can be alternative or complementary, depending on its use. For example, a dietary program for treating cancer sometimes is used as a complement to surgery but also may be employed as an alternative to chemotherapy. The term *complementary and alternative medicine* (CAM) is a standard way of referring to both, whereas *integrative medicine* refers to medical practices that bring together conventional medicine and CAM. *Experimental medicine* refers to therapies, usually drugs, that are undergoing testing for regulatory approval.

Classification of CAM

The National Center for Complementary and Alternative Medicine (2003) of the U.S. National Institutes of Health classifies CAM into the following subcategories: alternative medical systems such as Chinese medicine and naturopathic (a type of nutritional and dietary) medicine; mind-body interventions that are not mainstream, such as prayer, meditation, and mental healing; biologically based therapies such as dietary supplements and herbs (one also would include here immunological therapies that are not in clinical trials); manipulative therapies such as chiropractic; and therapies based on electromagnetic energy or forms of energy that are not accepted by contemporary science.

Applying Bioethics Principles

Most of the literature on medical ethics and CAM is based on the mainstream bioethical principles of beneficence (guiding and helping a patient), nonmaleficence (avoiding harmful and futile treatments), autonomy (protecting a patient's informed consent to choose treatments), and justice (fairness in terms of the right of access). There have been attempts to introduce other principles that are relevant to CAM (Guinn 2001), but the vast majority of the discussions take place in the context of conventional bioethical principles (Sugarman and Burk 1998). Furthermore, most ethics discussions related to CAM focus on the relationship between the health-care provider and the patient. The principle of justice gets much less attention.

Patients' use of CAM therapies has grown since the 1980s, and in the United States CAM increasingly is offered through licensed alternative professions such as naturopathy, chiropractic, and acupuncture/Chinese medicine. Other countries also provide legal recognition of various types of CAM providers. In the United States the Federation of State Medical Boards (2002) developed guidelines for physicians who use CAM or work with licensed CAM providers. The statement outlines three types of possible harm from CAM: economic harm from spending money on futile therapies, indirect harm caused by avoiding efficacious conventional therapies or having hopes raised falsely, and direct harm caused by negative side effects of CAM therapies. The statement also specifies four ethically relevant categories of CAM: documented as effective and safe, documented as effective but with side effects and risk, inadequately studied but safe, and ineffective and dangerous. The federation suggests that physicians recommend CAM treatment when there is a favorable risk-benefit ratio, a favorable expected outcome, and a greater benefit with CAM than with no treatment. Under those conditions physicians should not lose their licenses for recommending CAM and should respect a patient's right to choose CAM (the principle of autonomy).

The guidelines provide some help in answering two of the most frequently discussed ethical issues regarding CAM: obligation to inform and obligation to treat. Is a physician obligated to inform a patient of an available CAM option? Failure to do so for conventional therapies generally is considered a violation of informed consent, and this principle is being extended to CAM therapies, but only if they meet fairly high standards for efficacy and/or safety. Is a physician obligated to treat a patient if the patient has full informed consent with regard to the risk-benefit ratio yet opts instead for a CAM therapy that the physician considers dangerous? Here there is a conflict between the principles of beneficence (the physician's assumed superior knowledge) and maleficence (the purported danger of the CAM therapy) and the principle of autonomy (the patient's right to choose). Frequently in this situation physicians will refuse additional treatment or comanagement of the case. In addition to their ethical defense based on concern for the patient's well-being physicians may cite their personal risk of malpractice litigation or loss of license (Studdert et al. 1998).

The guidelines represent a significant shift from older medical approaches to CAM, which dismissed it as quackery and considered recommendations to consider CAM therapies to be unethical. However, ethical ambiguities and questions remain.

First, frequently patients opt to receive a CAM therapy from a nonlicensed provider, such as a noninvasive spiritual or mind-body therapy that often is associated with a patient's religious belief in shamanism, spiritualism, or evangelical faith healing. How should physicians or CAM professionals answer questions about healing services offered by religious groups or other nonlicensed providers? Should absence of indirect and direct harm suffice to warrant discussions or even referrals?

A second ambiguity is the question of what constitutes adequate evidence for evaluations of safety and efficacy. In contemporary medical science evidence usually is organized in a hierarchy of credibility. At the top is the gold standard: the controlled clinical trial. In this form of research patients are divided on a random basis into two or more groups, one with the test therapy (in this case a CAM therapy) and others with placebos or conventional therapies. The following alternative methods often are viewed in a descending order of evidential value: a retrospective form of data analysis that takes existing cases, such as patients who used a CAM therapy, and compares them with a control group; the best case series, which shows promising results in a series of patients but lacks a statistical analysis with a comparison group; subclinical research such as experiments that test CAM substances on animals or cell cultures; and a lower level of subclinical research that provides biochemical analyses of a CAM substance (such as an herb) to determine if it has any known pharmacologically active agents. A significant debate has emerged regarding the value of clinical trials versus other methods for the evaluation of CAM (Hess 1999).

Most CAM therapies lack a body of consistent clinical trials with supporting evidence at the other levels. If the evidence were complete, consistent, and highly positive, the therapy probably would be considered conventional, not CAM. As a result both conventional and CAM providers face the dilemma of making recommendations in the absence of complete evidence. In many cases there is only some, often mixed, evidence for efficacy, but there is a long record of use with few or no risks, side effects, or negative interactions with other therapies. In such cases physicians who practice integrative medicine sometimes will add CAM therapies, but only as a complementary modality.

To understand some of the complexities one can consider the case of a patient whose tumor has metastasized, or spread, to other organs. Surgery was only partially successful, and the oncologist recommends additional chemotherapy. The chemotherapy for this tumor type has serious side effects and is not curative; it prolongs life for a few weeks or months at the cost of highly reduced quality of life. There are some CAM treatments with claims of long-term survival, but those treatments are expensive. There have not been clinical trials yet, but there are a few case study series that show impressive remissions, and there is a good biological rationale with some supportive subclinical data. If the patient opts for the alternative therapy instead of chemotherapy, is the oncologist's decision to abandon the patient ethically justified?

Justice Issues

A broader set of ethical issues involves the principle of justice. Conventional providers often place the responsibility for gathering evidence with CAM providers. They argue that it is unethical for CAM providers to offer therapies to patients without providing adequate evidence in support of their claims of therapeutic benefit; that CAM providers should enroll patients in clinical trials or other forms of clinical evaluation; that by failing to do so those providers put personal gain ahead of potential economic, indirect, or direct harm to patients; and that it would be legitimate for the government and medical associations to close down such providers.

From the CAM perspective the same argument applies in reverse. CAM practitioners charge that the pharmaceutical industry and the members of many medical specialties are economically threatened by the potential of alternative (rather than complementary) therapies. For example, if chelation therapy (the use of mineral ions to remove cardiovascular blockages) and dietary/lifestyle programs were to replace bypass surgery, hospitals and surgeons would lose revenue. Similarly, if dietary programs were to replace chemotherapy as follow-up to surgery for solid tumors, oncologists and pharmaceutical companies also would lose money. Consequently, by failing to investigate promising CAM therapies developed by credentialed researchers or clinicians, the medical profession and affiliated industries put their own financial gain ahead of potential benefits to patients.

CAM advocates argue that the lack of ethics lies not in their failure to provide extensive positive evidence but in the long history of suppression of CAM research and therapies. They argue that clinical trials are very expensive and that their applications for research support go unfunded. Even worse, applications for research support often trigger investigations that lead to the loss of licenses or clinic closures. CAM advocates further argue that in the few cases in which public pressure has led to government-supported clinical trials (e.g., laetrile, hydrazine sulfate, and vitamin C) studies of CAM by conventional researchers have been weakened by exclusion of CAM advocates from research teams, protocol modifications that introduce biases against CAM, biased interpretation of equivocal data, and follow-up media campaigns intended to discredit CAM.

Historical research has documented suppression of CAM research and therapies (Hess 1997, Moss 1996, Richards 1981). Researchers and clinicians who have attempted to investigate CAM have faced denial of

U.S. Food and Drug Administration (FDA) investigational drug permits, dismissal from universities or other organizations, bias and blockage of publication in peer-reviewed journals, media campaigns against CAM, and loss of funding. Clinicians who use alternative therapies, particularly for cancer, have faced restraining orders, raids on clinics, warnings and denial of drug permits from the FDA, hostile tax audits, revocation of licenses and hospital privileges, and criminal charges (fraud, manslaughter, etc.) and civil lawsuits by CAM opponents.

Where cases have ended up in court, in some cases the rulings have favored CAM practitioners and in other cases the medical profession and state. Whether the historical cases represent unethical suppression of potentially beneficial therapies or an ethically legitimate watchdog function of the medical profession and state depends on one's assessment of the potential of CAM. If CAM is viewed as largely the product of quacks who want to make money from suffering patients, an ethical public policy would emphasize paternalism (protection from maleficence), suppress those alternatives, and limit the range of therapeutic options available to patients. If the promise of CAM is viewed in a more favorable light, an ethical public policy would emphasize autonomy, favor a more tolerant approach to alternatives, and increase both research funding and clinical access for CAM.

To some extent the older patterns of suppression have subsided as the medical profession has called for limited acceptance of CAM on the basis of evidence. However, although surveys continue to document high levels of patient utilization, federal government funding for CAM research amounts to less than 1 percent of funding for conventional medicine. Furthermore, the pattern of integration tends to favor complementary usage of CAM over alternative usage (Hess 2002). For example, in cancer research nutritional programs are being incorporated as complements to conventional therapies rather than as alternatives to them.

Does CAM offer the possibility of more than complementary, palliative care for chronic disease? Does it offer the potential for less toxic, less expensive, and more efficacious alternative therapies for a significant range of chronic diseases? Although the framework of evidence-based medicine can answer those questions, the lack of funding and the channeling of existing funding toward complementary therapies suggest that the answer will be deferred for many years.

DAVID J. HESS

SEE ALSO *Acupuncture; Alternative Technology; Bioethics; Clinical Trials; Drugs; Health and Disease; Medical Ethics; National Institutes of Health.*

BIBLIOGRAPHY

Federation of State Medical Boards. (2002). "New Model Guidelines for the Use of Complementary and Alternative Therapies in Medical Practice." *Alternative Therapies in Health and Medicine* 8(4): 44–47.

Guinn, David E. (2001). "Ethics and Integrative Medicine: Moving beyond the Biomedical Model." *Alternative Therapies in Health and Medicine* 7(6): 68–72.

Hess, David. (1997). *Can Bacteria Cause Cancer?* New York: New York University Press. Historical survey of research and therapy based on the assumption that cancer is an infectious disease.

Hess, David. (1999). *Evaluating Alternative Cancer Therapies*. New Brunswick, NJ: Rutgers University Press. A survey of methodological and evaluation issues as seen by leaders of the CAM cancer therapy movement.

Hess, David. (2002). "Stronger Versus Weaker Integration Policies." *American Journal of Public Health* 92(10): 1579–1581.

Moss, Ralph. (1996). *The Cancer Industry*. Brooklyn, NY: Equinox Press. The classic source on the suppression of alternative cancer therapies by a leader of the CAM cancer therapy movement.

Richards, Evelleen. (1981). *Vitamin C and Cancer*. New York: St. Martin's Press. Study of clinical trials controversy involving Linus Pauling.

Studdert, David; Eisenberg, David; Miller, Frances; Curto, Daniel; Kaptchuk, Ted; and Brennan, Troyen. (1998). "Medical Malpractice Implications of Alternative Medicine." *Journal of the American Medial Association* 280(18): 1610–1615.

Sugarman, Jeremy, and Larry Burk. (1998). "Physicians' Ethical Obligations Regarding Alternative Medicine." *Journal of the American Medical Association* 280(18): 1623–1625. Introduction to ethical aspects of CAM from the perspective of the medical profession and conventional medical ethics.

INTERNET RESOURCES

National Center for Complementary and Alternative Medicine. (2003). "What Is Complementary and Alternative Medicine?" Available from http://nccam.nih.gov/health/whatiscam/index.htm. Official definitions by the U.S. government organization.

COMPLEXITY AND CHAOS

Complexity and chaos are intuitive notions not easily rendered into formal definitions, and yet they have become increasingly important to both science and technology—and thereby to ethics. One useful way to approach complexity is through the analysis of dynamic systems.

Dynamic or changing systems are of two types: those in which knowledge of current states enables the prediction of future states, and those in which knowledge of current states does not enable the prediction of future states. In general ethics has attributed the first type of system to the world (because this appears to reflect a large part of reality, and in the absence of such a system it would be hard to hold human beings responsible for the consequences of their actions), and the second type to human beings (again because this appears confirmed by some aspects of human behavior, and without it humans could not be held accountable for voluntarily choosing to perform one action rather than another). Only since the last third of the twentieth century has scientific understanding of dynamic systems been advanced enough to explain the intellectual framework behind these two attributions.

Linear Dynamics and Its Limits

In the wake of the scientific revolution of the sixteenth and seventeenth centuries, science projected that all natural phenomena, including human actions, could be fully explained with the same logic used to predict planetary motion. According to this view, events are fully explained only when their occurrence is inferred from a covering law together with initial condition statements. The following assumptions framed this approach to explanation: (a) All phenomena are essentially atemporal or, in the case of near-equilibrium thermodynamics, independent of their history; that is, only the future, not the past, is packed into the present; (b) All phenomena are linear, that is, similar causes, under similar conditions, always produce similar results; and (c) Wholes are epiphenomenal by-products no different from aggregates and can therefore be functionally decomposed into their component parts. Insofar as these assumptions hold, all phenomena were taken to be reducible and decomposable in a way that made them tractable to deductive explanation, and thus predictable. For many centuries, in short, a deterministic, clockwork universe served as the ontological underpinning for Western epistemology and ethics.

Because free will is commonly viewed as a precondition of normative behavior (if everything is fully determined and predictable, responsibility and agency go by the board), a mechanistic worldview makes it necessary either to conclude that human beings are as determined as the rest of the universe (which yielded Calvinist ethics as its axiological counterpart), or to imagine free will as a nonnatural faculty itself uncaused but with the ability to exercise causal power (a view espoused by Immanuel Kant). For ascriptions of moral responsibility to be possible, behavior must be voluntary and caused or controlled by a *meaningful* intention, reason, or purpose (and not just triggered by a forceful Newtonian cause). Postulating free will as a nonnatural trait in human beings allowed theorists to account for the philosophical concepts of moral value and responsibility. Grounding moral responsibility on an uncaused act of will is, however, as problematic a tactic for ethical theory as the determinism it was supposed to correct: If intentions are caused by external events, then they are not freely formed; if intentions just pop into existence for no reason whatsoever, ascriptions of moral responsibility are as arbitrary as their causal origins. In any case, according to the received worldview (and paralleling the received logic of explanation), moral education consists in learning a set of universal moral principles and then exercising free will to implement the specific normative prescriptions that follow from those principles in particular circumstances.

In the nineteenth century, the mechanistic framework was challenged by the appearance of two new scientific theories: thermodynamics and evolution. Unlike the time-reversible equations of Newtonian mechanics, the second law of thermodynamics postulates an arrow of time. For near-equilibrium thermodynamics, usable energy decreases inexorably over time, a death march that will ultimately end in a state characterized by a complete lack of energy potential. Since usable energy is associated with order, and unusable energy is associated with disorder, Victorians worried about the ethical implications of thermodynamics.

Charles Darwin's theory of evolution, by contrast, appeared to identify the mechanism responsible for the increasing complexity and order characteristic of ontogeny and phylogeny. Nineteenth-century moralists did not quite know what to make of Darwin's ideas. On one hand, they were welcomed because the sequence of creation described by Genesis—from simple organisms to the most complex human beings—seemed to find support in the trajectory of evolution. On the other, his ideas were uncomfortable insofar as evolution suggested that nature was *red in tooth and claw,* removed altruism and agape from the natural realm, and called into question the origin and ontological status of the human mind and soul. Finally, because of the role of random mutations in evolution, its trajectory was shown not to be predictable and determinable, even in principle, an obstacle that made Darwin (who subscribed to the deductive logic of explanation) doubt that evolution was even explicable.

Attempts to force evolution (and biology in general) to fit the mechanistic view met with failure time and again; it became clear that organisms are not clockwork-like. Because complex systems (including biological organisms) are described by second order, nonlinear differential equations that are not formally solvable, they were for centuries considered intractable.

Nonlinear Dynamics and Its Achievements

The advent of computer simulation changed all this. Computer simulation research during the last quarter of the twentieth century demonstrated that turbulent flow and other seemingly *chaotic* processes in fact exhibit a very sophisticated form of order that is nevertheless unpredictable in detail. In the early 1960s, Edward Lorenz of the Massachusetts Institute of Technology (MIT) discovered the underlying mechanism responsible for deterministic chaos. Working with meteorological models, Lorenz showed that systems with only a few variables, even though deterministic, display highly complex behavior that is unpredictable in fact because slight differences in one variable produce dramatic effects on the overall system. This feature of complex and chaotic systems has come to be called *sensitivity to initial conditions*.

In 1977 the Russian-born Belgian scientist Ilya Prigogine received the Nobel Prize in chemistry for his formulation of the theory of *dissipative structures*, whose fundamental insight is that nonequilibrium is a source of order and complexity. Prigogine demonstrated that open systems (which include organisms) that exchange matter and energy with their environments can show a reduction of local or internal entropy; that is, they are able to self-organize and complexify. Complex systems are dynamical systems whose cooperating and interacting parts display spontaneous, self-organized pattern formation with emergent properties that are not reducible to the sum of their constituent parts. Early-twenty-first-century proponents of a complex dynamical systems approach to the mind (Scott Kelso, Francisco Varela) maintain that mental and axiological properties are high-level dynamical neurological patterns.

For a dynamical system to show structure formation, the process must take place far from equilibrium; it must be nonlinear; and the system must be open to exchanges with its environment. Nonlinearity appears whenever there is interaction among components, whenever the *organizational relationships* among parts determine the overall systemic behavior. Such nonlinear dynamical systems are typically characterized by feedback loops that embed the systems in their environment and history in such a way that their trajectory history is inscribed in their very structure. Thus the dynamical systems become deeply contextual and extremely sensitive to initial conditions. After a few iterations, the trajectory of two initially close nonlinear dynamical systems will diverge exponentially, and long-term predictions become impossible.

Phenomenologically, however, it was evident that some systems eventually settle down to an oscillatory pattern. Others, such as the Belousov-Zhabotinsky reaction (B-Z reaction), trace complexly patterned trajectories. Yet others, such as turbulent flow, become chaotic, displaying (not no order at all, as had initially been thought) a highly complex form of order. These complex and chaotic systems are described by second order nonlinear differential equations and, as noted, had previously been considered intractable.

The B-Z reaction sequence is an illustration of the abrupt self-organization of hidden order that occurs in open systems far from equilibrium. It shows what can happen when potassium bromate, malonic acid, and manganese sulfate are heated in a bath of sulfuric acid. The first three reactions of the sequence are not remarkable, but the fourth has the unusual feature of being autocatalytic: The product of the process is necessary for the activation of the process itself. Instead of damping oscillations, positive feedback loops around autocatalytic cycles increase system fluctuations around a reference value.

With the system driven far from equilibrium by this runaway process, at a certain critical distance an instability occurs: a threshold point at which small, randomly occurring fluctuations can no longer be damped. Instead the internal dynamics of the autocatalytic cycle amplify a fluctuation, driving the reaction to a new mode of organization. The new system is characterized by the *coherent behavior* of an amazingly large number of molecules that synchronize to form a chemical wave that oscillates from blue to red. A colorful macroscopic structure (the visible evidence of a phase change) appears. True self-organization has taken place because the internally driven dynamics of autocatalysis precipitate the sudden change.

Biological complex systems are adaptive: As a result of feedback, they change their internal structure to respond to a changing environment. Virus mutations are a good illustration. Fundamentally rooted in their environment and history through context-dependent constraints, complex adaptive systems are thus deeply enmeshed in their surroundings. Nor do they start from scratch; they are fundamentally historical entities that embody in their structure the very conditions under which they were created and the trajectory they followed. Snowflakes are examples of such systems. Not only is each unique; its very structure *carries its history on its back* by embodying the pressure and temperature conditions in which it formed. At the same time, self-organizing systems such as slime molds display an autonomy that effectively decouples them from their environment.

Such complex adaptive systems, a category that includes people and their actions, are not isolated atoms. They are always already networked and entangled in both time and space. Their relationships create an interdependent whole that is ontologically new. Thus the environment coevolves with human beings; niches change in response to the organisms that occupy them, every bit as much as the organisms are selected by the niches. And both ontogenetically and phylogenetically, they become increasingly individuated over time.

Ethics in and of Nonlinear Dynamics

The dynamical systems approach suggests an interesting new ethical discussion (Dupre 1993, Juarrero 1999). From the perspective of this new science, the prerequisite for moral action known as free will is not the absence of external determining (Newtonian) causes, but the human capacity to impose order on a progressively disordered world. Because all self-organizing systems select the stimuli to which they respond, their behavior is constrained top-down and becomes increasingly autonomous from environmental impact. More complex systems are more autonomous. Self-organized processes, in other words, act from their own point of view. Furthermore the more complexly structured the entity, the more varied its organization and its behavior, and the more decoupled from and independent of its environment—the more autonomous and authentic, in short.

In another sense, the more complex a nonlinear dynamical system is, the freer it is because increasing complexity corresponds to an increase in state space: The system has new, different, and more varied states to access. Intentional human action is free to the degree and extent that the behavior is controlled by higher-level neurological contextual constraints, those with the emergent properties of meaning, value, and even awareness to a certain degree. Insofar as a wink is an action for which an agent can be held morally responsible precisely because the behavior is caused and controlled by a meaningful intention, and the agent is aware of so acting, a wink is freer than a blink because the latter originates in less complex neurological structures that do not embody meaning and value, and may occur as a reflex reaction.

The atoms of a Newtonian universe are independent of one another. So too are moral agents in a Kantian world. Because they are essentially relational entities, however, complex adaptive systems show how interdependence can create an ontologically distinct phenomenon, an organic whole greater than its parts. This is a fundamental axiological lesson of nonlinear dynamics.

Beginning with Plato's utopia, *The Republic,* Western philosophers have attempted to design fail-safe social systems (whether legal, educational, penal, or other) that are perfect and so never go wrong, morally or otherwise. Complex systems theory shows this is a hopeless task. First, since people carry their history on their backs, they can never begin from scratch, either personally or as societies. Second, perfection allows no room for improvement. Plato was one of the few thinkers who understood that if a utopia were ever successfully established, the only way it could change would be for the worse. Stasis and isolation are therefore essential to maintaining the alleged perfection, not only of Plato's *Republic,* but of most other utopias as well. The noumenal self that Kant postulates as the seat of moral choice and free will is likewise not part of this world. The possibility of perfection requires isolation.

The only choice, from an evolutionary perspective, is to cobble together safe-fail family and social organizations, structures flexible and resilient enough to minimize damage when things go wrong as they inevitably will. But to do so, human beings must recognize the potential of interdependence to create an ontologically distinct, metastable entity. Society needs to reintegrate those pieces torn apart by the old Newtonian framework, whether personally or socially, in both its means of communication and its advocacy of public policy. "Personal ethics must now be augmented by policy making" (Mitcham 2003, p. 159).

The downside of historical and environmental embeddedness is that, as members of a community, human beings do lose some of their freedom. Living in society can and often does cramp one's style. By contrast, components in a system acquire characteristics and identities they previously lacked (and could never acquire on their own): They become nodes in a network of relationships that permits new forms of life and act-types unavailable either to the hermit or to Kant's noumenal self: Only as members of complex social systems can humans be citizens and senators, teachers and wives, scientists and philosophers. The more complex the entity, the more meaningful the choices as well: As citizens and teachers, senators and wives, whatever roles they choose, people can be responsible or irresponsible, conscientious or careless, virtuous or not.

Because of their sensitivity to initial conditions, complex dynamical systems are not only unpredictable, they also become increasingly individuated over time making each developmental or ontogenetic trajectory unique. In contrast to the science of both Aristotle and Newton, non-linear dynamical systems theory incorporates individuation and concreteness into its conceptual framework. Knowing that each complex system's trajectory is unique raises questions about the universality at the heart of Kant's famous moral command, the categorical imperative. Human individuality, historicity, and contextuality are forced into a one-size-fits-all mold. Unacknowledged recognition of the inevitable interdependence and entanglement highlighted by both complexity and quantum theories might well be behind the more recent emphasis on Kant's second formulation of the categorical imperative: Always treat people as ends, never merely as means.

In a world with room enough for both societies and unique individuals, and the creativity and novelty they promote, precise prediction is impossible. Accordingly, dynamical systems theory calls into question the morality of consequentialism, whether in the utilitarianism of John Stuart Mill or elsewhere. In a world where precise consequences cannot be predicted, and where phenomena are intertwined and entangled in their own histories, basing morality on the *actual* outcome of individual behavior is a poor foundation for moral decisions and judgments.

Both consequentialism and Kantian formalism reduce morality and ethics to a set of formal rules. The highly contextual nature of complex systems suggests, in contrast, a different approach to moral education, one that references the virtue ethics of Aristotle and the ancients. Instead of memorizing a set of moral principles, which the agent is then suppose to implement moral education would consist of a gradual shaping of character through feedback and habituation. Moral education under this approach is the process of molding certain desires and character traits that are activated in appropriate contexts.

Nonlinear dynamical systems theory also calls for an ethics appropriate to a universe of interdependence and uncertainty. The recent renewal of interest in virtue ethics seems to implicitly recognize this. By contrast, as Carl Rubino notes, because of the ruling mechanistic paradigm's continuing influence on axiology, uncertainty still carries negative connotations. It should not. Complex dynamical systems teach that "change, novelty, creativity and spontaneity are the real laws of nature, which makes up the rules as it goes along. This is good news, cause for rejoicing; we should lift up our voices, as the prophet says, and not be afraid" (Rubino 1990, p. 210).

ALICIA JUARRERO

SEE ALSO *Free Will; Incrementalism; Systems.*

BIBLIOGRAPHY

Dupre, John. (1993). *The Disorder of Things.* Cambridge, MA: Harvard University Press. In a fundamentally disordered world in which different perspectives reveal distinct domains of partial order, our choices about which scientific project to pursue determines not only what kinds of order we observe in nature but also what kinds of order we impose on the world we observe.

Gleick, James. (1987). *Chaos.* New York: Viking. An excellent popular introdution to chaos theory by an award-winning science writer.

Juarrero, Alicia. (1999). *Dynamics in Action: Intentional Behavior as a Complex System.* Cambridge, MA: MIT Press. A rethinking of the concept of causality in terms of context-sensitive constraints, and applied to intentional action.

Juarrero-Roque, Alicia. (1991). Fail-safe versus safe-fail: Suggestions toward an evolutionary model of justice. *Texas Law Review* 69(7):1745–1777. A diagnosis of the failures of utopian literature, and pointers toward a new model of justice, both formulated from the perspective of complex adaptive systems theory.

Kant, Immanuel. (1952). "The Critique of Teleological Judgement." In *The Critique of Judgement,* trans. J. C. Meredith. Oxford: Clarendon Press.

Kauffman, Stuart. (1993). *The Origins of Order.* Oxford: Oxford University Press. Centered on the debate on the origins of life and the maintenance of order in complex biological systems, the book focuses on how self-organization can be incorporated into evolutionary theory.

Kelso, J. A. S. (1995). *Dynamic Patterns: The Self Organization of Brain and Behavior.*Cambridge, MA: MIT Press. A new general framework within which to connect brain, mind and behavior, from the perspective of self-organization dynamic pattern formation.

McIntyre, Alasdair. (1981). *After Virtue*. Notre Dame, IN: Notre Dame University Press. With a thorough analysis of the failure of the ethical theories of the enlightenment, this work singlehandedly revived the ancient classical approach to values known at virtue ethics.

Mitcham, Carl. (2003). "Interacciones de complejidades: Ciencia, tecnología, sociedad y ética" ("Interactions of Complexities: Science, Technology, Society, and Ethics"), *Paradoxa* 10 (137–163).

Prigogine, I., and I. Stengers. (1984). *Order out of Chaos: Man's New Dialogue with Nature*. Princeton, NJ: Princeton University Press. One of the classics of the breakthrough period of chaos theory, complex systems, and self-organization theories, the work explores the history of the relations of the human and natural sciences, to the present from the perspective of the theory of dissipative structures.

Prigogine, Ilya. (1996). *The End of Certainty: Time, Chaos, and the New Laws of Nature*. New York: Free Press. An account of how the end of certainty and determinism implied by theory of evolving self-organizing structures is the birth of a new formulation of the natural laws of both science and culture.

Rubino, Carl. (1990). "The Evolution of Our Choices: Notes toward an Ethic of Uncertainty." In *Toward a Just Society for Future Generations: Proceedings of the 34th Annual Meeting of the International Society for Systems Sciences*, 1: 205–212. A thoughtful analysis of the axiological implications of nonlinear dynamical systems theory.

Waldrop, Mitchell. (1992). *Complexity: The Emerging Science at the Edge of Order and Chaos*. New York: Simon and Schuster. An excellent if popular introduction to complexity theory as seen through the eyes of five of the major scientists responsible for the new science.

Yates, F. E. ed. (1987). *Self-Organizing Systems: The Emergence of Order*. New York: Plenum. The best anthology on self-organization, it includes articles from leading researchers in the field, on a wide range of topics including neural organization, morphogenesis, and the genesis and evolution of life.

INTERNET RESOURCE

Peterson, Gabriel. "The Belousov-Zhabotinsky Reaction." College of the Redwoods. Available from http://online.redwoods.cc.ca.us/instruct/darnold/DEProj/Sp98/Gabe/intro.htm. A cinematic demonstration of the reaction.

COMPUTER ETHICS

The field of study referred to as *computer ethics* addresses ethical issues arising around the development and use of computers and related technology. Computer ethics can be thought of as the field of study that examines ethical issues distinctive to an *information society*. Information society is the term often used (especially by economists and sociologists) to characterize societies in which human activity and social institutions have been significantly transformed by computer and information technology (Webster 2002). The focus of attention in this field has varied over its twenty-five- to thirty-year history as the technology has evolved. Because the field is relatively new and computer technology is continually changing and being used in new domains, computer ethics overlaps with other fields of study such as information ethics, media ethics, and communication ethics, as well as domain-specific ethics such as medical ethics, business ethics, environmental ethics, and legal ethics. Computer ethics is centrally focused on understanding the interactions among science, technology, and ethics and, arguably, it is one of the most developed fields with such a focus.

A Short History of Computer Ethics

From the moment of their invention, computers raised complex social, ethical, and value concerns. While computers are not the first technology to raise ethical issues, they have been especially fascinating to scholars, science fiction writers, and the public. The origin of this fascination may well be related to computers having been initially perceived and characterized as *thinking machines*. As such, they were thought to challenge the distinguishing feature of humankind. For centuries, human beings had been thought of as unique because they were able to *reason* and had the capacity for *rational thinking*. When computers were first developed and used, they seemed capable of being programmed to think in some of the ways that humans think; some believed they had the potential to become even more sophisticated and eventually reach or even surpass human intelligence. In that context, it was thought that computers would revolutionize the way humans think about themselves and what it means to be human. While many of the original hopes and promises of artificial intelligence (AI) researchers have not come to fruition, computers have changed the way scientists think about human cognition and brain functions. Computer technology continues to be a fascination for scientists, science fiction writers, and humanities and social science scholars as well as ethicists.

From a historical perspective, the ethical issues identified in relation to computers seem to follow the sequence of development of the technology. In addition to the threat to notions of what it means to be human, in the very early days of computing the first ethical issues arose in relation to the enormous power that computers might give to government and large bureaucratic organizations. By the late 1970s, the first books on this topic were published. Joseph Weizenbaum's *Computer Power and Human Reason* (1976) and Abbe Mowshowitz's *Conquest of Will* (1976) were, perhaps, the most notable. In this period, the record-keeping capabilities of computers were a key focus, especially the privacy issues raised by this record keeping. Several major government reports were issued including: in 1972, *Databanks in a Free Society: Computers, Record-Keeping and Privacy* by Alan F. Westin and Michael A. Baker, a report of the National Academy of Sciences; in 1973, *Records, Computers, and the Rights of Citizens*, a report of the U.S. Department of Health, Education, and Welfare from the Secretary's Advisory Committee on Automated Personal Data Systems; and in 1977, *Personal Privacy in an Information Society: The Report of the Privacy Protection Study Commission*. The issues that took shape in this period were largely issues of privacy and the power of centralized government was often characterized as the threat of Big Brother. In the aftermath of World War II and the fight against totalitarianism, it was feared that computers would give government unprecedented power and reach.

In hindsight this concern was the result in part of the size of computers. At that time, they were huge mainframe systems that cost a lot, took up a lot of space, and were labor-intensive; hence large organizations were the only viable users. Moreover, in those early days of computing, mainframes were used for large-scale calculations and to create and maintain huge databases. Such calculations made weapons development, space travel, and census tracking possible on a broader scale than ever before. The databases mostly contained personal information. In any event, large organizations were the likely users and hence the concerns about centralization of power and privacy.

The next major technological shift was the development of small computers referred to initially as *microcomputers* and later *personal computers*. Public interest, for a time at least, turned to the democratizing aspects of computers. Computer enthusiasts saw in these small machines the potential for a major social revolution. With visions of computers in every home and shifts in power from large organizations to small businesses and individuals, the fear of Big Brother dissipated somewhat.

As microcomputers were being developed and taking hold in the marketplace, remote access became possible, first to contact large mainframes and later as a component of a network of telecommunications connections between large and small computers. That network eventually became the Internet. However, long before the advent of the Internet, attention turned to software. Microcomputers were less expensive and easier to use; this meant a much broader range of users and, in turn, a broad range of uses. During this phase in the development of computers, software became extremely important both for the development of the technology but also, in parallel, for computer ethics.

To make computers effective tools for the wide range of activities that seemed possible, user-friendly software was critical. Companies and individuals began developing software with a fury, and with that development came a new set of ethical issues. Issues having to do with property rights and platform dominance in software were particularly important in this era. Software was recognized as something with enormous market value; hence, the questions: Should software be owned? If so, how? Would existing intellectual property law—copyright, patents, trade secrecy—be adequate protection for software developers? Ownership rights in programs used to create computer or video games were the first kinds of software cases brought before the courts; the market value of owning these programs was significant.

Along with property rights issues came issues of liability and responsibility. Consumers who buy and use computers and software want to be able to rely on these tools, and when something goes wrong, they want to know whom to blame or they want to be compensated for their losses. Computer ethicists as well as lawyers and computing professionals rose to the challenge and questions of property rights and liability were debated in print as well as in courts.

In the 1980s, more attention began to focus on hackers. Hackers did not like the idea of property rights in software. However those who were acquiring such property rights or making a business of computing were threatened by hackers not only because the latter were breaking into systems but also because they had a different vision of how the system of computers, software, and telecommunications connections should be set up and how software should be distributed. At that time, there were no laws against breaking into computer systems or duplicating software. Hackers argued for open systems with fewer controls on access to information. Perhaps the best illustration of this movement is Richard Stallman's work and the development of the Free Software Association (Stallman 1995).

By the 1990s, the development of the Internet was well underway and seen as a revolutionary event. The coming together of computers, telecommunications, and media and the global scale of the Internet produced a seemingly endless array of ethical issues. The

Internet was being used in many different ways, in many different domains of life. In effect the Internet recreated much of the world in a new medium. Property rights, freedom of speech, trust, liability, and privacy had to be rethought for a medium in which instantaneous communication was the norm; the reproduction of information, documents, or programs was almost effortless; and anonymity was favored. Moreover the new medium facilitated interaction on a global scale, raising issues regarding what laws and conventions applied in *cyberspace*.

During the 1980s and 1990s, computer technology also began to be used for a wide variety of visualization activities. Computer graphics and gaming were part of this, but equally if not more important was the development of many simulation applications including medical imagining and graphical dynamic models of the natural world. The power and reliability of these technologies raised ethical concern. An offshoot of these developments was a focus on *virtual reality* and what it might mean to human experience. Would human beings become addicted to living in fantasy worlds? Would experiences in violent, virtual computer games make individuals more violent than they would otherwise be? These concerns continue in the early-twenty-first century as new applications are developed. For example, important ethical issues are being raised about *tele-medicine*. Computing together with the Internet makes it possible for many aspects of medical treatment to be performed electronically. Issues of responsibility and liability are diffused when doctors do surgery remotely. A doctor in one location can manipulate machines that are electronically connected to machines in a second location where the surgical procedure actually occurs. Should doctors be allowed to do this? That is, is it appropriate? Is it safe? Who is responsible if something goes wrong?

Ethical issues surrounding computer technology continue to arise as new developments in the technology occur. Many of these involve computing applications. For example, new areas of concern include surveillance technologies that result from using geographic information systems and digital imagining to keep track of individuals via digital cameras and satellites. There are projections about the use of tiny, biological computers that might be deployed in human bodies to seek out poorly functioning cells and fix them. Computer technology makes possible human behavior and social arrangements that have a moral character. Hence activities involving computers will continue to be a focus for computer ethics.

Persistent Issues

As computer technology evolves and is deployed in new ways, ethical issues proliferate. To illustrate the kinds of concerns that arise, issues of professional ethics, privacy, hacking and cracking, and the Internet will be briefly described.

PROFESSIONAL ETHICS. In an information society, a large number of individuals are educated for, and employed in, jobs that involve development, maintenance, buying and selling, and use of computer and information technology. Indeed an information society is dependent on such individuals—dependent on their special knowledge and expertise and on them fulfilling social and professional responsibilities. Expertise in computing can be used recklessly or cautiously, for good or ill, and the organization of information technology experts into occupations and professions is an important social means of ensuring that the expertise is used in ways that serve human well-being.

The social responsibilities of computer experts are connected to more general notions of duty and responsibility and computer ethicists have drawn on a variety of traditional philosophical concepts and theories to understand them. Computing professional associations have developed codes of ethical and professional conduct that represent what computer professionals believe to be their duties and the ideals to which they should aspire. However it is important to note that computing is not a single, homogenous profession. The responsibilities and likely areas of ethical concern vary widely with the computer professional's particular job and employment context. Consider, for example, the differences between academic computer scientists, software engineers working in industry, programmers, managers of information technology units in organizations, and computer and software marketers.

The largest and most visible organization of computer professionals is the Association for Computer Machinery (ACM). The ACM has a code of ethics and professional conduct and, with the Institute for Electrical and Electronic Engineers (IEEE), also has developed a code for software engineers, the ACM/IEEE Code of Ethics for Software Engineers. The key elements in both codes are very general edicts to contribute to society and human well-being; avoid harm; be honest and trustworthy; and act in a manner that is consistent with the interests of client, employer, and public. Yet both codes go beyond these general principles and give content and meaning to the principles. While one can argue that codes of conduct are not a very effective mechanism for regulating behavior, they are an important component in constituting a responsible profession. The codes are statements to the public as to what to expect; they articulate standards for the field and make clear that members are professionals. Codes can be used in relation to employers and others to emphasize that computer professionals must adhere to standards independent of the orders they receive at work.

PRIVACY. In an information society, privacy is a major concern in that much (though by no means all) of the information gathered and processed is information about individuals. Computer technology makes possible a magnitude of data collection, storage, retention, and exchange unimaginable before computers. Indeed computer technology has made information collection a built-in feature of many activities, for example, using a credit card, making a phone call, and browsing the Worldwide Web (WWW). Such information is often referred to as transaction-generated information (TGI).

Computer ethicists often draw on prior philosophical and legal analyses of privacy and focus on two fundamental questions, What is privacy? and Why is it of value? These questions have been contentious and privacy often appears to be an elusive concept. Some argue that privacy can be reduced to other concepts such as property or liberty; some argue that privacy is something in its own right and that it is intrinsically valuable; yet others argue that while not intrinsically valuable, privacy is instrumental to other values such as friendship, intimacy, and democracy.

Computer ethicists have taken up privacy issues in parallel with more popular public concerns about the social effects of so much personal information being gathered and exchanged. The fear is that an information society can easily become a *surveillance society*. Computer ethicists have drawn on the work of Jeremy Bentham and Michel Foucault suggesting that all the data being gathered about individuals may create a world in which people effectively live their daily lives in a *panopticon* (Reiman 1995). Panopticon is a term that describes the shape of a structure that Bentham designed for prisons. In a panopticon, prison cells are arranged in a circle with the inside wall of each cell made of glass so that a guard, sitting in a guard tower situated in the center of the circle, can see everything that happens in every cell. The effect is not two-way; that is, the prisoners cannot see the guard in the tower. In fact, a prison guard need not be in the guard tower for the panopticon to have its effect; it is enough that prisoners believe they are being watched. When individuals believe they are being watched, they adjust their behavior accordingly; they take into account how the watcher will perceive their behavior. This influences individual behavior and how individuals see themselves.

While computerized information gathering does not physically create the structure of a panopticon, it does something similar insofar as it makes much individual behavior available for observation. Thus the data collection activities of an information society could have a panoptic effect. Individuals know that most of what they do can be observed and that knowledge could influence how they behave. When human behavior is monitored, recorded, and tracked, individuals may become intent on conforming to norms for fear of negative consequences. If this were to happen to a significant extent, the ability of individuals to act freely and think critically—capacities necessary to realize democracy—may be compromised. In this respect, the privacy issues around computer technology go to the heart of freedom and democracy.

A good illustration of the panoptic environment is the use of cookies at web sites. A cookie is a file placed on a user's computer when the user visits a web site. The file allows the web site to keep track of subsequent visits by the user. Thus, the web site maintains a record of the user's visits. While this can help the web site provide better service to the user—based on information about use—users are being watched, records are being created and the panoptic effect may occur. Moreover, the records created can be matched with information from other web sites and domains.

It might be argued that the panoptic effect will not occur in information societies because data collection is invisible; individuals are unaware they are being watched. This is a possibility, but it is also possible that as individuals become more and more accustomed to information societies, they will become more aware of the extent to which they are being watched. They will see how information gathered in various places is put together and used to make decisions that affect their interactions with government agencies, credit bureaus, insurance companies, educational institutions, and employers, among others.

Concerns about privacy have been taken up in the policy arena with the passage of legislation to control and limit the collection and use of personal data. An important focus is comparative analyses of policies in different countries. The U.S. approach has been piecemeal with separate legislation for different kinds of records, for instance, medical records, employment histories, and credit records. By contrast, several European countries have comprehensive policies that specify what kind of information can be collected under what conditions in *all* domains. The growing importance of global business influences policy debates. Information-gathering organizations promise that they will use information only in certain ways; yet, in a global economy, data collected in one country—with a certain kind of data protection—can flow to another country where there is no protection, or where such protection differs from that of the original country. To assure that this does not happen, a good deal of attention is focused on working out international arrangements and agreements to protect data internationally.

HACKERS AND CRACKERS. While the threats to privacy described above arise from *uses* of computer and information technology, other threats arise from *abuses*. As individuals and companies do more and more electronically, their privacy and property rights become increasingly important. Individuals who defy the law or test its limits can threaten these rights. Such individuals, often called *hackers* or *crackers*, may seek personal gain or may just enjoy the challenge of figuring out how to *crack* security mechanisms. The term hacker originally referred to individuals who simply loved the challenge of working on programs and figuring out how to do complex things with computers, but who did not necessarily break the law. Crackers referred to individuals who did. However, in the early-twenty-first century, the terms are used somewhat interchangeably to refer to those who engage in criminal activity.

Distinguishing the terms, however, reveals two streams of development in computing and two streams of analysis in computer ethics. Hackers are not only individuals who love computing and are very knowledgeable about it, but in particular are those who advocate an alternative vision of how computer technology might be developed and used. Hackers are interested in a computing environment that has more sharing and less ownership. For many hackers, this is not just talk. They are involved in what is sometimes called the open source movement, which involves the development of software that is available for free and can be modified by the user. Over the years, through various organizations, a good deal of open source software has been developed including, notably, the Linux operating system.

Because hackers represent an alternative vision of software, they are seen as part of a social and political movement, a kind of counterculture. A strand of this movement goes beyond the development of open source software and engages in political activism, using computing expertise to make political statements. The term *hacktivism* refers to on-line political activism. Whether such behavior is legal or illegal remains ambiguous.

Another stream of analysis centers around crackers. Cracker refers, simply, to an online criminal. Crackers break into systems or disrupt activities on the Internet by launching viruses or worms or by engaging in a host of other kinds of disruptive behavior, including pinging, and taking control of websites. The ethical issues are not particularly deep. Cracking behavior interferes with innocent users who are trying to do what they have legal rights to do; the behavior of crackers may violate property rights or privacy, involve harassment, and more. Computer ethics literature examines this behavior for its ethical content but also to try to understand whether there is anything unique or special about cracking behavior and computer crime.

Law often lags behind technology and, in the early days of computing, there were no prohibitions against the disruptive behavior of crackers. In the early-twenty-first century, however, there are many laws regulating behavior on the Internet. Yet issues and problems persist. New technologies facilitate crackers and there are serious questions regarding harmonization of laws globally. Anonymity makes it difficult to catch computer criminals.

INTERNET ISSUES. Arguably the Internet is the most powerful technological development of the late-twentieth century. The Internet brings together many industries but especially the computer, telecommunications, and media enterprises. It provides a forum for millions of individuals and businesses around the world. It is not surprising, then, that the Internet is a major focus of attention for computer ethicists. The development of the Internet has involved moving many basic social institutions from a paper and ink environment to an electronic environment. The change in environment changes the features of activities. Thus a number of ethical issues arise as regards the behavior of individuals and organizations on the Internet.

The Internet has at least three features that make it unique. First, it has unusual scope in that it provides many-to-many communication on a global scale. Of course, television and radio, as well as the telephone, are global in scale, but television and radio are one-to-many forms of communication, and the telephone, which is many-to-many, is expensive and more difficult to use. Individuals and companies can communicate with one another on the Internet frequently, in real time, at relatively low cost, with ease, and with visual as well as sound components. Second, the Internet facilitates a certain kind of anonymity. One can communicate with individuals across the globe (with ease and minimal cost), using pseudonyms or real identities, and yet never actually meet those people. This type of anonymity affects the content and nature of the communication. The third special feature of the Internet is its reproducibility. Text, software programs, music, and video on the Internet can be duplicated ad infinitum and altered with ease. The reproducibility of the medium means that all activity on the Internet is recorded and can be traced.

These three features—global, many-to-many scope; anonymity; and reproducibility—have enormous positive, as well as negative, potential. The global, many-to-many capacity can bring people closer together, relegating geographic distance to insignificance. This feature is especially liberating to those for whom travel is physically challenging or prohibitively expensive. However these benefits come with drawbacks; one is that such capabilities are also available to those who use them for heinous purposes. Individuals can—while sitting anywhere in the world, with very little effort—launch viruses and disrupt communication. They can misrepresent themselves and dupe others on a much larger scale than was possible before the Internet.

Similarly anonymity has both benefits and dangers. The kind of anonymity available on the Internet frees some individuals by removing barriers based on physical appearance. For example, in contexts in which race and gender may get in the way of fair treatment, the anonymity provided by the Internet can eliminate bias (for example, in online education, race, gender, and physical appearance are removed as factors affecting student-to-student interactions as well as teacher evaluations of students). Anonymity may also facilitate participation in beneficial activities such as discussions among rape victims, battered wives, or criminal offenders, in which individuals might be reluctant to participate unless they had anonymity.

Nevertheless anonymity leads to serious problems of accountability and integrity of information. Perhaps the best illustration of this is information acquired in chat rooms on the Internet. It is difficult (though not impossible) to be certain of the identities of people with whom one is chatting. One person may participate under multiple identities; a number of individuals may use the same identity; or participants may have vested interests in the information being discussed (for instance, a participant may be an employee of the company or product being discussed). When one cannot determine the true source of information or develop a history of experiences with a particular source, it is impossible to gauge the reliability of the information.

Like global scope and anonymity, reproducibility also has benefits and dangers. Reproducibility facilitates access to information and communication; it allows words and documents to be forwarded (and downloaded) to an almost infinite number of sites. It also helps in tracing cybercriminals. At the same time, however, reproducibility threatens privacy and property rights. It adds to problems of accountability and integrity of information arising from anonymity. For example, students can send their assignments to teachers electronically. This saves time, is convenient, and saves paper. However the reproducibility of the medium raises questions about the integrity of the students' product. How can a teacher be sure a student actually wrote the submitted paper and did not download it from a web site?

As the daily activities of individuals and businesses have moved online, distinctive ethical questions and issues have been identified; some of these issues have been addressed by adopting or modifying relevant laws; others have been addressed by new technology; yet others persist as nagging problems without solution or only with solutions that are worse than the problem. Plagiarism is an example of a problem that can be at least partially addressed via new technology; that is, there are tools available for teachers and professors to use to detect student work that has been copied from the Internet or copied from other students. On the other hand, pornography is an example of an issue that defies solution. An incredibly large proportion of the traffic on the internet involves distributing, advertising, and accessing pornography. This seems an unworthy use of one of the most important, if not the most important, inventions of the twentieth century. Yet, eliminating or reducing pornography on the Internet would seem to require censorship and policing of a kind that would undermine the freedom of expression that is the bedrock of democratic societies. Hence, pornography on the internet persists.

Conclusion

Perhaps the deepest philosophical thinking on computer-ethical issues has been reflection on the field itself—its appropriate subject matter, its relationship to other fields, and its methodology. In a seminal piece titled "What is Computer Ethics?" James Moor (1985) recognized that when computers are first introduced into an environment, they make it possible for human beings (as individuals and through institutions) to do things they could not do before and that this creates *policy* *vacuums*. People do not have rules, policies, and conventions on how to behave with regard to the new possibilities. Should employers monitor employees with computer software? Should doctors perform surgery remotely? Is there any harm in taking on a pseudoidentity in an on-line chat room? Should companies doing business online be allowed to sell the TGI they collect? These are examples of policy vacuums created by computer technology.

Moor's account of computer ethics has shaped the field. Many computer ethicists see their role as that of filling policy vacuums. Indeed one topic of interest in computer ethics is defining the activity of filling policy vacuums.

Because computers and information technology will continue to evolve and become further integrated into human life, new ethical issues will certainly arise. However, as human beings become more and more accustomed to interacting with and through computer technology, the difference between ethics and computer ethics may well disappear.

DEBORAH G. JOHNSON

SEE ALSO *Artificial Intelligence; Communication Ethics; Computer Viruses/Infections; Engineering Ethics; Gates, Bill; Geographic Information Systems; Hardware and Software; Hypertext; Internet; Networks; Security; Special Effects; Turing, Alan; Video Games.*

BIBLIOGRAPHY

Advisory Committee on Automated Personal Data Systems. *Records, Computers, and the Rights of Citizens*. U. S. Department of Health, Education, and Welfare Publication No. (OS) 73–94, July 1973.

Johnson, Deborah G. (2001). *Computer ethics*, 3rd edition. Upper Saddle River, NJ: Prentice Hall. A philosophical survey of the ethical issues arising around computer technology.

Moor, James H. (1985). "What Is Computer Ethics?" *Metaphilosophy* 16(4): 266–275. Classic piece on why the study of computer ethics is needed.

Mowshowitz, Abbe. (1976). *The Conquest of Will: Information Processing in Human Affairs*. Reading, MA: Addison-Wesley.

Privacy Protection Study Commission. (1977). *Personal Privacy in an Information Society: The Report of the Privacy Protection Study Commission*. Washington, DC: Author. For sale by the U.S. Government Printing Office.

Reiman, Jeffrey H. (1995). "Driving to the Panopticon: A Philosophical Exploration of the Risks to Privacy Posed by the Highway Technology of The Future." *Computer and High Technology Law Journal* 11: 27–44. Provides an argument for the importance of privacy incorporating Foucault's analysis of the panoptic effect.

Stallman, Richard. (1995). "Are Computer Property Rights Absolute?" In *Computers, Ethics, and Social Values*, ed. Deborah G. Johnson and Helen Nissenbaum. Upper Saddle River, NJ: Prentice-Hall. Articulates a rationale for why software should not be private property.

Webster, Frank. (2002). *Theories of the Information Society*. New York: Routledge. Provides an account of the major theories describing information societies, their key features, and how they work.

Weizenbaum, Joseph. (1976). *Computer Power and Human Reason*. San Francisco: W. H. Freeman. A classic early work on the social implications of computers.

Westin, Alan F., and Michael A. Baker. (1972). *Databanks in a Free Society: Computers, Record-Keeping and Privacy*. New York: Quadrangel Books. Report of the Project on Computer Databanks of the Computer Science and Engineering Board of the National Academy of Sciences.

COMPUTER VIRUSES/ INFECTIONS

A computer virus is a piece of software that "invades" a computer. As such, a computer virus is one of several kinds of infections, including Trojan horses and worms. Infections are themselves a subset of possible attacks on computers and networks; other attacks include probes, unauthorized access, denial of service, Internet sniffers, and large-scale scanning. This entry focuses on viruses, worms, and Trojan horses—collectively termed *electronics infections*—the three most common kinds of attacks and the ones best known by the public (Carnegie Mellon University Internet site). All such infections constitute multiple ethical and political issues: the responsibilities to protect against them, determining consequences for those responsible for attacks, and how to educate users about their vulnerabilities.

Technical Features

A virus is a piece of software that is hidden inside a larger program. When the larger program is executed, the virus is executed as well. During that execution, the virus can try to fulfill its purpose, often to replicate (that is, copy) itself in other programs on its host machine or (via the Internet) to new host machines. This copying and sending takes up resources on the original machine, on the Internet's communications capacity, and on any new machines infected. For a major virus attack, the loss of resources can cost billions of dollars.

One variation on the more traditional application-borne computer virus is the e-mail virus. An e-mail virus attaches itself to a piece of e-mail instead of to a program. Another subspecies of computer virus is the "logic bomb." A logic bomb is a virus because it resides inside the operating system or an application; the variation is that a logic bomb executes its harmful side effect only when certain conditions are met, typically when the system clock reaches a particular date. At the appointed time, the virus can do something relatively harmless, like flashing a provocative text message on the screen; but it could also do something far more serious, such as erasing significant portions of the resident host's hard drive.

A virus requires a program or e-mail to hide in. But a computer worm works independently. A computer worm uses computer networks and security flaws to replicate itself on different networked computers. Each copy of the worm scans the network for an opening on another machine and tries to make a new copy on that machine. As this process is repeated over many generations, the computer worm spreads. As with viruses, both the propagation and any other side effects can be frivolous or draconian.

A Trojan horse is a complete computer program that masquerades as something different. For example, a web site might advertise a freeware computer game called Y. But when someone downloads and runs a copy of Y, Y erases the hard drive of the host machine. Unlike viruses, a Trojan horse does not include a self-replication mechanism inside its program.

Ethical Issues

Early in the history of computer development, some people thought of electronic infections as relatively harmless, high-tech pranks. But once these infections began to cost the public enormous amounts of time, energy, and money, they ceased to be laughing matters. The technical details that separate viruses, worms, and Trojan horses are useful distinctions when understanding the different techniques, but all infections share a common feature: They enter someone's computer without permission. Although different infections have different effects (and some claim to be benign), all of them take unauthorized control of another machine and/or memory.

In the early 1990s, there was actually some controversy about whether or not computer infections and other "hacking" activities were always unethical. In some instances benign infections simply used underutilized computer power in ways that did not compromise the owner's uses (Spafford 1992). But the reflective consensus in the early twenty-first century is that all infections and break-ins are wrong. Reasons for this consensus include the view that it causes real harms, it violates legitimate rights to non-intrusion, it steals resources that could be put to better use, and it encourages otherwise unnecessary spending on security that could be spent on better things (Johnson 2001).

Even when it is agreed that all computer infections are unethical, important questions remain. For example, most computer infections now known are aimed at Microsoft Corporation operating systems and applications. That may be a consequence of Microsoft's market share, of technical details about Microsoft's software, of hackers' attitudes toward Microsoft, or a combination of these. Each has ethical dimensions. When one condemns the creator of a harmful infection, should some of the blame for the damages not be shared by vendors who release software with security holes that are easily exploited? Are users who fail to install security updates or adopt easily broken passwords not partially responsible? Such questions are part of an ongoing discussion of responsibility that can be found in analyses of the degrees of victim contributions and extenuating circumstances with regard to a wide range or crimes, from fraud to theft and assault and battery.

Education

Consider also questions raised by teaching students about computer infections. Those offering such classes defend their actions as helping students learn how to defend against such infections; critics have argued that such classes may actually encourage students to write and propagate new infections.

Both the defenders and the critics of academic work on computer infections raise legitimate issues. Considering their positions consequentially, if such classes reduce the number and severity of infections, then they are morally justified; conversely, if they increase the number or severity of infections, then they are not justified. But it seems unlikely that enough information about consequences can be easily gathered to settle the question.

Another approach is to analyze classes that teach about computer infections in terms of course content. Surely it would be noncontroversial to teach historical facts about the occurance and severity of computer infections. Furthermore, discussing the ethics of computer infections and other attacks are also unlikely to raise objections. The content most likely to prove objectionable would be teaching the technical details of how to construct computer infections, with assignments that require students to design new infections.

Is it ethical to teach the technical details of computer infections? Consider an analogy: Is it ethical to teach accounting students the details of accounting fraud? Such classes exist and have not elicited the same kind of criticism that has been leveled against computer infection classes. It seems reasonable in both cases that professionals in the field should know how people have conducted "attacks" in order to detect and defend against them in the future.

Yet there are ethically significant differences between accounting and computing—the rules of proper accounting are more explicitly spelled out than the rules of "proper computing." Accountants are held to more formal, legal, and professional standards than computing professionals. Furthermore, it takes very little advanced skill to launch a computer attack, but it requires some sophistication (and often a high position in a company) to launch a major accounting fraud. Finally, although an accounting class might include the study of strategies to defraud a company, it seems unlikely that a student could actually implement a fraud during the class, whereas computer science students can indeed launch a computer virus (and some have).

The analogy suggests that the notion of teaching computer science students about computer infections seems reasonable, but that some cautions about what is taught and how it is taught may be necessary. There is no airtight case for or against classes that include details of computer infections, but there are two important perspectives to consider: consequentialist arguments and arguments from analogy. Other perspectives might include deontological obligations to share knowledge or to recognize traditions of forbidden knowledge, and the character or virtue implications for both teachers and students in such classes.

Preliminary explorations nevertheless suggest that the content of the courses and the context in which technical details are presented will determine whether or not such courses are ethical. One can envision a course in which a professor does not emphasize the responsibilities of a programmer and does not discuss the negative impact of computer infections; in such a class, the presentation of technical details of computer infections are likely inappropriate. One can also envision a course in which professional responsibilities and public safety are central themes; in such a course, details of computer infections might be entirely appropriate.

TABLE 1

Possible Sanctions Against Those Who Create and Launch Computer Infections

	Minor consequences to others	Major consequences to others
Unintended	Education	Education plus minor punishment
Intended	Education plus minor punishment	Education plus major punishment

SOURCE: Courtesy of Keith W. Miller and Carl Mitcham.

Sanctions

If infecting systems that don't belong to you is wrong, it is necessary to consider appropriate sanctions against those who create and launch computer infections. In general, punishments for any unethical behavior should take into account both consequences of the act and intentions of the actor. Table 1 shows a broad view of how sanctions could be applied using considerations of intent and consequences.

Unintended minor consequences (as when a person experimenting designs a virus to see how it works and accidentally lets it get away, but it does very little damage) surely deserves little in the way of punishment, although some acknowledgement of the damage done seems appropriate. Unintended major consequences and intended minor consequences both deserve education plus some form of punishment, although probably not the same in each case. But intended major consequences could be assigned significant punishments, including jail and restrictions on future computer use.

The computer software community of hackers also has responsibilities to exercise social pressure and the punishment of ostracism on intentional offenders. Indeed, to some extent it seems to do this by reserving the pejorative term *crackers* for such persons. But professional organizations such as the Association for Computing Machinery might also instigate formal forms of ostracism. Codes of ethics for computing professionals such already include explicit prohibitions against computer attacks. For example, section 2.8 of the ACM Code of Ethics states: "Access computing and communication resources only when authorized to do so" (ACM Internet site). However, the ACM rarely disciplines members, and removal from the ACM is not seen as a significant threat to most hackers.

KEITH W. MILLER

SEE ALSO *Communication Ethics; Computer Ethics; Internet; Security.*

BIBLIOGRAPHY

Johnson, Deborah G. (2001). *Computer Ethics,* 3rd edition. Upper Saddle River, NJ: Prentice Hall. A groundbreaking computer ethics textbook.

Spafford, Eugene H. (1992). "Are Computer Break-ins Ethical?" *Journal of Systems and Software* 17(1): 41–48. An relatively early work on the ethics of hacking by an expert in Internet security.

INTERNET RESOURCES

Association for Computing Machinery (ACM). "ACM: Code of Ethics." Available from http://www.acm.org/constitution/code.html#sect2. An influential code of ethics in the United States.

Brain, Marshall. "How Computer Viruses Work." HowStuffWorks. Available from http://computer.howstuffworks.com/virus1.htm.

Carnegie Mellon University. CERT Coordination Center. "CERT/CC Overview Incident and Vulnerability Trends," Module 4: "Types of Intruder Attacks." Available from http://www.cert.org/present/cert-overview-trends/. CERT is an acknowledged authority on computer security, and is often involved in quick reactions to Cyberspace threats.

COMTE, AUGUSTE

One of the French founders of modern sociology, Isidore-Auguste-Marie-François-Xavier Comte, better known simply as Auguste Comte (1798–1857), was born in Montpellier on January 19 (30 *Nivose* Year VI in the revolutionary calendar) and tried to reconcile the ideals of the Revolution of 1789 with early nineteenth century society. Comte's higher education began at the École Polytechnique in Paris, although he was expelled after two years following a quarrel with one of his mathematics professor. He then briefly studied biology at the École de Médecine in Montpellier before returning to Paris. Among his early influences, the philosophy of the Marquis de Condorcet (1743–1794) had the greatest impact. In 1817, Comte began his close association with Claude-Henri de Saint-Simon (1760–1825), one of the founders of French socialist thought who envisaged the reorganization of society by an elite of philosophers, engineers, and scientists. After an angry break between the two in 1824, Comte spent the next twenty years delivering lectures on "social physics." He suffered periods of intense mental collapse and died isolated and bitter on September 5 in Paris.

Positive Philosophy

Building on Condorcet's theory of human progress, Comte constructed what he called a "positive philosophy." Central to his philosophy was the "law of the three stages" between theological (mythological or fictitious), metaphysical (abstract), and positive (empirical and descriptive) knowledge. Over the course of history and across a broad range of disciplines and dimensions of human culture, the myths of theology have been gradually replaced by the general principles of metaphysics that were, in Comte's own time, being superseded by positive or empirical scientific knowledge. The positive stage constitutes the highest stage of human history because it is only when science has become "positive" that human beings will truly understand the world. For Comte, astronomy was the first science to become positive, because its phenomena are universal and affect other sciences without itself being affected. Because it is so complex, the last science to become positive is "social physics" or sociology.

Comte divided social physics into statics and dynamics, order and progress. The idea of order appears in society when there is stability because all members hold the same beliefs, a stage that occurred with the triumph of medieval Christianity. The idea of progress appeared with the Protestant Reformation and the French Revolution. For Comte, the contemporary challenge was to reconcile or synthesize order and progress, because revolution had destroyed the medieval sense of order but not yet created a new one to take its place. According to Comte, this new order required not only science but religion, with a new clergy to preach the laws of society. Comte eventually proposed himself as the high priest of this new scientific religion, and from 1844 signed his works, "The Founder of Universal Religion, Great Priest of Humanity."

Comte's Influence

Comte has been severely criticized for proposing that a technocratic elite was needed to educate and discipline society (see, for instance, the remarks on Comte in his contemporary John Stuart Mill's book *On Liberty*, 1859). But Comte was also interested in the moral improvement of humanity as a whole, and a social order in which self-interest is restrained within the bounds of an appreciation of the good of others as well as oneself. Morality for him was constituted by devotion to the whole of society. Such an idea clearly represented a critique of the unqualified competitiveness characteristic of the Industrial Revolution. Indeed, the need for some authoritarian, technocratic guidance—perhaps imbued

Auguste Comte, 1798–1857. Comte developed a system of positive philosophy. He held that science and history culminate in a new science of humanity, to which he gave the name "sociology." *(The Library of Congress.)*

to some degree with a religious sensibility—to facilitate the creation of a legal framework that supports qualified capitalist competition is not easily dismissed.

The importance of Comte must be placed in the historical context of a century in which vast systems of ideas were being fashioned in response to the forces unleashed by the French and Industrial Revolutions. Although the law of the three stages sounds contrived, and his plans for a new positive religion utterly fantastic, Comte succeeded in introducing the scientific study of society into nineteenth century intellectual discourse. His vision of a science of society to complement the emerging science of nature remains of fundamental importance to the relationship between science, technology, and ethics.

STEVEN KREIS

SEE ALSO *Enlightenment Social Theory; Secularization.*

BIBLIOGRAPHY

Comte, Auguste. (1853). *The Positive Philosophy of Auguste Comte,* trans. Harriet Martineau. London: J. Chapman.

Comte, Auguste. (1865). *A General View of Positivism,* trans. J. H. Bridges. London: Trübner.

Comte, Auguste. (1875–1877). *The System of Positive Polity,* trans. J. H. Bridges, et al. London: Longmans, Green.

Comte, Auguste. (1958). *The Catechism of Positive Religion,* trans. Richard Congreve. London: Kegan Paul.

Mill, John Stuart. (1866). *Auguste Comte and Positivism.* Philadelphia: Lippencott. One of the best introductions to Comte's work, by one of his contemporary admirers and critics.

Pickering, Mary. (1993). *Auguste Comte: An Intellectual Biography.* Cambridge, UK: Cambridge University Press. Excellent study of Comte's early life and difficulties; places his ideas within the context of the intellectual history of early nineteenth century France.

Scharff, Robert C. (1995). *Comte after Positivism.* Cambridge, UK: Cambridge University Press. A detailed consideration of Comte's ideas and of their applicability in the early twenty-first century.

CONDORCET, MARQUIS DE

SEE *Progress.*

CONFLICT OF INTEREST

A conflict of interest is a situation in which some person (whether an individual or corporate body) stands in a certain relation to one or more decisions. Often such persons are engineers, scientists, or organizations of engineers or scientists. On the standard view, *a person has a conflict of interest if, and only if, that person (a) is in a relationship with another requiring the exercise of judgment in the other's behalf and (b) has a (special) interest tending to interfere with the proper exercise of such judgment.*

Key Features of Conflict of Interest

The crucial terms here are *relationship, judgment, interest,* and *proper exercise.* Relationship is quite general, including any connection between persons or organizations justifying one's reliance on the other for a certain purpose. A relationship may be formal (as is that between the Academy of Science and the government it advises) or informal (as when an engineer responds to a neighbor's question about the best bicycle to buy). A relationship can last years (as the relationship between colleagues in a lab often does) or only a minute (as when one answers a stranger's question at a talk). The relationship required must, however, be fiduciary, that is, involve one person justifiably trusting (or, at least, being entitled to trust) another—to exercise judgment in the other's service.

Judgment refers to the ability to make certain kinds of decision correctly more often than would a simple clerk with a book of rules and all, and only, the same information. Insofar as decisions do not require judgment, they are *routine, ministerial, mechanical,* or *something a technician could do*; they have (something like) an algorithm. The decision maker contributes nothing special. Any difference between the decision maker's decision and that of someone equally well trained would mean that (at least) one of them erred (something easily shown by examining what they did). Ordinary math problems are routine in this way; so is the taking of readings from a gauge.

Where judgment is required, the decision is no longer routine. Judgment brings knowledge, skill, and insight to bear in unpredictable ways. Where judgment is necessary, different decision makers, however skilled, may disagree without either being obviously wrong. Over time, observers should be able to tell that some decision makers are better than others (indeed, that some are incompetent). But, except in extraordinary circumstances, an observer will not be able to do that *decision by decision;* nor will an observer be able to explain differences in outcomes in individual decisions merely by error—or even be able to establish decisively that one decision maker's judgment is better than another's in this or that case. Even if one decision maker is successful this time when another is not, the difference might as easily be the result of *dumb luck* as *insight*. Good judgment lasts. What makes a good scientist or a good engineer is good scientific or engineering judgment. Judgment is less general than *expertise*. Some of what is expected from experts is not judgment but merely special knowledge or routine application of a special skill.

Not every relationship, not even every relationship of trust or responsibility, requires judgment. A person may, for example, be asked to keep safe—but not look at—important lab notebooks until the owner returns. That person has been charged with a great trust as a fiduciary upon whom the owner may be relying to protect an important discovery. But the person need not exercise judgment to carry out the task. The task is entirely routine, however much the ability to behave as required is strained by a desire to peek. The notebooks need only be placed in a desk and left there until the owner returns and asks for them. The holder of the notebooks is a mere trustee, lacking the permissible options that make conflict of interest possible. Not all temptations to misbehave constitute conflict of interest in the strict sense.

Interest refers to any influence, loyalty, concern, emotion, or other feature of a situation tending to make a person's judgment (in that situation) less reliable than it would normally be, without rendering that person incompetent. Financial interests and family connections are the most common sources of conflict of interest, but love, prior statements, gratitude, and other subjective tugs on judgment can also be interests. For example, a biologist hired by a drug company to test some drug for efficacy has an interest (in the relevant sense) if the drug's inventor is a friend or enemy (just as if the biologist were paid with stock in the drug company).

What constitutes proper exercise of judgment is a *social fact,* that is, something decided by what people ordinarily expect, what the person exercising judgment or the group to which that person belongs invites others to expect, what that person has expressly contracted to do, and what various laws, professional codes, or other regulations require. Because what is proper exercise of judgment is so constituted, it changes over time and, at any time, may have a disputed boundary. For example, civil engineers in the United States today are expected to give substantial weight to considerations of environmental harm when deciding what to recommend, something (probably) not within the proper exercise of their judgment until the second half of the twentieth century.

The Problem with Conflict of Interest

What is wrong with conflict of interest? Having a conflict of interest is not wrong. However what one does about the conflict may be—for one of three reasons.

First, the person exercising judgment may be negligent in not responding to the conflict of interest. Society expects those who undertake to act in another's behalf to know the limits of their judgment when the limits are obvious. Conflict of interest *is* obvious. One cannot have an interest without knowing it—though one can easily fail to take notice of it or misjudge how much it might affect one's judgment. Insofar as the person exercising judgment is unaware of the conflict of interest, that person has failed to exercise reasonable care in acting in another's behalf. Failing to exercise reasonable care is negligent, and therefore the conduct is morally objectionable.

Second, if those justifiably relying on a person for a certain judgment do not know of the conflict of interest but the person knows (or should know) that they do not, then the person is allowing them to believe that the judgment in question is more reliable than it is—in effect, deceiving them. That deception is a betrayal of their (properly-placed) trust and therefore morally objectionable.

Third, even if the person exercising judgment informs those justifiably relying on that judgment that a conflict of interest exists, the judgment will still be less reliable than it ordinarily is. The person will still be less competent than usual—and perhaps appear less competent than members of the profession, occupation, or discipline in question should be. Conflict of interest can remain a technical problem, affecting reputation, even after it has ceased to be a moral problem.

How to Respond to Conflict of Interest

What can be done about conflict of interest? One common answer, one still enshrined in many codes, is: Avoid all conflicts of interest. That answer probably rests on at least one of two possible mistakes. One is assuming that all conflicts of interest can, as a practical matter, be avoided. Some certainly can be. For example, a journal editor can avoid most conflicts of interest by making sure all reviewing is *blind*. Reviewers would then (generally) not know what effect their official recommendations had on friends or enemies. An editor cannot, however, avoid all conflicts of interest in this way. Sometimes a reviewer will know enough to recognize that the author of a submission is an old friend (or enemy).

The other mistake is to assume that avoidance is the only proper response to conflict of interest. In fact, there are at least three others: escape, disclosure, and management.

Escape ends the conflict. So, for example, a reviewer who discovers that he or she is reviewing a friend's submission can stop reading, send the submission back to the editor with an explanation, and recommend a replacement.

Disclosure, even if sufficiently complete (and understood), merely gives those relying on a person's judgment the opportunity to give informed consent to the conflict of interest, to replace that person with another, or to adjust reliance in some less radical way (for example, by seeking a second opinion). Unlike escape, disclosure as such does not end the conflict of interest; it merely avoids the betrayal of trust.

Managing, though often the resolution reached after disclosure (as illustrated above), need not follow disclosure. Where disclosure is improper (because it would violate some rule of confidentiality) or impossible (because the person to whom disclosure should be made is absent, incompetent, or unable to respond in time), managing may still be a legitimate option.

Conclusion

Too frequently discussions of conflict of interest start with the biblical quotation, "Can a man have two masters?" This seems to be the wrong way to begin. The reason one cannot have two masters is that a master is someone to whom one owes complete loyalty, and complete loyalty to one excludes any loyalty to another. Having only one master *is* a strategy for avoiding conflict of interest, but a strategy making the concept uninteresting. Society must worry about conflict of interest only when avoiding all conflicts of interest is virtually impossible or so socially inefficient that there is general agreement that avoidance is often undesirable. Conflict of interest is an interesting concept only when loyalties are regularly and legitimately divided.

The term *conflict of interest* seems to have separated off from the related terms *conflicting interests* and *conflict of interests*," taking on the meaning given here, only in the middle of the twentieth century, a period in which two related trends seem to have accelerated. First, society has become more complex, making people increasingly dependent on experts. Second, society has become increasingly unsettled, making people increasingly reliant on strangers rather than on people they have known well for many years. People cannot manage the conflict of interest of those relied upon when they do not know enough about them. Society cannot tell experts to avoid all conflicts of interest because those experts could not then make a living. Society must therefore depend on such experts to disclose some conflicts (those that considerations of confidentiality allow them to disclose), to manage others, and to decline to exercise judgment where they can so decline without too much loss to those they serve. For that reason, the trend in codes of ethics in engineering and science has been away from flat prohibition of conflict of interest and toward more nuanced provisions. For example, the Code of Ethics of the Institute for Electrical and Electronic Engineers (1990) now urges members not only "to avoid real or perceived conflicts of interest whenever possible" but also "to disclose them to affected parties when they do exist."

MICHAEL DAVIS

SEE ALSO *Engineering Ethics; Professions and Professionalism.*

BIBLIOGRAPHY

Carson, Thomas L. (1994). "Conflicts of Interest." *Journal of Business Ethics* 13: 387–404. Argues that in the late twentieth century conflict of interest is endemic rather than rare.

Davis, Michael. (1993). "Conflict of Interest Revisited." *Business and Professional Ethics Journal* 12(Winter): 21–41. Classic statement of what has become the standard view.

Davis, Michael, and Andrew Stark, eds. (2002). *Conflict of Interest in the Professions*. New York: Oxford University Press. Especially Introduction, Chapter 6 (Engineering), Chapter 9 (Anthropology), Chapter 13 (Medicine), and Epilogue. A good survey of the state of thinking about conflict of interest across a broad range of professional and business activities.

Luebke, Neil R. (1987). "Conflict of Interest as a Moral Category." *Business and Professional Ethics Journal* 6(Spring): 66–81. Shows that the term conflict of interest developed its present meaning only in the middle of the twentieth century.

Krimsky, Sheldon, and L. S. Rotherberg. (2001). "The Conflict of Interest Policies in Science and Medical Journals: Editorial Practices and Author Disclosures." *Science and Engineering Ethics* 7: 205–218. Useful discussion of journal policies designed to manage conflict of interest.

Krimsky, Sheldon, and Ralph Nader. (2003). *Science in the Private Interest: Has the Lure of Profits Corrupted Biomedical Research?* Lanham, MD: Rowman and Littlefield. A study of conflict of interest in science, combining Krimsky's research with Nader's Jeremiad.

May, Larry. (1996). "Conflict of Interest." In *The Socially Responsive Self*. Chicago: University of Chicago Press. An interesting alternative to the standard approach to conflict of interest.

Pritchard, Michael. (1996). "Conflict of Interest: Conceptual and Normative Issues." *Academic Medicine* 71: 1305–1313. A thoughtful critique of the standard view.

Rodwin, Mark A. (1993). *Medicine, Money and Morals: Physicians' Conflicts of Interest*. New York: Oxford University Press. A grim indictment of a range of conflicts of interest in medicine.

Spece, Roy G., Jr.; David S. Shimm; and Allen E. Buchanan, eds. (1996). *Conflicts of Interest in Clinical Practice and Research*. New York: Oxford University Press. A collection of papers on conflict of interest in medicine covering many of the same topics as Rodwin but from a variety of viewpoints, much more nuanced.

CONFUCIAN PERSPECTIVES

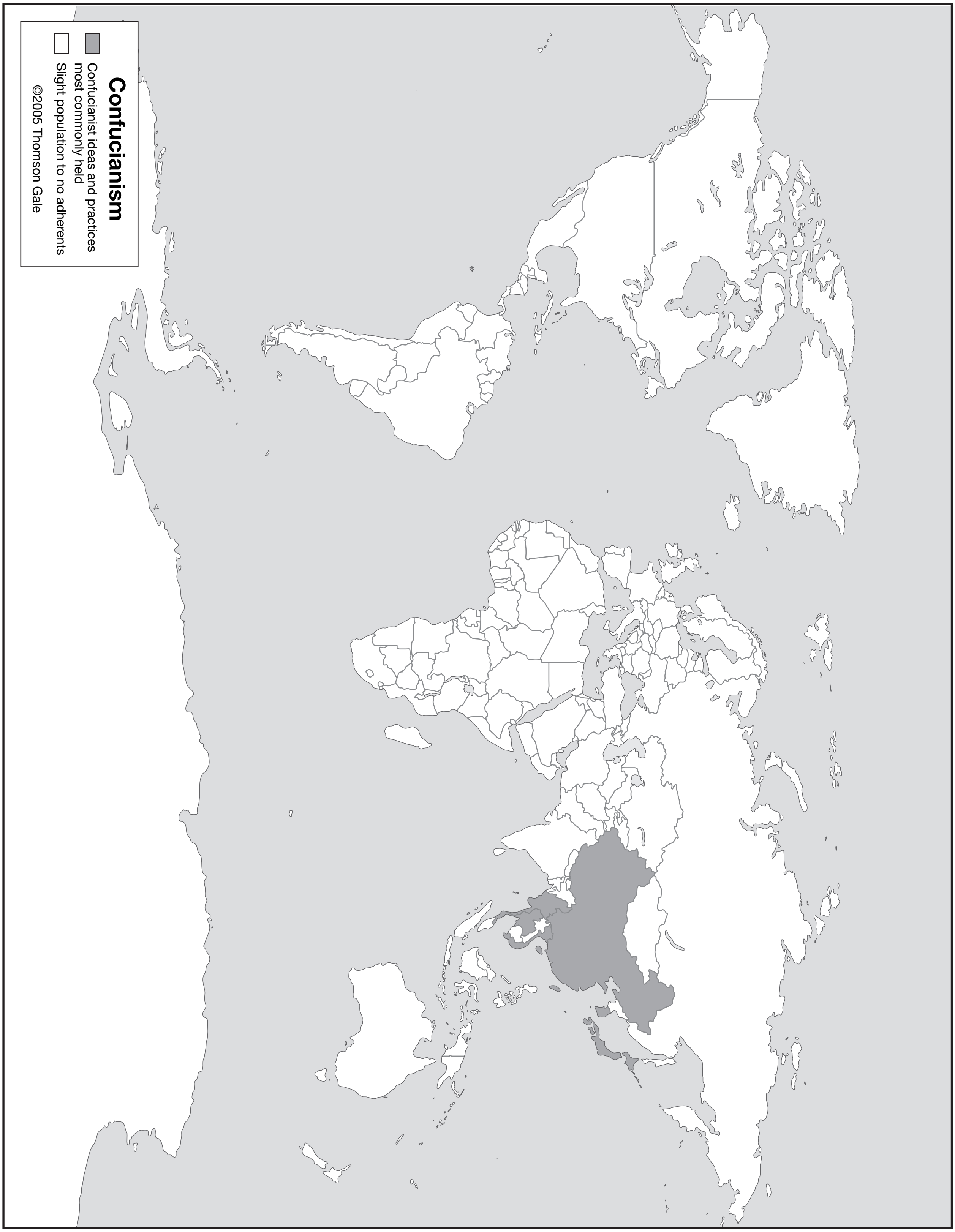
Confucianism originated more than 2,000 years ago in China in the thoughts of Confucius, or Kong Zi (Master Kong, 551–479 B.C.E.). Kong Zi lived during one of the formative periods of Chinese culture, when numerous philosophical schools, such as Daoism (Taoism) and Mohism, vied for social influence. Other major early thinkers in the Confucian tradition include Mencius, or Meng Zi (371–289 B.C.E.), and Xun Zi (298–238 B.C.E.). Confucianism was established as the state ideology during the Han dynasty (206 B.C.E.–220 C.E.). As an original thinker, a powerful persuader, and a successful educator, Kong Zi became the defining philosopher of Chinese culture and one of the most influential cultural philosophers in East Asia and beyond. In the early twenty-first century Confucianism stands for a distinctive voice in global dialogues on issues that range from human rights to gender equality. As a living tradition, Confucianism also provides a unique perspective on science, technology, and ethics.

Confucian Foundations

The primary text of Kong Zi's thought that is still in existence is the *Analects* (*Lun Yu*), a posthumous collection of his sayings and his disciples' reflective remarks on his teachings. Other major Confucian classics include *The Book of Meng Zi, The Book of Change, The Book of History, The Odes, The Book of Rites*, and *The Spring and Autumn*. Although the precise dates of these works cannot be ascertained, scholars generally believe they were compiled during the Spring–Autumn and Warring States period (770–221B.C.E.). The development of Confucianism usually is divided into three phases. Classical Confucianism was developed by Kong Zi and other early thinkers. Neo-Confucianism was developed during the Song (960–1276) and Ming (1368–1644) dynasties by thinkers such as Zhu Xi (1130–1200) and Wang Yangming (1472–1529). The third phase is contemporary New-Confucianism, represented by thinkers such as Xiong Shili (1885–1968) and Mou Zongsan (1909–1995).

Historically, however, Han-Confucianism as it developed during the Han dynasty is also an important episode not only because that was the period when the tradition first became dominant in China but also because Han-Confucians extensively incorporated the notions of *yin-yang* and the Five Phases (Water, Fire, Wood, Metal, and Earth) into Confucianism. Those notions later had a great influence on the relationship of Confucianism to science and technology.

Confucianism is primarily a moral philosophy with ethics as its core. Confucian ethics has been characterized as virtue ethics. It is concerned with developing a virtuous person rather than emphasizing the following of ethical principles. Confucians see human life as a journey toward the goal of forming a virtuous character in the context of the family and other interpersonal relationships.


Confucianism
Confucianist ideas and practices most commonly held
Slight population to no adherents
©2005 Thomson Gale

Confucianism is not a theism. Its moral philosophy does not rest on a god or a divine being. However, it holds that there is a cosmic moral order that serves as the foundation of the moral life. This order is not carved in stone and is not a static entity; it has to be sought through human endeavors and realized through human activities. In comparison with Daoism, Confucianism places more emphasis on a person's accomplishments in society and on the positive consequences of moral edification. Whereas Daoism leaves room for supernatural forces, Confucianism is focused firmly on the earthly world and its mundane affairs. Over a long period of history Confucianism and Daoism formed a unique complementary relationship in Chinese society.

Key Concepts

Key concepts of Confucian ethics include *dao, de, ren, li,* and *yi.* The first of these concepts, *dao,* or the Way, defines the cosmic moral order. Confucians understand the cosmos as a triadic unity of Heaven, Earth, and Humanity. The *dao* is found and realized in a harmonious interaction among these three components. When it is realized, the entire world goes smoothly and the myriad things in it thrive.

Human beings participate in the realization of the *dao* by developing their *de,* or virtues. Confucians have what may be called a "person-making" ethics: One makes one's own person through learning and by extending one's knowledge and social skills. Every person is born with the potential to become a sage. Whether a person realizes his or her moral potential depends on that person's own effort. A good person is one who realizes his or her moral potential and develops into a virtuous person, one with a good character.

Whereas *de* points to particular virtues in various aspects of human life, *ren,* or humanity, as the Confucian moral ideal, stands for holistic human excellence. A *ren* person is a fully developed and well-rounded individual. Kong Zi said that a *ren* person is one who can achieve five virtues: earnestness, consideration for others, trustworthiness, diligence, and generosity.

The meaning of *li* is complex. It has been translated into English as *rites, rituals, propriety,* and *rules of proper conduct.* In the Confucian moral life *li* is the social grammar, providing guidelines for socially appropriate behavior. Unlike *ren, li* is tangible in that it tells people what to do in specific circumstances. For example, it is *li* to yield a seat on the bus to an elderly person and not to speak loudly in the library. Learning *li* is a necessary step for a person to develop moral virtues and become *ren.* Observance of *li* is the natural path for a person of *ren.* A society without *li* is chaotic and uncivilized; an un-*li* person is socially retarded and barbarous. Confucians, however, do not take *li* to be absolute. Recognizing the complexity and the dynamic nature of social life, Confucians value the ability to determine a course of appropriate action in complex situations.

The concept of *yi* focuses principally on what is right and fitting in particular circumstances. It calls for sound judgment and reasonableness. At times *yi* may require people to forgo personal advantages in order to do what is right. A person of *yi* demonstrates moral maturity. Other important Confucian virtues include *xiao* (filial piety), *xue* (learning), and *zhi* (wisdom).

Applications to Science, Technology, and Ethics

As a complex philosophical tradition with a long history, Confucianism has a twofold relationship to science and technology. First, as a secular philosophy Confucianism has a natural affinity to science because it includes no superstitions and does not recognize supernatural forces. When asked, Kong Zi refused to speculate about gods, ghosts, and supernatural phenomena. His focus was entirely on this world and on things that can be known. In this respect Confucianism is not opposed to science and technology.

In ancient China technology had more to do with handicrafts than with science. The Confucian classic *Rites of the Zhou* (*Zhou Li*), which was compiled during the Warring States period, contains a chapter on various types of craftsmanship in society. It attributes to early sages the invention of various handicrafts, such as the making of knives and scissors, pottery, carriages, and boats, and explicitly recognizes the important role of handicrafts in society. The chapter maintains that excellence in craftsmanship requires an integration of four things:, good timing of the season, flourishing *qi* (cosmic energy) on earth, excellent material, and superior skills. From the Confucian perspective craftsmanship is not merely a matter of technique or skill but is understood holistically in the context of the Confucian cosmology. Whereas Daoism appeared to be antagonistic to handicraft, as indicated in the *Dao De Jing,* Confucianism was receptive to it because handicrafts can be instrumental to the prosperity of the family, which Confucianism values highly.

The affinity between Confucianism and science and technology has been evidenced by historical figures such as Shen Kuo (1031–1095), who was a prominent scientist in research, a successful technocrat in civic service, and a committed Confucian in his family life. His *Brush Talks from Dream Brook* is one of the most remarkable documents of early science and technology in China. Shen not only wrote commentaries on Confucian classics, a common practice among ancient Confucian scholars, but also in his theoretical discussions of scientific topics used philosophical concepts such as *yin-yang,* the Five Phases, and *qi*, which were shared by other Confucian scholars during his time. In Shen's eyes there is no contradiction between Confucianism and science and technology.

Traditional Chinese medicine has a close connection to Confucian cosmology. The *Yellow Emperor's Inner Chapters* (*Huang Di Nei Jing*), the primary ancient text of Chinese medical science and techniques, is consistent with Confucian cosmology. The fundamentals of the entire Chinese traditional medicine are rooted in the philosophical notions of *yin-yang,* the Five Phases, and *qi.* Although these notions also can be found in Daoism, Confucians embrace them profoundly, and they are the converging points of Confucianism and Daoism. Acupuncture, for example, is based on the belief that human health depends on the smooth flow of *qi* and a good balance of *yin-yang.* The philosophy of the Five Phases provides the foundation for Chinese herbal medicine in its belief that the myriad things in nature have various combinations of the Five Phases and that the balance of the Five Phases is instrumental to the balance of *yin-yang* and the nurturing of *qi.* For example, when someone's body has too much *yin* and is short of *yang,* a herb rich in Fire may boost that person's *yang* to restore the balance.

Confucius, 551 B.C.–479 A.D. Confucius founded his school of philosophy on the concepts of benevolence, ritual, and propriety. *(Source unknown.)*

Second, Confucianism is principally a moral philosophy and places the moral life above all other aspects of human activities. For Confucians the ultimate value of human activities depends solely on their contribution or lack of a contribution to the good moral life of humanity (*ren*). In other words, apart from its contribution to the good moral life, an activity does not possess any value.

This moral view has been subjected to narrow interpretations and at times has devalued science and technology. In particular, making too direct a connection between science and the moral life may not leave room for science to grow independently, which is often a necessary condition for the flourishing of science. Confucianism is not free from criticisms of this sort: At the beginning of the twentieth century one of the two main criticisms of Confucianism was its alleged impediment to science (the other was its alleged impediment to democracy). Some criticisms of Confucianism for its hostility to science might have been exaggerated, but they were not entirely groundless.

Kong Zi apparently was not interested in technical knowledge about the natural world. When a student asked him about agricultural knowledge and skills, his reaction was negative. Xun Zi was probably the only early Confucian who had a tendency to naturalize Confucianism, a viewpoint that could have assigned natural science a larger role in the Confucian value system if it had had a broader influence. Xun Zi believed that it is human nature to learn and to know and that what people learn and know is the nature of things. However, mainstream Confucian thought has always emphasized a moral worldview. That thought focuses on moral values as the core of the cosmos and centers human existence on moral existence. Kong Zi explicitly defined true knowledge as knowledge about human affairs rather than about the natural world. This attitude was reflected in the neo-Confucian Zhang Zai's (1020–1078) formulation of the contrast between "moral knowledge" and "knowledge of the senses" and his assertion that moral knowledge cannot grow out of knowledge of the senses. Placing these two kinds of knowledge in sharp contrast or even opposition further diminishes the importance of knowledge of the natural world in comparison to the importance of moral knowledge.

Zhu Xi was the second major figure after Xun Zi to offer a chance to elevate the status of knowledge about the natural world through his interpretation of *gewu zhizhi*, an ancient concept found in the *Daxue* chapter of the Confucian *Book of Rites*. He interpreted *gewu zhizhi* to mean the investigation of things and the expansion of knowledge. According to Zhu, things in the world have their reason or principle, which can be known through empirical observation. Zhu Xi evidently had a holistic view of the world and saw a direct connection between empirical knowledge of the natural world and moral knowledge. For him the purpose of *gewu zhizhi* is to improve people's moral knowledge. Because his notion of *gewu* includes the empirical study of the natural world, he opened a door to scientific knowledge. Presumably, the investigation of things could lead to scientific knowledge about the natural world.

Unfortunately, Zhu Xi's course was reversed by another major neo-Confucian thinker, Wang Yangming. Wang initially tried to act on Zhu's idea of *gewu zhizhi* by attempting to investigate the bamboo in his yard. However, he failed miserably because he could not get any meaningful knowledge through his diligent observation of the bamboo. Wang then changed course and claimed that all useful knowledge is to be found within the heart-mind (*xin*); there is no need to look outside the heart-mind. Wang's judgment inflated to an extreme the Confucian conviction that a person's primary mission in life is to develop his or her humanity and failed to assign adequate value to the pursuit of the knowledge of the natural world. This tendency lasted till the twentieth century.

Contemporary Discussions

As science started to gain ground in Chinese society in the early twentieth century, Confucian thinkers tried to preserve the territory of moral philosophy by separating science and philosophy into two distinct realms. They argued that whereas science deals with the physical world, (Confucian) philosophy deals with the metaphysical and moral realms; therefore, the two do not conflict. After the founding of the People's Republic of China in 1949, Confucianism was subjected to severe criticisms and at times brutal repression in mainland China, although it had a significant revival during the last two decades of the twentieth century.

However, Confucianism never stopped developing. Mou Zongsan, who lived his most productive years in fHong Kong during the second half of the twentieth century, articulated a new Confucian stance on science and greatly expanded the room within Confucianism for scientific knowledge. He maintained that traditional Confucian culture failed to give adequate recognition to the form of knowledge called *zhi xing* (formal, logical thinking) and argued that to embrace both science and democracy, the spirit of Chinese culture needed "to negate itself into" the mode of *zhi xing*. Mou's philosophy marked a turning point in the long debate among Confucian thinkers about the role science and technology play in the good life and was an important stage in the development of Confucianism. After Mou the importance of science and technology was no longer an issue for Confucians.

Some scholars have attempted to interpret the history of Confucianist interactions with science and technology in a different light, arguing that Confucianism has not been as unfriendly to science and technology as sometimes is alleged. They cite the fact that science and technology in early China under Confucianism flourished and that many ancient Confucian scholars were also great scientists and technological innovators. For example, it was during the Han dynasty, when Confucianism was made the state ideology, that the basic Chinese sciences were established. Those sciences included mathematics, mathematical harmonics, mathematical astronomy, and medicine. It is possible that the attitude of Confucianism toward science and technology varied at different times, affected by specific social circumstances and influenced by individual Confucian thinkers' personal beliefs. Confucianism might have been more congenial to science and technology at certain times. It is also true that within Confucianism there is a full range of opinions on issues related to science and technology, with some being more liberal and others more conservative.

Contemporary Confucians recognize the importance of science and technology in society and in moral philosophy. Because Confucianism advocates a virtue ethics and is concerned with the full development of the holistic person, it recognizes the indispensability of ethics in science and technology in achieving that goal. Furthermore, because the goal in Confucianism is to make the *ren* person, achieve a *ren* society, and generate a harmonious world, all human activities, including science, technology, and ethics, are to serve that purpose directly or indirectly. Kong Zi said that a good person should not be a mere tool. A committed Confucian does not engage in science for the sake of science or promote technology for the sake of technology. In addition to "Is it true?" or "Does it work?" a Confucian would ask questions such as "What purpose does it serve?" "How does it contribute to the good society?" and "Does it make the world a better place?"

A case can be made that Confucianism may be more receptive to contemporary medical research, such as embryonic stem cell research. Without a doctrine of the divinely created soul, Confucians believe that a person is not born with moral worth and has to earn it through moral cultivation. Therefore, strictly speaking, the human embryo or the fetus is merely a potential human person, not yet a moral entity. Drawing on this notion, Confucians may not see embryonic stem cell research, which requires the destruction of the embryo, as morally problematic. After all, cracking an acorn is not the same as destroying a giant oak tree even though an acorn could grow into a giant oak tree.

Although Confucianism is not opposed to the development of technology, with the rapid technological advancement in the early twenty-first century, Confucians are concerned with its negative impact on the environment, its harmful effects on a harmonious world where humans and nature are closely integrated. If one uses the word *ethics* broadly to encompass the Confucians' goals of the moral life, ethics remains the primary concern for Confucians; science and technology are important tools that serve these purposes.

CHENYANG LI

SEE ALSO *Acupuncture; Chinese Perspectives; Virtue Ethics.*

BIBLIOGRAPHY

Cheng, Chung-ying, ed. (2002). *Journal of Chinese Philosophy* 29(4). Special Issue on Science, Technology, and Chinese Philosophy. Includes several recent articles on Confucianism, science, and technology.

Fan, Dainian, and Robert S. Cohen, eds. (1996). *Chinese Studies in the History and Philosophy of Science and Technology*. Boston: Dordrecht; London: Kluwer Academic. A collection of numerous articles on Chinese philosophy, science, and technology from historical perspectives.

Fan, Ruiping, ed. (1999). *Confucian Bioethics*. Boston: Dordrecht; London: Kluwer Academic. Includes articles with Confucian views on issues such as experimenting with human subjects.

Le, Aiguo. (2002). *Confucian Culture and Ancient Science and Technology in China* (*Rujia Wenhua yu Zhongguo Gudai Keji*). Beijing: China Books (*Zhonghua Shujiu*). A recent work focused on the affinity between Confucianism and science and technology, with rich information and superb scholarship.

Needham, Joseph. (1954). *Science and Civilization in China*. Multiple volumes. Cambridge, UK: Cambridge University Press. The most massive study of science in ancient Chinese society.

Sivin, Nathan. (1995). *Science in Ancient China: Researches and Reflections*. Brookfield, VT: Variorum. A collection of eight studies of specific topics in science in ancient China.

Yosida, Mitukuni. (1979). "The Chinese Concept of Technology: A Historical Approach," *Acta Asiatica* 36: 49–66. Offers useful information on ancient views on technology in China.

CONSCIOUSNESS

Something is conscious if there is *something that it is like to be* that thing. This widely accepted definition, proposed by philosopher Thomas Nagel (1974, reprint 1997 p. 519), emphasizes the *subjective character* of conscious experience, which is the fundamental obstacle to its scientific investigation. Scientists have no objective access to conscious states (even their own) so consciousness can only be studied scientifically by indirect means, and some believe that a complete scientific description of the world can and should be made without reference to consciousness at all. However to exclude conscious decisions from the causal chain of events would undermine all ethical and legal systems based on personal responsibility for consciously willed actions.

In the 1980s, neurophysiologist Benjamin Libet showed that when subjects were asked to make a voluntary movement at a time of their own choosing, brain activity initiating the movement (the *readiness potential*) routinely preceded by about half a second the conscious decision to make the action. Many people interpreted this as scientific proof that conscious choice and freewill are illusory, which would fit with the view that the physical universe is causally closed and deterministic. Libet himself safeguards personal freedom of action by arguing that although the brain's non-conscious readiness potential initiates an action, there is still time for the conscious mind to monitor and abort the process before the action is carried through.

Libet's work was an early example of scientific research into consciousness that combines objective information about brain activity with subjective reports from experimental subjects concerning their conscious states. Earlier generations had been handicapped by the need to choose between subjective and objective methods. Typical of these were *introspectionism*, pioneered by German psychologist Wilhelm Wundt (1832–1920), which depended on individuals analyzing their subjective thoughts, feelings, and perceptions into thousands of basic mental sensations, and the *behaviorism* of John Watson (1878–1958) and his successor B. F. Skinner (1904–1990). Watson rejected introspection, maintaining that if psychologists wanted to be real scientists they must study objective, verifiable data, which meant observable behavior. Such was his influence that consciousness was effectively banned from psychology for half a century in the mid-1900s.

The scientific study of consciousness was rehabilitated in part by new technologies that allowed the working of the brain to be objectively studied while mental processes were being carried out. The *electroencephalogram* (EEG), recording electrical activity in the brain, was available from the 1930s and used by Libet among others. Brain scanning techniques such as *positron emission tomography* (PET) and *functional magnetic resonance imaging* (fMRI), developed in the 1980s and 1990s, enabled detailed observation of active areas of the brain at work and confirmed the hypothesis that mental states are closely related to the physical condition of nerve cells (neurons). Neuroscientists were now able to observe the areas of neural activity associated with particular conscious experiences reported by human subjects, or deduced from the behavior of animals such as monkeys. Various systems in the brain were investigated, from individual cells to large networks and pathways of interconnected neurons, in the quest to identify possible *neural correlates of consciousness* (NCCs).

The exact relationship between conscious experience and the physical brain, and how and why some brain processes are conscious at all, is the core dilemma. David Chalmers, Director of the Center for Consciousness Studies at the University of Arizona at Tucson, has dubbed it the *Hard Problem*. In the mid-twentieth century the influential Oxford philosopher Gilbert Ryle (1900–1976) dismissed Descartes's dualist concept of mind-body relation as the *ghost in the machine*, and opened the way for various materialist accounts of consciousness. By the turn of the millennium most consciousness researchers embraced some form of *non-reductive materialism*, which holds that mental states are wholly caused by the physical brain, but have some quality over and above the sum of their molecular components. Variations on this theme include *property dualism* (mental states exist as properties of underlying physical states), *dual aspect monism* (the mental and the physical are two ways of looking at a single underlying reality), *emergentism* (consciousness emerges at a certain level of complexity), and *panpsychism* (every material object has an actual or potential degree of consciousness).

Treating consciousness as a real aspect of the physical world brings it back into the realm of scientific inquiry and removes the suggestion that it is an *epiphenomenon*, lying outside the causal nexus of the universe. But it does not automatically refute the claim that free choice and moral responsibility are delusions. The physical world of which consciousness is a part still appears to be deterministic, at least according to classical physics. Researchers into artificial intelligence, for instance, have drawn parallels between neuronal activity in brains and the processing of information in computers The question of whether the conscious mind itself is computational, that is, completely describable mathematically and therefore in deterministic terms, is hotly disputed.

Deterministic views are challenged within science by evidence from quantum physics, although its relevance is disputed and some of the claims speculative. For example, Oxford mathematician Roger Penrose proposes that in certain special conditions, found in the microtubules within brain cells, quantum systems provide the physical mechanism that brings about noncomputational conscious events. From a different starting point, Berkeley physicist Henry Stapp argues that quantum theory can explain how consciousness plays a creative role in shaping events and creating the world as humans know it. These views are frequently criticized, but at the very least, quantum theory puts a large question mark over the old assumption that the universe is a collection of objective facts that are (in theory at least) completely knowable.

Consideration of the ethical questions posed by the investigation and manipulation of consciousness falls under the sub-discipline of neuroethics. But the challenge to produce an account of conscious experience that provides an adequate basis for morality at all, and is at the same time both philosophically and scientifically robust, lies at the heart of all consciousness studies.

ANTHONY FREEMAN

SEE ALSO *Artifical Intelligence; Decartes, René Emotion; Emotional Intelligence; Neuroethics; Robot Toys.*

BIBLIOGRAPHY

Chalmers, David J. (1996). *The Conscious Mind: In Search of a Fundamental Theory*. New York: Oxford University Press. A technical book, written by a philosopher making use of scientific research, mostly accessible to the general reader. The stance is non-reductive physicalism.

Dennett, Daniel. (2003). *Freedom Evolves*. New York: Viking Press. A representative title from many by this popular philosopher of mind. Written from a reductive viewpoint for both professional and general readers.

Freeman, Anthony. (2003). *Consciousness: A Guide to the Debates*. Santa Barbara, CA: ABC-CLIO. A non-technical introduction that includes extracts from classic texts.

Libet, Benjamin; Anthony Freeman; and Keith Sutherland, eds. (1999). *The Volitional Brain: Towards a Neuroscience of Freewill.* Exeter, UK: Imprint Academic. Collected essays by scientists and philosophers.

Nagel, Thomas. (1974). "What Is It Like to Be a Bat?" *Philosophical Review* 83(4): 435–450. Reprinted in the 1997 book *The Nature of Consciousness: Philosophical Debates*, eds. Ned Block, Owen Flanagan, and Güven Güzeldere. Cambridge, MA: MIT Press. A seminal paper raising the need for philosophers to address subjectivity.

Popper, Karl, and John Eccles. (1983). *The Self and Its Brain: An Argument for Interactionism*. London: Routledge. Two eminent authors make the case for the unfashionable dualist approach to mind-body interaction.

CONSENSUS CONFERENCES

Consensus conferences are one of several practices (including citizen juries, scenario workshops, and deliberative polls, among others) intended to enhance deliberative public involvement in shaping social decision making about science and technology. Because public issues increasingly include complex scientific and technological components, and because the general public lacks the needed scientific knowledge, the management of those issues seems inevitably to slip out of the hands of ordinary citizens. Democratic governance, however, rests on the informed consent of ordinary people, and many observers worry that in numerous areas ordinary citizens are becoming less able to shape public policies.

Basic Issues

The basic concept behind consensus conferences is that public policies about science and technology will be improved significantly if policy makers can hear informed, deliberative public perceptions, concerns, and recommendations as they consider the choices they face. Informed and thoughtful public participation may also help to blunt two features of contemporary policy making about science and technology: intense and acrimonious partisan advocacy by both proponents and opponents of specific scientific and technological projects, and local Not-In-My-Backyard (NIMBY) campaigns based in communities likely to be directly affected by those projects. In the first case, proponents and opponents of specific science and technology projects make sensationalized and exaggerated claims about the wisdom and foresight of their perspective and the mean-spirited and hysterical positions of their antagonists. All too often, ordinary citizens (who must live with the consequences of the policy decision) are unable to sort through the conflicting claims and counterclaims. In NIMBY situations, local citizens—often frustrated by the blare and noise of partisan bickering, and distrustful of all sides in the controversy—organize to oppose, delay, and obstruct projects desired by others.

Both processes result in political and policy paralysis, the spread of cynicism and apathy, and delay in addressing pressing public needs. Consensus conferences seek to address both problems by providing a group of average, non-expert citizens with the opportunity and the resources to conduct an informed and deliberative investigation of specific technologies, to develop policy recommendations they can all endorse, and to deliver those recommendations to policy makers and the public. In this way, consensus conferences allow the deliberating citizens to confront partisan advocates with reliable information rather than sensationalism, and also help to dissipate cynicism about governmental decision making that contributes to NIMBYism.

Danish Model

The Danish Board of Technology (BOT), a research arm of the Danish Parliament, developed the basic model of a consensus conference. Several months before the parliament must address an issue with significant science and technology elements, members of the parliament may ask the BOT to conduct a consensus conference on the issue. The lead time helps assure that citizen evaluations and recommendations are available to legislators in time to help shape parliamentary debates.

The BOT takes several steps to implement a consensus conference:

- It assembles an Oversight Committee, made up of experts and stakeholders in the specific technology under inspection.
- It develops background information about the technology and its probable social, economic, political, and ethical implications.
- It recruits twelve to fifteen Danish citizens to serve as the citizen panel. The citizens are paid a stipend to cover the costs of participation.
- And, finally, it conducts the consensus conference and makes the results available to parliament, the press, and the public.

The Oversight Committee serves to guide development of the background materials that will be given to citizen panelists. Because the Oversight Committee is composed of individuals reflecting the full spectrum of opinions about the technology in question, the Committee helps to assure that background materials are fair, accurate, and accessible to ordinary people. The Oversight Committee also monitors recruitment and selection of the citizen-panelists. In a broad sense, the Oversight Committee serves to keep the entire process honest, to prevent intentional or unintentional partisan slanting of background materials or of makeup of the panel.

The actual work of the consensus conference typically takes place over three weekends, about one month apart. This marks the consensus conference as one of the most intense public participation techniques, because most other practices last only one or two days, or even two or three hours.

During the first weekend, the panelists get acquainted with each other, with the staff facilitating the sessions, and with the processes and goals of the conference. They read and discuss the background materials, and are encouraged to raise whatever issues or concerns are important to them. In this sense, the consensus conference differs from a traditional focus group in which the panelists are asked their reactions to issues raised by the focus group sponsors. In effect citizens are given control of the agenda in a consensus conference. During the second weekend, the citizen members continue to discuss the technology and the background materials, and to sharpen their issues and concerns. They also begin to develop a series of follow-on questions for content experts who will attend during the final sessions.

During the final weekend—the actual Consensus Conference—three things occur. On the first day, a series of content experts, who reflect the spectrum of opinions within the expert community, provide responses to the follow-on questions the panelists raised earlier. This is followed by an open-ended question-and-answer session, with all the experts and panelists present. The panelists can thus ask any remaining questions, probe earlier responses, and seek clarifications.

After this, panelists withdraw (along with a facilitator) to deliberate. Their goal is to arrive at a common set of policy recommendations that express their collective judgment about how best to manage the technology. This task often lasts into the early hours of the morning.

The panel's report is submitted to the content experts to catch any remaining technical errors, but the experts do not comment on the policy recommendations. The report is then delivered to parliament and the public at a press conference. The staff of the BOT point to the frequency with which contending policy constituencies refer to consensus conference reports during parliamentary debates as evidence that consensus conferences help to shape policy outcomes.

In Denmark consensus conferences have addressed an array of science and technology issues, such as genetically modified foods, infertility, the human genome project, teleworking, and transgenic animals. Consensus conferences have been organized in several other countries—including Argentina, Australia, Austria, Canada, France, Germany, Israel, Japan, the Netherlands, New Zealand, Norway, South Korea, Switzerland, and the United Kingdom—although no other country has adopted the practice as thoroughly as the Danes. Consensus conferences have been conducted about fifteen times in the United States as parts of public deliberation research.

Consensus conferences in the United States have been held at the University of Massachusetts ("Telecommunications and the Future of Democracy"), the University of New Hampshire ("Genetically-Engineered Foods"), and ten times at North Carolina State University (two conferences dealing with "Genetically Modified Foods," six Internet-based conferences dealing with "Global Warming," and two conferences dealing with "Nanotechnology"). The North Carolina State conferences were part of a National Science Foundation supported research project dealing with public deliberations about science and technology.

Further Developments

The literature about public deliberations points to a number of concerns or problems that arise when citizens deliberate together. Groups of average citizens, when deliberating, employ a variety of *decision heuristics* which, observers worry, may introduce distortions into their thinking. Ordinary citizens, for instance, seem to focus on the *risk of the month*, shifting concern from one kind of risk to another based on which risk is currently receiving the most public discussion or which has been in the news (the *availability heuristic*). Similarly they seem to draw conclusions about the dangers of specific products through *mental shortcuts*that can lead to factual errors about actual risks (*intuitive toxicology*). Risks or dangers that are exceptionally vivid also seem to gain greater public awareness, regardless of actual statistical probability (the *affect heuristic*). Critics also point to various *social cascades* in which unsubstantiated beliefs gain credibility simply because they are constantly repeated. Group polarization is another feature of some pubic deliberations. This involves the tendency for a group's final conclusions to support the group's original position, rather than a more centrist or moderate one.

The majority of studies pointing to such cognitive problems among ordinary citizens, however, focus on unfacilitated public deliberations. The current research suggests that many of these cognitive problems can be adequately addressed if professional and well-trained facilitators lead the public deliberations. Effective facilitation can, for instance, ameliorate the influence of strong-willed or domineering personalities, insure that citizen panelists are exposed to a wide argument pool, and detect and correct inappropriate decision heuristics. Consensus conferences, in particular, provide ample room for the beneficial effects of good facilitation, and provide sufficient time for the panelists to acquire substantial background information and to interact with a range of content experts. While these steps may not correct all cognitive and process issues in public deliberations, they can successfully address the most egregious problems.

Supporters of consensus conferences hope that the technique can be used wherever democratic governance of new technologies is pursued. While the outcomes of informed, deliberative citizen consideration of new technologies cannot substitute for the procedures of democratically elected government, consensus conferences may provide a mechanism for greater influence by ordinary citizens in the shaping of public policies concerning technologies that all must live with, and thereby create an enhanced level of democratic credibility for governmental decisions.

PATRICK W. HAMLETT

SEE ALSO *Constructive Technology Assessment; Discourse Ethics; Science Shops.*

BIBLIOGRAPHY

Andersen, Ida-Elizabeth, and Birgit Jæger. (1999). "Scenario Workshops and Consensus Conferences: Towards More Democratic Decision-Making." *Science and Public Policy* 26(5): 331–340.

Fishkin, James S. (1991). *Democracy and Deliberation: New Directions for Democratic Reform*. New Haven, CT: Yale University Press. Asserts both theretical and empirical arguments in favor of enhanced public deliberation about public policy in general.

Hamlett, Patrick. (2002). "Citizens' Consensus Conferences: Learning and Public Confidence." Conference presentation, Annual Meeting of the American Association the Advancement of Science (AAAS), Boston.

Joss, Simon, and John Durant, eds. (1995). *Public Participation in Science: The Role of Consensus Conferences in Europe*. London: Science Museum. Contains general discussions of the origins of the Danish consensus conference process, developments and applications in Europe, and evaluations of the use of the technique.

Mayer, Igor. (1997). *Debating Technologies: A Methodological Contribution to the Design and Evaluation of Participatory Policy Analysis*. Tilburg, The Netherlands: Tilburg University Press. Examines the theoretical claims made in favor of enhanced participatory public policy analysis involving ordinary citizens and examines the impacts of consensus conferences.

Mayer, Igor S., and Geurts, Jac L. (1996). "Consensus Conferences as Participatory Policy Analysis, a Methodological Contribution to the Social Management of Technology." In *1996 International Symposium on Technology and Society: Technical Expertise and Public Decisions Proceedings*. Danvers, MA: IEEE Society on Social Implications of Technology.

Mendelberg, Tali. (2002). "The Deliberative Citizen: Theory and Evidence." In *Research in Micropolitics*, vol. 6, eds. Michael Delli Carpini, Leonie Huddy, and Robert Y. Shapiro. New York: Elsevier Press. Provides a comprehensive review of existing empirical literature on public deliberations.

Renn, Ortwin, Thomas Webler, and Peter Wiedemann, eds. (1995). *Fairness and Competence in Citizen Participation: Evaluating Models for Environmental Discourse*. Boston: Kluwer. Assesses the implementation and impacts of several kinds of participatory public policy and public deliberation techniques.

Sunstein, Cass R. (2002). *Risk and Reason: Safety, Law, and the Environment*. New York: Cambridge University Press. Examines analytical approaches to regulating technological risks, including critiques of both affective and cognitive problems associated with public deliberation.

CONSEQUENCES

SEE *Unintended Consequences*.

CONSEQUENTIALISM

As a general category of ethical or moral theories, consequentialism refers to theories that evaluate rightness or wrongness based *exclusively* on the consequences or effects of an act or acts. Consequentialist theories may differ over what kinds of consequences matter, while agreeing that the rightness or wrongness of actions cannot be based on motives or intentions of those who act, nor on the conformity of the act to duty, virtue, piety, moral rules, or the law. Consequences are all that matter for ethics, on this view. According to consequentialists, some murders might turn out to be morally right, while some acts of sincere generosity might be wrong.

Consequentialism is the ethical theory most compatible with the empirical and quantitative focus of much of science and technology. When a consequentialist studies ethical issues in science and technology, an act is usually understood broadly to include national and local policies, programs, distributions of resources, implementations of new technologies, and the like. Consequentialism seems particularly well suited to evaluate these kinds of complex acts, because it shares with modern, positivistic science an emphasis on observation. Just as one might form and test a hypothesis about electromagnetic radiation, so too could one test an act or policy that one believes to be right. In both cases, one looks to results in the real world in order make an evaluation.

Also, consequentialist theories take into account short- and long-term effects, and hence can evaluate developments such as nuclear power, where the immediate good effects (electricity without air pollution) may be outweighed by later harmful effects (radioactive waste, illness). In focusing on observable effects over time, consequentialists seem to look in the obvious places for answers to ethical questions concerning emerging technologies. To evaluate such complicated developments as genetic engineering, nanotechnology, the Internet, or even automobile transportation, where else would one look but to the effects?

Despite the intuitive appeal of consequentialism for such ethical inquiries, the view has faced serious opposition, especially from philosophers, as its proponents try to specify which consequences are relevant to moral evaluation. The historical development of consequentialism shows a constant struggle to identify the morally relevant effects of acts and to measure them. Consequentialists have sought to elucidate a scientific ethical theory for difficult contemporary issues, but with mixed results.

The Classical View: Act Utilitarianism

The most influential version of consequentialism is known as *utilitarianism*. The basic idea behind this view is quite simple. One consequence that almost anyone would want from an act is an increase in happiness, because happiness is undeniably a good. This is the conception of the good from which utilitarianism begins, and further developments in utilitarian theory almost always get back, in some way, to the content and measure of happiness.

Utilitarians are not merely interested in their own happiness; they advocate the "greatest happiness of the greatest number." According to the founder of classical or *act utilitarianism*, Jeremy Bentham (1748–1832), an act is right if its overall tendency is to increase the proportion of happiness (or pleasure) to pain.

If one has a choice between several acts in some situation, one ought to choose the act with the best *net* effect on utility. In some cases this will be the act that increases everyone's utility. In other cases, the best act would do no more than decrease everyone's pain. For most complex acts and policies, though, the result is complicated; the same act may include both some utility and some disutility. Hence Bentham realized that he would need a quantitative method for calculating the best utilitarian act. He proposed a "felicific calculus" that attempted (unsuccessfully) to supply cardinal measurements for the utility of an act based on its intensity, duration, certainty, and similar factors. By summing measurements for every act over all those who would be affected, utilitarians could instruct society on how incrementally to increase the amount of utility its members enjoyed. Act utilitarianism, if carried out rigorously, promised a program of social reform. For individuals who used the theory to evaluate their acts, the calculus required them to count the happiness of others as though it were their own. In principle, it provided an argument for an impartial and equitable distribution of the fruits of the new industrial revolution.

Another significant aspect of Bentham's view is that his principle of utility seeks, in the long run, to maximize the utility of all sentient beings—every being that can feel pleasure or pain. In this way his theory grants moral status not just to humans, who alone can reason and talk, but also to *any* animal that can feel or suffer. Bentham argued that the pain of non-human animals must count in the felicific calculus; his view would inspire later animal rights advocates and contemporary utilitarians such as Peter Singer. Utilitarianism thus became the first modern moral theory to take seriously the harm done by humans to other animals.

Despite its progressive social and political tendencies, act utilitarianism faced major problems. Even if individuals could calculate a cardinal measurement of personal utility from a particular act, they could not be sure that this measurement was on the same scale as a measurement for another person. But the theory requires the summing of utilities over the class of those affected by the act. Utilitarianism requires cardinal *interpersonal* measurements of utility—numbers on the same scale, valid for everyone. Supposing that the theory could provide such a scale, it then seemed to *demand* constant calculation for every act, because what is required morally is to come up with the greatest sum of utility. Every option in acting would have to be considered, and such exhaustive calculations might lead to paralysis.

Finally, act utilitarianism seemed to embrace a brutish theory of the good; the pleasure of thousands of cows, chewing their cud, might outweigh the utility of a college education for one person. If there were tradeoffs to be made—and the emerging free markets of Bentham's time made those tradeoffs possible—one might end up with many satisfied cows instead of a few educated people. Worse still, act utilitarianism might ask a sacrifice of the rights of some for the utility of others. Because every good was to be reduced to utility, even future commitments of justice seemed to be beholden to the arithmetic of maximization.

Rule Utilitarianism

Bentham's protégé, John Stuart Mill (1806–1873), addressed some of the shortcomings of act utilitarianism by proposing three changes. First, he found Bentham's ethical calculations too cumbersome, and proposed instead that society adopt and enforce a set of rules which, when followed, were likely to produce the highest overall utility. The best way to be a utilitarian, on this view, would be to act according to a rule that, in conjunction with other rules, prescribed behavior that maximized total social utility. One rule could replace another in the set, provided that the change would contribute to greater overall utility. But absent now in Mill's *rule utilitarianism* was the requirement—or even the possibility—of a quantitative calculus for determining which acts to choose. Second, Mill introduced a qualitative distinction between higher and lower pleasures, thus undermining the notion of a common scale for ethical measurement, and implicitly relegating the happiness of non-human animals to insignificance. Finally, Mill argued that certain rules, what he called the rules of justice, were so important to the long-term security (and hence happiness) of society that they must be considered practically inviolable. The results of these changes made the application of rule utilitarianism less scientific but much more in line with common sense morality. Mill's theory still shared the goal of Bentham's original utilitarianism, but it allowed notions such as duties, rights, and virtues to be means to the end of increased social utility.

Market Consequentialism

By the early twentieth century, utilitarian moral philosophers and economists became interested in market activity as a replacement for the direct measurement of the consequences of an act. They saw preferences, revealed in market supply and demand, as an approximate (though indirect) indication of the utility that a single person gains by a market "act." They also were able to represent mathematically an individual's preferences over bundles of goods, and to prove some interesting theorems about these "utility functions" of individuals. By analyzing market preferences, economic consequentialists could provide quantifiable evidence of what made consumers happy. To be a consequentialist about market preferences meant to choose the act or policy that allowed all persons their highest-ordered preferences, given what an economy could supply.

The economic version of utilitarianism was made even more sophisticated by the addition of a formal theory of individual choice under uncertainty, introduced by John von Neumann and Oskar Morgenstern (1944). Their theory generated cardinal measurements of expected utilities for strategic individual choices, given plausible assumptions about an individual's utility function. Working from the results of von Neumann and Morgenstern, John Harsanyi (1955) would later provide a complementary justification of utilitarianism for social choice by employing the notion of a "social welfare function." By the end of the twentieth century, economists had transformed ethical questions over how to reach the best consequences into economic questions over how to increase market activity, trade, social welfare, and global production.

The economic consequentialists have influenced many other fields. In jurisprudence, a theory known as the economic analysis of law has advocated the interpretation of legal concepts so as to maximize wealth. In business and public policy, the cost-benefit analysis has been introduced as a decision procedure for large-scale projects. A question such as where to dump toxic waste, when addressed by the cost-benefit analysis, provides a utilitarian solution to disputes by reference to the hypothetical willingness to pay of the interested parties affected by the possible outcomes of the decision. It is not surprising then that hypothetical willingness to pay is affected by the actual ability to pay, and so the fact that dump sites end up in poor neighborhoods is explained by this "ethical" decision procedure. The Nobel laureate Amartya Sen (1970, 1985) has been the most important critic of utilitarian economics on these issues. His contributions to the debate have focused on poverty, development, and the measurement of "capability" (as opposed to raw utility) in accounting for the bases of social choice.

Pluralist Conseqentialism

Many contemporary philosophers worry that developments in utilitarian theory have undermined the spirit of consequentialism. They point out that the everyday conception of human flourishing is not as thin as wealth maximization. The British philosopher G.E. Moore even advocated an "ideal" utilitarianism that got rid of the notion of pleasure as the good, and replaced it with the good of aesthetic experience and friendship (1993). It now seems clear that, while utility may be a good, and wealth one approximation of it, there are many other goods that do not reduce to either utility or wealth. By adopting a pluralist conception of goods, critics of utilitarianism allow into the ethical decision process notions like interests, rights, human freedom, biodiversity, sustainability, and other non-economic values.

The pluralists continue to maintain that what is right to do is decided by reference exclusively to consequences—but now the list of goods in the accounting is much broader than utility. Here talk of maximization no longer makes sense; the goal is to optimize the plural goods that result from acts or policies. Stakeholder theory is one such form of consequentialism, because it tries to tailor corporate decisions to the interests of all those who have a stake in the workings of the company, and not merely to those who hold stock in it.

Special Challenges

How useful is consequentialism when one morally evaluates technologies? A particular area of ethical concern is the effect of current and near-term technologies on future generations. Nuclear power, genetic engineering, human cloning, genetic modification of food, and other momentous programs will all have effects far into the future. Some versions of consequentialism would require a counting of the effects on those who are not yet alive, even though their preferences cannot be known, and actions and choices have not yet had an impact on them. It may be assumed that, if they live, they will want clean air to breathe, clean water, safe food, and other such necessities. Harms to distant generations may be discounted by some factor, but should not be neglected entirely, for then all the consequences of acts and policies are not taken into account.

Beyond the uncertainty of how much to discount, there is a deep problem for consequentialism that has been called by Derek Parfit (1984) the "non-identity problem." One assumes that the broad technological choices that are made now could harm particular people in future generations. But a consequentialist in some future generation could not complain that current policies and choices made his or her life worse off, because the things done now will affect *who* is actually born. That person will not exist, unless people currently living do exactly the good or bad things that they end up doing. Changes in manufacturing, travel, city planning, leisure, and work will determine which future people will meet and partner, and at what point in time they will produce children. The same is true for changes in technology. Similarly, for actual persons alive in the early twenty-first century, it is extremely unlikely that *they* would have been conceived were it not for the transportation systems, migration patterns, world wars, and other life aspects of their parents.

Philosophical debate over consequentialism is likely to persist. Nonetheless, its focus on observable results and effects will keep it in the center of ethical inquiries where science and technology are concerned.

THOMAS M. POWERS

SEE ALSO *Economics and Ethics; Engineering Ethics; Mill, John Stuart.*

BIBLIOGRAPHY

Bentham, Jeremy. (1989 [1789]). *On the Principle of Morals and Legislation*. New York: Oxford University Press. A foundational text in moral philosophy and political economy.

Harsanyi, John. (1955). "Cardinal Welfare, Individualistic Ethics, and Interpersonal Comparisons of Utility. *Journal of Political Economy* 63: 309–321. Essay connecting classical utilitarianism and the social welfare function in economics.

Mill, John Stuart. (1998 [1863]). *Utilitarianism*. Oxford, UK: Oxford University Press. Classic text in moral philosophy, arguing for utilitarianism in new dress, with a "proof" of the general principle of utility, a defense of rules (especially rules of justice), and novel arguments for qualitative distinctions in pleasures.

Moore, G.E. (1993 [1903]). *Principia Ethica*. Cambridge, UK: Cambridge University Press. Features a criticism of utilitarianism from within the tradition of analytic philosophy, and offers a reformulation in terms of "ideal utilitarianism."

Parfit, Derek. (1990 [1984]). *Reasons and Persons*. Oxford, UK: Oxford University Press. Includes a sophisticated analysis of utilitarianism and the problem of future generations.

Sen, Amartya Kumar. (1970). *Collective Choice and Social Welfare*. San Francisco: Holden-Day Inc. Sophisticated overview of work in utilitarian economic theory.

Sen, Amartya Kumar. (1985). *Commodities and Capabilities*. Amsterdam: Elsevier Science Publishers. Short but important book—from Sen's Hennipman lecture in Amsterdam—which introduces the "capability" measure into utilitarian social welfare calculations.

Singer, Peter. (1990). *Animal Liberation*, 2nd edition. New York: New York Review of Books. Widely read attack on "speciesism" and defense of the consideration of animal welfare on utilitarian grounds.

Smart, J.J.C., and Williams, Bernard. (1990). *Utilitarianism: For and Against*. Cambridge, UK: Cambridge University Press. Offers an outline and a critique of a new system of utilitarian ethics.

von Neumann, John, and Morgenstern, Oskar. (1944). *Theory of Games and Economic Behavior*. Princeton, NJ: Princeton University Press. Classic text in the formal theory of choice under uncertainty.

CONSERVATION AND PRESERVATION

Ideas of *conservation* and *preservation* play central roles in ethical discussions of science and technology, especially in relation to nature and the environment. The terms also figure prominently in museum and historical work, where programs of conservation (not losing) and preservation (protecting from deterioration) are associated with specialized sciences and technologies. With regard to environmental issues, the concepts appear more closely related, both implying respect for nature.

John Muir versus Gifford Pinchot

Since the early-twentieth-century break between Gifford Pinchot (1865–1946), first director of the U.S. Forest Service, and John Muir (1838–1914), founder of the Sierra Club, conservation and preservation have sometimes served as technical concepts with different connotations. In this context, conservation signals rational human use, preservation a protection from human use.

Although originally allies in creating Yellowstone, the first national park, in 1872, Pinchot and Muir took opposed positions in the debate, which lasted from 1909 to 1913, over building a dam in the Hetch Hetchy valley of Yosemite National Park in order to supply water to a growing San Francisco. Pinchot believed that "The first great fact about conservation is that it stands for development" (Pinchot 1910, p. 42); the only question was what kind of development, and whether for short-term single-focus exploitation or long-term multiple public use. For Muir, by contrast, national parks were to be preserved in their original form. "Dam Hetch Hetchy! As well dam for water-tanks the people's cathedrals and churches, for no holier temple has ever been consecrated by the heart of man" (Muir 1912, chap. 15).

Out of this debate, which Muir and the Sierra Club lost, began a tension in the environmental movement between those who seek to conserve and those who seek to preserve nature. Conservationists sometimes accuse preservationists of failing to appreciate human needs. Preservationists accuse conservationists of being too willing to compromise the intrinsic value of nature when faced with economic or political interests. The issue, in these terms, will only grow sharper as world population races toward doubling by 2050.

The Preservation-Conservation Spectrum

But the distinction between conservation and preservation is not always clear, and in fact environmental policies may often line up along a spectrum from protection of nature or ecosystems for their own sake to libertarian exploitation. The spectrum also to some degree parallels that between ecocentric (nature centered) and anthropocentric (human centered) environmental ethics. The extreme protectionist position, evident in wilderness preservation slogans and policies, and exemplified by *Earth First!* direct action, views natural systems as possessing intrinsic value independent of human use and as better off if protected from human interventions of any kind. Conservation would fall not necessarily on the other extreme, in which nature is presented as devoid of intrinsic value except insofar as it is available for obligatory human exploitation, but somewhere in the middle.

The spectrum is slightly complicated by self-defined conservationists such as those identifying with the *Wise Use* movement, which is especially hostile toward *radical environmentalists*. According to Wise Use advocates, the pastoral ideal was kidnapped by urban wilderness ideologues who lack the living relation to the land found among farmers and ranchers and thus fail to appreciate the value of the human transformation of the earth (Arnold 1996, 1998). But given its stress on the rights of property owners to develop land in virtually any way they see fit, Wise Use is perhaps more concerned with libertarian free enterprise than with the environment.

Nevertheless conservationists do tend to stress the importance of human interests, needs, and wants over any intrinsic values nature or the environment may be thought to possess. Yet this emphasis is easily combined with various gradations emphasizing high to moderate degrees of preservation of nature from human use and with a range of balances between natural and human needs in relation to natural exploitation.

Furthermore the spectrum need not be considered simply linear. Robert Paehlke (1989) argues that preservationist and conservationist views are distributed on a grid of two axes, with the left-right political spectrum crossed by a vertical axis running from environmentalism to anti-environmentalism. The point is that environmentalists and their opponents, on ethical as well as political grounds, use terms such as conservation and preservation—along with related terms such as sustainable development and restoration ecology—in myriad and often idiosyncratic ways. Careful analysis in conjunction with accurate observation of real-world practices is necessary to know what individual groups actually mean.

Practical Applications

The implications of these controversial word uses for science and technology may not always be obvious either. Certainly strong preservation environmentalists view major technological exploitations in nature (oil drilling and pipelines, for example) as wholly negative, whereas extreme opponents believe in a technological fix for any natural shortfall, even the extinction of species or ecosystems (through DNA rather than whole species preservation), while conservationists tend to be open to a modulated range of technological interventions, including the techniques of restoration ecology.

Radical preservationists sometimes oppose further scientific examination of nature, arguing instead for the sufficiency of existing research and for more aesthetic or experiential appreciation of nature. Their opponents, by contrast, often demand something close to scientific certitude concerning problems—as in the global climate change debate—to justify any change in exploitation patterns, and thus defend making more public funds available for environmental research. Such critics view radical preservationists as too willing to accept the flimsiest of scientific evidence.

In still one more somewhat ironic comparison, those who would protect the environment from human degradation often advocate advanced technologies that pollute less and promote high-tech gear to assist individuals in the noncontaminating exploration of wilderness. Such technologies may even include photographs and IMAX presentations designed to cultivate the aesthetic appreciation of nature as something good and beautiful in itself among those who may never have any direct wilderness experience. In opposition, those who would promote diversified human utilization sometimes find themselves apologizing for whatever technologies exist and denigrating innovations that could both improve exploitation and protect nature. One example might be defending personal automobile and snowmobile use in national parks when light rail or other innovations could enhance accessibility for all, including some such as the handicapped, who have previously been excluded. Diverse assessments of ecotourism have also been known to conflate expected conservation and preservation divides.

PAUL T. DURBIN

SEE ALSO *Environmental Ethics; National Parks*.

BIBLIOGRAPHY

Arnold, Ron. (1998). *Ecology Wars: Environmentalism as if People Mattered*. Bellevue, WA: Merril Press. Reprint of a book first published in 1987, with an introduction by Alan M. Gottlieb, founder of the Wise Use movement. See also Arnold's "Overcoming Ideology," in Philip D. Brick and R. McGreggor Cawley, eds., *A Wolf in the Garden: The Land Rights Movement and the New Environmental Debate* (Lanham, MD: Rowman and Littlefield [1996]).

Foreman, Dave. (2004). *Rewilding North America: A Bold, Hopeful Vision for Conservation in the 21st Century*. Covelo, CA: Island Press. By the founder of Earth First!

Muir, John. (1912). *The Yosemite*. New York: Century.

Paehlke, Robert C. (1989). *Environmentalism and the Future of Progressive Politics*. New Haven, CT: Yale University Press.

Pinchot, Gifford. (1910). *The Fight for Conservation*. New York: Doubleday.

VanDeVeer, Donald, and Christine Pierce, eds. (1994). *The Environmental Ethics and Policy Book: Philosophy, Ecology, Economics*. Belmont, CA: Wadsworth.

CONSERVATISM

An assessment of conservative ideas about the relationship between ethics, science, and technology must begin with a brief discussion of conservatism itself. Unlike liberalism, fascism, or communism, conservatism cannot be identified with a particular conception of the ideal society. In its broadest meaning, conservatism means simply "adherence to the old and tried, against the new and untried," as Abraham Lincoln put it in his Cooper Institute speech (Lincoln 1989, p. 122). If this definition is accepted, one can be "conservative" about almost anything that has lasted a long time.

In Europe and North America over the last few centuries, however, conservatism has been associated with a defense of classical liberalism in politics and economics against first the radicalism of the French Revolution and then against socialism, Communism, fascism, and Nazism. In making this defense, conservatism has also accepted and supported the achievements of science and technology so closely identified with liberalism and capitalism. European and North American conservatism since the French Revolution is thus an inherently paradoxical enterprise, because some of the key institutions it seeks to conserve, including science and technology, are themselves generators of change. Conservatives primarily interested in economics are more likely to welcome such change than religious and cultural conservatives. Conservatism nevertheless sharply differs from the philosophical liberalism of thinkers such as John Dewey or John Rawls in that all conservatives, whatever their primary interest, insist there are sources of moral authority beyond the liberal consensus. These include revealed religion, natural law, and the insights derived from humanistic study. Science, conservatives believe, cannot answer fundamental questions about the meaning of life, nor can technology resolve the most important ethical dilemmas.

Limited Criticism of Science and Technology

Because of its emphasis on the limits of knowledge that science can make available and the benefits technology may confer, conservatism is often mistakenly associated with the wholesale condemnation of technology associated with Romanticism and also promoted by radical theorists such as Herbert Marcuse who, in *One-Dimensional Man* (1964), views technology as a form of social control and domination. The Southern Agrarians, a group of poets and writers who defended the traditions of the U.S. South, including racial segregation, in *I'll Take My Stand* (1930), were writing as romantics rather than conservatives when they objected to technology itself, as when Andrew Lytle proclaimed "a war to the death between technology and the ordinary human functions of living" (p. 202) and argued that the South "should dread industrialism like a pizen snake" (p. 234). The most influential heir of the Agrarians, Richard Weaver (1910–1963), adopted a more representative conservative viewpoint when, in *Visions of Order* (1964), he criticized not science itself but "barbarism nourished by . . . scientistic fallacies" (p. 151) and "pseudoscientific images of man" (p. 153).

The Spanish philosopher José Ortega y Gasset (1883–1955) went further in defending science when he asserted in *The Revolt of the Masses* (1930) that "liberal democracy based on technical knowledge is the highest type of public life hitherto known" (p. 52). Yet mainstream twentieth century conservatives in England and the United States shared his belief that the key issue was to find a way to maintain the real achievements of liberal democracies in the face of totalitarianism, just as conservatives in the twenty-first century seek to guard those achievements against the threats posed by new political and religious fanaticisms. Ortega believed that totalitarian regimes were made possible by the rise of the "mass-man" who felt only "radical ingratitude" toward the developments in science and technology that "has made possible the ease of his existence" (p. 58).The masses do not grasp that the devices they take for granted are really "marvels of invention and construction which can only be maintained by great effort and foresight" (p. 60). Ortega believed scientists could scarcely avoid becoming mass-persons themselves, because the specialization required by modern science made it impossible for individual scientific workers to understand science as a whole and thus achieve comprehensive vision of the universe. At the same time Ortega warned that attempts to return to a pre-industrial way of life would be suicidal.

Limited Authority of Science and Technology

Western conservatism has accepted the authority of the physical and biological sciences within their own sphere, but has sharply questioned the application of the methods of the natural sciences to the study of human beings. Edmund Burke's description of the moving spirits of the French Revolution in his *Reflections* (1790) indicts not scientists but pseudo-scientists: "sophisters, oeconomists, and calculators" (p. 170). An American admirer of Burke, Irving Babbitt (1865–1933), based his New Humanism on the distinction between what Ralph Waldo Emerson called "law for man, and law for thing" in his "Ode, Inscribed to W. H. Channing." The neglect of that distinction, Babbitt argued in his first book *Literature and the American College* (1908), leads to an intellectual climate in which "Man himself and the products of his spirit, language, and literature, are treated not as having a law of their own, but as things; as entirely subject to the same methods that have won for science such triumphs over phenomenal nature" (p. 86). Babbitt summed up his views in a short 1930 essay, "What I Believe." Although he objects when "the pseudo-scientist claims for physical science a hegemony to which it is not entitled" (p. 11), he also disclaims the romantic condemnation of intellect itself. For Babbitt the exaltation of feeling unrestrained by thought and the exaltation of mechanical efficiency for its own sake are merely two sides of the same coin. He counters what he considers the dominant trend of the age with a call for a "positive and critical humanism" (p. 14) based on a reaffirmation of "the truths of the inner life" (p. 18).

Contradictions

George Santayana (1863–1952) argued in "The Genteel Tradition at Bay" (1931) that Babbitt's New Humanism was only the last gasp of a *genteel tradition* that neither expressed nor understood what was truly dynamic in American society. Santayana had described the United States in "The Genteel Tradition in American Philosophy" (1911) as a "country with two mentalities, one a survival of the beliefs and standards of the fathers, the other an expression of the instincts, practice, and discoveries of the younger generations" (p. 39). Scientific and especially technological developments were an expression of the younger generation, while religion, philosophy and the arts were under the control of the "hereditary spirit" (p. 39) of the genteel tradition. The contrast between the two mentalities could be symbolized by the difference between two characteristic products of American architecture: the "sky-scraper" (p. 40) and the "reproduction of the colonial mansion" (p. 40). A philosopher, Santayana intimated, should understand that the new society could not be judged according to the criteria of the genteel tradition but must be accepted on its merits and judged on its own terms.

In *Reason in Science* (1906) Santayana criticized the "school of political conservatives" (p. 307) who insist on retaining the language of "theology and metaphysics"(p. 307) rather than that of science because of the loss of social stability that might ensue. Such "sensitive conservatism" (p. 307) is "entangled in a pathetic delusion" (p. 307) ; it is "conservatism in a shipwreck" (p. 307). Santayana himself was more than ready to acknowledge the validity of science, which he considered "common knowledge extended and refined" (p. 393). He criticized the critique of science by idealist metaphysicians around the beginning of the twentieth century on grounds that seem applicable to the postmodernist critique of science at the beginning of the twenty-first. It is hardly convincing, observes Santayana, "when science is systematically disparaged in favour of a method that is merely disintegrating and incapable of establishing a single positive truth" (p. 312).

Russell Kirk (1918–1994) admired both Babbitt and Santayana and included both in his seminal *The Conservative Mind* (1953). In an essay on "Civilization Without Religion" (1996) Kirk goes further than Babbitt and disagrees with Santayana in arguing that the decline of European and North American civilization could be averted only by a "restoration of religious teachings as a credible body of doctrine" (p. 15). Even Kirk, however, is careful to criticize not science but rather a *scientistic* misunderstanding of the implications of science. According to Kirk, "the principal cause of the loss of the idea of the holy is the attitude called scientism" (p. 11). It is scientism, not science, that takes it as proved that "men and women are naked apes merely; that the ends of existence are production and consumption merely; that happiness is the gratification of sensual impulses; and that concepts of the resurrection of the flesh and the life everlasting are mere exploded superstitions" (p. 11). In an essay titled "Humane Learning in the Age of the Computer" (1996), Kirk argues that technology can never replace the flesh-and-blood teacher, but he does so in the name not only of the humanities but also of science, worrying that "if facility in operating computers tends to be emphasized at the expense of serious study of physics and mathematics, the springs of the scientific imagination may dry up" (p. 122).

Critique of Scientism

In "Science and the Studies of Man," a contribution to an anthology on *Scientism and Values* (1960), Eliseo Vivas makes a representative conservative argument when he criticizes the "so-called behavioral sciences" (p. 50) for attempting to adopt the methods and assume the prestige of chemistry and physics. Vivas does not deny and indeed insists on the validity of scientific method when applied in physics and biology, but he rejects the idea that "the only valid knowledge is scientific" (p. 50). Like most other conservatives, Vivas believes that "there is philosophical knowledge of a substantive nature and that there is moral and religious knowledge and, in a qualified sense, even aesthetic knowledge" (p. 50). Vivas argues that the attempt to study human beings and their institutions according to the methods of the natural sciences results not in science but in *scientism*.

The distinction between science and scientism was not, of course, noted only by conservatives. The prestige of science among radicals and militant reformers, however, made it difficult for them to draw a line with the clarity and firmness of conservatism, even when they wanted to do so. The appeal of Dewey's pragmatism, for example, was closely linked to his proposals to use scientific techniques to reform human society. Likewise two of the outstanding examples of scientism in the twentieth century, Marxism and Freudian psychoanalysis, appealed to those who wished to either radically change or destroy bourgeois society. Both used the vocabulary of science, and both attracted adherents by claiming the authority of science.

Though the influence of Marxism was vastly more destructive, both used their prestige to challenge and undermine the traditional moral principles at the heart of conservatism. By the twenty-first century the fraudulence of both has been revealed for all but the willfully blind to see. Other versions of scientism remain, however, including the attempt to use the prestige of the theory of biological evolution to shape a secularist philosophy of human nature and view of the universe.

The Conservative Middle Ground

In opposing repudiation of the concept of truth by postmodernist skepticism, conservatism in the twenty-first century has made common cause with the natural sciences in defending knowledge that is objective and universally true. Conservatives have opposed attempts to formulate a *feminist science* or any version of science based on ethnicity. Likewise conservatives have criticized the characterization of technology as in itself demonic as claimed by some environmental radicals.

In response to the development of biotechnology, however, conservatives such as Leon Kass have continued to be guided by traditional moral principles such as the sanctity of innocent human life and human dignity. Sometimes this has led them to oppose some new uses of medical technology, such as those involved in stem cell research. The same principle of the sanctity of life has also led conservatives to object to the withdrawal of technological support from patients without their consent, whether at the behest of the state or others. Conservatism in the twenty-first century, as earlier, continues to affirm the relevance and validity of traditional ethical principles in evaluating the moral implications of new developments in science and technology, whatever those might be.

In 1932 Winston Churchill observed that "while men are gathering knowledge and power with ever-increasing and measureless speed, their virtues and their wisdom have not shown any notable improvement" (p. 279). As a true conservative, however, Churchill believed that what was required was not "progress" in thought but rather he believed it "above all things important that the moral philosophy and spiritual conceptions of men and nations should hold their own amid these formidable scientific evolutions" (p. 279).

JAMES SEATON

SEE ALSO *Agrarianism; Capitalism; Democracy; Liberalism; Marxism; Ortega y Gasset, José; President's Council on Bioethics; Scientism; Totalitarianism.*

BIBLIOGRAPHY

Babbitt, Irving. (1981 [1930]). "What I Believe." In *Irving Babbitt: Representative Writings*, ed. George A. Panichas. Lincoln: University of Nebraska Press.

Babbitt, Irving. (1986 [1908]). *Literature and the American College: Essays in Defense of the Humanities*. Washington, DC: National Humanities Institute. Irving Babbitt, with his colleague Paul Elmer More, founded the "new humanism," an attempt to reform American culture in the light of principles derived from the classics of literature, thought and religion.

Burke, Edmund. (1968 [1790]). *Reflections on the Revolution in France*. London: Penguin. Burke's reflections, according to Russell Kirk and others, marks the beginning of modern conservatism in Europe and North America.

Churchill, Winston. (1932). "Fifty Years Hence." In his *Thoughts and Adventures*. London: Thornton Butterworth.

Kass, Leon. (2002). *Life, Liberty, and the Pursuit of Dignity*. San Francisco: Encounter Books.

Kirk, Russell. (1953). *The Conservative Mind, from Burke to Santayana*. Chicago: H. Regnery Company. This book, more than any other single work, may be credited with the revival of conservative thought in the United States.

Kirk, Russell. (1996). "Civilization Without Religion." In *Redeeming the Time*, ed. Jeffrey O. Nelson. Wilmington, DE: Intercollegiate Studies Institute.

Kirk, Russell. (1996). "Humane Learning in the Age of the Computer." In *Redeeming the Time*, ed. Jeffrey O. Nelson. Wilmington, DE: Intercollegiate Studies Institute.

Lincoln, Abraham. (1989). "Address at Cooper Institute, New York City, February 27, 1860." In *Abraham Lincoln: Speeches and Writings 1859–1865*, ed. Don E. Fehrenbacher. New York: Literary Classics of the United States.

Lytle, Andrew. (1977 [1930]). "The Hind Tit." In *I'll Take My Stand: The South and the Agrarian Tradition, by Twelve Southerners*. Baton Rouge: Louisiana State University Press. The "twelve southerners" who contributed to this manifesto included such important literary figures as John Crowe Ransom, Robert Penn Warren, and Allen Tate.

Marcuse, Herbert. (1964). *One-Dimensional Man: Studies in the Ideology of Advanced Industrial Society*. Boston: Beacon Press. Marcuse was one of the leading members of the Frankfurt school.

Ortega y Gasset, José. (1957 [1930]). *The Revolt of the Masses*. New York: Norton. This is the most influential book by one of the most important philosophers of the twentieth century.

Santayana, George. (1983 [1906]). *Reason in Science*. New York: Dover Books. This is the fifth and last volume of *The Life of Reason*, the series that established Santayana's philosophical reputation.

Santayana, George. (1998 [1911]). "The Genteel Tradition in American Philosophy." In *The Genteel Tradition: Nine Essays by George Santayana*, ed. Douglas L. Wilson. Lincoln: University of Nebraska Press, pp. 37–64. Although the title refers only to "American Philosophy," this essay is one of the most insightful and influential essays on American culture ever written.

Santayana, George. (1998 [1931]). "The Genteel Tradition at Bay." In *The Genteel Tradition: Nine Essays by George Santayana*, ed. Douglas L. Wilson. Lincoln: University of Nebraska Press. In this essay Santayana invokes the concept of the "genteel tradition" to criticize the "new humanism" of Irving Babbitt and Paul Elmer More.

Vivas, Eliseo. (1960). "Science and the Studies of Man." In *Scientism and Values*, eds. Helmut Schoeck and James W. Wiggins. Princeton, NJ: Van Nostrand.

Weaver, Richard M. (1964). *Visions of Order: The Cultural Crisis of Our Time*. Baton Rouge: Louisiana State University Press.

CONSTRUCTIVE TECHNOLOGY ASSESSMENT

The core idea of constructive technology assessment (CTA) is that the social problems surrounding technology can and must be addressed through the inclusion of a large diversity of actors in technological design and implementation processes, including especially social actors. Social actors are those who experience and/or articulate and define health, environmental, or other value-laden effects of evolving technologies but are not directly engaged in technological developments. They may be consumers, citizens, employees, corporations, social groups, and more. CTA activities thus depart from traditional technology assessment (TA), which limits itself to charting the effects of given technological options, and does not attempt directly to influence or broaden the design process.

Historical Background

During the last two decades of the twentieth century, TA was widely adopted in several countries in Europe and in the United States. At first mainly conducted by technical experts, it developed toward a more participatory mode, bringing public values and opinions into the assessment of new technologies (Grin and de Graaf 1996, Vig and Paschen 2000). Both conventional expert impact assessment and various forms of participatory TA focus on shaping public policies related to technical change. TA policies have often been institutionalized in separate organizations such as the U.S. Office of Technology Assessment and the Netherlands Organization for Technology Assessment (renamed in Rathenau Institute), which serve legislatures and try to inform the broader public.

The Rathenau Institute was also heavily involved in developing the theory and practice of CTA. Since its founding, CTA practices have been taken up by many organizations, including corporations, nongovernmental organizations (NGOs), and government agencies, although not necessarily in the same way and often not under this label. These actors face different opportunities and constraints depending on their position in the innovation process. They share, however, the insight that negotiation among all stakeholders is necessary in order to deal with social problems that come with technical change.

CTA activities can take the form of dialogue workshops, consensus conferences (public debates), scenario workshops, or citizen reports. These are methods that can be used to organize structured discussions between social actors and designers (or technological actors). They only become CTA practices, however, when they focus on influencing design and technical change (Schwarz and Thompson 1990, Misa et al. 2003, Schot and Rip 1998, Schot 2001, Sørensen and Williams 2002).

Because CTA addresses innovation, it becomes a form of technology policy, although regular technology policies are not aimed at the integration of societal aspects into technical change. Some organizations and authors have called for such integration. They have argued that technology policies should aim at promoting those technologies that promise positive societal effects or externalities, as economists would term them (Carnegie Commission on Science 1992, Freeman and Soete 1997).

CTA Perspective

From a broad historical perspective, CTA practices may be viewed as a new form of management, replacing a problematic modernist way of managing technology (Misa et al. 2003). The core of modernist management lies in the separation of technology and its social effects. The lack of what may be called negotiating space between the actors involved in the design process and spokespersons for actors who are directly affected by the technology is a feature of the modernization process as it has manifested itself until the beginning of the twenty-first century.

In the modern regime of technology management, two tracks are apparent: promotion and regulation. On the one hand, there have emerged separate sites—called laboratories—where designers are given plenty of room to tinker with new technologies without having to think about the effects, because creativity might suffer. After they have been tried and tested, the black boxes are sent off into the world to bring about welfare and progress. This model encourages just plugging the technology in; playing with the technology is even considered dangerous. On the other hand, there has emerged a regulatory arena to mitigate the appearance of negative effects. Regulation does not concern itself with steering the scientific and technical developments, but rather with setting limits to their application.

Beginning in the 1970s, more and more problems and limitations became associated with this dual-track approach. Problems cropped up and so-called negative side effects of existing technologies were not easily solved through ex post facto regulation. They only worsened. Environmental problems are good examples. Since the 1980s there has been an explosion of new governmental regulations including the use of economic instruments as well as great increases in knowledge of environmental problems and solutions. Environmental advisory agencies have flourished. Yet many environmental problems have not been solved. Chimney filters and catalytic converters appear unsatisfactory. It has become clear that environmental problems must be addressed through a drastic reduction of energy and resource use. Another form of production and consumption is required. This will not come about through government regulation only, also not if it would focus on creating new market mechanisms.

An alternative form of production and consumption implies not only making environmentally-friendly technologies, but also an alternative form of making technology. The character of the technology design and implementation process is in need of change. It must be broadened to include social aspects and actors. Ultimately such a broadening could lead to a change in the current pattern of technology management (the dual-track approach). New institutions should emerge that will become platforms for the constructive integration of technology and society. It is constructive not in the sense of conflict avoidance, but in the sense that all affected are in a position to take responsibility for the construction of technology and its effects.

Features of CTA

The view that design and implementation processes must be broadened is based on the presumption that social effects are present in the form of (sometimes implicit) assumptions about the world in which the product will function. Thus, when technologies are designed, assumptions are made about users, regulations, available infrastructures, and responsibilities between various actors.

In technology studies, the notion of *scripts* is used to refer to this set of assumptions (Akrich 1992). The effect of broadening (and thus of the application of CTA) is that the designers' scripts are articulated and laid out as early as possible to the users, governments, and other interested parties, all of whom have their own scripts, and who will feel the effects of the technology. From the point of view of CTA, it is important to make room for such an early and more regular confrontation and exchange of all the scripts. Thus CTA processes acquire their three normative beneficial features: (1) anticipation, (2) reflexivity, and (3) social learning.

ANTICIPATION. Whenever users, social groups, and citizens take part in the design processes, they are more likely to bring in social aspects at an early stage than are designers. Designers rarely anticipate social effect; they have a hard enough time anticipating market conditions in a timely fashion. They react to market signals and social effects only when they occur, which leads to ad hoc problem solving. In the field of management studies, this lack of sensitivity toward user needs has been identified as a barrier for successful innovation.

Despite the emphasis on anticipation, there is no presumption that all social effects can be predicted. On the contrary, it must be assumed that technological development is nonlinear and unpredictable. During development all kinds of unexpected side roads and branching emerge. The given unpredictability of technological development has two implications. First, anticipation must be organized into a regular activity, including during the phase of implementation. That is when unforeseen effects emerge by way of new interactions and applications. Owing to the importance of anticipating social effects as early as possible, corporations and other technology actors can be advised to organize a trajectory to develop scenarios for coping with social effects alongside product development trajectories. Second, the technology development process should be flexibly structured so that choices can be deferred or altered.

REFLEXIVITY. Broadening the design process results in being able to notice earlier and more clearly that social effects are coupled to specific technical options and that designers design not only technological but social effects. Scripts can no longer remain hidden. The effects that emerge are dependent not only on the designers' scripts but also often on the outcomes of complex interactions between designers, users, third parties, and the context in which these actors operate.

CTA activities aim to stimulate actors to take account of the presence of scripts and realize that technological developments and social effects are coproduced. Actors thereby become reflexive. They must integrate technology and its effects into their thoughts and actions. Consensus may be reached, but controversies could very well occur as CTA exposes hidden scripts and places them next to one another. This need not be such a great problem in societies where controversies are a routine and normal part of the process of technology development. Analyses of controversies have shown that attempts often are made to suppress reflexivity. Attempts are made to separate technical facts from assumptions about the social reality in which the technologies function. Controversies subsequently take the unproductive course of the dual-track regime, either emphasizing promotion or regulation of new technologies.

SOCIAL LEARNING PROCESSES. Learning may occur on two levels. First-order learning leads to developing a better ability to specify and define one's own design. Second-order learning means learning about one's own assumptions and scripts, learning that one is creating new couplings and demands. CTA relates to both forms of learning. It is important to embed technological development in social learning processes as early as possible so that users, designers, and third parties have the opportunity to scrutinize their own presumptions and come to new specifications. In practice, design processes then become more symmetrical from the beginning. As much attention is paid to technical as market and social issues. Design processes become open (so actors are ready to partake) and space is made for experimentation, for trying out various couplings and problem definitions.

Changing the Design Process

CTA activities are not directed in the first instance at such substantive goals as the reduction of environmental pollution, the defense of privacy, or other such social goals. Thus, for instance, the development of wind energy or a security system to guard against bank fraud cannot be automatically labeled CTA. The purpose of CTA is to shape technological development processes in such a way that social aspects are symmetrically considered.

When design processes assume the character of CTA, fewer undesired and more desired effects will result. Such a claim is based on two arguments: (1) By incorporating anticipation, reflexivity, and social learning, technology development becomes more transparent and more compliant to the wishes of various social actors. (2) In a society where CTA processes have become the norm, technology developers and those likely to be affected by the technology will be in the position to negotiate about the technology. An ability to formulate sociotechnical critique and contribute to design will become widespread. Resistance to specific social aspects will not be viewed as technophobia, but as an opportunity to optimize the design (or achieve a better fit in society).

The effect of CTA will not be to bring technology under control so that it plays a less dominant role in society. Rather, it aims to change the form of control and how technology development is played out. The goal is to anticipate earlier and more frequently, to set up design processes to stimulate reflexivity and learning, and thus to create greater space for experimentation. Possible technologies should be made more open and flexible so users easily can have control over them. Technological development will also become more complex. More coordination and new competencies will be required. In some cases the processes will slow. New institutions will emerge to encourage negotiation between developers, users, and third parties. Should design processes acquire the character of CTA, technologists will not suddenly see their work disappear or have it constantly evaluated by new bureaucracies. Almost all of the incremental design changes will not require negotiation. In the program of requirements, allowance routinely will have been made for social aspects (including flexibility). However, the variety of technological designs probably will increase, as more groups will be involved in their capacities as knowledge producers and technology developers.

The three quality criteria for CTA processes make apparent that broadening the design process is not an end in itself, and that "broader" does not necessarily mean "better." Broader is better only in those design processes where space has been created for anticipation, reflexivity, and learning. That provides some guarantee that processes should result in better technology, which is to say technology with more positive and fewer negative effects. These three criteria also allow existing CTA activities to be evaluated, and suggest directions for improvement.

JOHAN W. SCHOT

SEE ALSO *Consensus Conferences; Discourse Ethics; Expertise; Office of Technology Assessment.*

BIBLIOGRAPHY

Akrich, Madeleine. (1992). "The De-Scription of Technical Objects." In *Shaping Technology/Building Society: Studies in Sociotechnical Change*, ed. Wiebe E. Bijker and John Law. Cambridge, MA: MIT Press. Classic article on how technical objects are turned into black boxes, become stable, naturalized, and depoliticized. The process of their making is concealed. The article is informed by actor—network theory.

Carnegie Commission on Science. (1992). *Enabling the Future: Linking Science and Technology to Societal Goals*. New York: Carnegie Corp. A report that integrates social dimensions in a proposal for a new kind of technology policy.

Freeman, Chris, and Luc Soete. (1997). *The Economics of Industrial Innovation*, 3rd edition. Cambridge, MA: MIT Press. A highly influential yet stylized history and broad review of theories of innovation.

Grin, John, and Henk van de Graaf. (1996). "Technology Assessment as Learning." *Science, Technology, and Human Values* 20: 349–366. An excellent exploration of the nature of learning processes involved in technology assessment.

Misa, Thomas J.; Philip Brey; and Andrew Feenberg, eds. (2003). *Modernity and Technology*. Cambridge: MIT Press. A truly interdisciplinary exploration of the connections between technology and the modern world. The ambition is to lay the foundations for a new field, hence it includes discussions on theory and method, next to a wide range of empirical studies.

Rip, Arie; Thomas J. Misa; and Johan Schot, eds. (1995). *Managing Technology in Society*. London: Pinter. An analysis of the underdevelopment of innovative potential for achieving societal goals. Factors that block change, as well as conditions for successful learning, are identified in a wide-ranging selection of cases that encompass biotechnology, clean technologies, information and medical technologies.

Schot, Johan. (2001). "Constructive Technology Assessment as Reflexive Technology Politics." In *Technology and Ethics. A European Quest for Responsible Engineering*, ed. Philippe Goujon and Bertrand Hériard Dubreuil. Leuven, Belgium: Peeters. A history of the emergence of Constructive Technology Assessment and an analysis of experiences leading to suggestions for a new research agenda and practice.

Schot, Johan, and Arie Rip. (1998). "The Past and Future of Constructive Technology Assessment." *Technological Forecasting and Social Change* 54: 251–268. An attempt to define criteria for a good Constructive Technology Assessment practice.

Schwarz, Michael, and Michael Thompson. (1990). *Divided We Stand: Redefining Politics, Technology, and Social Choice*. Philadelphia: University of Pennsylvania Press. An introduction to a cultural theory of risk leading to a plea for constrained pluralism in technology introduction and adoption discussion and practices.

Sørensen, Knut H., and Robin Williams, eds. (2002). *Shaping Technology, Guiding Policy: Concepts, Spaces, and Tools*. Cheltenham, UK: Elgar. An overview of recent developments in technology studies. It introduces a range of new concepts and ideas, and it highlights both the policy implications of these concepts and explores new possibilities for intervention by government, policymakers, managers and the public.

Vig, Norman J., and Herbert Paschen, eds. (2000). *Parliaments and Technology: The Development of Technology Assessment in Europe*. Albany: State University of New York Press. An informative and historical country based overview of technology assessment.

CONSUMERISM

Consumerism is a way of life combining high levels of material affluence with an emphasis on symbolic and emotional meanings associated with shopping and possessions. The United States continues to lead the way, but the phenomenon increasingly is of global scope. Consumerism can be interpreted positively as a means of stimulating the economy while facilitating people's liberties to shape their identities and subcultures. In contrast, critics perceive consumerism as a manipulated and environmentally destructive habit leading to too many units of stuff being designed, produced, advertised, sold, and discarded (Rosenblatt 1999, World Watch Institute 2004). All may agree that "The one unambiguous result of modern capitalism, of the industrial revolution, and of marketing . . . is: In the way we live now, you are not what you make. You are what you consume" (Twitchell 2002, p. 1).

Infrastructure of Consumption

Consumerism involves not just the conventional *shopaholic,* but a complicated set of organizations, relationships, and ethically problematic practices involving science and technology. Product designers, manufacturing engineers, solid state physicists, and those trained in just about every other scientific and technical specialty have participated directly or indirectly in the development and spread of consumer society. Chemists created synthetic pesticides, PCBs, and PVC plastics, enabling businesses to produce and consumers to purchase products that inadvertently scattered billions of pounds of toxic compounds across the landscape. Civil engineers paved and built, making possible an automobile-centered way of life, that enhanced mobility while creating urban sprawl. Agricultural scientists helped construct the modern diet, combining unprecedented variety and nutrition with an obesity epidemic. Computer engineers' amazing achievements also were crucial in spreading pornography via the Internet, even though it was not the engineers themselves who produced or downloaded it.

Technologists are joined by government in fostering consumerism. The basic science integrated into leading-edge technologies such as carbon nanotubes derives partly from taxpayer-funded research and other government subsidies. Transport, electricity, communications, agriculture, and other infrastructure of consumer society all benefit from advantageous tax treatment or outright subsidy, a favorable legal environment, and government stimulation of the economy by means of monetary and fiscal policy. Military research and development (R&D) also has been indispensable; for example billions of aluminum beverage cans annually derive from aluminum smelting procedures developed for aircraft construction during the World War II.

Drawing in part on ideas developed via government-sponsored R&D, business executives search for market niches while hiring experts to deploy technological innovation as a competitive strategy. Franchises and fast food restaurants, *big box* stores and malls, cruise ships, theme parks, sports and musical performance arenas, resorts, and casinos all depend on technologically enabled data processing, communication, and transport of customers, merchandise, food, and drink from all over the globe. These and other forms of consumerism are reshaping everyday life worldwide by a process that some sociologists refer to as *McDonaldization.* The quest for efficiency, calculability, predictability, and "control through nonhuman technology" achieves amazing results, but cumulatively may constitute "the irrationality of rationality" (Ritzer 2004, p. 15–16).

Public Receptivity

As indispensable as technologists, business executives, and government officials have been in development of consumerism, they could not have done it without a receptive audience. If there is a dividing line between purchasing and consumerism, it perhaps occurs when purchasing becomes more about shopping and its psychosocial benefits than about actual use of the purchased items. Friends may prescribe a shopping trip for someone who is depressed; *bargains* and *sales* are avidly sought, even though the total expended is certain to be higher when one goes shopping than when one does not; and somewhere in many shoppers' minds is an expectation of approving looks or words that may be evoked by a new garment or tool. The symbolic, emotional, and interpersonal elements of consumerism are difficult to overstate.

That is not to deny that consumers exercise choice; of course they do, in part because the variety of possible purchases is so great that choice is inescapable. Nevertheless just as families come voluntarily to Disney World and then are channeled into preformed experiences, so more generally is consumer behavior in some respects channeled for the convenience and profitability of business. To attract customers, merchandisers play on consumers' envy, shame, and pride, expending 1 trillion dollars annually worldwide on advertising, attractive packaging, and other selling techniques. A small army of psychologists and statisticians conduct market research to learn how to stimulate sales, "constantly gaining more precision in pinpointing the demographic and lifestyle trends of consumer segments, employing new tools such as Internet *cookies* to monitor the *click-streams* of e-shoppers" (Cohen 2003, p. 402). The finance industry brilliantly stimulates the borrowing necessary to keep spending high.

Criticisms and Rejoinders

The disposable income required to purchase a growing array of goods and services is of course far more available to the affluent, who are located mainly in North America, Japan, and Europe. At the other end of the spectrum are approximately 1 billion persons who live in absolute poverty, about as many humans as the total number alive prior to the Industrial Revolution. To families without toilets or clean drinking water, television broadcasts the lifestyles of the rich and thereby stimulates consumer aspirations and helps spread consumer society across the globe. Within affluent cultures, intangible ethical consequences of consumerism appear to include deterioration of face-to-face community, increased rates of psychological depression without commensurate improvements in happiness (Lane 2000), and reduced interaction among family members as children turn increasingly to the televisions and computers in their bedrooms. Parents' long working hours sometimes come at the expense of sleep, leisure, family, and friends—a syndrome far more common in some countries (such as the United States) than in others (Schor 1998).

Consumerism is environmentally problematic in obvious ways, but also more subtly, as when distant consumers' appetites for shrimp, teak, and coffee disrupt fragile tropical ecosystems (Tucker 2002). Whether consumerism potentially can be made compatible with environmental sustainability is debatable. The formula for calculating ecological damage is roughly the total number of humans, multiplied by the amount consumed per person, multiplied by the resources utilized and toxicity released per unit of consumption. If the human population declines soon enough, and if technologists figure out how to dramatically reduce resource usage and pollution per unit produced and consumed, increasing material affluence per person might be compatible with greatly reduced environmental damage. Advocates of *natural capitalism* propose radically reconceptualized ways of providing housing, transport, and consumer products (Hawken et al. 1998, McDonough and Braungart 2002); and a few nanotechnologists believe that molecular manufacturing eventually may eliminate hazardous wastes and other side effects of production. As of the early twenty-first century, however, reductions in pollution per unit in most industries have been offset by population growth and by increased consumption per person.

Not everyone agrees with the above diagnosis. Among counterarguments, they point out that contemporary economies are organized to require an unpleasant choice: allow recession and unemployment, or stimulate the economy through ever-higher levels of consumer spending. In poorer nations, increased investment and purchasing theoretically might be devoted to basic needs including water supply systems, safe sanitation, housing, and nutrition. In the already affluent nations, however, economic growth tends to mean more elaborate barbeque grills, second homes, cosmetic surgery, and other luxuries. These are lesser evils, or not evils at all, to those who emphasize the benefits of full employment, interesting jobs, and liberty to purchase a lifestyle more of one's own choosing than previously possible for most of humanity, together with the value of technological innovation as a means of making life more diverse and more interesting (McCracken 1988).

The Challenge of Change

Few knowledgeable observers presently consider consumer trends compatible with environmental sustainability, but those concerned about unlimited consumerism face a difficult task in addressing the issue. It is easy to make products and production processes a bit greener by, for instance, creating biodegradable carpeting. But limiting the total volume of production and consumption is far more difficult, requiring people to forego some of what they have learned to want. Such a change in consumer mentality presumably would require slowing the drumbeat of messages encouraging consumption, and perhaps even a ban on advertising as well as tight restrictions on consumer credit. Such changes surely depend on ardent environmentalists and other slow-growth advocates winning more elections, which cannot happen without a different attitude among citizens. In other words, consumerism is constructed as a circle, a vicious circle in the eyes of critics.

Changed thinking among scientists, engineers, and other technically trained persons also might be necessary to intervene in the consumerist trajectory. In effect, technoscientists now gain governmental research funding by helping create weaponry, communications, transport, and other innovations helpful in military affairs and in economic activities valued by governing elites. A similar expectation leads industry to help fund scientific research, employ technoscientific consultants, and hire college graduates in chemistry, biotechnology, computer science, and other technical fields. All this makes good sense, in a way; but the partially unintended, collective consequences include the problematic aspects of consumerism.

Breaking out of the consumerist cycle would involve billions of persons over generations in evolving a commendable, interesting, high-technology, lower-consumption way of life. This, arguably, is the master challenge for human civilization—an activity so far-reaching and visionary that no one can fully imagine what would be involved. However a first step probably would require that more people begin to think of consumerism as an ethical, technological, economic, and political issue to be addressed.

EDWARD J. WOODHOUSE

SEE ALSO *Advertising, Marketing, and Public Relations; Affluence; Cosmetics; Material Culture; Materialism; Popular Culture; Population; Waste.*

BIBLIOGRAPHY

Cohen, Lizabeth. (2003). *A Consumer's Republic: The Politics of Mass Consumption in Postwar America*. New York: Basic Books. A historical study of the shift in the U.S. toward consumer-citizens who focus not on politics as a quest for the common good but on having government facilitate personal consumption.

Hawken, Paul, Amory Lovins; and L. Hunter Lovins. (1998). *Natural Capitalism: Creating the Next Industrial Revolution*. Boston: Little, Brown. Proposes changes in housing, transport, and many other aspects of production and consumption to make compatible the goals of business profitability, technological innovation, fairness, diversity, and environmental sustainability.

Lane, Robert E. (2000). *The Loss of Happiness in Market Democracies*. New Haven, CT: Yale University Press. Summarizes and interprets psychological research calling into question the hope that consumerism can lead to a permanent state of enhanced life satisfaction.

McCracken, Grant D. (1988). *Culture and Consumption: New Approaches to the Symbolic Character of Consumer Goods and Activities*. Bloomington: Indiana University Press. Materialism as a quest for intangible goods such as identity and belonging.

McDonough, William, and Michael Braungart. (2002). *Cradle to Cradle: Remaking the Way We Make Things*. New York: North Point Press. A visionary yet down-to-earth analysis of how a highly technological lifestyle could be elegantly designed to be environmentally benign.

Ritzer, George. (2004). *The McDonaldization of Society*, revised new century edition. Thousand Oaks, CA: Pine Forge Press. Sociological interpretation of the mechanisms that major organizations use to serve growing numbers of people in standardized ways, while displacing local businesses and helping change the culture of everyday life.

Rosenblatt, Roger, ed. (1999). *Consuming Desires: Consumption, Culture, and the Pursuit of Happiness*. Washington, DC: Island Press. A collection of essays by critics of consumer society.

Schor, Juliet B. (1998). *The Overspent American: Upscaling, Downshifting, and the New Consumer*. New York: Basic Books. A nonconventional economist's interpretation of the quest for status via consumption.

Tucker, Richard. (2002). "Environmentally Damaging Consumption: The Impact of American Markets on Tropical Ecosystems in the Twentieth Century." In *Confronting Consumption*, ed. Thomas Princen, Michael Maniates, and Ken Conca. Cambridge, MA: MIT Press.

Twitchell, James B. (2002). *Living It Up: Our Love Affair with Luxury*. New York: Columbia University Press. An even-handed attempt to find out what luxury means to consumers, based in part on ethnographic research in Beverly Hills and other shopping havens.

World Watch Institute. (2004). *State of the World 2004: The Consumer Society*. New York: W. W. Norton. Describes global environmental effects of consumption, and presents a plan for moving toward what the authors consider a more just and more sustainable civilization.

CONTRACEPTION

SEE *Birth Control.*

CONTRACTS

Contracts are legally enforceable agreements between persons that specify transactions or define relations between them. Either informal or written, they may concern any lawful human transaction, from purchases and loans to hiring and marriage. In engineering and science, contracts play important roles because, in both domains, practitioners do a great deal of work under some form of contract. Defining what the parties are obligated or permitted to do, contracts establish an ethical framework for engineering and scientific work, and they present ethical problems. The ethical framework has at its core one or more promises. Because the promises are legally enforceable, they involve a third actor in addition to the promisor and the promisee, government.

Contracts in Engineering

For most engineers and many scientists, the employment contract frames their professional activities. American courts apply the common law doctrine of "employment at will" when interpreting employment contracts for engineers and scientists. Under this doctrine, the employer is free to hire and fire at will, and the employee is free to take up employment and resign at will. This means that an employer may dismiss an "at will" employee, in the words of the court in an often cited case, "for good cause, no cause, or even cause morally wrong, without thereby being guilty of moral wrong" (*Payne* v. *Western and Atlantic RR*, 81 Tenn. 507, 519–20 [1884]). As a consequence, for example, engineers have reason to fear that by asking challenging questions about the safety of a project, they risk being fired. The "employment at will" doctrine is subject to limitations expressly indicated in federal and state statutes (for example, civil rights laws), to public policy exceptions courts have worked out, and to express provisions in the employment contract, such as provision for a term of one year.

The contract includes the usual terms of employment: salary, compensation, health and pension benefits, etc., but in addition may include "employment agreements" concerning intellectual property, confidentiality, and restrictions on future employment. At the time of taking employment, engineers and scientists often enter these agreements with insufficient appreciation of the implications. Sometimes, in this way, engineers or scientists unwittingly enter agreements that are so restrictive they could not be enforced. An example is an agreement that excludes future employment with a competitor to the extent of putting the engineer's future livelihood at risk.

Engineers or scientists may be surprised to discover that they are legally and ethically obligated by the employment agreement to maintain the secrecy of certain information even after changing employers. At the next job, an engineer or scientist may have to decide whether particular indirect uses of information gained from a former employer are permissible. Engineers or scientists may also have to decide whether to maintain the confidentiality of information that they believe a client or customer needs to avoid certain harms.

Some have argued that the code of ethics does or should rank as an implied element of the engineer's or scientist's employment contract. Viewed this way, the code would provide a barrier protecting engineers or scientists from being required by their employers to engage in behavior that violates the code. One way to interpret this claim is by invoking the status of an engineer as a professional: An employee trained and hired as an engineer is bound by all the standards of engineering, including ethical standards. The employment contract cannot require engineers to violate their ethical standards. Courts, however, have not been receptive to this interpretation.

Contracts bear on engineers' and scientists' work in another important way—through the contractual agreements that their employers (or they themselves) make with other business organizations, non-profit organizations, interest groups, and government agencies at every level of government. Engineers' functions—design, testing, maintenance, and operations—and their project-related dealings with purchasing agents, marketing specialists, customers, vendors, and construction contractors, as well as with other engineers, are usually associated with such contracts. The same is true of scientists when they function similarly.

Some common ethical problems for engineers typically arise from contracts of this sort. An example is the "deadline problem" that occurs, for example, when engineers discover in the course of their work that they cannot meet both the specifications for the product and the delivery date to which they originally agreed. They may have to develop options, such as working overtime or negotiating a compromise.

Yet engineers contribute to devising these sorts of contracts as well as to implementing them. They participate in defining projects and determining specifications for products even when they do not directly take part in contract negotiations. Their judgments about the time and resources needed to complete projects (a new chemical plant, for example) often help to decide the terms of contracts by which they and other engineers are bound. Strategies of preventive ethics may help engineers avoid ethical problems associated with devising contracts.

So far, this entry has focused on ethical problems and strategies from the perspective of engineers and scientists as promisors. In most cases when engineers and scientists are promisors, the promissee is a large company or firm. The company's perspective brings to the fore other ethical problems and needs for preventive ethics. For example, employers cannot easily determine whether engineers are faithfully abiding by their promise to maintain the secrecy of information at a new place of employment. Companies cannot pursue former employees by legal means if they do not have tangible evidence of, for example, the transfer of confidential information to the new employer. From this perspective, strategies of preventive ethics, such as rewards for creativity to valuable employees, may be useful. Companies can also use contracts to provide incentives to valued employees to stay with the company and to departing employees to maintain desired confidentiality, in this way protecting engineers and scientists from temptations to which they are subject.

In consulting firms (for example, environmental consulting firms) that require or permit the firm's engineers and scientists to obtain and implement contracts on their own, other problems arise. Scientists or engineers may unwittingly enter contracts with clients whose interests collide with those of other clients of the firm. Problems about the treatment of their reports may arise for engineers and scientists in these firms, and also in other contexts. The firm may object to the engineer's client using a report in a press conference or require the engineer to suppress a report altogether. An academic engineer who does independent consulting under contract may have to decide how to handle a client's decision to bury a report revealing the client's responsibility for some harm.

Contracts in Science

In scientific research and in academic engineering, contracts are pervasive in defining conditions attaching to awards of funding necessary for conducting research. In universities, investigators, students, and postdoctoral scholars have a contractual duty to abide by the institution's rules. Informal agreements in research groups under these rules are similarly binding. Graduate students are often surprised to learn that they do not own data they themselves collect. They may perceive this rule or agreement in research groups as an unfair hindrance to advancing their careers. Nevertheless, they are ethically bound to abide by these agreements unless they can negotiate other terms with the principal investigator.

The power disparity among senior investigators, graduate students, postdoctoral scholars, and junior investigators complicates the ethical situation in research groups. Their leaders have the power to make the ground rules for conducting research in their groups. Those subject to this power and dependent on their leaders for research support and recommendations for future employment are not in a position to contest rules. Because of the power disparity, safeguards should be built into the ground rules to protect the vulnerable, less powerful members of groups. Senior investigators can begin by making informal understandings explicit and open to discussion and revision.

In conducting research for commercial sector firms, scientists and engineering researchers are required to sign contracts that allow firms proprietary control not only over copyrights and patents, but usually also over data, tools, resources, and techniques. As a consequence, "virtually any piece of information or equipment used in industry-sponsored research can become company property" (Resnick 1988, p. 31). By these agreements, even chemical formulas and DNA sequences can become company property.

These contracts also commonly require scientists and engineers in the commercial sector to submit their publications or public presentations for company review and to accept delays beyond the limit acceptable in academe. In some cases, companies suppress publication altogether, in this way requiring engineers or scientists to violate professional standards. In light of the central value of open publication in science, a value that serves science and the public welfare, these requirements present ethical conflicts for scientists.

As encompassing as these agreements are, courts have upheld them. In doing so, they represent the public's interest in ongoing scientific research and development. The underlying assumption is that such proprietary control is essential for companies to gain a return on the heavy investment required for scientific research and product development. Without the assurance of a return, they will not take the risk of investing. However, some companies may suppress results and refuse to share useful tools and resources beyond the need to realize the return on their investment. Consequently, scientists and the public may fail to receive the benefits of the propagation of new knowledge and inventions.

In the interests of the promisor, the promisee, and the public, companies should allow their scientists and engineers to publish results and share resources and tools in a timely fashion. Industry-sponsored research contracts should not require scientists or engineering researchers to violate professional standards. Rather, contracts between companies and researchers should be written to strike an appropriate balance between proprietary control over information and scientists' responsibilities to publish results and share resources to the benefit of science and the public.

This overview of ethical obligations, responsibilities, and ethical problems associated with contracts in science and engineering points to the need for practitioners in these domains to be taught to pay close attention to contracts. In many circumstances, engineers and scientists can influence the terms of contracts in such a way as to reduce the likelihood of their facing ethical problems later. Promisors and promisees can become oriented to devising and using strategies of preventive ethics to avoid violating professional ethical standards.

VIVIAN WEIL

SEE ALSO *Conflict of Interest; Engineering Ethics.*

BIBLIOGRAPHY

Bennett, F. Lawrence. (1996). *The Management of Engineering: Human, Quality, Organizational, Legal, and Ethical Aspects of Professional Practice*. New York: Wiley. A reference volume as well as a textbook that considers contracting and ethical issues for engineers from the perspective of managers of engineers.

Campbell, Sally A. (1997). "Balancing the Responsibilities of the Environmental Consultant to Create a Personal Ethical System." In *Proceedings of the Air & Waste Management Association's 90th Annual Meeting & Exhibition, June 8–13, 1997*. Toronto: Air & Waste Management Association. An environmental consultant's perspective on engineers' and scientists' ethical responsibilities to the public and the scientific community when they provide estimates of environmental impacts and contribute to environmental decision making, under contract to management.

Orlans, Harold. (1973). *Contracting for Knowledge*. San Francisco: Jossey-Bass. A broad consideration of problems inherent in contracting for knowledge, including social scientists' research.

Resnick, David B. (1998). "Industry-Sponsored Research: Secrecy Versus Corporate Responsibility." *Business and Society Review* 99(1): 31–35. A philosopher's analysis of contractual constraints on industrial scientists and engineers that documents cases of excessive control and indicates how business organizations can manage such contracts to the benefit of the public and the scientific community as well as their own benefit.

Watson, Alan. (1991). *Roman Law and Comparative Law*. Athens: University of Georgia Press. A solid scholarly volume that explains contracts in the law, with an account of the origins of contracts in Roman Law.

CORRUPTION

Corruption derives from the Latin verb *corrumpere*, which means to break into pieces, destroy, defraud, falsify, seduce, or bribe. But the meanings hardly end with those. They are merely one set of a procession of definitions and interpretations amassed over the centuries, all signifying some contagiously harmful, unjust, self-serving, often repulsive divergence from moral conduct.

Definitions

Corruption defies and defiles what is generally perceived as the common good. In its malevolent extreme—such as systematic and widespread murder, torture, rape, or pillage, undertaken to maximize power—corruption can attain the dimensions of evil. At the lesser extreme, acts such as bribery, embezzlement, plagiarism, or falsifying research data, when done on a small scale and episodically, can be seen as unethical, immoral, or deranged, though not necessarily corrupt. Scope can often define corruption.

Science has its own literal definitions of corruption. Data are sometimes called corrupted. In biology, corruption is the process of living matter's decomposition. Similarly, a spoiled laboratory sample can likewise be described as having been corrupted. Terms such as rot, putrescence, and decay all serve well as descriptives for the revulsion corruption can generate. Corruption covers a multitude of sins and therefore has an almost limitless repertoire of baleful synonyms and colorful case examples.

Scholarship on corruption in science is rare, in technology (e.g., patent piracy, computer hacking) increasingly frequent. But scholarly work on corruption in governments, wherever they may be, is abundant. The challenge in the science and technology sector is to connect the hidden motivations and behavior patterns of those in the technical world to that of the political and economic spheres so that technical professionals can play stronger roles in perceiving their own relevance in stemming corruption's incessant growth.

Organizational Approaches

A handful of organizations with ambitious programs to understand and prevent corruption have attempted to establish satisfactory definitions of corruption. The World Bank, which in 1999 launched a vigorous anti-corruption program, defines corruption as "the abuse of a public position for private gain." Transparency International, long the leading body in tracking and studying corruption, defines it as "behaviour on the part of officials in the public sector, whether politicians or civil servants, in which they improperly and unlawfully enrich themselves, or those close to them, by the misuse of the power entrusted to them." Because of the global trend toward the privatization of public functions, it extends that definition to abuses in the private sector.

A third body, the Organisation for Economic Co-operation and Development (OECD), shuns any attempt to define corruption but has undertaken considerable work in gathering statistics, convening conferences, and issuing reports on such subjects as bribery, export credits, corruption in individual countries, and corruption's impact on development.

Any generalized treatment of corruption that is less than criminal or evil can entail considerable subjective judgment, thus inviting both a self-critical eye and rhetorical reflection. Often the word is used loosely in tirades against political opponents, such as a "corrupt" policy by one political party or another involving the environment, the elderly, or illicit campaign tactics. Charges of corruption can be flung when scientists rally against the packing of technical panels by a government whose political party they oppose. In the brutal give and take of politics, judgments about corruption's severity and perhaps its very existence are best done with care, case by case, even item by item, with emotions held in tow.

The Situation within Science, Engineering, and Technology

Science, engineering, and technology—technology being the useful products of engineering—are themselves fertile soils for corruption. Under the thrust of technological change, they can serve as tools (genetic engineering, virology, the computer, and digital communications as examples) to expand the range of corruption's infectivity. Thus, right at the start, the technical world can be mired within conflicting goals when business, engineering, and science comingle. Not only that, but history displays the macabre paradox of science and engineering specifically employed for evil means such as the freezing of human beings by Nazi scientists to study the process of death and the feasibility of resuscitation, or the infamous Tuskegee Syphilis Study (1932–1972) on prison inmates in Tuskegee, Alabama, as well as the radiation experiments performed on unwitting human subjects by the Atomic Energy Commission from 1944 to 1974. Further, it could easily be argued that weak implementation of occupational safety and health laws leading to worker deaths is also a form of corruption of the public good.

The values of science, which derive from philosophical and moral thought, are their own protection against any infestation of corruption. The inner character of science contains the ethical outcome of improving the lot of humankind and adhering to a strict code that imposes integrity on its practitioners. For years, the scientific community has striven to reduce the incidence of data falsification, arguing that the act of falsification erodes the honesty and openness that feeds scientific progress. Thus, science contains within itself a moral value all scientists are trained to revere. But, like other human beings, scientists can cheat, lie, and steal. The question is whether one chooses to call such flaws corruption—whether to expand the definition of corruption to include the corruption of values. At this moment in the sociology and psychology of science, divergent behavior in the technical fields rests in the discipline of ethics, broad enough in itself.

Thus, the tracking and policing of unethical behavior among technical professionals has been left to science and engineering societies, journals devoted to science/society issues and to the field of misconduct and malpractice, inspectors general for the technical agencies of government, the agencies themselves (through, for example, the Office of Research Integrity at the National Institutes of Health), and science and engineering workplaces. Corruption involving science and technology, however, does come in for significant treatment in the corruption literature because the capital transferred for development projects that involve science and engineering is often skimmed for payoffs at either the contractor or government level. Thus it is clear that those within the science and engineering community whose work engages them in development projects have a stake in corruption at the level of the Third World. Whistleblowing is one major response by technical people to perceived violations of ethical practice among their higher-ups. Unfortunately, whistleblowers are too infrequently rewarded—and often punished—for acting on their sense of outrage.

How corruption can be differentiated from immorality is an open question. If a lie is immoral, then scientific fraud—whether by plagiarizing texts or falsifying data—is immoral as well. But whether it is corruption is more a question of philosophy than practicality. Oftentimes, examples of fudging laboratory work for neater results might well be seen as advancing the cause of a research project. If the loss of research support for a worthy program, for example, is threatened by a bit of discrepant data, then the researcher might consider "tidying up" the results for the sake of saving the grant.

Trends and Outlook

Where corruption in science and engineering perhaps bears most watching is in the relatively recent marriage between corporations and universities in conducting genetic engineering research. The field itself has long presented ethical and moral dilemmas, but the risk of corruption increases in the high intellectual property stakes involved in genetic discoveries. The fear is that academic and intellectual freedom has been "corrupted" when scientists working under the support of the corporation deliberately withhold data from colleagues at competing institutions. These practices have taken place to a disturbing extent with no final consensus in view.

Corruption will always be present within the human realm. The war on it in the developing world has become vigorous and is showing success. Evidence shows that as those countries democratize and generate more internal wealth, corruption will decrease. At the same time, however, the growth of new scientific and technological tools will render corruption increasingly creative and sophisticated. The incursion into personal privacy through sensor technology applied to "protect democracy" can be seen as chilling enough. The challenge, then, is to anticipate what new forms of infectious malfeasance loom as the science behind biotechnology and nanotechnology, and the digital instruments of technology generate new ways of doing harm.

WIL LEPKOWSKI

SEE ALSO *Development Ethics; Engineering Ethics; Ethics: Overview; Office of Research Integrity; Tuskegee Experiment; Whistleblowing.*

BIBLIOGRAPHY

Caiden, Gerald E. (1988). "Toward a General Theory of Official Corruption." *Asian Journal of Public Administration* 10(1): 3–26.

Krimsky, Sheldon. (2003). *Science in the Private Interest: Has the Lure of Profits Corrupted Biomedical Research?* Lanham, MD: Rowman and Littlefield.

Rose-Ackerman, Susan. (1999). *Corruption and Government: Causes, Consequences, and Reform.* New York: Cambridge University Press.

INTERNET RESOURCE

Transparency International. Available from http://www.transparency.org.

COSMETICS

The term *cosmetics* comes from the Greek *kosmos* for order, referring in this case to the well-ordered face or appearance. Cosmetics are substances applied to the skin or hair to create a pleasing appearance. In the early-twenty-first century, they are alternately seen as the bane of modern women's existence (creating a time-consuming *third shift* [Wolf 1991] for women) and as a simple, popular tool for personal transformation. Some feminists deride the cosmetics industry as an ethically corrupt patriarchal institution that intentionally makes women feel that their natural faces are inadequate and exacerbates the identification of value with superficial appearance (Bordo 1995), whereas others cheer the liberating effects of bringing control over self-image and appearance within the grasp of every person. Ethical concerns raised in the history of the cosmetics industry remain and are exacerbated by technological innovations and the increasing consumer culture.

History of Cosmetics

The practice of painting and tattooing the body dates back to early-Neanderthal humans, when natural mud, ash, and natural dyes were used for not so much for enhancing beauty, but for camouflage, inspiring fear in others, and representation of animal gods in ritual ceremonies. In ancient Egypt, body painting focused on the eyes, with black antimony powder and green malachite lining used for protection from the sun as well as for decoration. Cosmetics and perfumes were used by both sexes in ancient Egypt and Rome. Later, in medieval Europe, strict religious norms identified cosmetics as the devil's work—a sign of vanity and deception. The Renaissance period brought cosmetics back in style, emphasizing the human ability to improve upon nature. In Elizabethan England, both sexes powdered their faces for a pale complexion, while women also used rouge and lip color, and covered the entire face with egg white for preservation. Men and women of the upper classes devoted significant amounts of money and time to maintaining an aristocratic appearance (Gunn 1973).

In *Hope in a Jar* (1998), social historian Kathy Peiss tells the story of the cosmetics industry in the United States. The American Revolution led to a rejection of the English tradition of wigs and facial powders as signs of aristocratic standing for men. Yet women's virtue continued to be linked with appearance. Women kept instructions for homemade cosmetics intermingled with potions for curing rashes and maintaining good health. Traditional family recipes (using household items such as oatmeal, lye, charcoal, and berries, among others) were commonly exchanged through social networks; for advice, one went to a friend or family member, not a pharmacist or physician. But more efficient and less risky substances were often available at the pharmacy, and soon women began buying special ingredients for their beauty concoctions. Pharmacists recognized an opportunity for packaging recipes of their own and selling them as finished products. Advertising created brand recognition and motivated women to seek the lifestyles they saw in print. Thus by the early 1930s, most women in the United States reported that *putting on a face* was a daily activity involving commercial beauty products (Peiss 1998).

Despite this increasing popularity for commercial cosmetics, early critics voiced concerns. Some questioned the monetary and time costs invested for such temporary results. Others expressed moral contempt for a practice that was viewed as an enemy of authenticity, a way to fake one's way into beauty. Early associations between cosmetics and women of low status (e.g., prostitutes and vaudeville showgirls) contributed to this distrust. Yet in a society that historically undervalued women's intellectual capacities and overemphasized their aesthetic value, the cosmetics industry flourished. Looking good was a ticket to increased social status. Even women who initially rejected cosmetics as an inappropriate solution to problems of inequality felt social pressure to use them. Similar pressures have more recently led to increased use of cosmetic surgery for women, the expansion of the cosmetics market to men's products, and biotech research into more effective and individualized cosmetics products.

As the cosmetics industry has become more dependent on science and technology, significant ethical issues have been highlighted, and termed *cosmethics*. The issues range from gender equity to safety concerns and animal testing. Codes of ethics have been formulated by the cosmetics industry to begin to address these issues as they arise in development, manufacturing, distribution, and advertising (ICMAD). In the United States, the Food and Drug Administration (FDA) does not require cosmetics safety testing prior to public sales because cosmetics are not considered drugs. However the FDA publishes guidelines for good manufacturing, and all cosmetics manufacturers must comply with the Food, Drug, and Cosmetic Act and the Fair Packaging and Labeling Act; products without substantiated safety must bear the warning, "The safety of this product has not been determined."

Equity Issues

The contemporary cosmetics industry was largely founded by women (e.g., Elizabeth Arden, Madam C. J. Walker), who recognized the opportunity to make use of recalcitrant appearance norms for their benefit (elevating women's status by turning men's weaknesses against them) and built on the tradition of women's home-beauty networks. Women who were overworked, underappreciated, lacked self-esteem, or simply desired attention for themselves were offered a medium through which to connect with other women, pamper each other, and share concerns. Furthermore women could experiment with new identities for themselves through the use of cosmetics. Such benefits continue to be heralded in the early-twenty-first century. Of course, for convenience, most women settle on a standard routine that best fits their sense of themselves. Thus, in order to maintain a *normal* appearance, they come to rely on regular purchases of the associated products. Consumer purchases are required simply to be oneself. How ironic that the product heralded as an opportunity for self-creation, self-care, and shared intimacy among women turns into a requirement of time, energy, and financial investment. In a society highly attuned to appearance, serious consequences ride on conforming to the norm: preservation of jobs, relationships, and self-esteem. Indeed the pernicious dynamic of commercialization and biased norms of appearance has resulted in studies showing that many contemporary women spend significant time each day applying cosmetics, find them essential to wear in a wide variety of circumstances, and believe that their attractiveness depends on cosmetics (Cash and Wunderlee 1987, Kelson et al. 1990).

Various cosmetics. Use of cosmetics for the purpose of enhancing beauty dates back to ancient Egypt. *(AP/Wide World Photos.)*

This situation is problematic for several reasons. First, although emphasis on men's grooming is increasing (Bordo 2000), the value placed on appearance is still decidedly greater for women than men. For women, the use of cosmetics is tied to social status and credibility in the workplace (Dellinger and Williams 1997). Second the image of beauty proclaimed by the industry is decidedly narrow, favoring a white, Western ideal, even when models are from different racial or ethnic groups (Perlmutter 2000, Bordo 1995). This imposition of one version of beauty on all reinforces the historically unjust social status of many women of color. The Western beauty bias can also be seen in scholarship on racialized uses of cosmetic surgery (Kaw 1993).

Safety and Animal Testing

To ensure that cosmetics are safe for human use, animal testing has been employed to determine toxicity and likely reactions to chemicals in the products. The LD-50 test (lethal toxicity for 50% of the animals tested) started in 1927 (Singer 1999) and was developed to determine the strength of various drugs for medical purposes. The testing quickly spread to other applications, including ingestion of lipstick and other cosmetics. It was an industry standard until the early 1980s, when animals rights groups pressured the industries to rethink both the efficacy and ethics of the test. Given species differences and drastic disparities in the amount and time frame for ingestion, the applicability of the test for human usage was unclear at best, and half the experimental animal populations had to die to complete the test. As one activist wrote, "The test defies common sense. Does one really need to know how many bars of pure Ivory soap kill a dog?" (Singer 1999, p. 10). Following public pressure, in 1985 the cosmetics industry moved to a limited test that feeds a smaller amount of the product to a smaller group of animals, and discontinues the study if no harmful effects are found. Similarly, since the 1940s, the Draize eye test has used conscious but immobilized rabbits to ascertain effects such as redness, blistering, and blindness that might result from direct contact of a cosmetic product with the eye. Rabbits' eyes are dabbed with the product, and observed over time to record eye damage and discomfort. Pressure from animal rights activists for alternative models to ensure safety convinced the industry to contribute its own funds to research aimed at refinement, reduction, and replacement of animal use. *Animal-free testing* now has marketing appeal as well as ethical grounding. In 2002 the European Parliament banned the sales of animal-tested cosmetics produced throughout the European Union, a ban that will, in the future, apply to animal-tested cosmetics produced in other areas of the world.

Although contemporary cosmetics has advanced significantly from the heyday of animal testing and the previous dangers of unregulated and untested products (e.g., in the Elizabethan period the use of ceruse, or white lead, for complexion whitening led to toxic reactions, sometimes with deadly consequences), the risks of cosmetic use have not been eradicated. Advances in science and technology have brought the advent of *cosmeceuticals* or beauty products designed to make use of medical and pharmaceutical advances for nonmedical purposes. These include Retin A-enriched facial cream to diminish wrinkles, baldness treatments, and other cosmetic products with biologically active agents. In the United States, this rapidly growing industry (Lamas 2003) is not subject to regulation and testing by the FDA because cosmeceuticals are not considered drugs (which affect the body's structure and function). Yet this claim is difficult to confirm without the very testing that has been waived due to the categorization scheme. Cosmeceuticals are often sold in the offices of dermatologists and other physicians, and may be easily mistaken for tested medical treatments by patient-consumers. Even overlooking the likely ethical conflict of interests, one wonders whether such new and improved cosmetic treatments really advance human options or instead quietly increase burdens, as people try to keep up appearances.

SARA GOERING

SEE ALSO *Affluence; Body; Consumerism.*

BIBLIOGRAPHY

Bordo, Susan. (1995). *Unbearable Weight: Feminism, Western Culture, and the Body.* Berkeley: University of California Press.

Bordo, Susan. (2000). "Beauty (Re)Discovers the Male Body." In *Beauty Matters,* ed. Peg Brand. Bloomington: Indiana University Press. Wide-ranging, accessible coverage of issues related to gender and the body.

Cash, Thomas, and James Wunderlee Jr. (1987). "Self-Monitoring and Cosmetics Use among College Women." *Journal of Social Behavior and Personality* 2(4): 563–566.

Dellinger, Kirsten, and Christine Williams. (1997). "Makeup at Work: Negotiating Appearance Rules in the Workplace." *Gender & Society* 11(2): 151–177.

Gunn, Fenja. (1973). *The Artificial Face: A History of Cosmetics.* New York: Hippocrene Books. Coverage of the world history of cosmetics from Neanderthal times through the twentieth century.

Kaw, Eugenia. (1993). "Medicalization of Racial Features: Asian American Women and Cosmetic Surgery." *Medical Anthropology Quarterly* 7(1): 74–89.

Kelson, Tamar; Ann Kearney-Cooke; and Leonard Lansky. (1990). "Body-Image and Body-Beautification among

Female College Students." *Perceptual and Motor Skills* 71: 281–289.

Lamas, Daniela. (2003). "The Business of Beauty." *Miami Herald,* September 23, p. 11E.

Peiss, Kathy Lee. (1998). *Hope in a Jar: The Making of America's Beauty Culture.* New York: Metropolitan Books.

Perlmutter, Dawn. (2000). "Miss America: Whose Ideal?" In *Beauty Matters,* ed. Peg Brand. Bloomington: Indiana University Press.

Singer, Peter. (1999). "Henry Spira's Search for Common Ground on Animal Testing." *Cambridge Quarterly of Healthcare Ethics* 8: 9–22. Interesting discussion of one individual's contributions to the animal rights movement.

Wolf, Naomi. (1991). *The Beauty Myth: How Images of Beauty are Used against Women.* New York: Bantam/Doubleday. Popular work on beauty and the pressures to achieve it.

INTERNET RESOURCE

Independent Cosmetics Manufacturer and Distributors, Inc. (ICMAD). Code of ethics available from http://icmad.org/join/codeofethics1.pdf

COSMOLOGY

The night sky is a primal wonder whose infinite nature spurs a longing to understand human existence. The realization that they are beneath a vastness and majesty beyond their personal experience impels people to attempt to know themselves and their place in all that there is. This is a religious impulse and is also the impulse behind cosmology.

From Astronomy to Cosmology

Cosmology is, however, a uniquely modern science of the history, structure, and dynamics of the universe. Although *astronomy* is a transliteration from the Greek, the word *cosmology* is a seventeenth-century coinage from an imaginary Greek term. It thus denotes a new, uniquely scientific way to deal with primal wonder about the night sky that was designed to replace the myths that represented primordial efforts to respond to that wonder.

The myths on which traditional societies were built were inspired by and speak to the origins of humankind and its place in the universe. Because the nature of the firmament is unknowable by the direct senses, until recently those myths were untestable and therefore perennial. The birth of technology changed that situation. Tools that take advantage of natural laws and allow humankind to manipulate those laws changed what was knowable. Systematic observations of the motion of the planets that were motivated by Tycho Brahe's (1546–1601) desire to find God's perfection in the sky led Johannes Kepler (1571–1630) to devise a model of the solar system with the sun at its center. Timepieces and levers set the stage for Isaac Newton's (1643–1727) grasp of gravity and its implications for the cosmos. Newton's calculus, a kind of conceptual technology, captured physical law with a generality and precision of unprecedented scope.

Today fossil light from the beginning of time is collected by immense machines both on the earth and in space and analyzed electronically to reveal the most intimate details of the universe and its beginnings. Modern cosmology weaves a creation story that passes the tests of science. The same methodology that has laid out physical truth and made possible the ability to control nature has allowed humankind to know the extent and origin of all that there is. In the process the inevitable imperial nature of science has taken over, displacing the old myths with cold certainty and weakening the ground beneath religions, belief systems, and structures of morality. As science replaces older foundational beliefs, it becomes complicit in the moral confusion of the modern age.

Can heaven survive the heat death of the universe? Will the cherished views of earlier cultures on the origin and meaning of human existence be another casualty of modern science? As astronomers divine the mysteries of the origin and evolution of the universe, are they culpable for the elimination of worldviews that may have had legitimate purposes but did not stand up to the scrutiny of scientific methodology?

The Emergence of the Big Bang Theory

In 1929 the astronomer Edwin Hubble (1889–1953) announced that the recessional velocities of galaxies are proportional to how far away they are. The farthest galaxies were said to be receding the fastest, as measured by the Doppler shifts of their emitted light. The Doppler shift is the stretching of light waves from objects that are receding from the earth at high velocity. Hence, distant galaxies appear redder. The constant of proportionality (between distance and recession velocity) became known as the Hubble constant. The implications of this relationship are profound. The simplest explanation of it is that at some time in the very distant past all the galaxies were packed together. The reciprocal of the Hubble constant is approximately the age of the universe: about 14 billion years.

How far back in time is it possible to see? What immense, sophisticated, and expensive instruments are required to see something as esoteric as the first light of the universe? In fact, one can see the radiation from the explosion of the Big Bang in almost every living room in the United States and almost any household in the world. All that it is necessary to do is to unplug the cable from a television set and set it to a channel where there is no broadcast. Part of that chaotic, somewhat disturbing pattern known as snow is the microwave echo of the Big Bang, which was released when the universe became transparent 200,000 years after it was born.

In 1965 Arnio Penzias (b. 1933) and Robert Wilson (b. 1936) of Bell Laboratories were working on a state-of-the-art antenna for the emerging technology of satellite telecommunications. Wherever they pointed their antenna in the sky, they heard a constant hum. In one of the most serendipitous discoveries in the history science, the cosmic microwave background (CMB) radiation had been found, and at a frequency exactly in agreement with the theory of the Big Bang (Sciama 1973). (Penzias and Wilson won the 1978 Nobel Prize for their discovery.) Since the Big Bang space has been cooling as it expands. If one runs the movie of the evolution of the universe backward to the point where all the galaxies coalesce, one finds that the "primeval egg" began expanding at nearly the speed of light 14 billion years ago. From the inferno of creation to the present the science of thermodynamics predicts that space should have cooled to 2.7 degrees Celsius above absolute zero. The frequencies Penzias and Wilson heard in the CMB correspond exactly to that temperature.

Cosmology and nuclear physics began to merge when scientists started to consider the first three minutes of the universe, a point made clear in Steven Weinberg's *The First Three Minutes: A Modern View of the Origin of the Universe* (Weinberg 1977). During that time all the fundamental particles—the neutrons, protons, and electrons that make up atoms and the rest of the fundamental particle zoo—were formed. As the universe expanded and cooled, mostly hydrogen nuclei were formed, but a fraction of them teamed with neutrons to make helium, deuterium, and lithium. According to nuclear physics, the relative amounts of each of these elements are quite sensitive to the conditions of the early universe. From that period of nucleosynthesis right after the Big Bang nuclear physics predicted that the universe should have been formed with about 76 percent hydrogen, 24 percent helium, and less than 1 percent heavier elements. In an affirmation of the Big Bang theory spectroscopists have shown that wherever one looks in the universe those ratios prevail.

With the evidence provided by Hubble's observation that the universe is expanding, the measurement of the CMB, and the correct prediction of nucleosynthesis during the first three minutes of the universe the Big Bang has been accepted as the real story of the universe. However, adjustments have been made to it.

The Structure of the Universe

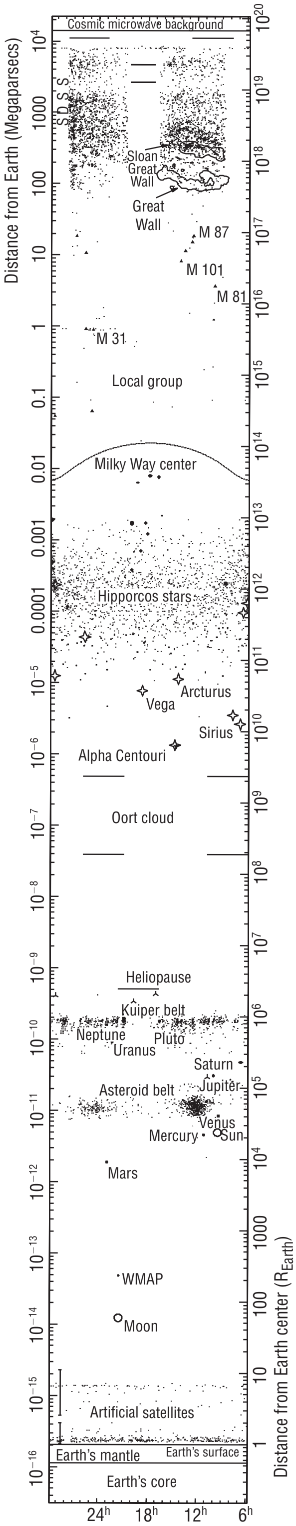
A map of the universe as it is currently understood is shown in Figure 1. The bottom of the chart shows the center of the earth, and the top represents the farthest that can be seen: the CMB. The scale is logarithmic so that any quarter inch on the chart represents ten times the distance of the quarter inch below it. Two populations of artificial satellites populate space immediately above the earth: low orbit satellites at about 200 miles and geostationary satellites at 23,000 miles. The planets, asteroid belt, and Kuiper belt can be seen in the bottom half of the chart. The Kuiper belt is a vast ring of large comets that orbit the sun outside Pluto. Midway on the chart is the Oort cloud, a much larger spherical shell of comets that are bound loosely to the sun. Nearby stars, galactic stars, and the center and edge of the galaxy follow as one moves outward. The Milky Way is part of the local group, a loose collection of about two dozen galaxies that are gravitationally bound. Beyond that is the large-scale structure of the universe. Galaxies fill the heavens in these vast reaches, but they are not randomly placed. Not only do they form clusters, there are coherent structures that are significant fractions of the size of the universe. The Great Wall is one such structure: a long filament of galaxies that is 300 million light-years from the earth.

In fact, the large-scale structure of the universe is foamy and filamentary, as shown in Figure 2 (Gott et al. 2004). In this figure each point represents a galaxy: The foamy nature of the universe can be seen out to 2.7 billion light-years in this diagram. The foam seems to become less dense farther from the earth or, equivalently, farther back in time. In fact, it extends as far back as can be seen. The blank wedge-shaped regions are places in the sky where it is impossible to see out of this galaxy. This is the plane of the Milky Way.

The foamy structure of the universe must be indicative of the small, quantum asymmetries that were imparted during the Big Bang. One can imagine that a perfectly spherical explosion would result in a smooth, uniform universe with no structure. However, somehow

FIGURE 1

A Map of the Universe



SOURCE: Gott, J. Richard and Mario Juric et al. for the SDSS Collaboration.

A map of the Universe (Gott et al., 2004). The vertical axis is distance on a logarithmic scale. At the bottom is th center of the Earth, and at the top is the most distant feature of the Universe, the Cosmic Microwave Background.

small asymmetries must have been present and were amplified by the force of gravity as the universe evolved and expanded. The structure that is seen is not consistent with the amount of matter and energy observed in the universe. There does not appear to be enough gravity to hold it all together, and this is where dark matter comes in.

Dark Matter

The direct evidence for dark matter is simple. Galaxies usually exist in gravitationally bound clusters of a few to several dozen. The motion of the galaxies around their common center, a matter of Newtonian physics, is completely inconsistent with the amount of matter that is seen. The motion of individual galaxies within a cluster can be explained only by the existence of an additional strong gravitational field. In fact, every galaxy or cluster must have a spherical halo of matter around it that is undetectable with electromagnetic radiation but is five times more abundant than the matter in the galaxies themselves. Little else is known about this mysterious cold dark matter, but its existence is generally accepted and there is an ongoing effort to detect it directly.

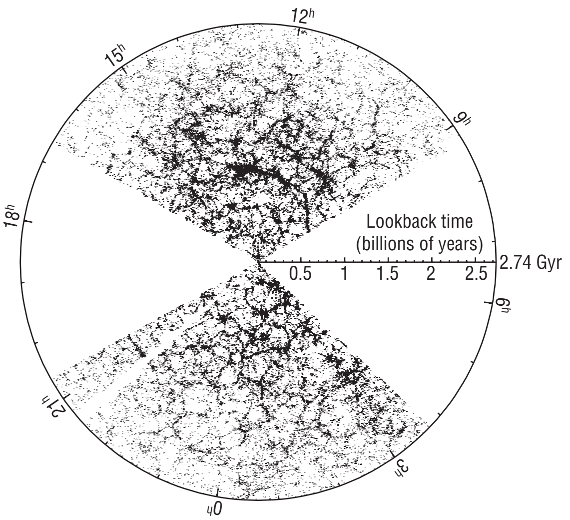
The Cosmic Microwave Background and Dark Energy

The microwave background also has structure. If the universe began as a microscopic primeval egg, it must have undergone vigorous quantum fluctuations in energy, shape, and even dimensionality. The imprint of those quantum fluctuations is seen in the spatial structure of the microwave background. To an incredible degree, however (about one part in a million), the microwave background is uniform. This implies that at one time the universe was small enough that it could come to thermal equilibrium but then grew rapidly, freezing in both the large-scale isotropy and the quantum fluctuations. This freezing in would have happened during an inflationary period when the universe accelerated outward at an exponential rate.

This is a decidedly nonintuitive move for a universe to make. What caused the universe to accelerate in the first place? In the old standard model of the Big Bang, without inflation, a prime mover is required, but only at the instant of creation. The explosion casts matter and

FIGURE 2

A Map of the Universe out to 2.74 Billion Light Years from the Earth



SOURCE: Gott, J. Richard and Mario Juric et al. for the SDSS Collaboration.

A map of the Universe out to 2.74 billion light years from the Earth (Gott et al., 2004). The scale is linear. Galaxies are represented by dots; the large scale, foamy, bubbly, filamentary structure of the Universe is visible. The blank wedges on the left and right are due to our lack of ability to see outside our own galaxy in these regions. They are in the plane of the Milky Way.

energy outward, expanding under this initial, unimaginable force but eventually slowing down as gravity pulls everything back to the center. The central question in cosmology at the start of the twenty-first century has been, What is the density of the universe? If the density is too low, gravity will never win and the universe will expand forever. If the density is high, beyond a critical point, the universe eventually will slow to a stop and begin to fall in on itself. The end is the Big Crunch, perhaps followed by reincarnation as the cycle begins all over again.

Neither of these scenarios appears to be the likely fate of the universe, however, based on the smooth nature of the microwave background radiation. Instead, the universe appears to exist in a state in between these scenarios, like a penny that has landed on its edge. It seems that the universe is flat, a spacetime geometry that means that the universe will continue to expand forever, although more and more slowly, approaching a stop at *t* equals infinity. The problem is that when one adds up all the mass and energy and dark matter, the universe is shy of the total amount required for a flat geometry by a factor of two.

This is where two problems are solved at once by the inflationary theory. There are quantum mechanical reasons to suspect that the vacuum itself has energy. That is, there is some underlying fabric that wildly undulates, popping fundamental particles into existence from nothing and swiftly returning them to the weave. Those particles have been observed, although the nature of the fabric and the energy it imparts to the vacuum remain mysterious. At one time the physicist Albert Einstein (1879–1955) postulated that energy, which he inserted into his equations as a cosmological constant. His goal was to produce a model of a steady-state universe, infinite and isotropic in time and space, largely because he felt that that was more aesthetically reasonable than a universe that began with a Big Bang. Although Alexander Friedman (1888–1925) showed that the Big Bang was a valid solution to Einstein's equations, Einstein abhorred that theory. However, he abhorred the ad hoc adjustment to his equations even more, and when the empirical evidence for a Big Bang could not be ignored, he declared the cosmological constant his biggest mistake. On new empirical grounds it must be included again, although a fundamental theory of its origins probably will require the achievement of a grand unified theory, a theory of everything, that string theory seems to promise for the future (Greene 2003).

This quantum vacuum energy is called the dark energy, and there is twice as much of it as there is of everything else that can be seen and measured. The dark energy has been implicated in the inflationary era of the universe and may have been the driving force for it. Still, aside from problems with identifying the quantum vacuum energy with the missing energy of the universe, the invention of the dark energy seems contrived.

There has, however, been an important recent discovery whose status has increased steadily. By very carefully measuring the red shifts, and hence the recessional velocities of galaxies deep into the universe, cosmologists have been able to map the evolution of the expansion rate of the universe. They have found that although the universe slowed down steadily after inflation, as a result of gravity, about 5 billion years ago it began to speed up again (Greene 2003). Today not only is the universe expanding, its expansion rate is increasing. The universe is accelerating, and something must be causing that. The culprit is the dark energy that permeates the vacuum.

The Story of The Creation

The newest creation story is surely not the final answer. A final theory will emerge only when there is a full understanding of how gravity is related to the other three forces and when the theories of gravitation and quantum mechanics are united. Enormous conceptual progress has been made with the development of string theory and its big brother, M (membrane) theory. String theory envisions particles as one-dimensional strings that vibrate not only in the known universe but also within six other hidden dimensions that are curled too small to be seen but that exist at every point in space (Greene 2003). A majority of cosmologists and theoretical physicists consider string theory the most promising and testable avenue for developing a true "theory of everything."

In the beginning there was an incredibly hot multidimensional nugget that was about one Planck scale (10^{-33} centimeters) in length. According to string theory, this Planckian egg is the smallest that anything can be. Squeezing it tighter makes it bigger and cooler. String theory avoids the singularity of the conventional Big Bang theory by considering the behavior of matter and energy at the very finest scales. It cannot say, however, what may have existed before this state, although this is an area of ongoing research.

The nugget had the entire mass of the universe in it, and it underwent transitions in its topography rapidly and randomly. Between 10^{-36} and 10^{-34} seconds after the start of time three dimensions suddenly broke free of their confining strings and inflated ferociously in a violent, exponential expansion. Alan Guth (b. 1947) of the Massachusetts Institute of Technology first showed that inflationary expansion of the universe represents a particular solution to Einstein's equations and can explain a deeply perplexing aspect of the CMB: its overall isotropy. The remaining dimensions stayed curled together, fundamentally influencing the nature of the particles and forces that became manifest in the three macroscopic dimensions. At one-hundred-thousandth of a second quarks began to clump into protons and neutrons.

Meanwhile, as the universe cooled, something strange was happening to the force within it. It was born with only one force, but as it cooled, it underwent phase transitions by which new forces were cleaved from the original one. Ultimately, for reasons that are not understood, the universe ended up with four forces: gravitation, electromagnetism, and the weak and strong nuclear forces. From a hundredth of a second to three minutes after the Big Bang the elements were formed. At 200,000 years the universe had cooled enough for stable atoms to form. In other words, the universe cooled from a plasma to a gas and became transparent. The photons streaming outward at that time are the blips seen on television sets.

Perhaps a billion years after the Big Bang galaxies began to form. The universe continued to expand at close to the speed of light, but the relentless action of gravity caused its expansion to slow. However, 9 billion years after the origin of the universe its expansion began to accelerate, most likely as a result of the repulsive force of the quantum vacuum energy. If this trend continues, the acceleration of the universe will cause galaxies to fly ever more rapidly away from one another. Some day even the closest galaxy will be too far away to see; the galaxies will be beyond the light horizon. Some day all the fuel for the stars will be used up, first hydrogen and then helium, carbon, and oxygen, until the last sun flickers and the universe is plunged into eternal darkness.

The Ethical and Political Dimensions of Cosmology

For many scientific disciplines the cause-and-effect relationship between scientific outcomes and the well-being of people is of great importance: Scientific results and their technological progeny are the dominant forces shaping the future of the world. The role science will play in determining the quality of life for every human being on the planet is of course determined by the elite that funds science. In this way all scientific enterprise is embedded in the greater moral problem of how individuals and groups should conduct themselves. Is it better for the powerful to channel their efforts solely for competitive self-benefit or to distribute knowledge and technology among all people? What are the consequences of pushing technologies on societies that may not want them? In some fields these issues spring directly from contemplation of the promise and implications of their projects. If it is possible to choose the human qualities of a person through genetic engineering, who will decide what those qualities will be, and to whose progeny will they go? Other subjects may be further afield, but the conceptual shift forced on science by the quantum nature of the infinitesimal in the 1920s has led to the most transforming technology in history: electronics.

Cosmology evokes a sense of the most benign and pure of sciences. The fascination of contemplating what is out there, combined with the fact that humankind cannot do anything to it, lends the study of space its alluring innocence. That of course is the old view. Cosmology is coming dangerously close to asking God rather direct questions.

To some degree scientific disciplines can be categorized by how influential ethics is thought to be in a particular field. Indeed, the ethical weight of astronomy, compared with that of genetics, lends it a kind of lightness and purity that is perceived by the people who fund it. Virtually everyone on the planet has gazed up and rested briefly in that human space where one wonders what it all is and what it all means. The pursuit of these wonders feels ennobling, partly because of the human space it comes from and partly because it is difficult to imagine how contemplation of the stars could alter the fate of humankind.

The modern science of cosmology is perhaps as far removed from the day-to-day concerns of humanity as any human endeavor can be. Futurists may conjure colorful uses for the discoveries of scientific research on the nature and origin of the universe, but this is not a matter of dealing with transistors or life-extending drugs. No one argues that cosmology is studied because of its economic impact. However, this does not mean that the study of the universe lacks an economic impact. The latest discoveries in astronomy have always depended on progress in computer, space, and detector technology (Tegmark 2002). Synergism between the astronomical sciences and industrial and military concerns is strong and growing, and both enterprises benefit.

Philosophical Issues

As self-aware beings people share a special, emergent property of the universe: consciousness. Is the quality of this aspect of nature in some way different from, say, the way space is curved as a result of the distribution of mass in the universe? What is special about the way living, replicating systems employ available resources to thrive, evolve, and produce beings that are capable of studying the deepest questions about their existence? Is mind a statistically unlikely property to have emerged from a universe with 1,000,000,000,000,000,000,000 solar systems? Or is the quality of mind ubiquitous and unifying like gravitation or other universal physical laws? Science is engaged in exploring the origin and nature of the universe as it never has before, along with the role of life and consciousness within it.

Every culture has a cosmology. Science has become the sine qua non of truth, and its revelations are taken as gospel. The insights of science into the nature of the universe therefore are assumed to or allowed to subsume all prior knowledge. It is incumbent on all scientists to ask whether their work leads to living together in harmony or interferes with that harmony. Where is the role of heart or spirit in the exploration of the cosmos or, for that matter, in any scientific endeavor? The scientific study of the origin and structure of the universe is a journey that has begun to yield answers to questions that once were the purview of religion and myth. What is done with this knowledge and what its ultimate meaning may be should be an essential component of the science of cosmology.

MARK A. BULLOCK

SEE ALSO *Astronomy*.

BIBLIOGRAPHY

Greene, Brian. (2003). *The Elegant Universe: Superstrings, Hidden Dimensions, and the Quest for the Ultimate Theory*, 2nd edition. New York: Vintage. A superb popular treatment of the physics of the ultra-small.

Gott, J. Richard; Mario Juric; David Schlegel; *et al.* (2004). *A Map of the Universe*. Princeton, NJ: Princeton University Press. Available from http://arxiv.org/abs/astro-ph/?0310571. An innovative approach to mapping the universe at all scales.

Sciama, D. W. (1973). *Modern Cosmology*. Cambridge, UK: Cambridge University Press. A classic text in cosmology.

Tegmark, Max. (2002). "Measuring Spacetime: From the Big Bang to Black Holes." *Science* 296: 1427–1433. A technical article by one of the leaders in cosmology.

Weinberg, Steven. (1977). *The First Three Minutes: A Modern View of the Origin of the Universe*. New York: Basic Books. A widely-read popular account of the role of nuclear physics in the origin of the universe.

COUNCIL ON BIOETHICS

SEE *Bioethics Commissions and Committees; President's Council on Bioethics*.

CREATIONISM

SEE *Evolution-Creationism Debate*.

CRIME

Crimes are commissions of acts that are publicly proscribed or the omissions of duties that thereby make offenders liable to legal punishment. More colloquially, a crime is any grave offense, particularly against morality, and thus something reprehensible, foolish, or disgraceful. Criminal behavior is in most cases unethical; it has also been subjected to scientific study in criminology. Technological change has in turn given rise to new forms of crime.

Legal Traditions

In some legal traditions, there is a distinction between *crimes* and *torts*. The former are offenses against the state or society that are enforced by agents of the state. The latter are offenses against specific citizens, which the machinery of the state will enforce only if victims pursue their grievances in the form of a civil suit. The boundary between these categories is fluid, as discussed below with respect to homicide's historical transition from tort to crime. In keeping with ordinary parlance, both sorts of offenses are considered here.

What qualifies as crime in both its technical and informal meanings is cross-culturally variable, because laws and norms are cross-culturally variable. Premarital sex, profanity, abortion, political dissent, alcohol use, homosexuality, littering, and remaining standing in the presence of the king are all crimes in some societies but not in others. Theories of crime are thus concerned not only with the causes of criminal behavior, but with social norms and the labeling of acts. However, the fact that what is considered crime varies between times and places does not imply that it is arbitrarily constituted. There is substantial overlap in the content of criminal codes, both written and traditional, from around the world. The acts that are most consistently criminalized are concentrated in a few principal domains: certain acts of violence, certain sexual acts, certain acts of expropriation, and certain betrayals of the collectivity to rival collectivities. In general, crime entails self-interested action that violates the interests of others.

Most crimes have identifiable victims, and for criminal sanctions to be widely accepted as legitimate and just, it is important both that the victimization was undeserved and that the offender behaved with inadequate consideration of the victim's interests. Law sometimes excludes consideration of whether a victimization was deserved when deciding an offender's guilt, but this is by no means generally true—consider the breadth of cases in which "provocation" can mitigate criminal responsibility—and even where it is true, the prevalent defense practice of "putting the victim on trial" suggests that desert is a more influential consideration than a literal reading of criminal codes might suggest. As for the offender, it is not enough in Anglo-American law that a wrongful act (an *actus reus*) was committed; there must also have been a wrongful intent (*mens rea*).

The essence of the *mens rea* criterion is that the wrong-doer was overvaluing his own interests and undervaluing those of others. The two principal justifications for criminal sanctions both demand such a criterion. If criminal sanctions constitute just moral retribution, then assigning culpability without reference to intent is wrong. Alternatively, if criminal sanctions are justified by their social utility, then punishing outcomes without regard to intentions is unlikely to deter antisocial behavior. However, the concept of *mens rea* is necessarily broader than just a specifically *malevolent* intent, because it encompasses reckless disregard for the well-being of others, thereby permitting the criminalization of acts such as drunk driving in which the perpetrator may have intended no harm to anyone but was still excessively overvaluing his own desires relative to the interests of others.

In modern nation-states, criminal offenses are considered offenses against the state and it is the state that prosecutes them. This practice has evolved historically from the "self-help" justice characteristic of traditional societies lacking professional police or judiciary, where victims or their relatives might demand material compensation or undertake retaliatory action in response to offenses against persons or property. Blood revenge in retaliation for homicide and persistent blood feuds between lineages are cross-culturally widespread manifestations of such self-help justice. The first step toward a criminal justice system occurs when a socially recognized power, such as a king or a council of elders, rules on the validity of grievances and hence the legitimacy of retaliation. Note, however, that punitive response remains in the hands of victims, with the consequence, for example, that killing someone who lacked family and friends would not be penalized.

It is only relatively recently that nation-states have assumed the responsibility (at least in principle) of punishing violations against all citizens. In Britain, for example, crimes became crimes against the state only after the Norman conquest of 1066, and even then, a murder victim's lord or kinsman might still negotiate monetary compensation from the killer or his/her kin. However, because such agreements did not affect prosecution by the crown and resultant fines, confiscation of the offender's belongings, and corporal or capital punishment, and because William the Conqueror also treated private retaliation as a crime, there was little incentive for a killer or his kinsmen to reach an accord with the victims. These practices gradually faded away, as did any central role for victims of crime other than as witnesses.

From the king's or state's perspective, blood revenge and feuds between powerful families were disruptive of social order, jeopardized the tax base, and weakened societal defensive capabilities against external threat. Why the citizenry succumbed to the rise of state authority also seems clear. An ideal of impersonal state-administered justice has been associated historically, and presumably causally, with a decline in the solidarity of kin groups and a rise in contractual relationships and individual responsibility. Impersonal justice is widely considered essential for keeping the citizenry safe from predatory victimization, and it certainly does extend the umbrella of protection to the relatively powerless. Moreover, even those with retaliatory and deterrent capability may welcome it. In the case of homicides, for example, the powerful as well as the weak may be relieved to relinquish the duty of vengeance, but only if they can trust the machinery of state to punish their enemies on their behalf.

Criminology

Although crimes always entail conflicts of interest, not all conflictual action is criminal. It follows that a general theory of crime requires both a theory of the nature of human interests and a theory of what legitimizes some, but not other, ways of pursuing self-interest at others' expense. The academic discipline of criminology arose primarily within sociology, and most theories of crime rely primarily on sociological concepts such as inequity, power, norms, legitimacy, and social control. Underlying psychological theories, in the form of assumptions about human desires, developmental susceptibilities, and social inferences, are typically more implicit than explicit, and at an even more basic level, criminological theories almost never explicitly address the origins and elements of a human being's interests, which must be identified before one can recognize violations thereof. Arguably, this question is within the domain of evolutionary biology, which provides the only relevant scientific theory, namely that the apprehension of where one's interests reside has evolved to promote Darwinian fitness within the circumstances prevailing in ancestral environments. This level of analysis is uniquely able to shed light on such questions as why rape is considered a particularly horrific violation regardless of attendant physical trauma, why men are more likely than women to respond violently to social disadvantage, why maternally perpetrated infanticide is widely considered a less heinous offense than other homicides if indeed it is an offense at all, and why adultery is a sexually asymmetrical offense defined as sexual contact between a married woman and a man other than her husband in all premodern legal codes.

Psychological science is primarily concerned with elucidating the mental and behavioral processes characteristic of a prototypical human being: how memories are laid down and retrieved, how people make probabilistic inferences, what emotions people all share, and so forth. A secondary focus of psychological science is the elucidation of how individuals differ. Both lines of inquiry are relevant to understanding crime.

At the panhuman level of analysis, psychologists investigate basic mental processes, and attempt to explain historical, cultural, and ecological variability in behavior as contingent products of a universal psychology's responses to variable circumstances and experiences. Anger, for example, is a motivational/emotional state that can be elicited in any normal person, with characteristic effects on physiology and information processing; it plays a role both in mobilizing physiological resources for violent action and in advertising one's likelihood of engaging in such action. Note that these claims entail hypotheses about the functions of being angry. A psychologist who assumes, for example, that the principal function of the psychophysiology of anger is to mobilize the organism for effective physical assaults will look for a somewhat different set of manifestations and social controls than another who instead assumes that anger functions primarily to threaten and deter so as to limit the costs of violent confrontations. Within this universalist research tradition, the reasons why people vary in their frequency and intensity of anger are to be sought in the social and material forces impinging upon them.

Notwithstanding advances in the understanding of how this universal human response operates, both centrally and peripherally, it is also evident that individuals differ in their responses to identical circumstances and stimuli. Whether these differences can be attributed to the cumulative effects of prior experiences acting on a universal human nature, or instead require a different sort of theory of individual differences, is not always apparent. Psychiatrists have identified a personality type that is disproportionately responsible for crime, especially violent crime: the "antisocial personality." Risk factors associated with the development and maintenance of antisocial personality include poverty, maleness, early maturity, poor school performance, parental criminal history, and psychopathology, implying that antisocial personality is in large part a facultative developmental response to experiential indicators of the lesser utility of developing a more "prosocial" personality. However, there is also evidence from twin and adoption studies that antisocial personality is substantially heritable, implying that individual differences in behavior are attributable to genetic differences.

Despite a large body of research on the genetics of crime, there has been relatively little consideration of this puzzle: why does genetic variability affecting phenomena such as criminal behavior exist? The reason for asking is because natural selection generally tends to eliminate genotypes with suboptimal phenotypic consequences, and one might expect that selection would have favored a panhuman phenotypic "design" with violence and other conflict behavior under appropriate contingent control. One possible answer to the puzzle is that heritable variation in antisocial behavior is a modern phenomenon and there has been insufficient time and/or fitness cost to eliminate the variability from human populations. A more interesting possibility is that antisocial personality types have social and material advantages in populations where they are rare and can exploit the trust and friendliness of the prosocial types.

Discussions of crime are often couched in the language of pathology. This is appropriate insofar as criminal acts reflect psychoses, delusions, and brain damage, but the language of pathology can mislead. Pathologies are failures of anatomical, physiological, and psychological adaptations, as a result of mishap, senescent decline, or subversion by biotic agents, such that the adaptations are no longer achieving the functions for which they evolved. The prototype of a pathology is a fracture: A broken bone can no longer perform its function. But crimes against people and property are not clearly pathological, and the term is certainly not applicable to violence in general. Violence is often well-regulated, self-interested behavior, and there are parts of the normally-functioning human brain that are dedicated to the production of controlled violence. The misconception that human violence is pathological has perhaps been reinforced by studies linking it to disadvantaged backgrounds and environments, but these associations are by no means universal. In nonstate societies, violence has been a prominent attribute of high-status men and a contributor to their social success. In modern state societies, the welfare of most people no longer depends on their own or their allies' violent capabilities, so violence is relatively rare and relatively likely to reflect psychological pathology. Nevertheless, disproportionate numbers of violent offenders are drawn from groups who lack access to the opportunities and protective state services available to more fortunate citizens, and who therefore find themselves in "self-help" circumstances much like those experienced by most people's ancestors.

Most crime is committed by men, and more specifically by young men. Criminologists and other social scientists have offered various hypotheses to explain these facts, but most of these hypotheses invoke local aspects of particular societies and thus provide no candidate explanation for the cross-cultural generality. Such consistently gendered behavior is better understood in terms of the different selection pressures confronting humanity's male versus female ancestors. There is morphological, physiological, developmental, and psychological evidence that humans evolved under chronic circumstances in which the variance in fitness was greater among males than among females: men had both a higher ceiling on their potential progeny and a higher chance of dying childless. In human beings, as in other animals, a higher variance in reproductive success has selected for a psyche that is more inclined to see life as a competitive contest with same-sex rivals, and is more willing to accept risks in the pursuit of material and social resources, including a willingness to embrace dangerous confrontations.

Criminal offenders have been characterized as lacking self-control and the capacity to delay gratification. In effect, criminal offenders tend to value the near future more highly, relative to more distant futures, than do law-abiding citizens. Discussion of these phenomena often presupposes that steep discounting of the future is dysfunctional, but an alternative view is that the human psyche has been designed by selection to adjust the discount rate ("patience") in relation to age, sex, and social and material circumstances. In this view, a short time horizon may be a rational response to information that indicates an uncertain or low probability of surviving to reap delayed benefits, and the sort of reckless, risk-accepting mindset that facilitates criminal acts may be aroused when the expected material or social profits from safer courses of action are negligible.

Variations in rates of crime are social phenomena, affected by sociological and demographic variables such as local cultural practices and the population's age structure. Elucidating exactly how and why these variables affect criminal acts by some and not other citizens is a project requiring interdisciplinary synthesis involving all social and biological sciences.

MARGO WILSON
MARTIN DALY

SEE ALSO *Death Penalty; Monitoring and Surveillance; Police; Science, Technology, and Law.*

BIBLIOGRAPHY

Gibson, Mary. (2002). *Born to Crime: Cesare Lombroso and the Origins of Biological Criminology*. Westport, CT: Praeger.

Hare, Robert. (1993). *Without Conscience: The Disturbing World of the Psychopaths Among Us*. New York: Pocket Books.

Wilson, James Q., and Richard Herrnstein. (1985). *Crime and Human Nature*. New York: Simon & Schuster.

CRITICAL SOCIAL THEORY

Critical social theory constitutes an effort to rethink and reform Marxist social criticism; it characteristically rejects mainstream political and intellectual views, criticizes capitalism, promotes human liberation, and consequently attempts to expose domination and oppression in their many forms. The extent to which science and technology may be associated with domination and oppression has been a major theme of critical theory.

Background and Method

Critical theory is not so much a particular theory as a tradition of thought historically associated with the Institute for Social Research, founded at the University of Frankfurt, Germany, in 1923. It is thus also commonly known as the Frankfurt School. The rise of Nazism forced Institute members into exile in 1933; the Institute then became affiliated with the Studies in Philosophy and Social Science program at Columbia University in New York City in 1935. The original school was reestablished in Frankfurt in 1953.

The Frankfurt School was a multidisciplinary group that included philosophers, sociologists, economists, political scientists, legal theorists, psychoanalysts, and others. Key members of the first generation were Max Horkheimer (1895–1973), Theodor Adorno (1903–1969), Erich Fromm (1900–1980), Herbert Marcuse (1898–1979), Leo Lowenthal (1900–1993), and Franz Neumann (1900–1954), with Walter Benjamin (1892–1940) as a close associate. Important members of second and third generations include Jürgen Habermas (a student of Adorno), Axel Honneth, Andrew Feenberg (a student of Habermas), Douglas Kellner, Steven Best (a student of Kellner), Albrecht Wellmer, Claus Offe, Nancy Fraser, and Martin Beck Matustik. Distributed now among institutions in the United States (Kellner is at the University of California in Los Angeles, Best at the University of Texas in El Paso, Fraser at the New School in New York) and Canada (Feenberg is at Simon Fraser University in Vancouver, British Columbia) as well as Germany, critical theorists have continued to include as part of their engagements with contemporary issues a critical dialogue with the works of Immanuel Kant (1724–1804), Georg Wilhelm Friedrich Hegel (1770–1831), Karl Marx (1818–1883), Søren Kierkegaard (1813–1855), Max Weber (1864–1920), Gyorgy Lukács (1885–1971), and Sigmund Freud (1856–1939).

The key method of critical theory is *immanent critique*, which focuses on the internal tensions of the theory or social form under analysis. Using immanent critique, critical theorists identify the internal contradictions in society and in thought, with the aim of analyzing and identifying (a) prospects for progressive social change and (b) those structures of society and consciousness that contribute to human domination. Critical theorists aim to aid the process of progressive social change by identifying not only what is, but also identifying the existing (explicit and implicit) ideals of any given situation, and analyzing the gap between what is and what might and ought to be. When applying immanent critique to science and technology, critical theorists identify both oppressive and the liberatory potentials.

Regarding science and technology, all critical theorists hold that science and technology are intertwined into a single complex or realm of human activity that in the early twenty-first century is commonly called *technoscience*. Further, they believe that technoscience is not neutral with respect to human values, but rather creates and bears value. They argue that the tools people use shape ways of life in societies where technoscience has become pervasive. Hence, how individuals do things determines who and what they are, and technological development transforms what it is to be human. But while critical theorists agree that the apparently neutral formulations of science and technology often hide oppressive or repressive interests, they differ in their ideas about whether technoscience is of necessity a force for dehumanization, and if not, why and how it might serve as a force for greater freedom.

From Hope to Dystopia: Horkheimer and Adorno

One strand of the critical theory tradition contains an initially hopeful view that technoscientific progress might inevitably drive forward human progress and contribute to the realization of greater freedom. This later gives way to a dystopian view, in which technoscience is equated with domination. In the 1920 and 1930s, many members of the Institute adopted a rather orthodox version of Marxism, arguing that the socialist revolution is a natural and inevitable outcome of the internal contradictions of capitalism. In line with this idea, Horkheimer, the second director of the Institute and the person who first named the members' work "critical theory," argues that progress in the forces of production has created objective possibilities for human liberation. These possibilities have not yet been realized because capitalism limits the progress of science and technology and thus restricts human progress. For Horkheimer, only a social and political revolution can unleash greater progress in the technosciences and harness technoscience to the cause of human liberation (Horkheimer 1972).

INSTRUMENTAL DOMINATION. While in exile in the United States during the late 1930s and 1940s, Horkheimer and Adorno reconceptualized their views on science and technology. They came to believe that the project of the European Enlightenment has turned into a mythology, and that modern reason and modern autonomy are rooted in the domination of non-human nature, other humans, and people's inner lives (Adorno and Horkheimer, 2002). They claim that the ideal of the Enlightenment is an ever-larger rational conversation about goals, values, and desires that expands the realm of human knowledge and action. Thus, they believe, the Enlightenment is an effort to increase human freedom and self-determination. But the course of reason since the Enlightenment has been increasingly to refuse to think about real alternatives. Rationality becomes, they argue, reduced to instrumental thinking: that is, to reasoning about efficient means to already given ends. This mode of thinking—instrumental reasoning—has become, they argue, the mode of thought characteristic of western culture in general, and of the technosciences in particular.

As they investigate the increasing integration of economics and politics, they find that society is ever more structured around the capitalist value of profit making and the technoscientific value of efficiency. Technological advances, including the increasing fragmentation and mechanization of work tasks, transform the work process. Work becomes more repetitive and mind numbing; workers are ever more isolated from one another, and have ever less time to critically reflect on their work or lives.

Thus, for Adorno and Horkheimer, technoscientific development brings with it increasing dehumanization. Modern institutions and ideas, including transnational organizations and democracy, are shaped and guided by instrumental rationality, and exist primarily to preserve themselves. It is no longer possible to ask about, or critically evaluate, ends; these are taken for granted. Because only questions about means can be considered by instrumental rationality, questions about ends are now considered irrational. So the progress of Enlightenment reason, restricted to instrumental rationality, contradicts the very goal sought by the Enlightenment—the increasing liberation of human beings. And modern technoscience, which should contribute to greater human freedom, increasingly becomes a cage of our own making.

CULTURE INDUSTRY. According to Adorno and Horkheimer, technology now carries the values of capitalism and of a consumer society. They coin the term "culture industry" to signify the process of the industrialization of mass-produced culture and the commercial imperatives that drive the system. The culture industry creates distractions, and the semblance of freedom (such as through the choice of which TV show to watch, or which breakfast cereal to purchase). But it offers no real alternative and only serves to distract people from careful reflection on the conditions of their lives. Adorno and Horkheimer attempt to demonstrate that the products of the culture industry commodify and mechanize everyday life, and that consumers of popular culture accept the pre-given ends of their culture and worry about how to organize their lives to acquire as many of these goods as possible. Thus the values of efficiency and instrumentality that characterize the technosciences and industrial production slowly shape the whole of society.

They further claim that in contemporary culture there is little critical awareness of technology because what is thinkable is constrained to those options considered rational under a narrow instrumental definition of rationality. Thus it is difficult for people to think of technology as a bearer of values. The technosciences appear to be value neutral, and the values of efficiency and instrumentality seem to be the only values it is rational to adopt. Hence, the dominant conception of technoscience is as something good if in the right hands. Adorno and Horkheimer argue that so long as instrumental reasoning is the dominant mode of thinking in Western culture, then human liberation will be blocked. Further, because instrumental rationality characterizes the Enlightenment and subsequent cultures at their very core, and is at the essence of technoscience, then technoscience necessarily leads to domination and dehumanization.

This increasingly dystopian view of technoscience is reinforced by the exposure of the great depths of evil that technoscience produced in the service of fascism, and in the Soviet system. By focusing only on means, many engineers, scientists, and technicians made death camps more efficient and produced propaganda and weapons for the oppression and control of people. As Horkheimer and Adorno understand things, all of this was made possible by instrumental reason that comes to see everything, even human beings, as objects of study and manipulation. They see liberal capitalism as also a system of domination because the growth of the culture industry, and the spread of technocratic thinking, only spreads domination over inner and outer nature. This process is all the more insidious because it does not appear as domination, but rather as entertainment, or simply as reality.

AESTHETIC LIBERATION. There is, however, one sphere of culture, they argue, that resists instrumentalization, and this is the fine arts. The great artists have, in their works, preserved and exemplified autonomy, thereby resisting merely instrumental concerns. In his last great work Adorno develops a complex theory of aesthetic resistance as maintaining a critical function, and as preserving the last vestige of humanness in an increasingly technological and inhumane world (Adorno 1998).

There are many questions and responses to this version of critical theory and its dystopian view of technoscience. American pragmatists, especially John Dewey and Larry Hickman, develop a version of instrumentalism that, rather than rejecting critical reflection on the ends of activity, requires it. Pragmatists have further criticized Adorno and Horkheimer for their increasing disengagement from any projects of real social change. Another criticism is that the work of Adorno and Horkheimer is elitist and escapist, especially in recommending the highly formal and abstract work of artists such as Arnold Schönberg (1874–1951). Such a detached view fails to live up to the goal of decreasing oppression. From within critical theory, Benjamin, Marcuse, Habermas, and Feenberg all break with dire pessimism and offer theories of technoscience as potentially aiding human liberation.

Liberatory Possibilities

There is another strand of thinking about technoscience within critical theory, composed of those who reject the pessimism of Horkheimer and Adorno and who maintain that technoscience can be useful in fighting domination. As with critical theory as a whole, this tradition contains multiple particular positions, some of which are at odds with each other. All maintain, however, the method of immanent critique, and the commitment to a critical analysis of culture with the aim of aiding human liberation. The four strands of critical theory that identify liberatory possibilities in technoscience are:

(1) the idea that technological change will sweep away old and oppressive cultural forms (Benjamin);

(2) that technoscience is oppressive under capitalism, but might be otherwise under a different social order, and hence might embody different values (Marcuse);

(3) that technoscience has an internal logic appropriate to its own realm, but that it must be restrained or all of life will fall under its sway (Habermas);

(4) that technoscience always contains internal contradictions, and thus always contains potentials both for oppression and liberation (Feenberg, Kellner, and Best).

WALTER BENJAMIN. The idea that technological change might sweep away oppressive aspects of culture is most clearly stated by Benjamin. For him, there are progressive possibilities in new technologies of cultural production, especially film, radio, and photography. Traditional forms of art maintain their cultural power through the aura of the authentic original. This gives the great works of art a mythic status that has served to present, maintain, and further the power of some, such as the church, the wealthy, and the state, over others.

Benjamin argues that the technologies of mechanical reproduction break down the aura and shatter the myth of authenticity. For example, not only is it difficult to determine which, if any, photographic print is the original, but also mechanical reproduction allows people to replicate the great works from history. Thus high culture loses its mystifying power. Further, media culture could cultivate individuals better able to judge and analyze their culture. By processing the flow of images in film, people develop the ability to better parry and comprehend the erratic and powerful flow of experiences in industrialized, urbanized societies. For Benjamin, the buildings, pictures, and stories of avant-garde artists, work that was often highly dependent on technology, was a form in which humanity was preparing itself to survive even the darkest night of fascism.

HERBERT MARCUSE. The position that technoscience is oppressive under capitalism, but might be otherwise, is clearly articulated in the work of Marcuse. Unlike Adorno and Horkheimer, who see technoscience as having a necessarily oppressive essence, Marcuse believes it is possible to identify and understand the specific historical and social forces that lead to oppressive technoscience.

Under capitalism, Marcuse argues, technology produces a mass culture that habituates individuals to conform to the dominant patterns of thought and behavior, and thus provides powerful instruments of social control and domination. This is so, he claims, because under capitalism, technology reflects particular class interests in what he calls a "one-dimensional society" (Marcuse 1964). Consumer culture, which is made possible by the rapid advances of the technosciences, is seductive, and sexually charged, while work is ever longer and more soul-killing. Rather than the sublimation of desire discussed by Freud, which leads to the great and meaningful products of human culture, Marcuse identifies a process of repressive desublimation in which everything becomes sexualized, but meaning and satisfaction are ever more elusive.

However, for Marcuse, technology could, through its advance and transformation, mechanize most socially necessary work, and thus free human beings for greater creative self-expression and social experimentation. Technology would cease to be autonomous, as it is in the one-dimensional society, and would become subordinate to a substantive notion of the good life, one that is fundamentally aesthetic in nature. Marcuse has an aesthetic model of human beings as free, self-creative beings. He believes that only spontaneous creative activity could break out of the one-dimensionality of life under capitalism. Hence, a new form of technoscience, one that embodies not mere instrumentality, but also allows for spontaneity and creativity, might further human liberation. Because of the centrality of one-dimensional intrumental rationality in modern society, Marcuse hypothesized that the likely sources of the ideas and energies for radical social change, including new forms of science and technology, would come not from the working class as traditionally conceived, but would be found in those most marginalized in society—people of color, women, and the disenchanted young. Among others, Angela Davis was both inspired by, and inspiration for Marcuse's work.

Critics rightly note that this alternative is highly speculative and underdeveloped. In his development of still another strand of critical theory that sees technoscience in a potentially positive light, Habermas criticizes Marcuse's position as hopeless romanticism, and one that dangerously will restrict the careful use of instrumental reasoning in the areas where it is appropriate to use it.

JÜRGEN HABERMAS. The third version of critical theory that views technoscience as having some liberatory potential is exemplified in the work of Habermas. He argues that technoscience brings great benefits to humans in modern cultures, and that insofar as it is concerned with technoscientific questions it should remain true to its own internal values. A problem arises when individuals allow technoscience and technoscientific values to take over other realms of human life that should not be organized around values of productivity and efficiency. Habermas criticizes the tendency of modern societies to subject all areas of human life to instrumental reasoning. For example, the sorts of thinking best suited to determining how to build a bridge are not the same as those best suited to nurturing friendship, neither are the skills and modes of thinking that characterize consumption those best suited to responsible citizenship. Habermas claims that it is dangerous to allow the values of either realm to seep into the other. On the one hand, the result is dehumanization of human relationships, and many of the destructive possibilities identified by other critical theorists. On the other, the consequence is bad science, and the pursuit of technical knowledge will be subordinated to ideology. Thus, technoscience, properly constrained, is necessary to human liberation, and to decreasing suffering and oppression.

Some critics argue that his position offers no concrete criteria for changing technology. Others claim that his position is hopelessly naïve, and that the technosciences cannot be constrained in the manner he suggests, so that Habermas's theory is actually a justification of the status quo.

ANDREW FEENBERG. The most recent work in critical theory of technology adopts a fourth position and argues that technoscience always contains contradictory possibilities. This is so because there are many dimensions to technoscience, many of which traditional accounts fail to identify. For this reason Feenberg argues that technology should be reconceived of through instrumentalization theory. This theory distinguishes between the understanding of technology by technical experts and philosophers of technology, and the understanding of technology within a specific social context by those who use it and are affected by it. Users of technology often deploy it in unintended and often unanticipated but imaginative ways. These uses often challenge existing technological systems and social orders. By better understanding and developing these contradictory potentials, he argues, the critical theorist can further the goal of assisting the cause of human liberation. Feenberg continues the Frankfurt school interest in popular culture, but is more sensitive to the political complexity of contemporary culture, and thus to the ambipotent nature of technological change. His work engages not only theorists such as Habermas and Heidegger, but included empirically rich case studies of French communications technologies, Japanese conceptions of technology, science fiction, and film. Feenberg returns the tradition of critical social theory to its multi-disciplinary roots, and is active in empirical research on the development and uses of technology, especially educational technologies.

DOUGLAS KELLNER AND STEVEN BEST. Kellner and Best bring critical theory into dialogue with postmodern and poststructuralist thinkers such as Jean Baudrillard, Michel Foucault, and Arthur Croker. Along with Feenberg, they also bring critical theory into dialogue with the pragmatist tradition. Kellner and Best also continue and revitalize the tradition of culture industry critique. However, unlike Adorno, they work to identify the contradictory potentials present in popular culture. Kellner has long explored the oppositional possibilities within technology, especially in alternative media and education. Best is also expanding critical theory into environmental philosophy.

Assessment

Contemporary critical theorists agree that there are liberatory possibilities in technoscience, but only the careful use of human will and consciousness can bring these to fruition. The future of critical theory promises an ever-greater dialogue with other applied traditions in philosophy, especially with pragmatism. Although some, such as Larry Hickman, have argued that critical theory is still too tied to an anti-technology paradigm that limits its practical usefulness, critical theorists are becoming more involved in concrete issues, from the alternative media work of Kellner to the work on computer-based learning of Feenberg, and this trend too promises to make critical theory more empirically rich, and thus better able to work toward the goal of increasing the realm of human freedom.

J. CRAIG HANKS

SEE ALSO *Autonomous Technology; Capitalism; Efficiency; Fascism; Freedom; Habermas, Jürgen; Marcuse, Herbert; Marxism; Marx, Karl; Neutrality in Science and Technology; Popular Culture; Socialism; Utopia and Dystopia; Work.*

BIBLIOGRAPHY

Adorno, Theodor. (1983). *Negative Dialectics*. New York: Continuum. Explores the limits of conceptualization, and hence of any instrumental understanding.

Adorno, Theodor. (1998). *Aesthetic Theory*, trans. Robert Hullot-Kentor. Minneapolis: University of Minnesota Press. Adorno's account of how the aesthetic dimension offers the possibility of resistance to instrumental rationality.

Adorno, Theodor, and Max Horkheimer. (2002). *Dialectic of Enlightenment*, ed. Gunzelin Schmid Noerr, trans. Edmund Jephcott. Stanford, CA: Stanford University Press. An account of how enlightenment rationality turns in on itself and leads to an irrational society.

Benjamin, Walter. (1968). *Illuminations*, ed. Hannah Arendt, trans. Harry Zohn. New York: Harcourt, Brace & World. Collected essays, including his important work on art in the age of mechanical reproduction.

Feenberg, Andrew. (1995). *Alternative Modernity: The Technical Turn in Philosophy and Social Theory*. Berkeley: University of California Press.

Feenberg, Andrew. (1999). *Questioning Technology*. New York: Routledge. A critical account of philosophy of technology and of the possibilities of democratic interventions in the course of technology.

Feenberg, Andrew. (2002). *Transforming Technology*. New York: Oxford University Press. An examination of the multivalent possibilities of technological change and its effects on labor, education, the environment, and politics.

Habermas, Jürgen. (1970). *Toward a Rational Society: Student Protest, Science, and Politics*, trans. Jeremy J. Shapiro. Boston: Beacon Press. An early explication of Habermas's account of positive possibilities of science and technology, offered in the context of a discussion of education, science, communication, and political action.

Habermas, Jürgen. (1971). *Knowledge and Human Interests*, trans. Jeremy J. Shapiro. Boston: Beacon Press. Habermas discusses the quasi-transcendental anthropological interests in communication, survival and control, and liberation, and how these interests shape our quest for knowledge.

Habermas, Jürgen. (1984–1987). *The Theory of Communicative Action*, 2 vols., trans. Thomas McCarthy. Boston: Beacon Press. Habermas works out implications of, and revises, his account of communicative rationality, and thus the promises and limits of science and technology.

Habermas, Jürgen. (2003). *The Future of Human Nature*. Cambridge, UK: Polity. A critique of biotechnology.

Horkheimer, Max. (1947). *The Eclipse of Reason*. New York: Continuum. An extended argument that objective reason has been overcome by partial, instrumental, and subjective reason.

Horkheimer, Max. (1972). *Critical Theory: Selected Essays*, trans. Mathew J. O'Connell. New York: Herder and Herder. Critique of instrumental rationality, and his important account of how critical theory differs from traditional theory.

Kellner, Douglas, and Steven Best. (2001). *The Postmodern Adventure: Science, Technology, and Cultural Studies at the Third Millennium*. New York: Guilford Press. A critique not only of post-modernist celebrations of science and technology, but also a critique of wholesale rejections of science and technology.

Marcuse, Herbert. (1955). *Eros and Civilization: A Philosophical Inquiry into Freud*. Boston: Beacon Press. Marcuse brings Freud and Marx together and examines ways in which contemporary society deals with desire.

Marcuse, Herbert. (1964). *One Dimensional Man*. Boston: Beacon Press. A discussion of how an affluent capitalist society can buy off, or co-opt, its members and thus diffuse opposition. Central is an account of the force of instrumental rationality and how contemporary science and technology restrict thinking and creativity.

Marcuse, Herbert. (1978). *The Aesthetic Dimension*. Boston, Beacon Press. Marcuse's argument that art can transform how people see the world, and offers help in imagining new and better possibilities.

CRITICAL THEORY

SEE *Critical Social Theory*.

CULTURAL CRITICISM

SEE *Anglo-Catholic Cultural Criticism*.

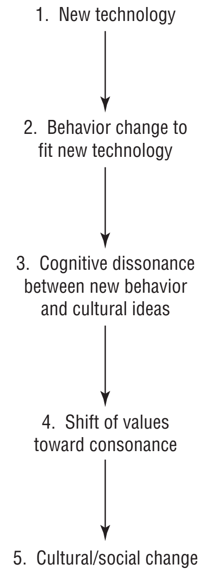
CULTURAL LAG

The U.S. sociologist William F. Ogburn (1886–1959) developed the concept of cultural lag, which occurs when unequal rates or degrees of change between interdependent parts of culture leads to "maladjustment" (1922). According to Ogburn, as new inventions are introduced into society, a maladjustment occurs and a period of adjustment is required. Most often these inventions are technological in nature, and are part of what he termed "material culture." However, Ogburn noted that "non-material culture" can also drive change. For example, he cites India in the early years of Buddhism as a case where religion was driving change in other areas of culture (1964).

Ogburn's classic description of technologically-driven cultural lag was the period required for society to adapt to the speed of the automobile (1964). It took some time for the social institutions and customs of road building to adapt to the ability of new cars to travel much faster than horses and older car models. A more pressing example is provided by the advent of nuclear

FIGURE 1

Relationship Between New Technology and Culture



SOURCE: Courtesy of Adam Briggle and Carl Mitcham.

weapons, which represent an enormous leap in scientific knowledge without a complimentary advance in political institutions capable of regulating and using that knowledge wisely. Another example is provided by the rapid advances in biomedical technologies and the ability of institutionalized ethics committees, such as Institutional Review Boards (IRBs) and Institutional Biosafety Committees (IBCs), to adapt to those changes and make wise decisions. The depletion of natural resources, especially oil, represents a broader interpretation of cultural lag, where changes in the material environment may outpace the cultural response to those changes.

Numerous other cases exist where science and technology have advanced more rapidly than the spiritual, social, or political aspects of culture. Indeed, the anthropological studies collected by Edward H. Spicer (1952) and H. Russell Bernard and Pertti J. Pelto (1987) document examples of a relationship that Bernard and Pelto simplify as shown in Figure 1. Such maladjustment can prove socially harmful.

However, the concept of cultural lag must be interpreted and applied carefully in order to avoid dubious assumptions about progress. First, it must be recognized that culture can also lead rather than follow. Many historical analyses of how modern science and technology arose in Europe after the 1500s, such as those by Max Weber (1904), Lynn White, Jr. (1978), and others, have argued that cultural change preceded technological change. Second, it need not follow that "lagging" aspects of culture must simply be altered in order to "catch up" with more rapidly changing elements. If applied interculturally, the concept can also promote Eurocentric assumptions about "underdeveloped" parts of the world, and lead to irresponsible transfer and application of technologies.

Several evaluations of cultural lag exist in terms of its ability to describe and predict cultural change (Brinkman and Brinkman 1997). More important, however, is the need to deconstruct any bias toward an inadequate notion of *progress* within the metaphor of cultural lag. It is intuitive that various parts of culture change at different rates and thus no longer fit together smoothly. Yet this does not necessarily mean that one part now "lags behind" another. The metaphor of *cultural lag* easily connotes the "failure" of different cultures or parts of culture to adjust to change, as if there were no agency or choice outside of simply running along the treadmill of material change.

In other words, as Alvin Toffler argues, cultural lag needs a balancing term of "future shock," which describes "the shattering stress and disorientation that we induce in individuals by subjecting them to too much change in too short a time" (1970, p. 4). Building directly off of Ogburn's concept, Toffler explains, "The concept of future shock ... suggests that there must be balance, not merely between rates of change in different sectors [of society], but between the pace of environmental change and the limited pace of human response. For future shock grows out of the increasing lag between the two" (p. 5).

He makes the argument that rapid change is neither indisputably good nor out of one's control to shape and sometimes slow down. The future can arrive too soon for society's own good. This highlights the central idea within cultural lag of proportionality, equilibrium, and harmony (the right adjustment) among the parts of culture. As Toffler argues, "The only way to maintain any semblance of equilibrium ... will be to meet invention with invention—to design new personal and social change-regulators. Thus we need neither blind acceptance nor blind resistance, but an array of creative strategies for shaping, deflecting, accelerating, or decelerating change selectively" (p. 331). Achieving this selective change is not a simple, technical matter of "catching up," but rather a series of decisions about the meaning of the good life and the ideal society.

ADAM BRIGGLE
CARL MITCHAM

SEE ALSO *Double Effect and Dual Use; Science, Technology, and Society Studies; Social Theory of Science and Technology; Unintended Consequences.*

BIBLIOGRAPHY

Bernard, H. Russell, and Pertti Pelto, eds. (1987). *Technology and Social Change,* 2nd edition. Prospect Heights, IL: Waveland Press.

Brinkman, R.L., and J.E. Brinkman. (1997). "Cultural Lag: Conception and Theory." *International Journal of Social Economics* 24(6): 609–627. Surveys and evaluates the theory of cultural lag and some of its applications.

Ogburn, William F. (1922). *Social Change with Respect to Nature and Original Culture.* New York: Viking. Ogburn's first systematic formulation of cultural lag as a part of his theory of social change, which is presented in the chapter "The Hypothesis of Cultural Lag."

Ogburn, William F. (1964). "Cultural Lag as Theory." In *On Culture and Social Change,* ed. Otis Dudley Duncan. Chicago: University of Chicago Press. A concise overview of the concept with several examples where lags accumulate as the result of rapid technological change. Also provides some background to its development and addresses criticisms.

Ogburn, William F. (1964). *On Culture and Social Change,* ed. Otis Dudley Duncan. Chicago: University of Chicago Press. A posthumous collection of 25 essays by Ogburn. Includes works on social evolution, social trends, short-run changes, and methods.

Spicer, Edward H., ed. (1952). *Human Problems in Technological Change: A Casebook.* New York: Russell Sage. Fifteen case studies, including the often cited "Steel Axes for Stone Age Australians" by Luriston Sharp.

Toffler, Alvin. (1970). *Future Shock.* New York: Random House. A 505-page book that argues that there can be too much change in too short of a time, and therefore peoples need to improve their ability to wisely regulate, moderate, and apply technology to serve human ends.

Weber, Max. (2001 [1904]). *The Protestant Ethic and the Spirit of Capitalism,* trans. Stephen Kalberg. Chicago: Fitzroy Dearborn.

White, Lynn Jr. (1978). *Medieval Religion and Technology: Collected Essays.* Berkeley: University of California Press.

CYBERCULTURE

In a restricted but popular sense, cyberculture denotes the hacker subculture along with various social and artistic manifestations; as such it references feedback loops, computer slang, video games, the Internet, hypertext, virtual communities, and more. In a wider and more argumentative sense, cyberculture refers to contemporary culture in its totality, insofar as it has been influenced by cybernetic technology and its creative ideas. In both senses cyberculture has become a new scientific and technological context that stimulates ethical reflection.

Historical Development

The term *cyberculture* appeared in the 1980s but is ultimately dependent on Norbert Wiener's creation of the science of "cybernetics" (1948). An initial cyberculture emerged before the term itself when the scholarly community attempted to apply cybernetics to the interpretation of phenomena in psychology, economics, politics, anthropology, and education. The work of Gregory Bateson (1972) and Heinz von Foerster (1984) in the development of "second-order cybernetics" was central to this development, as was the promotion of information and systems theory. In the Soviet Union cybernetics, after initially being rejected under late Stalinism as another form of bourgeois ideology, also exercised a special attraction as a possible means to reconcile central planning with the increasing complexities of large-scale systems that were straining under top-down management inefficiencies (Gerovitch 2002). Cyberculture in these senses was never so named, and was never more than an issue among specialist intellectuals.

A second-stage cyberculture emerged in science fiction from the mid-1980s. Bruce Bethke (in his 1983 short story "Cyberpunk"), William Gibson (in 1984's *Neuromancer*), and others developed a new form of science fiction; in opposition to classical science fiction, which had become somewhat domesticated, such authors introduced raw (punklike) elements and expressed a negative vision of the short-term future. Bruce Sterling (1986) provides a general introduction to this form of cyberculture. Promoted in part simply by the linguistic accident that *cyber* could be easily prefixed to anything from space to sex, cyberculture experienced a rapid inflationary moment in *cyburbia* and *cyberia, cyberphilia* and *cyberphobia*.

Science-fiction writer Neal Stephenson justified this inflation by declaring: "Our concept of cyberspace, cyberculture, and cyber-everything is . . . a European idea, rooted in Deuteronomy, Socrates, Galileo, Jefferson, Edison, Jobs, Wozniak, glasnost, perestroika, and the United Federation of Planets" (1994, p. 100). In this sense, cyberculture includes everything from science and technology to politics and literature as it has been altered by the mediation of computers, digital interactivity, and "hacktivism" (Himanen 2001). From such an amplified perspective, cyberculture is simply that culture which emerges through symbiosis with cybernetic or information technology, itself understood as the fulfillment of technoscience, after the manner of Martin Heidegger's identification of cybernetics as the ultimate stage of metaphysics (Heidegger 1972). Indeed, the methods of experimentation and logical analysis that are central to science have now been supplemented with simulation modeling that introduces something such as cyber-experimentation into science.

Using a distinction between culture (of and related to nature or the body) and civilization (of or related to politics and rationality), cyberculture may also be thought of as constituted primarily by those human interactions with the material world of advanced technological artifice that are replacing nature as the basic context for human experience. Cybertechnology in some form has come to exist in the background of all new political orders and rational discourse, and even encourages human beings to consider the ways in which they are becoming cyborgs (Haraway 1991) or posthumans (Hayles 1999).

The general examination of cyberculture in these disparate senses is found in cyberculture studies, which includes the more focused field of cyborg studies. According to David Silver, director of the Resource Center for Cyberculture Studies, this kind of activity has passed from popular promotion based on the image of a "cybernetic frontier" through an initial scholarly concern for sociological (virtual communities) and psychological (online identity transformation) implications, to what he terms "critical cyberculture studies." In critical cyberculture studies the ethical issues implicit in such works as Howard Rheingold's *The Virtual Community: Homesteading on the Electronic Frontier* (1993) and Sherry Turkle's *Life on the Screen: Identity in the Age of the Internet* (1995) become explicit themes.

Ethical Issues

The shift from description to critical assessment has taken place around four overlapping themes. First, questions are raised about the personal and environmental safety of cybernetic hardware. The silicon chip and carbon-zinc battery industries are not as obviously polluting as steel mills and chemical plants; they nonetheless present major challenges to worker safety and environmental contamination in both the production and disposal cycles. Safety and ergonomic issues are further associated with the use of screens (eyestrain) and hands (keyboard and mouse strain).

Second, critical issues are further associated with economic and political discussions of dot-com cyber-industries. Concerns for the economic and political impacts of automation extend into discussions about cybernation, cybercrime, accounting fraud, marketing hype, treatment of labor, and concentrations of wealth and power in the networked society. Debates about a possible digital divide also fit in this category. At the same time, Pekka Himanen (2001) has argued that a distinctive cyber-economics is growing out of the "hacker ethic" applied to business affairs using open-source software. Finally, questions of cyberpower have been posed in relation to adaptions of the Internet to enhance democracy, to plot or practice criminal and terrorist communications (including venial hacking or "cracking" and the launching of viruses), and to police those same communications.

Third, detailed historical, sociological, and psychological studies have attempted to contextualize the practices characteristic of cyberculture. Empirical case studies qualify both promotional hype and jeremiad alarms. Cybersex is not unexpectedly one of the most written about topics (see, for example, Ben-Ze'ev 2004). But cyberculture is revealed as not so much cut loose from culture as culture in a new form, full of subtle negotiations taking place between online and off-line worlds, yet still with persistent dangers. The standards of acceptable behavior in cyberspace—for online communications, for instance—are constructed in ways that mirror what happens in playgrounds or offices.

Fourth, the narratives of cyberculture call for aesthetic and literary criticism. What are the distinctive structures of motion pictures of the cyberfuture such as *Blade Runner* (1982), *The Terminator* (1984), and *The Matrix* (1999)? Is cyberart a distinctive form that enhances—or does it only exploit and entertain? Can computers write poetry? In what ways do such stories and productions inform or obscure the phenomena they both use and challenge? What distinctive roles do violence, glamour, sex, and speed play in cyberspace? The mass production of virtual pornography, including bestiality and pederasty, poses special questions for cultural criticism.

These four themes, along with issues of ethical responsibilities among cyberprofessionals and questions about the ontological status of cyberrealities, are included in an increasing number of books focused on cyberethics. (The Association for Information Systems nevertheless restricts "cyberethics" to information system ethics.) Although all these themes appear in other encyclopedia articles, their relations deserve to be highlighted here to emphasize synergies and interactions among the various dimensions of coming to ethical terms with the new life human beings are creating for themselves through cyberculture, whether narrowly or broadly defined.

ANDONI ALONSO
IÑAKI ARZOZ
CARL MITCHAM

SEE ALSO *Cybernetics; Information Overload; Science, Technology, and Literature.*

BIBLIOGRAPHY

Bateson, Gregory. (1972). *Steps to an Ecology of Mind: Collected Essays in Anthropology, Psychiatry, Evolution, and Epistemology*. San Francisco: Chandler.

Ben-Ze'ev, Aaron. (2004). *Love Online: Emotions on the Internet*. Cambridge, UK: Cambridge University Press.

Bethke, Bruce. (1983). "Cyberpunk." *Amazing Science Fiction Stories* 57(4): 94–105.

Gerovitch, Slava. (2002). *From Newspeak to Cyberspeak: A History of Soviet Cybernetics*. Cambridge, MA: MIT Press.

Gibson, William. (1984). *Neuromancer*. New York: Berkeley.

Haraway, Donna J. (1991). *Simians, Cyborgs, and Women: The Reinvention of Nature*. New York: Routledge.

Hayles, N. Katherine. (1999). *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*. Chicago: University of Chicago Press.

Heidegger, Martin. (1972). "The End of Philosophy and the Task of Thinking." In *On Time and Being*, trans. Joan Stambaugh. New York: Harper and Row. Originally published, 1964. For interpretation, see Herbert L. Dreyfus, "Cybernetics as the Last Stage of Metaphysics." In *Proceedings of the XIVth International Congress of Philosophy*, Vol. 2. Vienna: Herder.

Himanen, Pekka. (2001). *The Hacker Ethic, and the Spirit of the Information Age*. New York: Random House.

Jones, Steven G. (1997). *Virtual Culture: Identity and Communication in Cybersociety*. Thousand Oaks, CA: Sage.

Rheingold, Howard. (2000). *The Virtual Community: Homesteading on the Electronic Frontier*, rev. edition. Cambridge, MA: MIT Press.

Silver, David, and Donald Snyder. (2003). "Cyberculture and Related Studies." In *Education and Technology: An Encyclopedia*, Vol. 1, ed. Ann Kovalchick and Kara Dawson. Santa Barbara, CA: ABC-CLIO.

Stephenson, Neal. (1994). "In the Kingdom of Mao Bell; or, Destroy the Users on the Waiting List!" *Wired*, no. 2.02: 98–103, 128–132.

Sterling, Bruce, ed. (1986). *Mirrorshades: The Cyberpunk Anthology*. New York: Arbor House.

Turkle, Sherry. (1995). *Life on the Screen: Identity in the Age of the Internet*. New York: Simon and Schuster.

von Foerster, Heinz. (1984). *Observing Systems*. Seaside, CA: Intersystems Publications.

Wiener, Norbert. (1948). *Cybernetics; or, Control and Communication in the Animal and the Machine.* New York: Wiley. 2nd edition, Cambridge, MA: MIT Press, 1961.

INTERNET RESOURCE

Resource Center for Cyberculture Studies. Available from http://www.com.washington.edu/rccs/.

CYBERNETICS

Cybernetics is defined classically as the study of "control and communication in the animal and the machine" (Wiener 1948). After the decline of classical cybernetics, the field underwent a rebirth as "second-order cybernetics" in the early 1970s. Second-order cybernetics is more closely and more obviously involved with ethics than classical cybernetics (and certainly promotes a radically different worldview), but both have important contributions to make to reflections on science, technology, and ethics. Cyberculture, an increasingly important phenomenon that includes elements as diverse as email and chat rooms, electronic commerce and gaming, virtual reality and digital politics, has its origins not just in computers but also in the lesser known field of cybernetics (from which it takes its name).

Cybernetics

Cybernetics was originally promoted by the mathematician Norbert Wiener (1894–1964) in his 1948 book of that name (although W. Ross Ashby's 1956 book, *An Introduction to Cybernetics*, is considered the classic introductory text). The terms of cybernetics (including *goals* and *purposiveness*, *feedback*, and *mechanism as metaphor*) had been previously used, as was the concept of control as attaining and maintaining desired states, rather than restricting the actions of others—but not as concepts forged into a coherent field. In the development of cybernetics, two groups were particularly important: the informal association of Wiener, Arturo Rosenblueth (1900–1970), and Julian Bigelow (1913–2003) at the Massachusetts Institute of Technology (MIT); and the Josiah Macy Jr. Foundation meetings on "Circular, Causal, and Feedback Mechanisms" (which assumed the supertitle "Cybernetics" after the publication of Wiener's book), which included Warren McCulloch (1898–1969), Walter Pitts (1923–1969), Margaret Mead (1901–1978), Gregory Bateson (1904–1980), Heinz von Foerster (1911–2002), and Wiener and Rosenblueth.

The term *cybernetics* was derived from the Greek *kybernetes*, meaning "helmsman," and the field initially examined the behavior of (often complex) systems to develop models for improving system performance. The models were based on a notion of universally applicable mechanism: No essential differentiation was made between animate and inanimate systems. Examination of behaviors meant that systems which seemed impossibly complex or obscure no longer needed to remain so. If cyberneticians could not see what constituted a system, they could treat the system as a black box, which, through careful study of the inputs and consequent outputs, could be notionally "whitened" to the point that a viable mechanism relating input and output could be imagined, even if the actual mechanism remained unknown.

The intention was that systems would become controllable or better able to achieve the aims for which they were intended. The systems that cyberneticians studied were assumed to have observer-defined goals. Potential for error was understood to be omnipresent. To correct an aberration in the behavior of a system, differences between the (hypothesized) goal and behavior were examined, and the system adjusted to compensate for any difference (error). The process of error determination and correction continued until the system began to attain (and continue to attain) its goal.

Although the physical systems initially considered by cyberneticians were military and mechanical (starting with antiaircraft guns and developed through W. Grey Walter's electronic "tortoise" and Ashby's "homeostat," as much as through the computer and the robot), the animate quickly grew to be of equal significance. Application to social, anthropological, and psychological issues was pursued by Mead and Bateson (Bateson 1972a), especially in regard to mental health issues—a concern that Bateson shared with Ashby, also a psychologist. Management cybernetics was born of Stafford Beer (1926–2002) in the 1960s, and Gordon Pask (1928–1996) began cybernetic studies of teaching and learning in the 1950s.

There are many similarities between classical cybernetics and the slightly later mathematical theory of communication, or information theory, of Claude Shannon and Warren Weaver (1949); and general systems theory and its siblings, such as systems science, as developed by Ludwig von Bertalanffy (1950), making differentiation between these approaches difficult. Which term is used is frequently no more than a personal preference or historical accident. All of these approaches made notable contributions to such scientific and technological understandings and developments as the relationship between wholes and parts, automated control systems, approaches to complexity, developments in computing and communications hardware and software, and homeostasis in biological systems—to list but a few.

Early on, Wiener recognized ethical dangers in the cybernetic approach. The conjunction of animal and machine, even used metaphorically, has ethical implications—especially when the metaphor is predominantly of the animal as machine rather than the machine as animal. Another typical (and well-known) danger is that associated with the power of the machine, as exemplified, for example, in Isaac Asimov's "Three Laws of Robotics," from his science-fiction writings, which read:

First Law: A robot may not injure a human being, or, through inaction, allow a human being to come to harm.

Second Law: A robot must obey orders given it by human beings, except where such orders would conflict with the First Law.

Third Law: A robot must protect its own existence as long as such protection does not conflict with the First or Second Law. (Asimov 1942)

Wiener's *Human Use of Human Beings* (1950) is his attempt to come to terms with the most important of these dangers. He was not alone in this awareness. These ethical considerations, however, are not peculiar to cybernetics.

Second-Order Cybernetics

The initial promise of cybernetics was more than could be delivered, and the subject fell out of favor. By 1970 its funding base had eroded (with assistance from the Mansfield Agreement, a U.S. law introduced to prevent the military from funding any speculative research, or research that might not lead to an immediate military outcome). For some cyberneticians this indicated retrenchment, for others reconsideration leading to a new beginning: second-order cybernetics. The critical insight differentiating second-order cybernetics from classical (first-order) cybernetics is that second-order cybernetics takes cybernetic circularity more seriously.

Classical cybernetics exists within a worldview in which energy considerations reign paramount. The feedback loop is understood as requiring insignificant amounts of energy, thus creating a hierarchy. The controller, using relatively (and ignorably) little energy, controls the controlled, which is the big energy using part of the system. In second-order cybernetics, form and information are considered in preference to energy. In a second-order cybernetic control loop, the information passed between controller and controlled is understood to be of equal status. First-order hierarchy disappears. Each component in the loop contributes to the control of the whole. In effect, each component controls the other and the controller/controlled distinction is seen as a matter of role. The circular form of the cybernetic system is no longer disguised.

The difference was not initially presented this way. The originator of second-order cybernetics, von Foerster, made the following distinction on the frontispiece of his compilation "The Cybernetics of Cybernetics" (1975):

> First order cybernetics—the cybernetics of observed systems / Second order cybernetics—the cybernetics of observing systems.

These two characterizations, however, appear similar if one treats *observe* and *control* as interchangeable verbs, and remembers that the observing/controlling system is observing/controlling the observed/controlled system in order to develop understanding, which requires feedback. Furthermore, these concerns are similar to those expressed in the involved observer of Ernst von Glasersfeld's *Radical Constructivism* (1987).

The circular systems of Second Order Cybernetics are essentially autonomous. Their stability derives from their (internal) maintenance of their circular processes. To an external observer they may appear to veer wildly. An example is the Autopoietic system of Humberto Maturana, Francisco Varela and Ricardo Uribe. This system constructs and then maintains itself, providing a model of "life"—or, rather, "living." Such systems are said to be *organisationally closed* but *informationally open*: the form of the system maintains (distinguishes) itself, is in this manner autonomous (Maturana and Varela 1992). Information enters, passes through (is processed by) and exits it. The system distinguishes itself as itself. Because these systems are autonomous, any meaning the information passing through them may have is unique, private to each system. Communication between these systems cannot be by transmission of meaning because each system builds its own meaning: Meanings are not communicated. Uncoded communication may, however, occur through conversation. Pask's conversation theory (a formalized version of everyday conversation developed, initially, to support communication in learning environments) provides a structure to sustain communication that is formally equivalent to the other circular systems of second-order cybernetics (Glanville 1996).

Admitting autonomy and conversation requires a system that accepts that, individually, one sees differently and understand uniquely, while acting as though one believes the objects one observes are the same. Otherwise, one's relativism would lead to isolation because one has nothing communicable and there is no one to communicate with. Ranulph Glanville's theory of "Objects" (1975) provides the framework that allows individuals to believe they each make different observations of the world, yet can act as if observing the same "Object"—the essential conceptual basis making second-order cybernetics and its ethical implications viable.

Second-order cybernetics has made notable contributions in such areas of human understanding as learning, conversational communication, and the emergence of the unanticipated (often through conversational processes). In particular, through the concepts and mechanisms of autopoiesis, it has aided in the understanding of how social systems acquire stability. Nevertheless, second-order cybernetics is probably better thought of more as a way of understanding than as a technology.

Ethics

There are those who would argue that, perhaps more than any other scientific or technological field, second-order cybernetics constitutes an effort to develop a scientific basis for ethics. As such it constitutes an important contribution to any discussion concerned with science, technology, and ethics. This section sketches the basis of this contribution.

Second-order cybernetics' circular systems are autonomous—the starting point for the ethical implications of second-order cybernetics. Von Foerster was among the first to register the ethical dimension in his essay, originally published in 1973, titled "On Constructing a Reality" (von Foerster 2003a); even more relevant was his 1992 essay, "Ethics and Second-Order Cybernetics." (Von Foerster's 1993 German book *KybernEthik* originated the term *CybernEthics*.)

Von Foerster proposed two imperatives:

> Ethical imperative:/Act always so as to increase the number of choices. / Aesthetical imperative: / If you desire to see, learn how to act.

The ethical imperative insists that cybernetics has a dimension in ethics. Cybernetics implies generosity, increasing options. Von Foerster contrasted the essential meanness of morality (restrictions applied to others) to the generosity of ethics (which comes from within.)

The origin of this ethical concern can be seen to lie in the age-old question of what reality, if any, we can know independent of our knowing (i.e., is there a mind-independent reality [MIR]?). Although making a strong assumption of MIR is now commonplace, the question is in principle undecidable. Von Foerster remarked, "only we can decide the undecidable," leaving responsibility for answering this question (and, hence, for determining how we act) with each individual: one pursues whichever option one chooses. One's approach to one's world starts from this choice, which can be made once, or remade at will.

In second-order cybernetics, one's understanding of the world may be said to derive from a position of essential ignorance. The black box provides a mechanism for this. The understanding an observer builds through interacting with experience is (in the black box model) tentative: A reliable description of behavior emanating from the box may suggest it has been whitened, but nothing about the black box and our relationship to it has changed. It remains unopened (and unopenable)—provisional, as black as ever. Knowledge gained from using this model is based in profound ignorance. One cannot, therefore, insist on rightness and should tread warily, respecting the different views of others. The ethical implication of ignorance is respect for the views of others since one can never be certain, oneself. The views of others are considered as equal in stature to one's own—which does not mean theirs—or one's own—are either correct or viable.

Furthermore, the relationship between the behaviors (or signals), that is, the input and the output that black boxes are taken to act on—causing input to become output—results from interaction between observers and their own black boxes. Causality and its legal counterpart, blame, are seen to arise not from mechanism but from patterns observed by observers. The value of this understanding in how one acts cannot be overemphasized, and is confirmed in many psychotherapies that depend for their effectiveness on persuading people that the blaming causality they see is their construction and responsibility. It is not what happens to one that matters, but how one responds to it.

The black box model requires that one distinguishes: If there is no distinction between behaviors there is nothing to experience. In essence, why distinguish myself if I am alone? Distinguishing myself, I distinguish myself also from another. This act of distinguishing brings into being and implies mutualism:

whatever qualities may be attributed to one side of the distinction may (but need not) be attributed to the other. What I take for myself I may give you—this is von Foerster's ethical imperative again.

Distinctions, made in observing, can be considered a basis upon which observers construct experience, including experience of themselves. In order to assume experience is not solipsistic we assume that the other constructs (its experience of) itself (and us) in a reciprocal manner—another form of mutuality. Self-construction and maintenance indicate organizational closure: There is a boundary (it distinguishes its self) and the system is autonomous. An autonomous system is responsible. It has built itself, maintains itself (is organizationally closed), while it remains informationally open (communicates with its environment, thus substantiating the claim that, in distinguishing, one both distinguishes and distinguishes from). Bateson brings these ideas together when he uses the notion of difference (distinction) to define information: the difference that makes a difference (Bateson 1972b). The acceptance of responsibility grows out of autonomy (von Foerster 2003b): Autonomous systems are responsible for their actions. Here is the source of the aesthetical imperative.

There remains communication—that is, conversation. When communication is understood as individual construction of—and responsibility for—meaning and understanding by each participant (rather than the transmission of meanings and understandings), one can see that to understand the other one trusts the other's goodwill, acting with generosity, trust, honesty, and openness to build the understandings one will map onto each other's. This is an interaction. Teaching and learning (and much else beside) are interactive—the reason Pask developed conversation theory.

In turn, this understanding reveals that all one knows requires an observer's (knower's) presence, an understanding crucial in how one treats learning. Maturana said, "Everything said is said by an observer." Von Foerster retorted, "Everything said is said to an observer" (Von Foerster in Krippendorf 1979, p. 5). Respecting the observer is an ethical behavior.

Conclusion

Second-order cybernetics implies individuals are willing to treat each other, and (other, second-order) cybernetic systems, with a goodwill and generosity that can and should be understood as ethical implications. These go against some of the meaner understandings people currently and fashionably hold about their position in the world. Second-order cybernetics provides, in the ethical arena, hope and delight: those behaviors that are often considered higher, more civilized, and better are assumed and sustained in this way of understanding—a better-than-good reason for taking its lessons seriously.

RANULPH GLANVILLE

SEE ALSO *Automation; Cyberspace; Posthumanism; Science, Technology, and Literature; Wiener, Norbert.*

BIBLIOGRAPHY

Ashby, W. Ross. (1956). *An Introduction to Cybernetics*. London: Chapman and Hall. The most complete textbook introduction to cybernetics presented with simple profundity.

Asimov, Isaac. (1942). "Runaround." Reprinted in his *Robot Dreams*. London: Victor Gollancz, London, 1989.

Bateson, Gregory. (1972a). *Steps to an Ecology of Mind: Collected Essays in Anthropology, Psychiatry, Evolution, and Epistemology*. San Francisco: Chandler. Collected essays and commentaries from a multidisciplinary scholar who was one of the founding fathers of cybernetics, and whose writings can be seen to anticipate second-order cybernetics in several respects.

Bateson, Gregory. (1972b). "Pathologies of Epistemology." In *Steps to an Ecology of Mind*. An exploration of why we need the sort of shift that second order cybernetics embodies.

Glanville, Ranulph. (1975). *A Cybernetic Development of Theories of Epistemology and Observation, with reference to Space and Time, as seen in Architecture*. Ph.D. Thesis, Brunel University, 1975. Also known as *The Object of Objects, the Point of Points,—or Something about Things*.

Glanville, Ranulph. (1996). "Communication without Coding: Cybernetics, Meaning and Language (How Language, Becoming a System, Betrays Itself)." Invited paper in *Modern Language Notes* 111 (3): 441–462. Explores communication, language and meaning when the mechanism is conversation rather than code.

Glanville, Ranulph. (2002). "Second-Order Cybernetics." In *Systems Science and Cybernetics: The Long Road to World Sociosystemicity*, ed. F. Para-Luna. Oxford: Encyclopaedia of Life Support Systems (EOLSS) Publishers. One of the clearest explanations of a second-order cybernetic position and its epistemology.

Maturana, Humberto R., and Francisco J. Varela. (1992). *The Tree of Knowledge: The Biological Roots of Human Understanding*, rev. edition, trans. Robert Paolucci. Boston: Shambala.

Shannon, Claude, and Warren Weaver. (1998 [1949]). *The Mathematical Theory of Communication*. Urbana: University of Illinois Press. The classic text introducing what came to be called Information Theory.

Von Bertalanffy, Ludwig. (1950). "An Outline of General Systems Theory." *British Journal for the Philosophy of Science*

1: 134–165. One of von Bertalanffy's earlier papers discussing his proposals for a General Systems Theory.

Von Foerster, Heinz. (1979). "Cybernetics of Cybernetics." In *Communication and Control in Society*, ed. Klaus Krippendorf. New York: Gordon and Breach. Reprinted in *Understanding Understanding: Essays on Cybernetics and Cognition*, ed. Heinz Von Foerster. New York: Springer (2003).

Von Foerster, Heinz. (1991). "Ethics and Second-Order Cybernetics." In French in *Systemes, Ethique, Perspectives en therapie familiale*, ed. Yveline Rey and Bernard Prieur. Paris, ESF Editeur. Also in *Understanding Understanding: Essays on Cybernetics and Cognition*, ed. Heinz Von Foerster. New York: Springer (2003).

Von Foerster, Heinz. (1993). *Kybernethik*. Berlin: Merve Verlag.

Von Foerster, Heinz. (1995 [1975]). *The Cybernetics of Cybernetics*. Minneapolis: Future Systems Inc. A collection of cybernetic papers treated to cybernetic analysis providing a starting point for second order cybernetics. Von Foerster compiled and edited this collection, which was assembled by students at the University of Illinois and published by the publisher of the *Whole Earth Catalogue*, Stewart Brand.

Von Foerster, Heinz. (2003a). "On Constructing a Reality." In his *Understanding Understanding: Essays on Cybernetics and Cognition*. New York: Springer. Originally published in *Environmental Design Research*, Vol. 2, ed. Wolfgang F. E. Preiser (Stroudsburg, PA: Dowden, Hutchinson and Ross, 1973).

Von Foerster, Heinz. (2003b). "Responsibilities of Competence." In his *Understanding Understanding: Essays on Cybernetics and Cognition*. New York: Springer. Originally published in *Journal of Cybernetics* 2, no. 2 (1972): 1–6. The first venture into ethics by the father of second-order cybernetics.

Wiener, Norbert. (1948). *Cybernetics; or, Communication and Control in the Animal and the Machine*. New York: Wiley. 2nd edition, Cambridge, MA: MIT Press, 1961.

Wiener, Norbert. (1950). *The Human Use of Human Beings: Cybernetics and Society*. Boston: Houghton Mifflin.

INTERNET RESOURCE

Ashby, W. Ross. *An Introduction to Cybernetics*. Available from http://pespmc1.vub.ac.be/ASHBBOOK.html.

CYBERSPACE

Cyberspace is a term used to describe a new kind of "space" that has been made possible by the Internet. The word has a short but complex history with obscure and shifting meanings and constitutes a context for ethical issues related to science and technology.

In everyday life the notion of space is self-evident and denotes that, along with time, "in which" people live. In mathematics it refers to a collection of elements, such as points, that satisfy certain mathematical postulates. In both cases space is more given than created. In the first case, space is given, while in the second case it is a created, abstract space that people can understand conceptually but cannot directly experience.

The term *cyberspace* gained notice after William Gibson's use of it in his science fiction novel *Neuromancer* (1984). Through one of the novel's characters Gibson speaks of cyberspace as "consensual hallucination experienced daily by billions" of people, thus referring to a "non-real" space that is common to all. More specifically, he speaks about a "graphical representation of data" that emerges by abstraction from "every computer." One comes to be in cyberspace by turning a switch "on" and thus producing an instantaneous transition to it. Once there, people can enjoy the "bodiless exultation of cyberspace." Although they are somewhat confusing, these are powerful characterizations.

Background

The prefix *cyber* derives from *cybernetics*, a term coined by the mathematician Norbert Wiener (1894–1964) in 1948 to denote the study of control processes in machines and animals. That term was derived from the Greek *kubernetes*, meaning "governor" or "pilot." Cyberspace, then, is a kind of "controlled," humanly produced space.

Different Senses

In one of its senses cyberspace refers to the "spaces" associated with virtual reality, an advanced computer-based technology in which people wear headsets with stereoscopic displays, carry trackers that sense their motion, and use special input devices. With the help of those devices people navigate in "simulated" spaces, typically graphical representations of three-dimensional mathematical spaces. The integrated use of these devices creates an experience of immersion in a "virtual" reality, thus realizing an important aspect of Gibson's vision: that it is possible to enter into cyberspace, leaving the body behind.

In another sense, which became predominant in the mid-1990s, cyberspace refers to the integrated "space" made possible by the Internet, which is populated by large numbers of entities of various kinds and in which people perform multiple activities. Although this space does not support immersion, it brings to life another important ingredient of Gibson's cyberspace: the fact that it is common to all.

In *City of Bits*, William Mitchell approaches the Internet from the perspective of space and place and suggests that "the worldwide computer network—the electronic agora—subverts, displaces, and radically redefines our notions of gathering place, community, and urban life" (1995, p. 8). Mitchell proposes that the Internet is *antispatial* in the sense that it is "nowhere in particular but everywhere at once" and that it is *noncorporeal* because people's identity in it is "electronic" and disembodied. In addition, because of this disembodiment, the constructions others make of people in an effort to give those people an identity are *fragmented*. Also, the Internet favors *asynchronic* communication.

Increasingly, the word *Internet* is being invested with a broad meaning to encompass the notion of cyberspace in the second sense discussed above. For this reason ethical issues arising in cyberspace are covered under the entry "Internet." Other ethical issues are discussed in the entries "Cyberculture" and "Computer Ethics."

AGUSTIN A. ARAYA

SEE ALSO *Cybernetics; Internet; Space; Virtual Reality.*

BIBLIOGRAPHY

Gibson, William. (1984). *Neuromancer*. New York: Ace Books. This is a science fiction novel that became very popular among science fiction readers. It was also a source of inspiration for people working on certain advanced computer technologies.

Halbert, Terry, and Elaine Ingulli. (2002). *CyberEthics*. Cincinnati: West-Thomson Learning. A textbook on ethical issues that arise in the Internet and cyberspace. It combines analysis by the two authors with extensive reprints from works of several well-known authors in the area. Emphasizes a legal perspective and strives to present a balanced view of the issues by examining them from multiple viewpoints.

Mitchell, William J. (1995). *City of Bits: Space, Place and the Infobahn*. Cambridge, MA: MIT Press. Perceptive analysis of several dimensions of the Internet and cyberspace, made partly from the point of view of architecture, with its emphasis on space and place, and partly from the author's early experience with the Internet.

CYBORGS

A cyborg is a crossbreed of a human and a machine. The cyborg metaphor was coined by the astronautics researcher Manfred Clynes and the psychiatrist Nathan Kline (Clynes and Kline 1960, pp. 26–27), who argued that space travel required the development of "self-regulating human-machine systems." Such systems were termed cyborgs, from *cyb*ernetic technology and *org*anism. However, the term is not restricted to astronautics. Robotic beings that blur the distinction between humans and machines inhabit myriad science fiction novels and films, such as *Star Trek* (1979), *Robocop* (1987), *Blade Runner* (1982), and *Terminator* (1984). Above all, *cyborg* derives its intellectual influence from Donna Haraway's "Cyborg Manifesto (1985).

This manifesto rang in Haraway's presence as a leading theorist in the field broadly defined as science and technology studies. Haraway was educated as a primatologist, philosopher and historian of science and technology. In the early twenty-first century she teaches as a professor of the history of consciousness at the university at Santa Cruz, United States. In addition to a long list of essays, Haraway is the author of *Crystals, Fabrics and Fields* (1976), *Primate Visions* (1989) and most recently, the *Companion Species Manifesto* (2003), in which she revises her view of cyborgs by arguing that dogs are more important.

The Cyborg Manifesto is a complex, ironic, cacophonous text. Although it initially was addressed to feminist thinkers, it has had a considerable impact in the broader field of science and technology studies. It moves from reflection on the human condition in technological culture to a critique of politics and power relations. Haraway's critique includes current feminist strategies, which she describes as an extension of "identity politics" that defends fixed identities by victimizing the excluded. The manifesto argues for the pleasure of confusing identities. It invites feminists to play with ideas as hybridization and crossing boundaries.

People ceaselessly strive for an ordered world. Science and technology are considered as means to improve that ordering. But at the same time, they unwillingly destroy the ordering principles. As a result of findings in science, technology, and medicine, traditional binary oppositions between human and animal, organism and machine, nature and culture, man and woman, fact and fiction, body and mind, and subject and object increasingly have been blurred. Humans and animals more and more resemble cyborgs, with their bodies being equipped with pacemakers, dental prostheses, implants, and xenotransplants or modified by genetic engineering or cloning. Outside the body the dependency between living beings and machines has increased too.

The cyborg is not only a descriptive category. According to Haraway, the blurring of borders should be actively pursued. "By the late twentieth century, our time, a mythic time, we are all chimeras, theorized and fabricated hybrids of machine and organism; in short we are cyborgs. The cyborg is our ontology; it gives us our politics" (Haraway 1994, p. 150).

Cyborgs not only disrupt orderly power structures and fixed interests but also signify a challenge to settled politics, which assumes that binary oppositions or identities are natural distinctions. Actually those oppositions are cultural constructions. Haraway underlines the critical function of the cyborg concept, especially for feminist politics. The current dualistic thinking involves a "logic of dominance" because the parts of the dualisms are not equivalent. Thus, the logic produces hierarchies that legitimize men dominating women, whites dominating blacks, and humans dominating animals.

Instead, Haraway suggests that people should undermine these hierarchies by actively exploring and mobilizing the blurring of borders. "Perhaps, ironically, we can learn from our fusions with animals and machines how not to be man, the embodiment of western logos"(Haraway 1991b, p. 173).

This might suggest that Haraway simply reinforces what science and technology already do: blurring boundaries. But Haraway wants to make explicit the assumed identities and boundaries, whereas science and technology blur them in an implicit and unintended way in their strive for control of nature and order. This unintended blurring has also been articulated by the French philosopher Bruno Latour in "we have never been modern" (Latour 1993). Latour speaks about *hybrids*, which are mixtures of humans and nonhumans, like cyborgs. According to Latour, modern science and technology have caused a "proliferation of hybrids." Cyborg politics tries to escape the logic of dominance and its inherent essentialism: "Queering what counts as nature is my categorical imperative. Queering specific normalized categories is not for the easy frisson of transgression, but for the hope of lovable worlds" (Haraway 1994, p. 60).

The virtue of cyborg politics is that as soon as individuals acknowledge their identities and boundaries to be culturally constructed, they can reconstruct them in a more thoughtful way. And as soon as people acknowledge that their identity and that of others is necessarily fragmented, they can no longer dominate others, neither be dominated, Haraway asserts. Thus, the ironical play with boundaries is not without obligations. Players should take responsibility in reconstructing them (Haraway 1991a). The model of dominance should be replaced for a model of responsibility for other people as well as for machines. Like people, machines have no singular identity: "the machine is us, our processes, an aspect of our embodiment. We can be responsible for machines, *they* do not dominate or threaten us. We are responsible for boundaries, we are they" (Haraway 1991b, p. 180). However, how this responsibility towards machines and boundaries should be shaped in practice, remains unsettled in Haraway's work.

The philosophical importance of cyborg politics is not situated entirely in its anti-essentialism, for this is a common philosophical theme (Munnik 2001). Its importance is in the focus on the political potencies and challenges of technology crossing fundamental boundaries. Cyborg politics distinguishes itself from most critical approaches by not one-sidedly stressing the fearful risks of new technologies. By emphasizing peoples' responsibility of reconstructing identities, cyborg theory offers a radical and original approach toward the philosophy of technology.

MARTIJNTJE W. SMITS

SEE ALSO *Androids; Posthumanism; Robots and Robotics.*

BIBLIOGRAPHY

Clynes, Manfred, and Nathan Kline. (1960). "Cyborgs and Space." *Astronautics* 13: 26–27, 74–75.

Gray, Chris Hables, ed., with assistance of Heidi J. Figueroa-Sarriera and Steven Mentor. (1995). *The Cyborg Handbook*. New York: Routledge. Forty-three original and reprinted articles on the origin of the cyborg concept; cyborgs in engineering, medicine, and fiction; and cyborg anthropology and politics. The foreword is by Donna Haraway.

Haraway, Donna. (1991a). "A Cyborg Manifesto: Science Technology and Socialist-Feminism in the Late Twentieth Century." *Socialist Reviews* 8: 65–108. Included in Haraway's *Simians, Cyborgs and Women: The Reinvention of Nature*. New York: Routledge, 1991.

Haraway, Donna. (1991b). *Simians, Cyborgs and Women: The Reinvention of Nature*. New York: Routledge, 1991.

Haraway, Donna. (1994). "A Game of Cat's Cradle: Science Studies, Feminist Theory, Cultural Studies." *Configurations* 2(no. 1): 59–71.

Latour, Bruno (1993). *We Have Never Been Modern*. New York, Harvester Wheatsheaf. Translation of *Nous N'avons Été Modernes* (Paris: La Découverte, 1991).

Levidow, Les, and Kevin Robins, eds. (1989). *Cyborg Worlds: The Military Information Society*. London: Free Association Books.

Munnik, René. (2001). "Donna Haraway: Cyborgs for Earthly Survival?" In *American Philosophy of Technology. The Empirical Turn*, ed. Hans Achterhuis. Bloomington: Indiana University Press.

Smits, Martijntje. (2002). *Monsterbezwering*. Amsterdam: Boom.

ENCYCLOPEDIA OF science technology AND ethics

EDITORS AND CONSULTANTS

ENCYCLOPEDIA OF science technology AND ethics

EDITED BY
CARL MITCHAM

volume
2
d–k

MACMILLAN REFERENCE USA
An imprint of Thomson Gale, a part of The Thomson Corporation

THOMSON GALE™

Detroit • New York • San Francisco • San Diego • New Haven, Conn. • Waterville, Maine • London • Munich

THOMSON

GALE

Encyclopedia of Science, Technology, and Ethics

Carl Mitcham, Editor in Chief

For more information, contact
Macmillan Reference USA
An imprint of Thomson Gale
27500 Drake Rd.
Farmington,
Hills, MI 48331-3535
Or you can visit our Internet site at
http://www.gale.com

LIBRARY OF CONGRESS CATALOGING-IN-PUBLICATION DATA

Encyclopedia of science, technology, and ethics / edited by Carl Mitcham.
p. cm.
Includes bibliographical references and index.
ISBN 0-02-865831-0 (set, hardcover : alk. paper)—ISBN 0-02-865832-9 (v. 1) —
ISBN 0-02-865833-7 (v. 2)—ISBN 0-02-865834-5 (v. 3)—ISBN 0-02-865901-5 (v. 4)
1. Science—Moral and ethical aspects—Encyclopedias.
2. Technology—Moral and ethical aspects–Encyclopedias.
I. Mitcham, Carl. Q175.35.E53 2005
503—dc22 005006968

This title is also available as an e-book.
ISBN 0-02-865991-0
Contact your Thomson Gale representative for ordering information.

Printed in the United States of America
10 9 8 7 6 5 4 3 2 1

D

DAMS

Dams, barriers to alter flowing bodies of water, are among the most ancient and powerful examples of the proclivity of humans to alter nature for their own benefit. (Dams are also a type of construction shared with other animals, that is, beavers.) Before the advent of written history, dams were already being built to provide water storage and irrigation. An earthen dam in the Orontes Valley in Syria was ancient when visited by the Greek geographer Strabo around the beginning of the Common Era. The oldest large dam of which traces survive today is at Sadd-el-Kafara, near Cairo. Ninety-eight meters long, there are indications that it was intended to stand 125 meters high. It is estimated that this structure was built around 2500 B.C.E.

Dam Engineering

Despite their ubiquity and importance, dams are a stepchild of traditional engineering. Premodern treatises on construction such as Vitruvius's *De architectura* (first century B.C.E.) do not mention dams, although Roman dam achievements were not to be matched for 1,500 years. The scientific engineering of dams begins in the 1800s and was one of the early achievements of civil engineering as it replaced trial-and-error intuition with empirical rules of thumb for dam design.

In terms of function, dams primarily supply water for irrigation or urban use, or serve as sources of power. In conjunction with closely related structures called dikes, dams may also protect from flooding and/or facilitate transportation by creating navigable bodies of water such as canals.

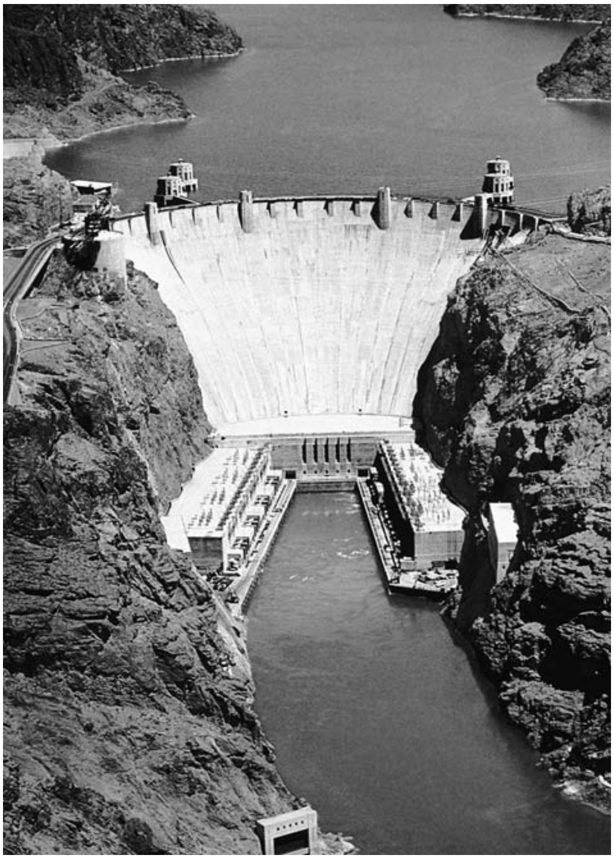
In terms of design, dams are of two basic types: earth- or rock-filled gravity embankment dams and masonry or concrete dams. The former take the general shape of a large-based equilateral triangle with sloping embankments facing both upstream and downstream; the latter have more the shape of a right-angle triangle with a perpendicular upstream face and a sloping downstream face.

It was not until the mid-1800s that French engineers designed the first dams using scientific procedures to determine such issues as the slope of repose for embankments. At the same time engineers began to consider the geological structures on which various types of dams might rest and to analyze the internal stresses of masonry and concrete dams. Such analyses promoted the design of arch dams, in which a vertical upstream face is given a convex horizontal curve to help transfer forces from the impounded water into the walls of a canyon. The engineering of auxiliary structures such as spillways, locks, and power conversion systems also became part of dam design.

Progressive demands for water and power together with advances in dam engineering led in the first half of the twentieth century to what may be called the golden age of dam construction. But the second half of the twentieth century witnessed a technical reassessment of dam engineering in terms of safety and ecology, social and natural.

Dam Debates

For most of human history, dams were conceived and built with an eye only to the task to be accomplished, such as water storage, irrigation, or more recently,



Hoover Dam. Constructed in 1935, the dam holds back twelve trillion gallons of water and generates enough hydroelectric power to serve 1.3 million people. (*© Corbis.*)

promotion of tourism, and without much concern for other implications, such as the impact on local populations or the environment. Of all major rivers in the United States, only the Salmon and Yellowstone are without dams. Half of the American wetlands that existed in 1790 have been flooded and destroyed by dam projects—up to 80 percent in river states such as Missouri, where one-third of all the water in the Missouri River is stored behind dams.

At the same time some experts argue that dams are often inefficient mechanisms for water storage, spreading water out over large areas in hot, dry desert climates where it evaporates. As much as 8 percent of Colorado River water may be lost to evaporation behind the Glen Canyon Dam in northern Arizona. Dams, by promoting water use, also contribute to the eventual depletion of aquifers.

In the modern world dams nevertheless continue to be seen as important symbols of human domination of the environment, sometimes outweighing all other issues. China's Three Gorges Dam, which will flood thousands of acres of agricultural land and displace more than one million people, is nevertheless viewed by the Chinese government as a powerful symbol of mastery and progress.

DAM SAFETY AND FAILURES. Like other huge, complex human technology projects, dams can fail if ill-designed or negligently maintained. The most famous failure in the United States was that of the South Fork Dam in Johnstown, Pennsylvania, in May 1889. Over the years, successive owners of the dam made dangerous modifications, eliminating outlet pipes, reducing its height, and narrowing the spillway. During an unprecedented rainfall, the water rose 3 meters (10 feet) above the usual lake level, breaking the dam and inundating Johnstown, with the loss of almost 3,000 lives.

RELOCATING PEOPLE. Dam projects have often involved the removal of the populations least able to defend themselves politically. Most often the groups forced to relocate are poor members of minority groups, subsisting on small-scale agriculture.

In June 1957 Congress voted the creation of Kinzua Dam in western New York, flooding half of a Seneca Indian reservation. More than 500 Seneca were forcibly moved in the dead of winter to trailer camps. Without access to hunting grounds, and denied compensation for their homes, these already poor individuals were, according to the sociologist Joy A. Bilharz (1998), driven into greater poverty, which lasted for decades.

Organized political opposition to large dam projects was pioneered in India, where in the late 1940s important projects backed by the prime minister, Jawaharlal Nehru, made little provision for the relocation of affected villages. Large demonstrations and other opposition increased the costs unacceptably, causing the government to back away from some of these projects.

ENVIRONMENTAL CONCERNS. During the twentieth century, the environmental movement advanced the argument that natural beauty was a factor to be taken into account in dam construction. John Muir led an early campaign against the O'Shaughnessy Dam in Yosemite National Park's Hetch Hetchy Valley on the grounds that it would destroy a unique environment. Later came the related idea that wild species themselves had interests worthy of protection, interests that might be harmed by dam construction. Environmentalists went to court to end construction of the Tellico Dam on the Little Tennessee River, on the grounds that it would destroy the remaining population of snail darters, an endangered fish. In response, federal courts halted construction of a dam already 80 percent completed. In

1978 the U.S. Supreme Court affirmed the court order halting construction, stating that the Endangered Species Act unambiguously bars projects that threaten the continued existence of a listed species. Congress, however, later passed legislation exempting Tellico from the Endangered Species Act, and the dam was completed.

Egypt's Aswan High Dam has been argued to have caused an environmental disaster, starving the Mediterranean of nutrients, making croplands excessively salty, and creating a reservoir in one of the highest evaporation zones on Earth.

DAM REMOVALS. Because of changing views of the utility of dams and the relative importance of environmental considerations, more than 500 dam removal projects were undertaken in the United States during the last decades of the twentieth century. The first dam removed for purely environmental reasons was the Quaker Neck Dam on the Neuse River in North Carolina. Built in 1952 to provide cooling water for a steam-driven electrical generating plant owned by Carolina Power & Light Company, the dam prevented shad from migrating upstream. The shad catch, 318,000 kilograms (700,000 pounds) in 1951, was only 11,400 kilograms (25,000 pounds) by 1996.

Carolina Power & Light was glad to get rid of Quaker Neck. The dam was expensive to maintain and also created litter and liability problems. Instead of the dam, a canal between two channels of the river now provides cooling water. More than 1,600 kilometers (1,000 miles) of local rivers have since been reopened to fish.

As the political and psychological importance of dams has faded and other considerations have come to the fore, Americans have stopped building dams. Since the mid-1970s, there has not been a single major dam construction project commenced in the United States.

JONATHAN WALLACE

SEE ALSO *Bridges; Environmental Ethics; Three Gorges Dam; Water.*

BIBLIOGRAPHY

Bilharz, Joy A. (1998). *The Allegany Senecas and Kinzua Dam: Forced Relocation through Two Generations*. Lincoln: University of Nebraska Press. Examines impacts on the Seneca nation of forced relocation to accommodate the Kinzua Dam project.

Devine, Robert S. (1995). "The Trouble with Dams." *Atlantic Monthly* 276(2): 64–74. Influential article arguing that most dams serve no significant purpose.

Goldsmith, Edward, and Nicholas Hildyard. (1984). *The Social and Environmental Effects of Large Dams*. San Francisco: Sierra Club Books. Representative of arguments critically reassessing dams during the last half of the twentieth century.

Jackson, Donald C. (1995). *Building the Ultimate Dam: John S. Eastwood and the Control of Water in the West*. Lawrence: University Press of Kansas. A biography of Eastwood (1857–1924), who from 1906 until his death designed more than sixty dam projects in the western United States, that stresses the psychological attractiveness of the multiple arch dam.

Jackson, Donald C., ed. (1997). *Dams*. Brookfield, VT: Ashgate. Collects seventeen previously published articles highlighting technical and social developments.

Khagram, Sanjeev. (2004). *Dams and Development: Transnational Struggles for Water and Power*. Ithaca, NY: Cornell University Press.

Levy, Matthys, and Mario Salvadori. (2002). *Why Buildings Fall Down*, rev. edition. New York: Norton. Analyzes dam collapses from a structural engineering standpoint.

Petersen, Shannon. (2002). *Acting for Endangered Species: The Statutory Ark*. Lawrence: University Press of Kansas. Contains an account of the snail darter and Tellico Dam.

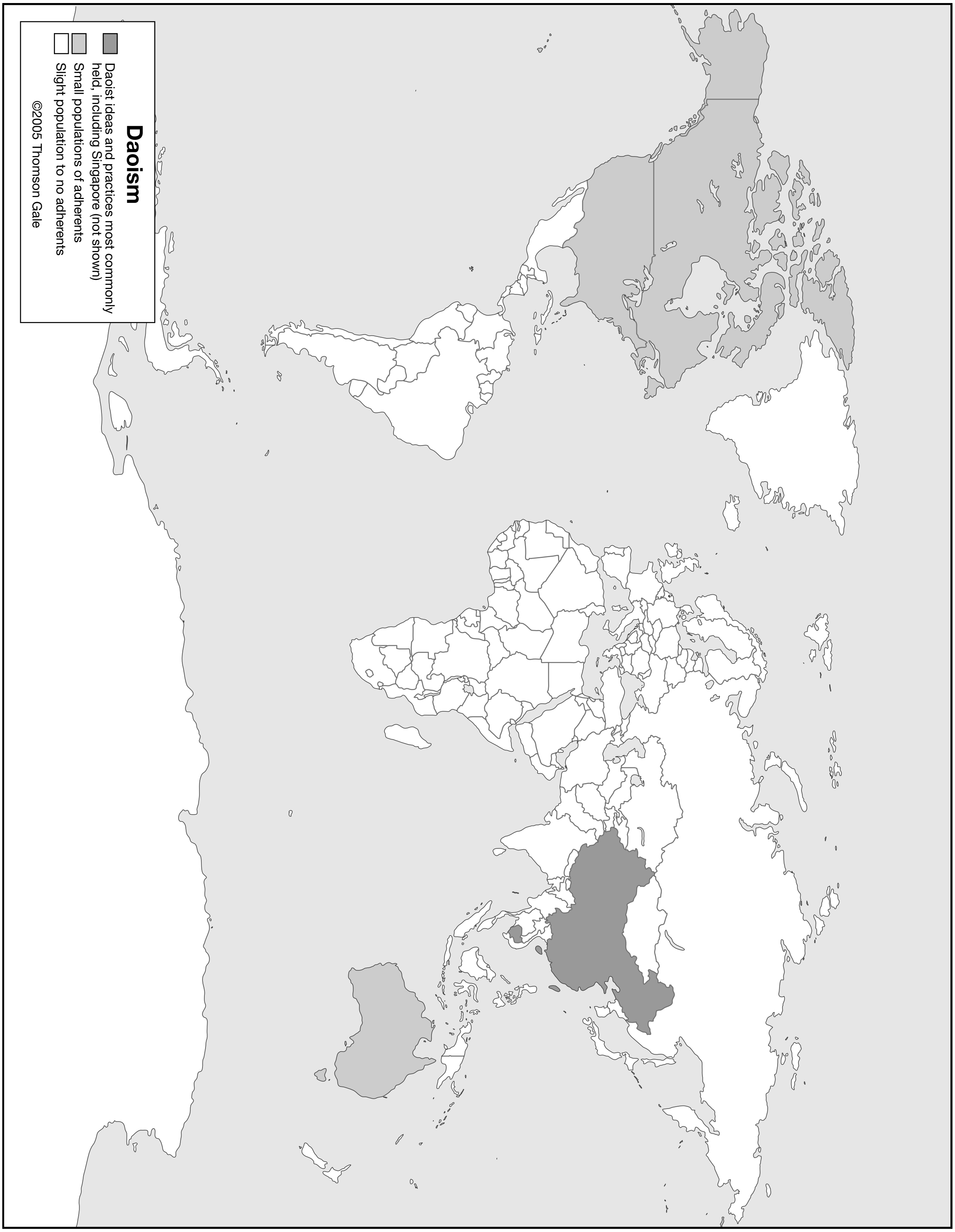
Schnitter, Nicholas J. (1994). *A History of Dams: The Useful Pyramids*. Rotterdam, Netherlands: A. A. Balkema. A technical history with some comments on social context that takes its subtitle from the praise of dams by the Roman Sextus Julius Frontinus (c. 35–c. 103 C.E.).

Smith, Norman. (1971). *A History of Dams*. London: Peter Davies. The first general history of dams.

World Commission on Dams. (2000). *Dams and Development: A New Framework for Decision-Making*. London: Earthscan. A report that grew out of a 1997 World Bank workshop, arguing for a critical assessment of large-scale dam projects in terms of technical, economic, environmental, and social impacts.

DAOIST PERSPECTIVES

The word *Daoism* (or *Taoism*) was coined in the early nineteenth century from the Chinese expression "*dao jiao* teachings" (*tao*), which encompasses both the intellectual activities and historical religious movements that shaped the various and changing meanings of the term *Dao* (or *Tao*), meaning, literally, "the Way." Modern scholars have claimed that the term specifically refers to Daoist schools or Daoist sects, though some European Daoism scholars contend that this distinction is unnecessary or even misleading. In contemporary academic circles the words *religion* and *philosophy* are inevitably applied to Chinese traditions; one must remember, however, that in the Chinese context these two words


Daoism
Daoist ideas and practices most commonly held, including Singapore (not shown)
Small populations of adherents
Slight population to no adherents
©2005 Thomson Gale

diverge from their Western usages. Nevertheless, Daoism has suggestive importance as a perspective on science, technology, and ethics.

Daoist philosophy is attributed to Laozi, who, according to the ancient and authoritative *Records of History,* is believed to have been an elder contemporary of Confucius (551–479 B.C.E.) and the author of the *Laozi* (*Daode jing,* or *Tao-te-ching*), a work roughly 5,000 characters long. This traditional account has been challenged by skeptics, yet the three Guodian bamboo versions of the *Laozi* unearthed in 1997 prove that the text was extant and prevailing in the fourth century B.C.E. and may have been composed still earlier. Another founding thinker of Daoism was Zhuangzi. He and his followers created the *Zhuangzi,* a much longer work that is full of thought-provoking fables, stories, anecdotes, and inspiring ideas and arguments.

The religious worship of Laozi, together with the Buddha, is recounted in the official dynastic history in the first century C.E. Daoist religious movements, inspired by and combined with immortality beliefs, traditional medicine, yin–yang theories, *Yijing* (Classic of change) theories, and prognostication and apocrypha, developed in the following centuries. Regional Daoist religious activities, however, were not recognized by an independent royal court until the fifth century C.E. Because of its origination, Daoist religion had strong associations with folk and royal religious practices and beliefs, such as polytheistic worship, the pursuit of longevity, and the belief in immortality, physical or spiritual. Daoist priests and scholars may simultaneously be believers in Buddhism and practitioners of Confucianism.

A Philosophical Paradox

Daoism is commonly tagged as a sort of irrational mysticism. Actually, Daoist attitudes toward science and technology are mixed and varied. There are statements in the *Laozi* that seem directed against knowledge and artistry: "Eliminate knowledge, get rid of differentiation, and the people will benefit one hundredfold. Eliminate craftiness, get rid of profit, and there will be no robbers and thieves" (chap. 19, bamboo version). "The more cunning and skill a person possesses, the more vicious things will occur" (chap. 57).

In the *Zhuangzi,* one can find stories such as this one: Confucius's disciple Zigong while traveling saw an old man working in a garden. Having dug his channels, he made many trips to a well, returning with water in a large jar. This caused him a great expenditure of energy for very small returns. Zigong said to him, "There is a contrivance by means of which a hundred plots of ground may be irrigated in one day. Little effort will thus accomplish much. Would you, Sir, not like to try it?" After hearing Zigong's description of the contrivance based on the lever principle, the farmer's face suddenly changed and he laughed, "I have heard from my master," he said, "that those who have cunning devices use cunning in their affairs, and that those who use cunning in their affairs have cunning hearts. . . . I already knew all about it, but I would be ashamed to use it" (chap. 19). The farmer presents a typical Daoist criticism of technology and scientific invention. This is nevertheless a moral observation on the side effects of technological inventions, not an overall theory about technology and science.

Actually, the *Zhuangzi* contains many intriguing fables praising craftsmen who demonstrate fascinating artistry, such as boatmen, a butcher, sword makers, carvers of bell stands, arrow makers, and wheelwrights. A wheelwright once gave a lesson to the Duke Huan about the limitations of communication through the example of his artistry. He said:

> If my stroke is too slow, then the tool bites deep but is not steady; if my stroke is too fast, then it is steady but does not go deep. The right pace, neither too slow nor too fast, is the hand responding to the heart. But I cannot tell the skill by words to my son and he cannot learn it from me. Thus, it is that though in my seventieth year, I am still making wheels. The ancient author of the classic you are reading are dead and gone—so then what you are reading, is but the sages' dregs and refuse! (chap. 13)

This fable is not only a paean to the artisan and his artistry but also an ancient version of modern or postmodern theories of hermeneutics and linguistics.

In one chapter, the *Zhuangzi* raises questions about the natural world and its movements:

> How ceaselessly heaven revolves! How constantly earth abides at rest! Do the sun and the moon contend about their respective places? Is there someone presiding over and directing these things? Who binds and connects them together? Who causes and maintains them, without trouble or exertion? . . . Then how does a cloud become rain, and the rain again form clouds?" (chap. 14)

These questions come from and in turn stimulate curiosity about the natural world, which inspires investigation into scientific and technological mysteries. Daoism considers human beings to be equally part of the natural world and has a strong interest in the ultimate origins of, reasons behind, mechanisms of, and mysteries of the universe, including human lives—especially in comparison with Confucianism and Buddhism.

One distinctively Daoist concept is *wuwei* (nonaction), which is often misunderstood as inactivity or literally doing nothing. But the *Huainanzi* (142 B.C.E.), a Daoist work of the early Han period, argues that this term does not mean inactivity. *Wuwei* actually suggests that no personal prejudice interferes with the universal Way and that no desires or obsessions lead the true courses of Daoist techniques astray. To undertake an enterprise one must follow reason, and to realize an achievement one must take account of surrounding conditions to be consistent with the principle of naturalness. For example, if one used fire to dry up a well or led the waters of the Huai River uphill to irrigate a mountain, these would be contrary to the principle of naturalness and be called taking action (*youwei*, the opposite of *wuwei*). Nevertheless, such activities as using boats on water or sledges on sand, making fields on high ground, and reserving low ground for a pond constitute Daoist *wuwei* or nonaction. This interpretation of *wuwei*, deriving from the *Laozi*'s idea of "assisting the naturalness of the ten thousand things without daring to act," promotes a rational and observant attitude in everyday life, which favors the scientific spirit.

Religious Pursuits

While Daoist thinkers presented reflective and inspiring ideas, religious scholars and priests, in their informal roles as inventors, practitioners, compilers, or distributors, made great practical and academic contributions to the development of science and technology in China. According to the first official 5,305-volume *Daoist Canon* (completed in 1445), Daoist scholarship and practice pursued knowledge and technology in various fields, such as chemistry, mineralogy, biology, botany, pharmacy, medicine, anatomy, sexology, physics, mathematics, astronomy, and cosmology. Ancient Daoists were not professional scientists or technicians, and their essential concern was attaining longevity and material immortality, rather than science and technology for their own sake. This pursuit makes Daoism distinct among religions and led Daoists to seriously observe and explore the natural world, including the human body and life, from generation to generation. Thus, religious enterprise provided fertile ground for the development of science and technology.

A good example of this confluence is the discovery of gunpowder. Joseph Needham (1981) contends that saltpeter (potassium nitrate) was recognized and isolated at least by the fifth century in China. This first compounding of an explosive mixture arose in the course of exploring the chemical and pharmaceutical properties of a great variety of inorganic and organic substances. It was the hope of realizing longevity and physical immortality that led to this discovery, one of the greatest technical achievements of the medieval Chinese world. One finds the first reference to it in the ninth century, toward the end of the Tang dynasty, in a description of the mixing of charcoal, saltpeter, and sulfur. This mention occurs in a Daoist book that strongly recommends not mixing these substances, especially with arsenic, because some alchemists who had done so had the mixture deflagrate, singe their beards, and even burn down the house in which they were working.

The fields of medicine and pharmacology were also directly shaped by the Daoist pursuit of longevity and immortality. Daoist scholars and priests advanced Chinese medical theory and compiled important herbal medicine classics. Tao Hongjing (451–536), a direct descendant of the founder of the Supreme Purity Sect, is the most prominent of these scholars. His eighty works involve astronomy, calendrics, geography, literature, arts, and the arts of war, in addition to medicine and pharmacology. He argued that humans control human destiny, not Heaven. The reason people die early is not because of fate, but because their way of living harms their spirits or bodies. A piece of semifinished pottery is made of earth, yet is different from earth. Still it will dissolve in water before it is fired, even though it has already dried. If it is not fired properly, it will not hold up. If it is fired well and becomes thoroughly strong, it will survive over vast stretches of time. Similarly, people who pursue immortality take drugs and elixirs to make the body strong, breathe in fresh air, and participate in gymnastic exercise.

All these practices complement each other without conflict. If the spirit and the body are refined together, as in a senior immortal, one can ride clouds and drive a dragon; if the spirit and the body become separated, as in a junior immortal, one can leave one's old body and take on a new one. To preserve spirit and body, Daoists emphasized the significance of moderation in desires and emotion. It is impossible for the average person to have no desires or do nothing, but they can keep their minds in a state of harmony and minimize concerns. The "seven kinds of emotion" (anger, anxiety, worry, sorrow, fear, aversion, and astonishment) and the "six desires" (for life and death, and of the eyes, ears, mouth, and nose) are all harmful to the spirit and should be controlled.

Tao Hongjing also argued that the harm caused by bad eating habits is more serious than that of lust, because people eat daily, and he urged restraint in taking food. To be healthy, he claimed, less food is better than being overly full; walking after meals is more helpful than lying down; and physical labor is preferable to an easy life. Most of this early Daoist's advice accords with suggestions from modern doctors and professional medical workers.

Furthermore, Tao Hongjing compiled the *Collected Commentaries on Medicinal Herbs*, without which the contents of the earliest Chinese medicine classics would have been lost forever. He was the person who created a typology of Chinese medicinal herbs and inorganic substances in the treatment of various diseases and symptoms; this became and remains the foundation of Chinese medical theory.

According to Daoist tradition, the technology of sexual life is related to prolonging youth and vigor, though it was rejected by some later Daoists. Ge Hong (283–364?) once argued that sexual intercourse was necessary to achieve longevity and immortality. Even if one were to take all the famous medicines, Ge claimed, without knowledge of how to store up the essence of life through sexual activity, attaining health, let alone longevity, would be impossible. While people should not give up sex entirely, lest they contract melancholia through inactivity and die prematurely from the many illnesses resulting from depression and celibacy, overindulgence can diminish one's life, and it is only by harmonizing the two extremes that damage can be avoided.

It was further held that foreplay and slow and complete arousal are important for healthy intercourse. Men should pay attention to women's reflexes step by step and delay climax to adjust for the differential in arousal time to ensure the woman's full satisfaction. Some of these theories seem to have been confirmed and adopted by modern sexologists. Kristofer Schipper (1993), a Dutch Daoist scholar, claims that Chinese sex manuals reflect an impressive knowledge of female anatomy and reflexes; they are the only ancient books on this subject that do not present sexuality solely from the male point of view. Indeed, compared to other traditions, Daoism includes much less discrimination against women, perhaps because of Daoists' strong belief in the harmony of yin and yang, which work in all things and processes in the universe.

Modern Resonance

Although Daoism is an indigenous Chinese cultural tradition of some antiquity, modern scientists have found that it resonates with certain aspects of the spirit of modern science and responds to modern social and environmental issues. Raymond J. Barnett (1986) found a surprising degree of similarity between Daoism and biological science in their views on death, reversion (cyclicity of phenomena), the place of humans in the universe, and the complementary interactions of dichotomous systems. The use of the terms yin and yang is similar to the way scientists describe the behavior of subatomic particles: One can say some things about these particles, but only if one realizes that what is said is a statement of statistical probability and that a certain modicum of uncertainty is unavoidable. And in the autonomic nervous system both the sympathetic and parasympathetic subsystems, like the yin and yang, affect most organs. The state of an organ is not a function of one system being totally "off" and the other totally "on." Rather, the health of an organ depends on the balance between the activities of both systems, with each able to change its input and alter the balance.

Similar parallels between Daoist ideas and science are too numerous to be discussed at length, but a few deserve brief mentions. James W. Stines (1985) demonstrated that the philosophy of science of British chemist Michael Polanyi (1891–1976), especially his theory of tacit knowledge, correlated with Daoist intuition. Hideki Yukawa (1907–1981), who in 1949 became the first Japanese physicist to receive a Noble Prize, claimed that his creativeness was greatly inspired by Laozi's and Zhuangzi's philosophical insights. The famous American humanistic psychologist Abraham H. Maslow (1993) found the advantage and complementary role of Daoist objectivity in scientific investigation. Fritjof Capra, in his best-seller *The Dao of Physics* (2000), revealed the parallel between Daoism (along with other Eastern traditions) and the notion of a basic "quantum interconnectedness" emphasized by the Danish physicist Niels Bohr (1885–1962) and the German physicist Werner Heisenberg (1901–1976). Norman J. Girardot and colleagues (2001) discuss broadly and significantly the relationship of Daoism and modern ecological issues. Finally, one should certainly not forget the pioneer researcher Needham, who contended that Daoist thought is basic to Chinese science and technology.

LIU XIAOGAN

SEE ALSO *Acupuncture; Buddhist Perspectives; Confucian Perspectives.*

BIBLIOGRAPHY

Barnett, Raymond J. (1986). "Taoism and Biological Science." *Zygon* 21(3): 297–317.

Capra, Fritjof. (2000). *The Tao of Physics: An Exploration of the Parallels between Modern Physics and Eastern Mysticism,* 4th edition. Boston: Shambhala.

Chan, Wing-tsit. (1963). "The Natural Way of Lao Tze." In *A Source Book in Chinese Philosophy*. Princeton, NJ: Princeton University Press. This is a philosophical translation of the Laozi with brief comments.

Girardot, Norman J.; James Miller; and Liu Xiaogan, eds. (2001). *Daoism and Ecology: Ways within a Cosmic Landscape*. Cambridge, MA: Harvard University Center for the Study of World Religions. A collection of papers authored by philosophical, religious, literary, and ecological scholars, as well as practitioners of Daoism.

Liu Xiaogan. (1993). "Taoism." In *Our Religions,* ed. Arvind Sharma. San Francisco: Harper San Francisco. A relatively comprehensive introduction to Daoism from its origination to modern development, including Daoist philosophy and religion, their relationship, and other perspectives.

Maslow, Abraham H. (1993). *The Farther Reaches of Human Nature*. New York: Arkana. Maslow presents the concept of "Daoist objectivity" as a development of his earlier concept of "Daoist science" discussed in his *The Psychology of Science* (Gateway edition, 1966).

Needham, Joseph. (1981). *Science in Traditional China: A Comparative Perspective*. Hong Kong: Chinese University Press.

Needham, Joseph, with Wang Ling. (1956). *Science and Civilization in China,* Vol. 2: *History of Scientific Thought*. Cambridge, UK: Cambridge University Press. This is an initiative comprehensive study with tremendous materials and references. Needham attributes many Chinese scientific and technological inventions and contributions to Daoist thought and practice.

Schipper, Kristofer. (1993). *The Taoist Body,* trans. Karen C. Duval. Berkeley: University of California Press. Schipper is not only a leading scholar, but also an ordained Daoist priest. This book is an introduction to aspects of Daoist religion, such as teachings, divinity, alchemy, immortals, ritual, and meditation.

Sivin, Nathan. (1968). *Chinese Alchemy: Preliminary Studies*. Cambridge, MA: Harvard University Press.

Sivin, Nathan. (1995). *Medicine, Philosophy, and Religion in Ancient China: Researches and Reflection*. Aldershot, Hampshire, UK: Variorum. Sivin strongly contends that many of Needom's Daoist scientists do not belong to Daoist communities.

Stines, James W. (1985). "I Am the Way: Michael Polanyi's Taoism." *Zygon* 20(1): 59–77.

Watson, Burton. (1968). *The Complete Works of Chuang Tzu*. New York: Columbia University Press. A popular and complete translation of the Zhuangzi.

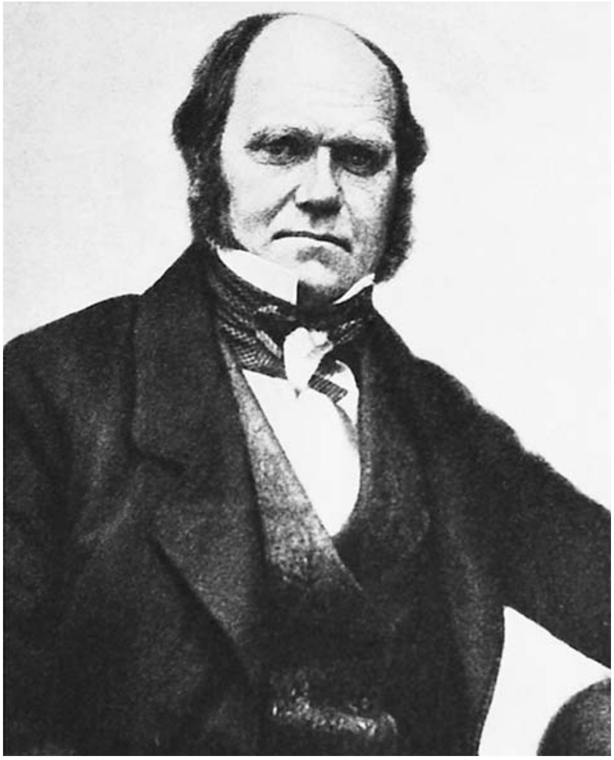
Yukawa, Hideki. (1973). *Creativity and Intuition: A Physicist Looks at East and West,* trans. John Bester. Tokyo: Kodansha International.

DARWIN, CHARLES

Naturalist Charles Darwin originated the theory of evolution by means of natural selection. Darwin (1809–1882), who was born in Shrewsbury, England, on February 12, established the modern scientific understanding of humanity's place in nature. After his undergraduate education at Cambridge, Darwin served for nearly five years as a naturalist aboard a surveying ship, HMS *Beagle,* which traveled up and down the coasts of South America and then circled the globe. Darwin spent several years after his voyage publishing the results of his researches into fossils, botany, zoology, and geology. On the basis of this work, he formulated his initial ideas on evolution in the late 1830s and then spent two decades developing the theory of natural selection before publishing his chief work, *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life* (1859). In *The Descent of Man, and Selection in Relation to Sex* (1871), Darwin explicitly included human beings within the theory of evolution and analyzed the biological basis of human social and moral behavior. Darwin died on April 19 in England and is buried at Westminster Abbey.

In his autobiography, Darwin says that the one book he most admired as an undergraduate was William Paley's *Natural Theology: or, Evidences of the Existence and Attributes of the Deity, Collected from the Appearances of Nature* (1802). Paley (1743–1805) was the best-known proponent of natural theology, a school of thought that combined providential theology with inquiry into adaptive structures in animals. From the perspective of natural theology, adaptive structure or *design* is evidence for the beneficent governance of the world by its creator. Darwin's theory of natural selection provided an alternative scientific explanation for adaptive structure. Within Darwin's theory, adaptive structure is the result of *natural selection.* Innate variations in physiology or anatomy regularly occur. Many such variations are neutral or harmful to an organism, but some variations offer advantages that enable an organism to survive or reproduce more effectively than its competitors. These favorable variations are inherited and transmitted, and over many generations inherited variations produce new species.

Darwin's theory of natural selection is not grounded in theology or ethics, but it has implications for metaphysical and ethical beliefs. In his later years, Darwin became a professed agnostic, but at the time of writing *On the Origin of Species*, he was still vaguely theistic and



Charles Darwin, 1809–1882. Darwin discovered that natural selection was the agent for the transmutation of organisms during evolution, a theory he presented in *Origin of Species*. (© *Bettmann/Corbis*.)

regarded the development of life on earth as the result of a divine creation. The evolutionary process that he explains nonetheless exhibits qualities of ruthlessness and cruelty. In order to describe this process, Darwin frequently uses metaphors such as the "Struggle for Life," the "battle of life," or the "war of nature." In all species, many more individuals are born than can ever survive or reproduce. This disproportion between birth rates and the rates of survival and reproduction provides the competitive situation within which natural selection operates. Individuals within and among species compete for food and other resources; individuals of one species prey on individuals of other species; and most species eventually become extinct and leave no successor species. In a letter of 1856 to his botanist friend Joseph Hooker (1817–1911), Darwin exclaims almost in despair over "the clumsy, wasteful, blundering, low, and horribly cruel works of nature!" In the last paragraph of the *Origin,* he declares that there is "grandeur in this view of life," but it is a grandeur that emerges out of "famine and death."

Both before and after Darwin, it has been common practice to invest the larger natural order with some moral quality, either of beneficence or of ruthlessness, and to use that quality as a model or norm for human ethical behavior. The injunction to *follow nature* has been interpreted to mean either that one should imitate the supposedly benign character of the providential order or that one should ignore all conventional social constraints and seek only to satisfy one's own desire and ambition. Since the middle of the nineteenth century, many thinkers have rejected this approach and have argued that human morality is something separate from the natural order. In their view, humans should not follow nature but should instead cultivate their own specifically human moral sentiments independently of nature. Among Darwin's contemporaries, John Stuart Mill and Thomas Henry Huxley (1825–1895) advocated this moral philosophy, and in the later twentieth century it was advocated by prominent Darwinian thinkers such as George C. Williams (b. 1926), Richard Alexander (b. 1929), Richard Dawkins (b. 1941), and Donald Symons (b. 1942).

Darwin's own theory of human morality breaks away from the idea that one should take the larger order of nature as the model for human moral behavior, but Darwin does not argue that human morality is simply separate from the order of nature. He argues instead that human moral sentiments derive from the evolved and adapted structure of human psychology. The human capacity for moral behavior results from two aspects of our evolved psychology: our character as social animals, and our uniquely human ability to think abstractly. Our social nature enables us to feel sympathy for other humans, to feel pain at their suffering and pleasure at their happiness. Our ability to think abstractly makes it possible for us to rise above the present moment, to link the present with the past and future, and thus to take account of the long-term consequences of our behavior.

In typical Victorian fashion, Darwin hoped that humanity would progress steadily toward a higher state of moral consciousness, and he envisioned human moral progress as circles of sympathy expanding out from kin and tribe, to nations and cultures, to all human beings, and eventually to all life on earth. At the highest level of human development, Darwin hoped that humans would become ecological curators for the earth.

In *Descent of Man,* Darwin considered the issue of eugenics. He acknowledged that care of the weak has dysgenic effects, but he nonetheless rejected *social Darwinism* or ruthless social competition because, he felt, that sort of behavior would damage the more "noble" qualities of social sympathy on which all human moral behavior depends.

From the second through the sixth decade of the twentieth century, the adaptationist psychology that Darwin inaugurated in *Descent of Man* went into eclipse, supplanted by the belief that culture and society control behavior and are not themselves prompted and constrained by biology. The advent of human sociobiology in the 1970s brought Darwinian thinking back into psychology, anthropology, and the other human sciences. In sociobiology and related schools such as *human ethology*, *evolutionary psychology*, and *behavioral ecology*, the adaptationist view of human nature has had a deep and far-reaching influence on twenty-first century ethical thinking. For contemporary Darwinian theorists of human ethical behavior, the most significant issue under debate is a question about the level at which natural selection operates. Proponents of *selfish gene* theory argue that natural selection operates exclusively at the level of genes, and they extrapolate the idea of "selfishness" from the level of genes to the level of individual human motives. Proponents of *group selection*, in contrast, affirm the reality of altruistic or "unselfish" motives. Many theorists argue that selection operates at multiple levels and that these levels are interactive and interdependent. The idea of a genetically encoded "altruism" that ultimately subverts inclusive fitness would contradict the logic of natural selection, but a co-operative and interdependent structure is a fact of evolutionary history and manifests itself at the level of cells, organs, social groups, and ecosystems.

JOSEPH CARROLL

SEE ALSO *Aggression; Christian Perspectives; Evolutionary Ethics; Evolution-Creationism Debate; Gatton, Francis; Social Darwinism; Sociobiology; Treat, Mary.*

BIBLIOGRAPHY

Darwin, Charles. (1845). *Journal of Researches into the Geology and Natural History of the Various Countries Visited by H. M. S. Beagle, Under the Command of Captain Fitzroy from 1832 to 1836*, 2nd edition. London: John Murray.

Darwin, Charles. (1859). *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life*. London: John Murray.

Darwin, Charles. (1871). *The Descent of Man, and Selection in Relation to Sex*. London: John Murray.

Darwin, Charles. (1958). *The Autobiography of Charles Darwin, 1809–1882. With Original Omissions Restored*, ed. Nora Barlow. London: Collins.

DATA MINING

SEE *Transaction Generated Information and Data Mining.*

DC-10 CASE

• • •

The troubled history of the DC-10 aircraft, especially in relation to questions raised as a result of its involvement in three major accidents between 1974 and 1989, provides a multidimensional case study in the ethics of engineering design and the uses of technology.

The DC-10 is a wide-bodied aircraft with two wing engines and a third engine distinctively placed in the tail fin. It was introduced into commercial service in 1972, during a time of unusually intense competition in the U.S. aviation industry. The market would support only two viable manufacturers, and because the Boeing 747 was well established, either Lockheed Corporation or McDonnell Douglas Corporation would have to withdraw and suffer a substantial financial loss. McDonnell Douglas won the competition, but evidence of its haste to beat Lockheed is reflected in these case studies.

Design Vulnerability

Because airliners fly at high altitudes, the passenger cabin must be pressurized, up to 38 pounds per square inch. Because a heavy floor able to withstand this force would not be economical, the cargo hold is also pressurized. Thus the floor has to be strong enough to support only the weight of passengers, crew, seats, and so on. If, however, either part of the aircraft experiences a sudden decompression, the loss of equalizing pressure would cause the floor to buckle or collapse, resulting in damage to the control system, which is located in the interior spaces of the floor beams.

The 1972 Windsor Incident

Less than a year after the DC-10 was in service, a rear cargo door was improperly closed on a flight from Detroit, Michigan, and it blew open over Windsor, Ontario, causing the floor above it to collapse downward. Only the skill of the American Airlines pilot and a very lightly loaded airplane enabled the plane to land safely.

Ordinarily a problem of this magnitude would result in the Federal Aviation Administration (FAA) issuing an Airworthiness Directive (AD), a public document that has the force of law, requiring owners of a particular aircraft to modify their airplanes within a certain time. But the FAA charter contains a dual mandate: The FAA must not only ensure aviation safety but also promote the aviation industry. An AD at this time would have given Lockheed a competitive advantage by drawing attention to the DC-10 problem. Instead, John Sheaffer, the head of the FAA, finessed these conflicting objectives by making a "gentleman's agreement" with McDonnell Douglas to develop a fix for the cargo door and implement it through service bulletins sent only to owners of DC-10s, thus avoiding harmful publicity.

Two weeks after Windsor, Dan Applegate, head of project engineering at Convair, a subcontractor for the DC-10 cargo doors, expressed grave doubts about the "Band-Aid" fixes being proposed for the cargo door lock and latch system. He took his concerns to higher management in an effort to have Convair contact McDonnell Douglas and develop a more secure fix. Although he wrote a strong memo, management felt its hands were tied by a "reliance clause" in the contract, which stated that if Convair disagreed with the design philosophy it must make its concerns known in the design stage or pay for any later required changes. Because DC-10s were already rolling off the production line, Convair was faced with the prospect of paying for expensive retrofits to the DC-10 if it raised questions now. No approach to McDonnell Douglas was made.

The 1974 Paris Crash

When the service bulletins were sent out, many DC-10s were sitting on the McDonnell Douglas lot awaiting delivery. Ship 29, later sold to Turkish Airlines, was recorded as having all service bulletins for the cargo door performed, but in fact a critical item was omitted. Critics believe that an AD would have been taken more seriously.

On a fully loaded flight from Paris to London, on March 3, 1974, Ship 29 lost its rear cargo door shortly after takeoff, and the floor collapsed. Deprived of its control system, the plane crashed: Six passengers from the rear of the aircraft were found, still strapped in their seats, nine miles away; the cargo door that failed was nearby. French investigators collected more than 20,000 human fragments of the 346 passengers and crew. At the time, it was the worst aircraft accident in history.

The 1979 Chicago Crash

On May 25, 1979, American Airlines DC-10 crashed shortly after takeoff from Chicago when a wing engine broke loose and damaged the leading edge of the wing. Loss of the engine and damage to the wing resulted in decreased lift: One wing was pushing up harder than the other. A photo shows the plane, wings vertical, plunging to the ground.

Had the pilots known that the wing was damaged, they would have been able to take corrective measures to control the plane. But they could not see the wing from the cockpit and had to rely on instruments. Ironically, the needed warning devices were powered by the engine that broke off, and there was no provision for a backup power supply. The crash killed all 271 persons onboard the DC-10 and two persons on the ground.

The separation of the engine was caused by a maintenance procedure designed to save more than 200 person-hours of work. The engine is held in place by a large pylon attached to the wing, and the McDonnell Douglas removal procedure required that the engine (weighing 5,000 kilograms) be removed first, followed by the pylon (900 kilograms). The new procedure used a forklift to bear the weight of the engine, allowing engine and pylon to be removed as a unit. The pylon is not designed for the stresses this procedure can introduce and developed cracks, which eventually led to it and the engine breaking away from the wing.

It is normal for airlines to develop innovative maintenance procedures without FAA approval. McDonnell Douglas knew that Continental Airlines and American were using the forklift procedure and that it required extreme precision in positioning. It also knew that Continental had reported two cases of cracks to the pylons that required repair. Neither the FAA nor American learned of these potential dangers because FAA regulations do not require such reporting. But an engineer's first professional obligation is to protect the public from harm, and engineers at McDonnell Douglas and Continental had clear evidence of the danger of this procedure and should have investigated further and warned others. For a professional, following the regulations is not good enough when there is clear evidence of danger.

The 1989 Sioux City, Iowa, Crash

On July 19, 1989, a United Airlines DC-10 tail engine disintegrated in flight, resulting in the loss of fluid in all three hydraulic systems. The 170-kilogram front fan disk, rotating at high speed, broke apart, and the fragments took out everything in their path. Without hydraulics, none of the control surfaces on the wings and tail could be operated. The plane could only be crudely maneuvered by varying the speed of the two wing

A McDonnell-Douglas DC-10. A string of highly publicized crashes doomed the aircraft to a short lifespan. (© *George Hall/Corbis*.)

engines. Remarkably, the pilots managed to crash-land at the Sioux City, Iowa, airport, with only 111 deaths among the 296 passengers.

The other wide-body jet with a large tail engine, the Lockheed L-1011, has four independent hydraulic systems, one of which has a shutoff valve forward of the engine. If there is a leak, the valve closes the line, preventing further fluid loss. After the accident, the FAA issued an airworthiness directive requiring a shutoff valve for the DC-10.

Assessment

All three DC-10 crashes were caused by failures that need not have resulted in the loss of the aircraft. The inadequately protected control system of the DC-10 allowed these otherwise predictable problems to cause the crashes that took 728 lives. It would be satisfying to find engineers and managers who clearly disregarded the safety of air travelers, but the reality is a complex and ambiguous interplay of engineering, design, financial, legal, historical, and organizational factors that allowed an underprotected aircraft to enter the stream of commerce. Without the intense economic competition with Lockheed, there might have been more attention to the cargo door design, redundancy added to warning systems, and a shutoff valve placed in the hydraulic lines. Add to this Douglas Aircraft Company's complete dominance of the aviation industry from the 1930s to the 1950s, which may have fostered a climate of complacency about the problems with the DC-10. (McDonnell Douglas had been formed in 1967 from the merger of Douglas Aircraft and McDonnell Aircraft Corporation.) The regulatory safety net, as always, was catching up to the problems posed by the new generation of wide-body jets.

After each of these crashes the FAA required changes in design, procedures, or training. Critics call this "tombstone technology," meaning that safety changes are made only if there are enough deaths to prove the changes are needed. But safety is defined as "of acceptable risk," which changes over time, and often it takes a severe accident to determine what level of risk is socially acceptable. Safety entails higher costs, and regulators must try to balance the safety and cost factors in evaluating complex, sophisticated technology that has a substantial interface with large numbers of people. Inevitably, mistakes will sometimes be made and innocent people will die before adequate regulations are in place.

JOHN H. FIELDER

SEE ALSO *Airplanes; Aviation Regulatory Agencies; Engineering Ethics.*

BIBLIOGRAPHY

Fielder, John H., and Douglas Birsch, eds. (1992). *The DC-10 Case: A Study in Applied Ethics, Technology, and Society.* Albany: State University of New York Press.

DDT

DDT ranks among the most infamous acronyms in history. During the mid-twentieth century, its effectiveness at killing insects made it one of the miracle products of wartime investments in science and technology. Yet within thirty years, many industrialized countries banned the synthetic insecticide due to fears of its long-term effects on humans and wildlife. At the turn of the twenty-first century, the devastating resurgence of malaria across the developing world reignited debates over the ethics of using DDT.

The chemical compound that is DDT, dichlorodiphenyl-trichloroethane, was first synthesized in 1873, but not until 1939 did Swiss chemist Paul Müller discover its insecticidal properties. The U.S. military used DDT during World War II to protect soldiers and civilians from the destructive insect-borne diseases typhus and malaria. DDT's persistence and its broad spectrum of action made it extremely successful at killing insects over a long period, in small doses, and at low cost. In response to civilian demand, the U.S. government made the celebrated chemical available to the public in 1945, despite private concerns among federal scientists of potential long-term hazards. The agricultural and public health promise of DDT led to mass aerial spraying programs, and Müller won the 1948 Nobel Prize in physiology or medicine. Production by U.S. companies increased from 10 million pounds in 1944 to more than 100 million pounds in 1951.

Rachel Carson burst the bubble of confidence concerning the safety of DDT in 1962 with her best-selling exposé of the overuse of synthetic chemical pesticides, *Silent Spring*. The book publicized scientific evidence of the toxic effects of DDT on humans and animals, including nervous system dysfunction, reproductive abnormalities, and cancer. It explained how DDT's insolubility in water and fat-solubility enable it to persist in the soil and water, enter the food chain, and accumulate in the fatty tissues of non-target organisms such as the bald eagle, whose plummeting numbers were linked to DDT-induced eggshell thinning. *Silent Spring* also showed how mosquitoes and other target insect populations develop genetic resistance to DDT, thereby undermining its efficacy.

Carson criticized the arrogance of entomologists who presumed they could control pests by waging chemical warfare. She made a strong ethical argument for the need to respect the other creatures with which humans share the earth. Although some critics accused her of privileging wildlife over people, she testified to Congress on behalf of "the right of the citizen to be secure in his own home against the intrusion of poisons applied by other persons" (Lear 1997, p. 454). Spurred by increasing evidence of DDT's carcinogenicity, Congress banned the sale of DDT in the United States in 1972. Within three decades DDT was banned in thirty-four countries, and severely restricted in thirty-four others. It continued to be used in several developing nations, primarily in the *malaria belt*.

Since the 1970s, malaria has become one of the deadliest infectious diseases in the world, killing at least 1.1 million people each year. Children under age five comprise more than half the victims. Many environmentalists and health experts blame malaria's huge resurgence on the overuse of both chemical insecticides and anti-malarial drugs, which led their respective targets—anopheles mosquitoes and plasmodium parasites—to develop genetic resistance. Anti-DDT groups advocate preventive methods, including the use of mosquito nets dipped in the nontoxic insecticide permethrin and the cultivation of fish that consume mosquito larvae, as part of a systematic approach to the disease. In their opinion, DDT should be used only as a last resort due to its well-documented negative effects.

In contrast a strong opposition movement argues that DDT is still the cheapest, most effective anti-malarial measure, and that its declining use is responsible for the recent resurgence of malaria. Pro-DDT groups condemn environmentalists for scaring developing countries from using the chemical, and for caring more about bald eagles than suffering children. They point to scientific studies that fail to confirm evidence of long-term risks of exposure to DDT, and contend that it serves as a crucial insect repellent even in places

Two women are sprayed with DDT. Although widely used in pesticides in the 1940s and 50s, the compound has been banned in North America and most of Europe since the 1970s due to fears of detrimental long-term effects. *(The Library of Congress.)*

where mosquitoes have become resistant. From their perspective, it is unethical not to utilize DDT as a first resort against malaria, because its life-saving capacity for millions of people outweighs any potential negative environmental or human health effects.

Despite such conflicting outlooks, a compromise was struck in 2001, when delegates from 127 nations signed an international treaty to phase out twelve toxic, persistent, fat-soluble chemicals, including DDT. After intense debate, developing nations received exemptions permitting them to continue using DDT against the mosquito vectors of malaria until safer, affordable substitutes become available. The Stockholm Convention on Persistent Organic Pollutants entered into force on May 17, 2004.

CHRISTINE KEINER

SEE ALSO *Agricultural Ethics; Carson, Rachel; Food Science and Technology.*

BIBLIOGRAPHY

Carson, Rachel. (1962). *Silent Spring*. Boston: Houghton Mifflin. A must-read for anyone interested in the impact of synthetic pesticides on human and environmental health.

Lapkin, Ted. (2003). "DDT and the New Colonialists." *Quadrant* 47: 16–19. Argues for the use of DDT for malaria control.

Lear, Linda. (1997). *Rachel Carson: Witness for Nature*. New York: Holt. The definitive biography of Carson.

McGinn, Anne Platt. (2002). "Malaria, Mosquitoes, and DDT." *WorldWatch* 15: 10–17. Argues against the use of DDT for malaria control.

Russell, Edmund P. (1999). "The Strange Career of DDT: Experts, Federal Capacity, and *Environmentalism* in World War II." *Technology and Culture* 40: 770–796. Presents new historical evidence about early DDT research.

DEATH AND DYING

Death is defined as the irreversible loss of biological life functions, and occurs in all organisms. It is the inevitable conclusion of a finite existence, and is often applied by analogy even to geological features that contain life (the death of a river), social orders (death of a city), or machines (one's car or computer died). Science can study the phenomenon of death, technology may delay its approach, but medicine cannot cure humans of their mortality.

Dying, by contrast, is the process that leads to death, and is a distinctly human event, embedded in numerous moral traditions and well-circumscribed by prescriptions for appropriate conduct in its presence. No other animal attends as carefully to the dying process or accords it such significance. Modern medical technologies, including drugs and therapies, aim to delay the onset of this process (life-saving technologies), extend it (life-sustaining or life-support technologies), take control of it (technologies of euthanasia), or provide comfort (palliative technologies) as the time of death nears. Whereas premodern thought commonly interpreted dying in religious terms, viewing it as a process of transformation from one state to another and calling forth techniques of ritual engagement with larger orders of reality, contemporary technical achievements are the result of aspirations for control over the process that pose challenges in a moral framework.

Historical and Cultural Background

As described by the cultural historian Philippe Ariès (1991), the European experience of death has itself undergone significant transformations. Dying is not simply a basic feature of the human condition and the termination of an individual history; it has its own history. From the Graeco-Roman world up through the first millennium of the Christian era, death was so ever-present as to have been accepted as a normal aspect of human affairs. Theologically death was also often interpreted as a result of living in a fallen world marked by sin. When someone died, people paid their respects but did not dwell on the issue because of the greater importance of the community as a whole.

During the eleventh century in Europe, the rise of individualism brought with it a new perspective on death as a threat not to the community but to the self, which in turn gave rise to the development of *Ars moriendi* or treatises on the art of dying well. In the sixteenth century the emphasis shifted toward concern for the death of loved ones in a family. The romantic pathos at the death bed of family and friends ironically contributed to the transfer of the event of dying from home to hospital, where it acquired a higher public profile.

How is it, asks Ariès, that "the community feels less and less involved in the death of one of its members"? One answer is that the community "no longer thinks it necessary to defend itself against a nature which has been domesticated once and for all by the advance of technology" (Ariès 1991, p. 612). Another is that individualism has fractured the sense of solidarity. As death ceases to be a public threat it is progressively transformed into an emotional issue and relegated to the realm of privacy. Medical science and technology are brought in to study the process and reduce the pain, but behind this rational management "the death of the patient in the hospital, covered with tubes, [becomes] a popular image, more terrifying than the … skeleton of macabre rhetoric" (Ariès 1991, p. 614).

There are, however, other perspectives on death and dying that have likewise been impacted by scientific and technological change. Outside European traditions, for instance, the Hindu view embraces death as part of a great spiritual journey. The soul is in a state of continuous evolution and awareness from the limited to the limitless. Death separates the indestructible soul-body from the weakened physical-body. The soul-body reincarnates a physical-body, which matures and develops the soul-body in a life and death cycle. The act of reincarnation enables the soul to renew its work of resolving karma or moral effects arising from failures to conduct oneself in harmony with the dharma or moral order of the cosmos. The fulfillment of this process leads to liberation from the cycle of rebirth in a state called *moksha* and is characterized by *sat chit ananda* or limitless being, awareness, and bliss.

One influential Buddhist tradition *The Tibetan Book of the Dead* (from the fourteenth or fifteenth centuries), a guidebook for the deceased that echoes similar Egyptian, Daoist, and even Kabbalist literature, teaches how death is a process of moving toward pure truth. Once liberated from the confines of a mortal body, awareness enters a series of intermediate states called *bardos* in which it experiences various, sometimes frightening visions. To work through these *bardos* calls for assistance in order to attain either reincarnation or nirvana, a state in which confusion and suffering cease.

Across these various cultural perspectives one common theme is a distinction between natural and unnatural death and dying (Young). Natural deaths are associated with old age and disease, unnatural with accident and murder. In Hinduism, Jainism, Buddhism, Confucianism, and Daoism natural death has a normative value, thus implying criticism of the technological or artificial manipulations of the dying process, especially in the form of active euthanasia. Insofar as the natural is also seen as a manifestation of the spiritual, such a view reaffirms death as a gateway between the natural and the supernatural.

It is in reaction against such metaphysical perspectives—perspectives that have much in common with the premodern Christian views—that the Enlightenment gave birth to the typically modern, empirical explanation of death and efforts to take instrumental control of dying. From the invention of the microscope and the discovery of a small pox vaccination emerged the germ theory of disease. According to germ theory, microbes enter a body and attack its metabolic functioning. Public health initiatives are thus required to develop external means of protection against such attacks. With the discovery of antibiotics physicians were able to go inside the body and kill germs there as well. Death is no longer considered a consequence of sin, but is simply the result of disease and old age.

The Psychology of Dying and Death Redefined

Further developments in scientific and technological medicine have made it possible not only to protect from and respond to disease, but to aggressively manage the dying process with lifesaving or life-support technologies and to provide high-tech palliative care—and even take control of it with techniques for euthanasia. Psychological models of the dying process (which faintly echo the traditional guidebooks for the dying) and efforts to redefine death itself highlight alternative responses to the challenges thus raised.

The most popular psychological analysis of the dying process is *On Death and Dying* (1969) by Elizabeth Kübler-Ross. In her thanatology, she distinguishes five stages of dying through which people progress when informed that they have a terminal illness: denial, anger, bargaining, depression, and acceptance. This analysis has become so influential that some advocate its application in other situations in which people suffer loss or experience traumatic change. Indeed in the face of issues arising from revolutionary new technologies such as human cloning, there is room to argue that a culture passes through stages in which there is public denial of the possibility, anger at its scientific creation, bargaining for how it is to be used, depression that it seems inevitable, and finally acceptance as just another aspect of the advanced technological condition. Others, however, advocate modification and revision of Kübler-Ross's model, although no one has rejected the general idea that in the course of dying people typically go through different stages. To what extent this description is a normative as well as a descriptive paradigm remains unclear.

Kübler-Ross and others (see Moody 2001) also claim that empirical studies of the dying process and especially near-death experiences confirm the existence of an afterlife. This is a highly contentious position that nevertheless to some extent makes common cause with traditional guidebooks for the art of dying. More widely accepted are manuals that provide psychological guidance that extend Kübler-Ross's original approach (see Byock 1998).

In contrast to psychological studies of the dying experience, which was simply an open research question inviting scientific scrutiny, the need to redefine death was made acute by techno-medical advances. Death was traditionally defined in metabolic terms and indicated by cardiac or pulmonary arrest. But with the invention of artifacts that are able to substitute for the functions of heart and lungs, the human metabolism can often be indefinitely sustained. The Karen Ann Quinlan case of 1975, in which parents were initially denied the right to remove their comatose daughter from life support, was only one of a series of related cases that brought this issue to public attention, and served as a powerful stimulus to the creation of the field of bioethics. In response the 1978 Presidential Commission on the Study of Ethical Problems in Medicine and Biomedical and Behavioral Research, in conjunction with the American Bar Association (ABA), the American Medical Association (AMA), and the National Conference of Commissioners of Uniform State Laws, proposed a Uniform Determination of Death Act (UDDA). According to this draft act, "An individual who has sustained either (1) irreversible cessation of circulatory and respiratory function, or (2) irreversible cessation of the entire brain, including the brain stem, is dead." The draft UDDA has in various forms been enacted in most of the United States and has become the most widely adopted standard.

Tensions in Autonomy

As dying and death are reconceptualized under the influence of ever-advancing science and technology, a host of related decisions become progressively problematic—especially with regard to autonomy, one of the fundamental principles of contemporary Western ethics. The individual right to choose or self-determine whether or not to be placed on life-sustaining treatment is typical. Traditionally people did not have the *right to choose* their deaths. Age, accidents, sicknesses, and disease determined it for them. Individuals were ultimately passive as death approached. The goal of the patient-physician relationship was no more than the easing of symptoms related to life-limiting illnesses or the aging process.

All this changed as personal autonomy became a moral ideal and medical procedures and therapies altered what constituted unpreventable death and sustainable life. For example, during the late-nineteenth and early-twentieth centuries many patients with life-threatening conditions such as polio were sent home to die. By the late 1920s, lifesaving treatments such as the iron lung enabled them to live for years in machines that breathed for them. Under such conditions, even mere acceptance of whatever contemporary medical procedure has the most professional momentum behind it constitutes a choice, and the traditional attitude of passive acceptance in the face of extreme illness increasingly means an acceptance not of nature but of science and technology.

The dying and those who care for them are thus faced with progressively difficult decisions regarding nutrition, hydration, antibiotics, ventilation, and a host of more aggressive medical technologies. Dilemmas become especially apparent when advanced techniques of life-support enable sustaining basic metabolic functions with little hope for full recovery. Attempts to reflect on the dimensions of autonomous decision making under such conditions involve at least four overlapping tensions: (a) informed consent and ignorance; (b) private decisions and public demands; (c) curative care and futile care; and (d) benefits of treatment and the burden of care.

The tension between informed consent and ignorance is particularly difficult to negotiate when considering high-tech medical treatments under the stress of illness and pain that may well be terminal. Although there is a widely shared consensus that patients must be informed about and freely consent to treatments, how much should patients be expected to understand? What are the communication responsibilities of medical professionals? Even when patients claim to understand, can they always be trusted? What if they want to avoid becoming knowledgeable about their condition or desire to abdicate decision making to others, whether family members or medical professionals?

When confronting tensions between private decisions and public demands in a pluralistic society, it is commonly argued that private decisions take precedence. Presumably personal values inform private decisions while public attitudes differ and reflect fragmented cultural, religious, and emotional biases. For example, although most Americans express public opposition to euthanasia or physician-assisted suicide, they are personally more accepting when faced with extended, terminal suffering and pain. Thus there is a tendency to promote individual choice. Certainly most states and many countries give people the opportunity to make their wishes known with respect to possible life-limiting illnesses in the form of physician directives, medical powers-of-attorney, and do-not-resuscitate (DNR) orders.

A third tension arises between curative care and futile care. The desire to extend life is pervasive in Western cultures, but life support treatments sometimes prolong death more than they extend life. Curative care employs life-supporting technologies with the goal of recovery, but the consequences of living on continuous life-support, without hope of recovery, must be considered as well. The alternative of palliation or comfort care that allows the process of dying to take its course is another option. There are even instances when an otherwise curative procedure such as chemotherapy may be used as a palliative treatment.

Closely related to the curative versus futility tension is one between quality of life and quality of function. Quality of life issues generally revolve around physical or mental disabilities, which may impede but not destroy a person's ability to interact with and engage the environment. For example, persons with head injuries confined to hospital beds may be aware of the environment and engage the world around them. Although their quality of life is altered, such circumstance does not justify withholding or withdrawing life-sustaining treatment. Quality of function issues, however, may justify withdrawal of life-sustaining treatments when the ability to function is seriously impaired due to some significant pathology. Persons with head injuries who are in a persistent vegetative state and unaware of or unable to engage their environment have a low quality of functioning.

Finally tensions exists between the benefits of treatment and the burden of care. Life-support treatment always comes with both physical and financial costs. Therapies such as ventilation carry risks of infection, aspiration, and skin breakdown. When outcomes are successful, benefits are usually taken to outweigh burdens, although burn victim Dax Cowart has argued that this is not always so (Kliever 1989). Moreover while it is generally agreed that financial costs should not be the determinative factor when considering life-support, they must be considered. As the private burdens and public costs for funding life-support technologies rise, some argue that there are instances in which individuals may have a duty to die.

Burdens of care also often raise questions of equity and social justice. In principle all persons should have equal access to life-saving and life-sustaining technologies. In reality the poor, uneducated, and uninsured are far less likely to be treated or have the opportunity to make decisions about such treatment. At the same time, although it is commonly argued that death and dying decisions must relate to personal needs, some forms of this position have been challenged as excessively individualistic.

The Question of Modernity

Once viewed as spiritual experiences, in the early-twenty-first century death and dying are often considered no more than the cessation of metabolic or brain functioning. However, related issues continue to provoke strong responses because views on death and dying emerge in a variety of cultural contexts. It often appears that as technology and medicines advance, the fear of death increases, encouraging greater efforts to prolong life. Daniel Callahan (1973, 2000) argues that a fundamental rejection and fear of death is at the foundation of modern science and technology.

Certainly in Western scientific and technological culture, death has a negative connotation. Attempts to deny death are manifest both in the scientific efforts to map its physiological details and genetic basis as well as in technological efforts to hold it at bay as long as possible. Denial is further reinforced through the sequestering of the aged, ill, and dying, especially in the United States. Such individuals are institutionalized in hospitals, long-term nursing facilities, and retirement villages. Euphemisms such as *slumber*, *expired*, and *passed away* further reinforce the denial of death. Even contemporary religious customs enforce denial by limiting grieving time and trying to help families cope with personal losses.

Yet in an insightful reflection on death and dying in relation to the ideal of autonomy and technological mastery—what is termed the *instrumental activism* of the West—Talcott Parsons and Victor Lidz suggest an alternative interpretation. They identify a range of efforts to control and manage death and dying through "scientific medicine and public health services designed to protect life; insurance, retirement, and estate planning to manage the practical consequences of deaths; and mourning customs that emphasize recovery of survivors' abilities to perform ordinary social roles soon after the death of family members, friends, and associates" (Parsons and Lidz 2004a, p. 597). From such perspective, what others described as attempts to hide or ignore death are seen as techniques for its management under conditions in which there is no strong cultural consensus about the meaning of either life or death, short of what can be concluded from the empirical evidence (that it is bound to occur) and postulated on the basis of scientific theory (its evolutionary benefits to both organisms and society).

To what extent might these same techniques be integrated into a different cultural context in which death and dying continue to be experienced as a spiritual transition between worlds? The question is not easy to answer, and may not be answerable at all apart from historical efforts at adaptation. But whether the standard bioethical efforts to promote patient autonomy, equity of access, and a quality hospital experience can transcend the contemporary cultural framework remains unclear.

ERIC T. HAMMER
CARL MITCHAM

SEE ALSO *Brain Death; Cancer; Euthanasia; Euthanasia in the Netherlands; Medical Ethics; Playing God; Right to Die.*

BIBLIOGRAPHY

Ariès, Phillipe. (1991). *The Hour of our Death*, reissue edition. Oxford: Oxford University Press. French original 1981. An influential study of the cultural experience of death.

Barley, Nigel. (1997). *Grave Matters: A Lively History of Death around the World*. New York: Henry Holt. A popular review of anthropological knowledge.

Bulger, Ruth Ellen; Elizabeth Meyer Bobby; and Harvey V. Fineberg, eds. (1995). *Society's Choices: Social and Ethical Decision Making in Biomedicine*. Washington, DC: National Academy Press.

Byock, Ira. (1998). *Dying Well: Peace and Possibilities at the End of Life*. New York: Penguin Riverhead Books.

Callahan, Daniel. (1973). *The Tyranny of Survival and Other Pathologies of Civilized Life*. New York: Macmillan.

Callahan, Daniel. (2000). *The Troubled Dream of Life: In Search of a Peaceful Death*. Washington, DC: Georgetown University Press.

Dunn, Hank. (2001). *Hard Choices for Loving People*. Herndon, VA: A & A Publishers.

Fox, Renée C., ed. (1980). "The Social Meaning of Death." *Annals of the American Academy of Political and Social Science* 447: 1–101.

Kliever, Lonnie D., ed. (1989). *Dax's Case: Essays in Medical Ethics and Human Meaning*. Dallas, TX: Southern Methodist University Press.

Kübler-Ross, Elizabeth. (1969). *On Death and Dying*. New York: Simon & Schuster.

Lo, Bernard; Delaney Ruston; Laura W. Kates; et al. (2002). "Discussing Religious and Spiritual Issues at the

End of Life: A Practical Guide for Physicians." *Journal of the American Medical Association* 287(6)(February): 749–754.

Moody, Raymond A. (2001). *Life after Life: The Investigation of a Phenomenon—Survival of Bodily Death*. San Francisco: Harper.

Parsons, Talcott, and Victor Lidz. (2004a). "Death, V: Death in the Western World." In *Encyclopedia of Bioethics*, 3rd edition, Vol. 4, ed. Stephen G. Post. New York: Macmillan.

Parsons, Talcott, and Victor Lidz. (2004b). "Postscript." In *Encyclopedia of Bioethics*, 3rd edition, Vol. 4, ed. Stephen G. Post. New York: Macmillan.

Pattison, E. M. (1990). "Biomedical Definition of Death." In *Dictionary of Pastoral Care and Counseling*, ed. Rodney J. Hunter. Nashville, TN: Abingdon Press.

President's Commission for the Study of Ethical Problems in Medicine and Biomedical and Behavioral Research. *Defining Death: Medical, Legal and Ethical Issues in the Determination of Death*. Washington, DC: Government Printing Office.

Tobin, Daniel R, M.D., with Karen Lindsey. (1999). *Peaceful Dying*. New York: Perseus Books.

Young, Katherine K. (2004). "Death, II: Eastern Thought." In *Encyclopedia of Bioethics*, 3rd edition, Vol. 4, ed. Stephen G. Post. New York: Macmillan.

INTERNET RESOURCE

"Withholding and Withdrawing Life-prolonging Treatments: Good Practice in Decision-making." General Medical Council. Available from http://www.gmc-uk.org/global_sections/search_frameset.htm.

DEATH PENALTY

There is an ongoing crucial debate within the criminal justice system as to the moral status of the death penalty. Retentionists hold that the death penalty is morally justified; abolitionists argue that it is not. Proponents of the death penalty justify it from either a retributive or a utilitarian framework, sometimes using both theories for a combined justification. Abolitionists reject these contentions arguing that the principle of the sanctity of human life gives each person an inalienable right to life and thus prohibits imposition of the death penalty. Scientific research and technological developments provide modest contributions to both arguments.

Retributive Arguments

The retributivist argues (1) that all the guilty deserve to be punished; (2) that only the guilty deserve to be punished; and (3) that the guilty deserve a punishment proportional to their crime. It follows that death is a suitable punishment for anyone who commits a capital offense (that is, those offenses such as murder and treason that are especially morally heinous). The concept is suggested in the Bible: "Thou shalt give life for life, an eye for an eye, a tooth for a tooth, a hand for a hand, burning for burning, wound for wound, stripe for stripe" (*Exod*. 21: 23–25).

A classic expression of the retributivist position on the death penalty is Immanuel Kant's statement that if an offender "has committed murder, he must *die*. In this case, no possible substitute can satisfy justice. For there is no *parallel* between death and even the most miserable life, so that there is no equality of crime and retribution unless the perpetrator is judicially put to death (at all events without any maltreatment which might make humanity an object of horror in the person of the sufferer)" (Kant 1887, p. 155).

For Kant, the death penalty was a conclusion of the argument for justice: just recompense to the victim and just punishment to the offender. As a person of dignity, the victim deserves (as a kind of compensatory justice) to have the offender harmed in proportion to the gravity of the crime, and as a person of high worth and responsibility, the offender is deserving of the death penalty. Accordingly the torturer should be tortured exactly to the severity that he tortured the victim, the rapist should be raped, and the cheater should be harmed to a degree equal to that suffered by the one cheated. Criminals deserve such punishment in accordance with the principle of proportionality.

The abolitionist disagrees. Putting the criminal to death only compounds evil. If killing is an evil, then the evil is doubled when the state executes the murderer, violating the latter's right to life. The state commits *legalized murder*. To quote the famous eighteenth-century abolitionist Cesare di Beccaria, "The death penalty cannot be useful because of the example of barbarity it gives to men … it seems to me absurd that the laws … which punish homicide should themselves commit it" (*On Crimes and Punishment*, 1764).

The retentionist responds that the abolitionist is mistaken. The state does not violate the criminal's right to life, for the right to life (more precisely, the right not to be killed) is not an absolute right that can never be overridden (or forfeited). If the right to life were absolute, one could not kill an aggressor even when such action is necessary to defend one's own life or the lives of loved ones. It is a *prima facie* or conditional right that can be superseded in light of a superior moral reason. The individual right to life, liberty, and property is connected to the societal duty to respect the rights of others to life, liberty, and property. A person can forfeit the right to liberty by violating the liberty rights of others. A person can forfeit property rights by violating the property rights of others. Similarly the right to life can be forfeited when a person violates the right to life of another. An individual's *prima facie* right to life no longer exists if that person has committed murder.

Utilitarian Arguments

The utilitarian argument for capital punishment is that it deters would-be offenders from committing first degree murder (that is, types of murder that seem especially vicious, brutal, or deleterious, such as assassination). However some studies that compared states that allow capital punishment to those that do not permit it concluded that imprisonment works as well as the death penalty in deterring homicide. Other studies purport to show that when complex sociological data (race, heredity, regional lines, standards of housing, education, and opportunities, among others) are taken into account, the death penalty does deter. Anecdotal evidence exists to support this. Abolitionists argue that isolated cases are poor indicia of the reality regarding deterrence.

Abolitionists point out that the United States is the only Western democracy to retain the death penalty. The retentionist responds that this is not an argument, but an appeal to popularity. Furthermore, in many Western countries that prohibit the death penalty (such as England, Italy, and France), there is evidence that the majority of citizens favor it.

Scientific and Technological Contributions

Science and technological issues are relevant to the debate in so far as some argue that neuroscience and psychology show that criminals, including murderers, commit crimes due to neurological dysfunction and are not responsible for what they do. However the same arguments could be used to deny human responsibility altogether.

An application of technology to the death penalty is illustrated by attempts to find more benign forms of execution, for example, replacing the electric chair (which some consider cruel and unusual punishment) with lethal injection. Such changes have caused debate about whether the condemned deserves humane treatment or should be subjected to some pain and anxiety as part of the punishment.

Other abolitionists argue, on the basis of social scientific studies, that the U.S. penal system is inherently unfair, is biased against the poor and minorities, and favors the rich who can afford to hire better legal counsel. Furthermore they contend that there is always the possibility that an innocent person will be executed. The retentionist, recognizing these dangers, responds, Amend it, don't end it.

LOUIS P. POJMAN

SEE ALSO *Crime; Justice; Police; Science, Technology, and Law.*

BIBLIOGRAPHY

Bedau, Hugo Adam, ed. (1982). *The Death Penalty in America*, 3rd edition. New York: Oxford University Press.

Kant, Immanuel. (1887). *The Metaphysics of Morals*. Edinburgh: T & T Clark.

Murphy, Jeffrie, ed. (1968). *Punishment and Rehabilitation*. Belmont, CA: Wadsworth Publishing.

Pojman, Louis P., and Jeffrey Reiman. (1998). *The Death Penalty: For and Against*. Lanham, MD: Rowman & Littlefield.

Sorrel, Tom. (1987). *Moral Theory and Capital Punishment*. Oxford: Blackwell.

DECISION SUPPORT SYSTEMS

Decision support systems (DSS) are tools meant to assist in human decision-making (Turban and Aronson 2001). In an increasingly complex and rapidly changing world where information from human, software, and sensor sources can be overwhelming, DSS tools can serve as a bridge between the social and technical spheres. DSS tools offer support based on formal, technical approaches, but do so within a context that is often largely socially mediated.

Most DSS tools are assembled out of hardware devices and software constructs. The hardware devices, in the early twenty-first century, are dominated by digital computers and peripherals such as sensors, network infrastructure, and display and alerting devices meant to interact with these. Historically, many DSS were hardwired to solve a specific task; control systems in nuclear power plants are an example. DSS hardware is increasingly dominated by physically distributed systems that make use of wired and wireless networks to gather and share information from and with remote sources (Shim et al. 2002). The convergence of remote sensing, sensor-networks, and distributed computational grids using the Internet as a foundation in the late 1990s–early 2000's reflects this trend.

The software, or algorithmic, component of DSS derives from historical research in statistics, operations research, cybernetics, artificial intelligence, knowledge management, and cognitive science. In early monitoring decision support systems the algorithms were typically hard-wired into the system, and these systems tended to be unchanging once built. Software-based decision support allows for multiple approaches to be applied in parallel, and for systems to evolve either through new software development or via software that "learns" through artificial intelligence techniques such as rule induction (Turban and Aronson 2001).

When used appropriately, DSS tools are not meant to replace human decision-making—they are meant to make it more effective (Sprague and Watson 1996). DSS tools do this by presenting justified answers with explanations, displaying key data relevant to the current problem, performing calculations in support of user decision tasks, showing related cases to suggest alternatives, and alerting the user to current states and patterns. In order to be a support rather than a hindrance, these tools must be constructed with careful attention to human cognitive constraints. As a result, DSS design is a prime area of human-computer interaction and usability research. In many cases, DSS tools make use of adaptive software interfaces; depending on the situation, different contents will be displayed on the interface, so as not to overwhelm the user with secondary or irrelevant information.

Decision Support Tools

Decision support tools fall into two broad classes: those that operate at the pace of the user (for example, to support planning decisions) and those that operate at or near the pace of real-time world events (such as air traffic control systems). The decision-making domain can be further divided into situations in which the system can be completely and accurately defined (in other words, closed and formal systems) and those where this is not feasible, desirable, or possible. The former is not normally considered a prime situation for decision *support* because a formal situation can be addressed without human intervention, while the latter requires the hybrid human-machine pairing found in DSS. In the case of open systems, heuristic approximations (rules of thumb) are needed in lieu of formal models; these may also be needed in cases in which a formal model exists but cannot be computed in a reasonable amount of time.

Systems that operate at the pace of the user provide support for such tasks as planning and allocation, medical and technical diagnosis, and design. Typical examples include systems used in urban planning to support the complex process of utility construction, zoning, tax valuation, and environmental monitoring, and those used in business to determine when new facilities are needed for manufacturing. Such tools include significant historical case-knowledge and can be transitional with training systems that support and educate the user. Formal knowledge, often stored as rules in a modifiable knowledge base, represent both the state of the world that the system operates on and the processes by which decisions transform that world. In the cases where formal knowledge of state and process are not available, heuristic rules in a DSS expert system or associations in a neural network model might provide an approximate model. DSS tools typically provide both a ranked list of possible courses of action and a measure of certainty for each, in some cases coupled with the details of the resolution process (Giarratano and Riley 2005).

Systems that operate at or near real time provide support for monitoring natural or human systems. Nuclear power plant, air traffic control, and flood monitoring systems are typical examples, and recent disasters with each of these illustrate that these systems are fallible and have dire consequences when they fail. These systems typically provide support in a very short time frame and must not distract the user from the proper performance of critical tasks. By integrating data from physical devices (such as radar, water level monitors, and traffic density sensors) over a network with local heuristics, a real-time DSS can activate alarms, control safety equipment semi-automatically or automatically, allow operators to interact with a large system efficiently, provide rapid feedback, and show alternative cause and effect cases. A central issue in the design of such systems is that they should degrade gracefully; a flood monitoring system that fails utterly if one cable is shorted-out, for example, is of little use in a real emergency.

History of Decision Support Research and Tools

As indicated above, DSS evolved out of a wide range of disciplines in response to the need for planning-support and monitoring-support tools. Management and executive information systems, where model and data-based systems dominated, reflect the planning need; control and alerting systems, where sensor and model-based alerting systems were central, reflect the monitoring need. The original research on the fusion of the source disciplines, and in particular the blending of cognitive with artificial intelligence approaches, took place at Carnegie-Mellon University in the 1950s (Simon 1960). This research both defined the start of DSS and also was seminal in the history of artificial intelligence; these fields have to a large degree co-evolved ever since. By the 1970's research groups in DSS were widespread in business schools and electrical engineering departments at universities, in government research labs, and in private companies. Interestingly, ubiquitous computer peripherals such as the mouse originated as part of decision support research efforts.

By the 1980s the research scope for DSS had expanded dramatically, to include research on group-based decision making, on the management of knowledge and documents, to include highly specialized tools such as expert-system shells (tools for building new expert systems by adding only knowledge-based rules), to incorporate hypertext documentation, and towards the construction of distributed multi-user environments for decision making. In the mid-1980s the journal *Decision Support Systems* began publishing, and was soon followed by other academic journals. The appearance of the World Wide Web in the early 1990's sparked a renewed interest in distributed DSS and in document- and case-libraries that continues in the early twenty-first century.

Outstanding Technical Issues with Decision Support Tools

DSS tools, as described above, integrate data with formal or heuristic models to generate information in support of human decision making. A significant issue facing the builders of these tools is exactly how to define formal models or heuristics; experts make extensive use of tacit knowledge and are notoriously unreliable at reporting how they actually do make decisions (Stefik 1995). If the rules provided by domain experts do not reflect how they actually address decisions, there is little hope that the resulting automated system will perform well in practice.

A second, related, issue is that some systems are by their very nature difficult to assess. Chaotic systems, such as weather patterns, show such extreme sensitivity to initial (or sensed) conditions that long-term prediction and hence decision support is difficult at best. Even worse, many systems cannot be considered in isolation from the decision support tool itself; DSS tools for stock market trading, for example, have fundamentally changed the nature of markets.

Finally, both the DSS tools and the infrastructure on which they operate (typically, computer hardware and software) require periodic maintenance and are subject to failure from outside causes. Over the life of a DSS tool intended to, for example, monitor the electrical power distribution grid, changes to both the tools themselves (the hardware, the operating system, and the code of the tool) and to their greater environment (for example, the dramatic increase in computer viruses in recent history) mean that maintaining a reliable and effective DSS can be a challenge. It cannot be certain that a DSS that performs well now will do so even in the immediate future.

Ethical Issues

Decision support rules and cases by their very nature include values about what is important in a decision-making task. As a result, there are significant ethical issues around their construction and use (see, for example, Meredith and Arnott 2003 for a review of medical ethics issues). By deciding what constitutes efficient use in a planning support system for business, or what constitutes the warning signs of cardiac arrest in an intensive care monitoring system, these tools reflect the values and beliefs of the experts whose knowledge was used to construct the system. Additionally, the social obligation of those who build DSS tools is an issue. On the one hand, these are tools for specific purposes; on the other hand, many social and natural systems are so interrelated that, in choosing to build an isolated and affordable system, many issues will be left unresolved.

The ruling assumption of efforts to build DSS tools is that decision-making is primarily a technical process rather than a political and dialogical one. The bias here is not so much intellectual as informational: It may overestimate the usefulness of information in the decision-making process. Rather than more information, or ever more elaborate displays, people might need more time to reflect upon a problem. Coming to understand another perspective on an issue is a matter of sympathy and open-mindedness, not necessarily information delivery. Delivering detailed information, cases, and suggested courses of action to a single user is opposed to the idea of community-base processes. While placing these issues outside of the scope of a system design might be a useful design decision from a technical position, it is a value-laden judgment.

In fairness, the decision support literature does occasionally recognize that the public needs a better understanding not only of technology but also of science. There is often little appreciation, however, that decision support is an ethical and political process as much as a technical one—or that the flow of information needs to involve the scientist, the engineer, and the public. Exactly how the political process can be engaged for systems that must by their very nature operate in real time is an open question. Certainly the process of knowledge and value capture for such systems could be much more open than is currently the norm.

A second pressing issue regarding DSS tools is the degree to which the data, knowledge, sensors, and results of their integration represent a limitation on individual freedoms and/or an invasion of privacy. DSS tools based on expert-systems approaches actively monitor every credit card transaction made. Semi-automatic face recognition systems are widespread. Radio-frequency identification tags built into price tags on consumer goods allow consumer behavior to be monitored in real-time. Cell-phone records provide not only who a person was speaking to, but where they were at the time. Decision support tools for national security, market research, and strategic planning integrate information, apply rules, and inform decisions that affect human freedom and privacy every day.

Conclusions

DSS tools will only become more common in the future. The widespread reach of Internet connections and the dramatic decrease in the cost of sensors is driving the creation of decision support tools within governments and industries worldwide. It remains to be seen how these systems may impact on human lifestyles, freedoms, and privacy, and whether these tools can continue to evolve to handle the difficult questions facing decision makers in a complex and changing world.

ROBIN M. HARRAP
ROBERT FRODEMAN

SEE ALSO *Choice Behavior; Decision Theory; Engineering Method; Information Society; Rational Choice Theory; Science Policy.*

BIBLIOGRAPHY

Giarratano, Joseph C., and Gary D. Riley. (2005). *Expert Systems: Principles and Programming*, 4th ed. Boston: Thomson Course Technology. A focussed introduction to expert systems technology from the authors of the open source expert system tool CLIPS, widely used in decision support systems.

Meredith, Rob, and David Arnott. (2003). "On Ethics and Decision Support Systems Development." In *Proceedings of the Seventh Pacific Asia Conference on Information Systems, 10–13 July 2003*, ed. Jo Hanisch, Don Falconer, Sam Horrocks, and Matthew Hillier. Adelaide: University of South Australia. An examination of the methods of decision support systems in medical practice.

Shim, J. P.; Merrill Warkentin; James F. Courtney; et al. (2002). "Past, Present, and Future of Decision Support Technology." *Decision Support Systems* 33(2): 111–126. A systematic overview of the development of decision support systems.

Simon, Herbert A. (1960). *The New Science of Management Decision*. New York: Harper and Row. An early and highly influential look at the automation of decision making in business from the leading researcher of the era.

Sprague, Ralph H., Jr., and Hugh J. Watson. (1996). *Decision Support for Management*. Upper Saddle River, NJ: Prentice Hall. A broad overview of decision support systems, emphasizing systems used in business practice for financial and organizational planning.

Stefik, Mark. (1995). *Introduction to Knowledge Systems*. San Francisco: Morgan Kaufmann. A detailed examination of the human and software problems in constructing software-based knowledge systems.

Turban, Efraim, and Jay E. Aronson. (2001). *Decision Support Systems and Intelligent Systems*, 6th edition. Englewood Cliffs, Upper Saddle River, NJ: Prentice Hall. A broad overview of decision support research and artificial intelligence approaches that support decision making. Includes extensive case studies from the history of DSS tools.

DECISION THEORY

Decision theory is the science of rational choice in situations in which there is uncertainty about the outcome. Rational choice theory asserts that individuals whose behavior satisfies a few plausible conditions (such as transitivity, which means that if A is preferred to B and B is preferred to C, then A is preferred to C) will behave as though they are maximizing a preference function defined over the choice outcomes. For instance, consider an agent with the preference function $u(a, n)$ defined over two goods, Apples and Nuts, and with an amount of money M to spend. Thus, u(2, 5) is the "utility" the agent derives from consuming two apples and five nuts (for this reason, economists call a preference function a *utility function*). If the prices of Apples and Nuts are p_a and p_n, the individual will choose the amount of Apples a and the amount of Nuts n that will maximize $u(a, n)$, subject to the constraint that the total cost is not greater than M (i.e., $p_a a + p_n n \leq M$). Decision theory deals with such choices when there is uncertainty regarding the amount of Apples and Nuts that will be delivered.

Decision theory relies on probability theory, the development of which began in the seventeenth and eighteenth centuries, associated with scholars such as Blaise Pascal (1623–1662), Daniel Bernoulli (1700–1782), and Thomas Bayes (1702–1761). The analysis here will be confined to the case where there is only a finite set of outcomes A, written as $A = \{a_1, \ldots, a_n\}$. A *probability distribution* over A is called a *lottery* and consists of n numbers $p_1, \ldots, p_n$ such that each $p_i \geq 0$ and $p_1 + \cdots + p_n = 1$. In this case p_i is interpreted as the probability that outcome a_i occurs.

The Expected Value and Expected Utility of a Lottery

One of the first problems addressed by probability theorists was the determination of the *certainty equivalent* of a lottery: If someone offers to sell a person a lottery with monetary prizes for a certain amount of money, what is the maximum the buyer should be willing to pay? Early probability theorists suggested that that person should be willing to pay the "average" payoff of the lottery. However, it soon was shown that the average payoff of lottery x is equal to its expected value, which is defined as $\mathbf{E}x = p_1a_1 + \cdots + p_na_n$. For instance, the expected value of a lottery that pays $1,000,000 with a probability of 1/1,000,000 has an expected value of $1.

Daniel Bernoulli, however, developed a simple example, known as the *St. Petersburg Paradox*, that clearly showed that the idea that people will pay the expected value must be incorrect. Suppose a person is offered either a sum of money M or the following lottery: A coin is tossed a number of times until it turns up heads, after which the game is over. If the first toss is heads, the person is paid $1. If the first toss is tails and the second is heads, that person is paid $2, and so on, with each additional round paying twice as much ($4, $8, ...). Most people, if offered M = $20, will take this rather than play the coin-tossing game, yet the expected value of the game is infinite:

$$\mathbf{E} = \tfrac{1}{2}\times 1 + \tfrac{1}{4}\times 2 + \tfrac{1}{8}\times 4 + \ldots = \tfrac{1}{2} + \tfrac{1}{2} + \tfrac{1}{2} + \ldots = \infty.$$

Bernoulli suggested that the problem here is that the "utility" of each additional unit of money *decreases* as the amount increases, just as the additional utility of each additional scoop of ice cream decreases for a consumer. He suggested that the utility of money may be logarithmic and that people maximize the expected utility of a lottery, not the expected value. If the utility of an amount of money M is log(M), the expected utility of the St. Petersburg lottery is

$$\begin{aligned}\mathbf{E} &= \tfrac{1}{2}\log(1) + \tfrac{1}{4}\log(2) + \tfrac{1}{8}\log(4) + \tfrac{1}{16}\log(8) + \ldots\\ &= 0 + 0.17 + 0.17 + 0.13 + 0.09 + \ldots\\ &\approx 1.66\end{aligned}$$

The von Neumann–Morganstern Axioms

A general model of expected utility was not developed until centuries later. John von Neumann (1903–1957) and Oskar Morgenstern (1902–1976) developed decision theory as a model of rational choice in regard to lotteries. They supplied three conditions from which the expected utility principle could be derived. The first was, as in standard rational choice theory, that the agent has a weak preference relation $\succeq$ that is complete and transitive over the set of lotteries. By *complete* it is meant that for any two lotteries x and y, one is weakly preferred to the other (i.e., either $x \succeq y$ or $y \succeq x$). This is called a weak preference because any lottery x is weakly preferred to itself (i.e., for any lottery x, there is $x \succeq x$). Strong preference can be defined $\succ$ as $x \succ y$ means that "it is false that $y \succ x$." By *transitive* it is meant that if x is weakly preferred to y and y is weakly preferred to z, then x is weakly preferred to z ($x \succeq y$ and $y \succeq z$ implies $x \succeq z$).

Suppose x and y are lotteries and suppose p is a probability (i.e., a number between zero and one). One writes $px + (1 - p)y$ for the lottery that gives lottery x with probability p and lottery y with probability $1 - p$. For instance, suppose x is the lottery that pays off $20 with probability 0.25 and $10 with probability 0.75 and suppose y is the lottery that pays off $5 with probability 0.90 and $100 with probability 0.10. Then $0.33x + 0.67y$ is the lottery that pays off x with probability 0.33 and y with probability 0.67. This so-called compound lottery thus has payoffs $0.33x + 0.67y = 0.33[0.25(\$20) + 0.75(\$10)] + 0.67[0.90(\$5) + 0.10(\$100)]$, and so this is a lottery that pays $20 with probability (0.33)(0.25) = 0.0825, pays $10 with probability (0.33)(0.75) = 0.2475, pays $5 with probability (0.67)(0.90) = 0.6030, and pays $100 with probability (0.67)(0.10) = 0.067. Note that these probabilities add up to one, as they should. As an exercise, one may check to see that if $\mathbf{E}x$ and $\mathbf{E}y$ are the expected values of lotteries x and y, then $a\mathbf{E}x + (1 - a)\mathbf{E}y$ is the expected value of the lottery $ax + (1 - a)y$.

The second von Neumann–Morgenstern condition is that if $x \succ y$ and z is any lottery and $p < 1$ is a probability, then $px + (1 - p)z \succ py + (1 - p)z$. This is called the *independence* condition. It says that the value of a prize depends only on the prize and the probability of winning it, not on other payoffs or probabilities.

The third condition is that if x, y, z are lotteries and $x \succ y \succ z$, there are numbers p and q such that $px + (1 - p)z \succ y \succ qx + (1 - q)z$. This says that there is no lottery that is infinitely valuable or infinitely distasteful. This is called the *Archimedean condition*.

With these three conditions von Neumann and Morgenstern showed that the agent has a utility function $u(a)$ defined over the outcomes $a_1, \cdots, a_n$ such that for any two lotteries $x = p_1a_1 + \cdots + p_na_n$ and $y = q_1a_1 + \cdots + q_na_n$, $x \succ y$ if and only if

$$p_1u(a_1) + p_2u(a_2) + \cdots + p_n\mathrm{u}(a_n) > q_1u(a_1) + q_2u(a_2) + \cdots + q_n\mathrm{u}(a_n).$$

Note that the first sum is the expected value of the lottery x in which the payoffs are replaced by the *utility* of the payoffs, and this also applies to the second sum. This motivates the definition of the expected utility of a lottery x as

$$\mathbf{E}_pu = p_1u(a_1) + p_2u(a_2) + \cdots + p_n\mathrm{u}(a_n).$$

The *expected utility theorem* thus states that an individual whose behavior satisfies the conditions listed above (complete transitive preferences that satisfy the independence and Archimedean conditions) chooses among lotteries to maximize expected utility.

Subjective Probability Theory

The purpose of decision theory is to explain and predict behavior, and an agent's behavior depends on that agent's *subjective assessments* of the likelihood of different outcomes. Modern *subjective probability theory* was developed in the twentieth century by Frank Ramsey (1903–1930) and Bruno de Finetti (1906–1985) and was applied to decision theory by Leonard Savage (1917–1971).

Savage begins with a set of all possible mutually exclusive "states of the world" that are relevant for an agent's decision. For instance, to decide whether to buy a new car, a couple may consider (a) possible changes in their employment and health status over the next few years, (b) whether they may increase their family's size, (c) whether next year's models will be better or more affordable than this year's, and (d) whether they can find a lower price elsewhere.

Savage then defines an action f such that $f(s)$ is an outcome or payoff for each state of the world $s \in S$. For instance, for the couple, $f(s)$ = "buy car" for some states of the world and $f(s)$ = "don't buy car" for the other states. Savage shows that if the decision maker has preferences for actions that satisfy certain plausible conditions, it is possible to infer a probability distribution p over states of the world S and a utility function u over outcomes such that the decision maker maximizes expected utility $\mathbf{E}_pu(s) = \sum_{s\in S} p(s)u(s)$ (Kreps 1988).

Violations of Expected Utility Theory

The expected utility approach to decision theory is used widely in behavioral modeling, virtually to the exclusion of other approaches. However, laboratory studies of actual behavior have revealed consistent deviations from the application of the theory. For one thing, there are indications that the independence axiom may be violated, implying that the probability weights in the expression for $\mathbf{E}_pu(s)$ may be *nonlinear*. This fact was first discovered by Maurice Allais (b. 1911, winner of a Nobel Prize in economics in 1988), using the following schema.

Consider a choice between lotteries x_1, which offers \$1,000,000 with probability one, and x_2, which offers a 10 percent chance for \$5,000,000, an 89 percent chance for \$1,000,000, and a 1 percent chance for \$0. Consider a second choice between lotteries y_1, which offers a 10 percent chance for \$5,000,000 and a 90 percent chance for \$0, and y_2, which offers an 11 percent chance at \$1,000,000 and an 89 percent chance for \$0. An individual who prefers x_1 to x_2 prefers an 11 percent chance of \$1,000,000 to a 10 percent chance of \$5,000,000 plus a 1 percent chance of \$0. If an 89 percent chance of \$0 is added to both of these possibilities, this individual, if maximizing expected utility, must prefer an 11 percent chance of \$1,000,000 to a 10 percent chance of \$5,000,000 and therefore must prefer y_2 to y_1. However, in fact, most people prefer x_1 and y_2. An analysis of this and other violations of the independence axiom is provided in the work of Mark Machina (1989).

A second violation of the expected utility model is *loss aversion*, which first was proposed by Daniel Kahneman (b. 1934, winner of a Nobel Prize in economics in 2003) and Amos Tversky (1937–1996) in a 1991 paper. For example, if faced with the choice between a lottery that pays \$5 with probability one and a lottery that pays \$10 with probability ½ and \$0 with probability ½, most people will choose the former (they are said to be *risk-averse* because they prefer the expected value of a risky lottery to the risky lottery). For instance, a risk-averse person will prefer a certain \$5 to a risky lottery with expected value \$5, such as either winning \$10 or winning \$0, each with probability ½. However, if they are given \$10 (say, for showing up for an experimental session) and are faced with the choice between a lottery that loses \$5 with probability one and another that loses \$10 with probability ½ and loses \$0 with probability ½, most people will choose the latter. In this case the subjects are *risk-loving*. Note that the subjects go home with the same amount of money in either lottery. This is certainly a violation of the expected utility theorem. Loss aversion explains many phenomena that defy explanation in traditional decision theory, including the so-called *endowment effect* (Kahneman, Knetch, and Thaler 1990) and the *status quo bias* (Samuelson and Zeckhauser 1988).

Assessment

The rational choice model and its subsidiary, rational decision theory, offer the most powerful analytic tools for modeling human behavior and the behavior of living organisms in general. The laboratory experiments of Allais, Kahneman and Tversky and others (for a summary, see Kahneman and Tversky, 2000) show that in some circumstances expressions more complex than expected utility are needed and that there are important parameters in an individual's preference function, such as the current time and the agent's possessions at the time when decisions are made. Decision theory has been criticized, but its critics have offered nothing that could replace it, and the criticisms generally have been mutually contradictory and often misinformed.

The most famous sustained critique was offered by Herbert Simon (1916–2001, winner of a Nobel Prize in economics in 1978), who suggested that agents do not maximize but instead satisfy "bounded rationality." Simon's observations are correct but are not incompatible with rational decision theory as long as one adds a cost of decision making and interprets probabilities as subjective, not objective. Several disciplines in the social sciences, including sociology, anthropology, and social psychology, implicitly critique the theory by ignoring it in formulating their underlying core theories. This may account for their relative lack of coherence compared with disciplines that embrace rational choice theory (Gintis 2004).

Perhaps the major implication of decision theory is that human beings have a declining marginal utility of money. This is evidenced by the ubiquity of risk aversion and the willingness of individuals to insure against loss. This has an important ethical implication: A dollar transferred from a rich person to a poor person will increase the well-being of the poor person much more than it will reduce the well-being of the rich person.

Some philosophers and philosophically minded economists have played word games in attempting to refute this obvious implication of declining marginal utility (e.g., by suggesting that welfare is not comparable across individuals, an implausible assertion), but its force remains. It implies that with everything else being equal, a more equal distribution of wealth would improve the general welfare. Of course, there are often considerations that act against this principle, such as the maintenance of effective economic incentives and the just treatment of and respect for the rights of the wealthy.

HERBERT GINTIS

SEE ALSO *Choice Behavior; Game Theory; Prisoner's Dilemma; Rational Choice Theory; Scientific Ethics; von Neumann, John.*

BIBLIOGRAPHY

Gintis, Herbert. (2004). "On the Unity of the Behavioral Sciences." In *Logic, Epistemology, and the Unity of Science*, ed. Dov Gabbay, Shahid Rahman, John Symons, and Jean Paul Van Bendegeme. New York: Kluwer.

Herbert Simon, Herbert. (1982). *Models of Bounded Rationality*. Cambridge, MA: MIT Press.

Kahneman, Daniel; Jack L. Knetch; and Richard H. Thaler. (1990). "Experimental Tests of the Endowment Effect and the Coase Theorem." *Journal of Political Economy* 98(6): 1325–1348.

Kahneman, Daniel, and Amos Tversky. (2000). *Choices, Values, and Frames*. Cambridge, UK: Cambridge University Press.

Kreps, David M. (1988). *Notes on the Theory of Choice*. London: Westview.

Machina, Mark J. (1989). "Dynamic Consistency and Non-Expected Utility Models of Choice under Uncertainty." *Journal of Economic Literature* 27: 1622–1668.

Samuelson, William, and Richard. Zeckhauser. (1988). "Status-Quo Bias in Decision Making." *Journal of Risk and Uncertainty* 1: 1–59.

Simon, Herbert. (1982). *Models of Bounded Rationality*. Cambridge, MA: MIT Press.

Tversky, Amos, and Daniel Kahneman, (1981). "Loss Aversion in Riskless Choice: A Reference-Dependent Model." *Quarterly Journal of Economics* 106(4) [Nov]: 1039–1061.

DEFORESTATION AND DESERTIFICATION

A common claim of defenders of tropical rain forests is that because of the shallowness of rain forest soils cutting down those forests for crops or cattle grazing will lead to massive soil erosion and eventually create deserts in areas where lush forests once grew and provided a high percentage of the earth's biodiversity (Sponsel, Headland, and Bailey 1996; Burch 1994; *The Burning Season* 1994).

Complexity of Causes

However, the causes of desertification are much more complex than this scenario would suggest. It is true, for instance, that in the Mediterranean Basin deforestation over centuries has been a significant factor in desertification from Spain and the western part of North Africa in the west to Lebanon and Palestine in the east. Nevertheless, cutting down forests was only one among several human factors that advanced desertification in that region, along with climatic factors:

> First and most fundamental are climate factors. Here is one summary: Conditions [for desertification] are common in the Northern and Southern hemispheres between 20° and 30° latitude.... The most common factor in determining climate is the intense equatorial solar radiation, which heats the air and generates high levels of humidity. Warm tropical air rises; as it does it cools, and the atmospheric moisture condenses. That results in high rainfall patterns in the equatorial region. The rotating earth causes these air masses to move away from the equator toward both poles, and the air begins to descend on either side of the Tropic of Capricorn and the Tropic of Cancer around the 30° latitudinal band. As the air descends it warms and relative humidity declines, resulting in a warm belt of aridity around the globe (Mares 1999, p. 169).

This is the explanation for the existence of deserts worldwide, but for many people concerned with science, technology, and ethics the term *desertification* has a different meaning:

> Desertification is the degradation of productive drylands, including the Savannas of Africa, the Great Plains and the Pampas of the Americas, the Steppes of Asia, the "outback" of Australia and the margins of the Mediterranean. Desertification is occurring to such a degree that some lands can no longer sustain life (Middleton and Thomas 1997, p. iv).

It is controversial whether humans can do anything about climate change, and so the basic formation of the world's deserts is of less interest here—specifically as an ethical or social problem to the mitigation of which science and technology might contribute—than is desertification in the latter sense. However, even with respect to desertification related to humans and their lifestyles over the millennia, the issue is enormously complex.

Attempts at Remediation

One area of increasing desertification is the Mediterranean Basin of southern and southeastern Europe, along with limited areas of western and eastern North Africa. The *World Atlas of Desertification* (Middleton and Thomas 1997) is a product of the United Nations Environment Program (UNEP) and is related to the United Nations Convention to Combat Desertification (CCD). The atlas contains a chapter, "Desertification and Land Use in Mediterranean Europe," that helps illustrate the complexities of the issue. For example, the atlas states: "The region has suffered from land degradation at least since the Bronze Age" (p. 129). There has been damaging "terrace construction over many centuries . . . [and] in recent years major changes in the population distribution have occurred with . . . the movement of people to the major cities and coastal areas [for tourism] and the development of irrigated agriculture and industry . . . [with attendant] flooding and erosion, groundwater depletion, salinization and loss of ecosystem integrity" (p. 129). One of the hardest-hit areas is southeastern Spain, in a country that has seen all these impacts for centuries, including massive deforestation and extensive irrigated farming in the Valencia region.

One of the goals of the UNEP/CCD program is to utilize the latest science and technology, including remote sensing techniques to map desertification advances, and the Mediterranean Desertification and Land Use (MEDALUS) project includes the Guadalentin Target Area in southeastern Spain: "The most degraded and eroding areas are . . . former common grazing lands that were taken into cultivation due to an expansion of mechanized agriculture in the 1960s and . . . were abandoned, as systems failed" (p. 131).

All these factors have been at work to varying degrees throughout the Mediterranean Basin, where there is ongoing desertification. MEDALUS scientific studies and rehabilitative efforts are ongoing throughout the region, from Portugal, to Italy, to Greece and Asia Minor.

Desertification is increasing rapidly in the world's best-known desert, the Sahara, and particularly along its southern border, the Sahel region. Two major causes are overgrazing, especially after prolonged drought beginning in the 1960s, and the use of brushwood as fuel in homes (Middleton and Thomas 1997, pp. 46–48 and 68–69, 168ff).

The *World Atlas* includes reports on the Middle East, southern Asia, Australia, China, and Mexico. A United Nations CCD conference report, *Sustainable Land Use in Deserts* (Breckle, Veste, and Wucherer 2001) covers the Aral Sea reclamation effort, changing patterns of overgrazing in South Africa, the monitoring of desertification in Uzbekistan and Kazakhstan, and reclamation efforts in Israel, among many other topics.

Ethical Issues

The ethics of desertification reflects extremely diluted responsibilities. Since the Bronze Age in the Mediterranean Basin, for example, up to the present (such as in Spain), farmers have tried in numerous ways to eke out a hard living in arid lands. Some people would lay blame primarily on government planning agencies for overirrigation and groundwater depletion, salinization, and other impacts of population density and tourism in arid regions. However, in any particular case it is difficult to lay too much blame on individual agents, although some environmental ethicists would blame a culture that is and has been for centuries heedless of impacts on arid lands.

In regard to science, technology, and rehabilitation/restoration projects such as those of UNEP/CCD, it may be too early to tell whether they will be effective in the long run against what is widely perceived to be rapidly advancing desertification.

PAUL T. DURBIN

SEE ALSO *Agricultural Ethics; Biodiversity; Ecology; Environmental Ethics; Environmentalism; Global Climate Change; National Parks; Rain Forest; Sierra Club; United Nations Environmental Program.*

BIBLIOGRAPHY

Breckle, Siegmar-W.; Maik Veste; and Walter Wucherer, eds. (2001). *Sustainable Land Use in Deserts*. Berlin and New York: Springer.

Burch, Joann Johnson. (1994). *Chico Mendes, Defender of the Rainforest*. Brookfield, CT: Millbrook. Intended for younger readers.

The Burning Season: The Chico Mendes Story (1994). Warner Home Video. Theatrically released in 1981. Story of a man dedicating his life to saving the Amazon rain forest. Based on a novel by Andrew Revkin.

Mares, Michael A. (1999). *Encyclopedia of Deserts*. Norman: University of Oklahoma Press.

Middleton, Nick, and David Thomas, eds. (1997). *World Atlas of Desertification*, 2nd edition. London: Arnold.

Sponsel, Leslie E.; Thomas N. Headland; and Robert C. Bailey, eds. (1996). *Tropical Deforestation: The Human Dimension*. New York: Columbia University Press. Scholarly coverage of the issue.

DEHUMANIZATION

SEE *Humanization and Dehumanization*.

DEMATERIALIZATION AND IMMATERIALIZATION

Dematerialization refers to technological production using less energy and fewer or lighter-weight materials. *Immaterialization* is a similar approach, militating against the consumption of material goods.

Dematerialization

The concept of dematerialization is strongly associated with the work of economist and planner Paul Hawken, who proposed that industry should recalibrate inputs and outputs to adapt to environmental constraints. "To accomplish this, industrial design would employ 'dematerialization,' using less material per unit of output; improving industrial processes and materials employed to minimize inputs; and a large scale shift away from carbon-based fuels to hydrogen fuel, an evolution already under way that is referred to as 'decarbonization'" (Hawken 1993, p. 63). Indeed, Hawken sees dematerialization as a long-term trend, because much contemporary technology—refrigerators, televisions, cars, even houses—already weigh less and use less material than they did in the 1970s. According to Hawken's calculations, during the ten year period from 1972 to 1982, the redesign of automobiles in the United States reduced annual resource use by 250 million tons of steel, rubber, plastic, aluminum, iron, zinc, copper, and glass. Hawken's approach thus implies a rejection of heavy industry as the foundation of a technological economy, and is allied with notions of industrial ecology, green design, and natural capitalism.

Hawken, however, credits Buckminster Fuller (1895–1983) with originating the concept of dematerialization, which Fuller called "ephemeralization." Fuller's own invention of the geodesic dome was an example of ephemeralization, because it weighed only three percent of what a traditional structure of equivalent size would weigh, while being even more earthquake- and fire-resistant. According to Fuller, ephemeralization had already triumphed in his day. "[B]etween 1900 and today," he said in 1968, "we have gone from less than one percent to more than forty percent of humanity living at a high standard [with] the amount of resources [consumed per person] continually decreasing . . ." This "came only as fall-out of the doing-more-with-less design philosophy" (Fuller 1970, p. 68).

Fuller also described a design curve under which technologies increase in size soon after their invention until they "reach a giant peak, after which miniaturization sets in" (p. 73). Subsequent developments in personal computer, cell-phone, and portable music technologies such as CD, MP3, and iPod players bear out Fuller's theory. The prospects of nanotechnology provided further confirmation. He concluded, playfully, that "Ephemeralization trends towards an ultimate doing of everything with nothing at all—which is a trend of the omniweighable physical to be mastered by the omniweightless metaphysics of human intellect" (p. 73).

Dematerialization is also operative in science. The replacement of field work and laboratory experimentation by computer modeling and simulation may be described as another type of dematerialization.

Immaterialization

The immaterialization of consumption, as a companion process to dematerialization in production, has weak and strong forms. (It should not be confused with immaterialism in metaphysics, regarding the reality of immaterial phenomena such as the mind or soul.)

In its weak form, immaterialization is simply the consumption of dematerialized consumer goods—the same ones purchased in the past, such as refrigerators or automobiles, but now manufactured using less energy and materials. These goods are designed to consume less energy when used, and to be more easily recyclable, so that there is reduced waste.

In its strong form, immaterialization of consumption refers to the replacement of material goods with immaterial ones such as services, information, and social relationships. The use of an electronic telephone directory is an immaterial alternative to the use of a large paperback telephone directory. The Finnish cell phone manufacturer Nokia, whose motto is "Connecting People," sees both dematerialization and immaterialization as ways to promote a sustainable consumer economy. Immaterialization thus reflects another aspect of the service economy and the information, or knowledge, society.

Immaterialization in the strong sense also points toward possible cultural transformations, including shifts in ideas about the good life. Material consumption is not a good in itself, but a means to the end of human well-being. When analyzed in terms of well-being rather than material goods, productivity may actually be decreasing; human beings may be consuming more, but enjoying it less. Certainly the marginal utility of another unit of material consumption has declined, suggesting cultural or spiritual goods such as music and meditation as more inherently fulfilling than the purchase of another television set, however dematerialized. Yet just as the paperless office has remained full of paper, so immaterialized goods seem always to be complemented with material, such as music posters, coffee table art books, designer wardrobes, and specialized furniture for those who practice meditation.

CARL MITCHAM
JONATHAN WALLACE

SEE ALSO *Ecological Economics; Environmental Economics; Fuller, R. Buckminster; Green Design; Information Society; Materialism.*

BIBLIOGRAPHY

Hawken, Paul. (1993). *The Ecology of Commerce: A Declaration of Sustainability*. New York: HarperBusiness.

Fuller, R. Buckminster; Eric A. Walker; and James R. Killian. (1970). *Approaching the Benign Environment*. University: University of Alabama Press for Auburn University. A collection of 1968 talks.

Ryden, Lars, ed. *Foundations of Sustainable Development: Ethics, Law, Culture, and the Physical Limits*. Uppsala, Sweden: Baltic University Programme, Uppsala University. A multi-authored work reflecting Scandinavian interests in dematerialization and immaterialization as central to sustainable development.

DEMOCRACY

Democracy poses problems for science and technology because it leads to potential conflicts between two strong sets of ethical values. Democracy prizes the ethics of inclusiveness and political equality. Within a democratic system all citizens have an equal say in collective decisions. The fields of science and technology embrace the ethics of autonomy and respect for scientifically established findings, regardless of how other citizens receive or are affected by those findings. Scholars and practitioners have proposed a variety of processes and institutions in an attempt to resolve these conflicts.

Historical Development

Over the centuries philosophers have developed various conceptions about the nature of democracy. These different versions of democracy pose distinct conflicts among ethical values linked to science and technology, as well as suggest different solutions to those problems.

The classic form of democracy or rule by the people is generally taken from Athens in the fifth century B.C.E., where a form of direct or participatory government was practiced by the free males of the city-state. In Rome from the fifth to the first centuries B.C.E. there developed a classic form of republican or representative democracy, in which individuals are elected by the people to handle governmental decision making. During the Middle Ages democratic forms of government were relegated to the margins of public life where they continued to play important roles in religious institutions such as monasteries; they reemerged into public affairs during the rise of modern nation–states. Indeed modern political philosophy is characterized by diverse and continuing arguments for the primacy and legitimacy of democratic institutions, and struggles with efforts to create appropriate functioning democratic organizations under historically unique conditions.

One common observation is that the development of modern forms of science, technology, and democracy have in fact gone hand in hand. Modern science itself asserted a radical democracy, although only among a scientifically educated elite. The industrial revolution was certainly associated with the extension of political rights—from white property owners to all men to women. Expansions of citizenship have in turn been associated with the expansion of consumer economies, which thereby influenced technological change. And in many instances expansions in democracy have been proposed as solutions to the problems caused by scientific or technological change. Reflecting such associations, many commentators on science-technology-democracy relations have tended to emphasize synergies rather than oppositions. Certainly this was true of Alex de Tocqueville's *Democracy in America* (1835 and 1840), a perspective repeated even more forcefully in Daniel Boorstin's *The Republic of Technology* (1978).

Especially since the early mid-twentieth century, however, questions and problems have become increasingly prominent. Taking the two basic forms of democracy in reverse order to their historical origins, one may describe these as related to representation and direct democracy.

REPRESENTATION. After World War II scientists gained a great deal of attention and prestige from the government. Due to the scientists' great success in developing technologies for the war, from radar to nuclear weapons, government officials hired them into agencies and national laboratories and put them on important advisory committees. These developments raised the issue of how best to bring scientists and engineers, and their expertise, into the decision-making processes of representative democracy. This political involvement of scientists threatened two important ethical values. First, how could scientists avoid compromising their scientific autonomy and integrity as they became more involved in politics? Would they be able to speak freely, unencumbered by motivations of the government officials for whom they worked? When they advised government about research budgets, which affected them directly, would they succumb to the conflicts of interest that such roles entailed?

Second, how would this new scientific elite affect democracy? Would scientific pronouncements simply trump other forms of advice and political input? If the subject at hand was purely technical, deference to technical advice might be appropriate. However most important scientific and technological policy issues are a complex mixture of technical and political or social considerations, and scholars have shown that, in practice, it is difficult to separate these two features, even if it is desirable in principle. This concern over scientists gaining excessive power was most famously stated in President Dwight D. Eisenhower's famous warnings about a military-industrial complex in his farewell address in 1961.

DIRECT DEMOCRACY. Most theories of democracy state that citizens need to do more than simply vote for officials every few years. A robust democracy requires that citizens be able to participate directly, either as groups or individuals, in political decision making. If the issue at hand involves extensive scientific or technological knowledge, how can nonscientific citizens participate in deciding such an issue, an important democratic value, while still respecting the technical competence of experts, an important scientific value?

Responding to Problems

Late-twentieth-century developments in democratic theory have included a broad spectrum of responses to perceived problems in the science-technology-democracy relationship. These responses have included analyses and criticisms of a number of phenomena related especially to representation and direct democracy centered around such issues as peer review, lobbying, advisory bodies, and deliberation.

REPRESENTATION. A number of government agencies, in contrast to the direct mission driven distribution of funds by a program director on the basis of personal assessment have adopted peer review as a means to distribute funds. After World War II the federal government dramatically increased its funding of scientific and technological research. Following the model that it had developed during the war, much of that research was performed outside of the government itself. Instead of becoming the dominant employer of scientists, the government decided to fund scientists who were employed by universities or businesses.

In peer-reviewed funding, scientists submit proposals to the government requesting funding for particular research projects. Peer review is a method for evaluating and ranking those proposals and deciding which ones to fund. The funding agency, such as the National Science Foundation (NSF) or the National Institutes of Health (NIH), identifies scientists outside of government who are experts in the field relevant to the proposed research, who are the peers of the scientist submitting the proposal. Those scientists then review and evaluate the proposal, providing an expert opinion of its technical merits. The government keeps the names of the reviewers confidential so that they feel free to be objective in evaluating the proposal without having to worry about reprisals from the people they are reviewing. These reviews powerfully influence who the government funds.

Peer review is not perfect and has engendered numerous controversies and studies. Scientists also try to influence the total size of the government research budget, often through individual or group lobbying of Congress or the executive branch. In addition, many scientists may adapt their research agendas to be responsive to growing parts of the budget, which means that they are not as autonomous as peer review may make them appear. However it is still a reasonable attempt to balance scientific and democratic values. Scientists independent of the government provide evaluations of the merit of the proposed scientific research, emphasizing the ethics of scientific independence and autonomy. However, in many cases government officials make the final decisions on funding and in all cases governmental institutions determine the total amount of money that the government gives out for research, which lets representative institutions influence the research as well, emphasizing the value of democratic accountability.

Second, the federal government has created a host of science and technology advisory bodies. These groups attempt to bring technical expertise into making and executing government policy in a manner that respects both scientific integrity and democratic accountability. Some of these bodies are part of the government itself, and its scientists are government employees, as in the congressional Office of Technology Assessment (OTA) (disbanded by Congress in 1995) or the Office of Science and Technology Policy, an advisory group to the president. In addition, the government employs numerous technical specialists in various agencies and national laboratories.

In addition, the federal government utilizes many advisory committees made up of scientists and engineers from outside the government. Numerous agencies have such advisory committees and the White House has the President's Committee of Advisors on Science and Technology (PCAST). The National Academy of Sciences (NAS) also has an elaborate system for providing technical advice to the government. NAS, a private, though congressionally chartered, organization, possesses a research arm, the National Research Council (NRC). NRC assembles experts in particular fields to prepare reports that summarize the state of the science related to some particular topic. These groups have no formal authority, but they give the agencies access to expertise that is outside of government agencies and so hopefully is independent of such agencies' agendas. Of course the effectiveness of these advisory groups depends on the quality of the people appointed to them. In addition, these advisory groups lack any democratic accountability.

SOLVING PROBLEMS OF DIRECT PARTICIPATION. Citizens participate in policy making in two ways, either as groups or as individuals. The process of participating in groups is often called interest group liberalism, or pluralism. The justification for pluralism assumes that citizens recognize their interests and how government policy affects those interests. To further their interests they organize themselves into private groups and those groups pool their resources so that they may influence government policy. Different groups have different resources, from large numbers of voters to large sums of money to social status to charismatic leaders.

Such groups often center around scientific and technological issues and are a major part of the policy process. They include environmental groups, organizations representing different scientific disciplines, groups that lobby for research on certain diseases, industry groups that seek support for particular technologies, and so on. Many scholars have written about such groups and the ways they try to influence policy. In terms of ethical values, interest group involvement in scientific issues reflects the values that underlie pluralist democracy more generally. Pluralism requires only that all groups have equal opportunities to participate in politics. Groups are only supposed to represent their interests, as they perceive them. While outright lying about relevant science violates a general ethic of honesty, this form of democracy has no process to resolve more subtle scientific and technological disagreements. In most public disputes over scientific and technological issues, experts will disagree about some of the scientific questions. Within interest group pluralism, the groups have no obligation to find ways to resolve those disagreements; the theory assumes that honest competition among the groups will lead to satisfactory resolution of the issues, scientific and otherwise.

Citizens may also participate in scientific and technological policy issues as individuals. Scholars have concluded that this sort of participation works best when it involves extensive deliberation. In other words, citizens do not simply give their off-the-cuff opinion on some issue, either through voting or responding to an opinion poll. Instead they become involved in a process that requires them to learn about the issue and discuss it with others.

Theories of deliberative democracy have stated that such a process not only informs citizens about the substance of an issue, but also gives them a broader outlook, making them think about the public interest as well as their narrow private interests. It is the process of learning about and debating an issue, in an environment that is conducive to friendly give-and-take, which not only lets citizens state their interests but also makes them better citizens in how they think about their interests. This development satisfies a democratic ethic important to this theory of democracy, that citizens learn to deliberate over the public interest instead of merely advocating private interests.

The Cambridge Experimental Review Board is a classic example of such deliberation. In 1976 two universities in Cambridge, Massachusetts wanted to build biotechnology laboratories in the city. People in and out of the biology discipline worried that genetically modified organisms might escape from the labs and harm people. Cambridge is a very densely populated city and the building of these labs, and the risks that might accompany them, became a highly charged political issue. The mayor decided to appoint a special review board, consisting of ordinary citizens, to decide whether and under what circumstances the universities should be allowed to build the labs. The board heard testimony from all concerned parties, including university scientists who wanted to build the labs and people who opposed them. In the end the board decided to let the labs be built, with certain safety procedures for their operation. Those procedures were very similar to the ones later adopted by NIH, the principal federal funding agency for such research. NIH could impose regulatory conditions on the universities that it funded. Almost all sides to the controversy praised the work that the board had done.

This process encountered all the ethical issues related to science and democracy. Citizens had to learn about the technical issues. They did not have to become scientists, but had to understand the issues well enough to make sensible policy decisions about them. In educating citizens, the process demonstrated respect for scientific integrity. The process also satisfied the norms of deliberative democracy, in that it involved citizens deeply in an issue that potentially affected their lives, gave them the means to learn about it, and gave them the power to actually decide about it. The downside to this process, and all deliberative processes, is that it involved directly only a few citizens out of the many that lived in the city and required that they spend a great deal of time on the issue. Deliberative processes always involve this tradeoff: In exchange for deep participation, one sacrifices broad participation.

Since the 1970s organizations have sponsored a host of experiments using different forms of deliberative participation. For example, deliberative polling combines traditional opinion polling with a deliberative process. The process begins with a representative sample of citizens taking an opinion poll on the issue at hand. After the poll, the same group then assembles for a weekend of deliberation on the issue, guided by facilitators and with experts available to answer questions. At the end of the deliberations they are polled again. In most cases, their opinions change, often significantly, as a result of the deliberation.

A deliberative form of participation closer to the Cambridge example is the consensus conference. Initially developed in Denmark, this process brings together a small number of citizens to deliberate and see if they can reach a consensus on some issue, usually related to science and technology. The group then reports their results. In Denmark consensus conferences provide important input to parliament. In the United States they have not yet attained any official status. The not-for-profit organization The Loka Institute and a few academic groups have sponsored consensus conferences.

Contemporary Issues

Previous discussion of the practical issues of representation and participation are complemented by general theoretical discussions of technology and democracy. Among these discussions, one of the more salient arguments has been that of Langdon Winner and Richard Sclove that technological design itself constitutes a kind of political constitution writing that can be more or less democratic. These scholars point out that particular configurations of technological systems can favor some groups and discourage others, politically and socially, as well as economically. These social effects may be designed into technologies or may be unintended consequences, but either way, the "artifacts have politics," as Langdon Winner put it. This scholarly work means that those who are concerned with the science-technology-democracy relationship have to focus on the actual designs of the technologies themselves, as well as the institutions that govern them.

In the early twenty-first century forms of direct participation like consensus conferences are limited in the United States and do not enjoy the formal authority that they do in places like Denmark. However they are growing in number and their advocates hope they will have effects on policy making by local or state governments by force of moral suasion if not by law. All forms of participation, via groups or individuals, are growing in the United States and elsewhere. Legislation mandates some form of participation in many policy areas and some private firms are taking public participation seriously. So large is this activity that the government and business officials who run such programs have started their own professional association, the International Association for Public Participation, an organization that now has more than 1,000 members from twenty-two countries. Many of the issues in which such participation occurs involves science and technology.

One of the most difficult issues to deal with at the intersection of democracy and science and technology is the problem of boundaries between science and politics. As indicated above, one important aspect of democratizing science and technology is respecting the scientific value of the autonomy and integrity of science. But what parts of issues belong to the realm of science and what parts to the realm of politics? At first glance, this seems like an obvious question. The scientific parts of an issue are technical details about the issue, things that one would clearly ask of a technical expert, such as the existing reserves of oil, the toxicity of some pollutant, or the risks to patients of some new medical treatment. The political parts of an issue would seem to be questions like how much should oil be taxed and under what circumstances, or at what level is injury from pollution is politically acceptable. However these questions are not so neatly technical or political. Existing reserves of oil are uncertain, so for policy purposes should there be a high, low, or intermediate estimate? The toxicity of a pollutant may depend on whether the people exposed are healthy or more susceptible to it, as someone with asthma may be to air pollutants. Are we talking about toxicity for the average population or the most vulnerable members of the population? Answering these questions requires a complex mixture of technical and political decisions, which means that the boundaries between the technical and political parts of the issue are negotiated and often changing, not fixed and prompted by nature. An important part of participation is enabling participants to recognize and debate these boundaries. Only then can such participation satisfy both the scientific and democratic values involved in the process.

FRANK N. LAIRD

SEE ALSO *Conservatism; Direct Democracy; Discourse Ethics; Expertise; Liberalism; Libertarianism; Participation; Strauss, Leo; Tocqueville, Alexis de.*

BIBLIOGRAPHY

Boorstin, Daniel. (1978). *The Republic of Technology: Reflections on Our Future Community*. New York: Harper & Row.

Hill, Stuart. (1992). *Democratic Values and Technological Choices*. Stanford, CA: Stanford University Press. An in-depth case study that critiques the conventional notion of citizen participation examines citizens' values toward a controversial technology.

Laird, Frank N. (1993). "Participatory Analysis, Democracy, and Technological Decision Making." *Science, Technology, and Human Values* 18 (Summer): 341–361. A review and analysis of normative arguments for including citizens in technological policy making.

Renn, Ortwin; Thomas Webler; and Peter Wiedemann, eds. (1995). *Fairness and Competence in Citizen Participation*. Dordrecth, Boston, and London: Kluwer Academic Publishers. This edited volume provides both descriptions and analysis of numerous forms of citizen participation.

Sclove, Richard E. (1995). *Democracy and Technology*. New York: The Guilford Press. Develops an extensive normative theory of democracy and technology and spells out is implications for democratic practice, with numerous short cases.

Sclove, Richard E.; Madeleine L. Scammlee; and Brenna Holland. (1998). *Community-Based Research in the United States*. Amherst, MA: The Loka Institute. Available from the Loka Institute, www.loka.org. Contains twelve case studies of such participatory research, as well as comparisons with the Netherlands.

Von Schomberg, René, ed. (1999). *Democratising Technology: Theory and Practice of a Deliberative Technology Policy*. Hengelo, The Netherlands: International Centre for Human and Public Affairs. A series of essays by some of the leading American and European scholars on the subject.

Vig, Norman J., and Herbert Paschen, eds. (2000). *Parliaments and Technology: Tthe Development of Technology Assessment in Europe*. Albany: State University of New York Press. Provides cases of participatory technology assessment in different European countries.

Winner, Langdon, ed. (1992). *Democracy in a Technological Society*. Dordrecht, The Netherlands: Kluwer Academic Publishers. Contains essays by the major scholars of the time on democracy and technology.

Winner, Langdon. (1986). *The Whale and the Reactor: A Search for Limits in an Age of High Technology*. Chicago: University of Chicago Press. Develops some of the core ideas relevant to the justification for democracy in technology policy, including the notion that artifacts have politics and technologies as forms of life.

DEONTOLOGY

Deontology refers to a general category of ethical or moral theories that define right action in terms of duties and moral rules. Deontologists focus on the rightness of an act and not on what results from the act. Right action may end up being pleasant or unpleasant for the agent, may meet with approval or condemnation from others, and may produce pleasure, riches, pain, or even go unnoticed. What is crucial on this view is that right action is *obligatory*, and that the goal of moral behavior is simply that it be performed. The slogan of much of deontology is that the right is independent of the good. Deontology is opposed, therefore, to consequentialist or teleological theories in which the goal of moral behavior is the achievement of some good or beneficial state of affairs for oneself or others. For deontologists, the end of moral action is the very performance of it. For consequentialists, moral action is a means to some further end.

There are three interrelated questions that any deontological theory must answer. First, what is the content of duty? Which rules direct human beings to morally right action? Second, what is the logic of these duties or rules? Can their claims be delayed or defeated? Can they make conflicting claims? Third, why must human beings follow exactly those duties and rules, and not others? That is, what grounds or validates them as moral requirements?

The relevance of deontological ethics to issues in science and technology is not immediately obvious. Typical duties or rules in these theories are often quite abstract and sometimes address personal morality; hence they seem ill suited to broad and complicated questions in technical fields. As a matter of personal morality, deontologists might require one never to lie or steal, to give to charity, and to avoid unnecessary harm to people and animals. These rules are often internalized and are supported by religious, social, and civil institutions, and in some cases by enlightened self-interest. But is there a duty to support open source software, or to reject nanotechnology, or to avoid animal experimentation for human products? What list of rules is relevant to moral quandaries over cloning or information privacy?

Though the specific connection between ethical duties and scientific and technological practices may not be immediately obvious, it is clear that deontology can and should play an important role in evaluating these practices. Deontological theories give one a way to evaluate types of acts, so that one can judge a token of an act as obligatory, permissible, or forbidden even before the act is committed. Consequentialist evaluations, on the other hand, must await an accounting of the consequences of scientific and technological acts. Waiting on the consequentialist analysis may be perilous, because the long-term results of large-scale enterprises are often impossible to anticipate and very difficult to repair. As Edward Tenner (1997) has pointed out, modern technology often exacts a kind of revenge in the scope and severity of unintended consequences. Especially in fields such as bioethics, practitioners have often wanted bright lines between right and wrong acts in their ethical guidelines. That is, they want to have ethical rules or principals that are not wholly contingent on consequences. A form of deontological view in bioethics known as principalism focuses on the need for clear guidelines for action in order to avoid problems with unintended and far-reaching consequences of treatments and clinical practices. Even the basic and broadly applicable principle "Do no harm!" is deontological; it does not allow a tradeoff of benefit for some at the cost of harm to others.

Two deontological theories, from the works of Immanuel Kant (1724–1804) and W. D. Ross (1877–1971), serve as the foundations for much work in deontological ethics. Because they differ significantly in the content, logic, and ground of duties, it will be useful to examine them in modest detail before returning to questions of science and technology.

The Categorical Imperative

Kant developed the most important deontological ethical theory in Western philosophy. Scholars have come to agree that Kant provided not so much a list of duties as a procedure for determining duties. The procedure that specifies duty is the categorical imperative or *unconditional command* of morality. Kant articulated the categorical imperative in several distinct formulations. Even though these formulations provide different ways of generating duties, Kant maintained that his systematic ethic of duties was *rigorous*—in the technical sense that a "conflict of duties is inconceivable" (Kant 1997, p. 224). Indeed, a main feature of Kant's ethics is its reliance on consistency or harmony in action. This feature can be seen in the first formulation of Kant's categorical imperative, which goes as follows: "*Act only on that maxim through which you can at the same time will that it become a universal law*" (Kant 1997, p. 421).

Because a maxim in Kant's theory is a plan of action, the categorical imperative above provides an ethical test for intended actions, presumably to be used before one commits them. The point of the test is that one ought to be able to endorse the *universal* acceptability of the plans or intentions behind actions. People should not be partial to plans simply because they conceived such plans; the plans must be acceptable from any point of view. Maxims that cannot be universalized will produce logical contradiction or *disharmony* when they are run through the test of the categorical imperative. The grounding or validation of this principle lies in the universality of practical reason. For Kant, ethical duties arise from what is common to humans as rational beings. Humans have a kind of freedom that is gained in *creating* universal moral laws through intentional behavior. This moral and rational activity is, for Kant, what produces *self-legislation* or autonomy, and autonomy allows humans to transcend their animal nature.

The ability of humans to act from freely chosen moral rules explains the special moral status they enjoy; humans are, according to Kant, *ends-in-themselves*. Consequently this conception of a special status gives rise to another formulation of the categorical imperative: "*Act in such a way that you always treat humanity [yours or another person's] never merely as a means but always at the same time as an end-in-itself*" (Kant 1995a, p. 429).

This special moral status or intrinsic value implies that humans ought never to be valued as less significant than things that have merely instrumental value. Things of instrumental value are mere tools, and though they can be traded off with one another, they can never be more important than intrinsically valuable things. All technology is in some sense a mere tool; no matter how many resources society pours into technologies, the moral status of humans is supposed to trump the value of mere tools. Kantian duties are designed to protect that status.

The application of Kant's theory to issues in the ethics of technology produces intriguing questions. Do some technologies help persons treat others as mere means? The moral inquiry would have to consider aspects of the technologies and see whether technologies have "maxims" themselves—what Günther Anders called a "mode of treatment incarnated in those instruments" (Anders 1961, p. 134). These aspects might include the anonymity of online communities, the distributed effects of computer viruses, the externalizing of costs by polluting corporations, or the inherent destructiveness of a nuclear weapon. Further, one might ask whether some technologies *themselves* treat persons as mere means? Such a worry is related to Martin Heidegger's view that, under modern technology, humanity becomes a *standing reserve* to be exploited, and to Herbert Marcuse's claim that such a technological society debases humans by providing a *smooth comfortable unfreedom*. While these critics of technology do not always identify themselves as Kantians, the influence of Kant's humanistic account of duties has been so deep and broad that it is almost inescapable. Still there are deontologists who have parted ways with the Kantian tradition.

Prima Facie Duties

According to the British philosopher W. D. (Sir David) Ross, moral duties are not universal and unconditional constraints of universal practical reason. Rather they are conditional or prima facie obligations to act that arise out of the various relations in which humans stand to one another: neighbor, friend, parent, debtor, fellow citizen, and the like. This view gives content to duties based on a kind of role morality. It is through moral reflection that one apprehends these duties as being grounded in the nature of situated relations. Duty is something that, for Ross, arises between people, and not merely within the rational being as such. What exactly these prima facie duties are is not infallibly known until the problematic situations present themselves.

Nonetheless, Ross thinks, situated moral agents can grasp some obvious basic forms of duties. Fidelity, reparation, gratitude, justice, beneficence, self-improvement, and non-maleficence are what he identifies as nonreducible categories of duty—he admits that there may be others. Ultimately these duties are known by moral intuition and are objectively part of the world of moral relations and circumstances that humans inhabit. Much as one knows, in the right moment, what word *fits* in a poem, so too can one know what to do when duty makes demands. Sometimes an agent will intuit that more than a single duty applies, and in these cases must judge which duty carries more weight in order to resolve the conflict.

Ross's view is therefore both flexible and pluralistic, and is grounded in the actual roles of human lives. In these respects, it provides a foundation for a variety of professional codes of ethics, many of which are found in the scientific and technological community.

Hans Jonas and the Imperative of Responsibility

While Kant and Ross argued specifically against consequentialist theories in explaining their respective deontological views, other theorists are motivated by concerns over consequences in ways that influence the content of duties. Such is the case with the *imperative of responsibility* put forward by Hans Jonas (1984). Jonas calls for a new formula of duty because he thinks that traditional ethical theories are not up to the task of protecting the human species in light of the power of modern technology. His worry relates directly to the irreversible damage that modern technology could do to the biosphere, and hence to the human species. Because humans have acquired the ability to radically change nature through technology, they must adjust their ethics to constrain that power.

In language intentionally reminiscent of Kant's categorical imperative, Jonas gives his formula of duty as follows: "Act so that the effects of your action are compatible with the permanence of genuine human life" or so that they are "not destructive of the future possibility of such life" (Jonas 1984, p. 11). Referring to Kant's first version of the categorical imperative, Jonas criticizes its reliance on the test of logical consistency to establish duties. There is no *logical* contradiction, he notes, in preferring the future to the present, or in allowing the extinction of the human species by despoiling the biosphere. The imperative of responsibility, as a deontological obligation, differs from the ethics of Kant and Ross because it claims that humans owe something to others who are not now alive. For Jonas, neither the rational nature nor the particular, situated relations of human beings exhaustively define their duties. Indeed one will never be in situated relationships with people in far-off generations, but remoteness in time does not absolve the living of responsibilities to them.

Are All Duties Deontological?

Most professional codes of ethics in science and engineering consist of duties and rules. Does it follow that their authors tacitly accept the deontological orientation in ethics? It does not, and there is an important lesson here about the choice between deontology and other ethical orientations. The primary difference between professional codes and deontological ethical theories is that, in the former, the duties or rules are put forth as instrumental for competent or even excellent conduct within the particular profession. Some duties are directed toward the interests of clients or firms, but ultimately the performance of these duties supports the particular profession. The grounding of duties in professional codes resembles the function of rules under rule utilitarianism.

These rules would not be morally required for the general public, as would the rules of a deontological ethics. Professional codes are tools to improve the profession; the end of right action, in this case, is dependent upon the good of the profession, and the content of duties will depend on the particular views of the authors concerning that good.

Further Applications and Challenges

Duty ethics have been applied with some success in technological fields where consequentialist or utilitarian reasoning seems inappropriate. In biomedical ethics there is general acceptance of the view that do-not-resuscitate orders and living wills are to be respected, even when doing so means death for the patient and possibly great unhappiness for loved ones. In computer ethics, the argument for privacy of personal data does not generally depend on the use to which *stolen* data would be put. It is the principle, and not the damage, that is at the heart of the issue. There also seem to be lines of a deontological sort that *cannot be crossed* when it comes to some forms of experimentation on animals and treatment of human research subjects. For some emerging technologies, there are well-grounded deontological reasons for opposing research and development, even though the technologies eventually could yield great benefits. No one denies the good of the end, but they do deny that the end justifies any and all means. Where the claims of duties are not well grounded, a deontological approach to ethics runs the risk of sounding reactionary and moralistic.

THOMAS M. POWERS

SEE ALSO *Consequentialism; Discourse Ethics; Engineering Ethics; Jonas, Hans; Kant, Immanuel; Scientific Ethics.*

BIBLIOGRAPHY

Anders, Günther. (1961). "Commandments in the Atomic Age." In *Burning Conscience: The Case of the Hiroshima Pilot, Claude Eatherly, Told in His Letters to Günther Anders*. New York: Monthly Review Press.

Beachamp, Tom L., and Childress, James F. (2001). *Principles of Biomedical Ethics,* 5th edition. New York: Oxford University Press.

Darwall, Stephen L., ed. (2002). *Deontology*. Oxford: Basil Blackwell Publishers.

Jonas, Hans. (1984). *The Imperative of Responsibility: In Search of an Ethics for the Technological Age* Chicago: University of Chicago Press. Originally published in 1979 as *Das prinzip verantwortung,* this book made Jonas famous.

Kant, Immanuel. (1995a). "Grounding for the Metaphysics of Morals." In *Ethical Philosophy* 2nd edition, trans. James W. Ellington. Indianapolis: Hackett Publishing. Originally published in 1785. Kant's most widely read and accessible work in ethics.

Kant, Immanuel. (1995b). "Metaphysical Principles of Virtue." In *Ethical Philosophy*, 2nd edition, trans. James W. Ellington. Indianapolis: Hackett Publishing. Originally published in 1797. Part of Kant's metaphysics of morals, the other half of which concerns the principles of political right

Marcuse, Herbert. (1992 [1964]). *One-Dimensional Man: Studies in the Ideology of Advanced Industrial Civilization*, 2nd edition. New York: Beacon Press. Popular treatise that inspired a progressive critique of technology.

Ross, W. D. 1965 (1930). *The Right and the Good*. London: Oxford University Press. Classic text by an important British philosopher.

Tenner, Edward. (1997). *Why Things Bite Back: Technology and the Revenge of Unintended Consequences*. Cambridge, MA: Harvard University Press.

DESCARTES, RENÉ

René Descartes (1596–1650) was born in La Haye (now Descartes), France, on March 31, and he died in Stockholm, Sweden, on February 11. Although of Roman Catholic heritage, he lived in a region controlled by Protestant Huguenots at a time when Protestants and Catholics were frequently at war. His inherited wealth

René Descartes, 1596–1650. Descartes ranks as one of the most important and influential thinkers in modern western history. His views on science and technology are similar to those of Francis Bacon. *(The Library of Congress.)*

allowed him freedom to study and travel around Europe. He made important contributions to metaphysics, mathematics, and physiology. In mathematics, he invented coordinate geometry, which combines algebra and geometry into a powerful tool for the mathematical study of the physical world. Although he offered proofs for the existence of God and the immortality of the soul, he was suspected of being an atheistic materialist, and lived in fear of persecution. When Galileo Galilei (1564–1642) was condemned in 1633 as a heretic for teaching that the earth revolved around the sun, Descartes suppressed any publication of his agreement with Galileo. After Descartes's death, his books were put on the Catholic Church's Index of Prohibited Books.

Because he broke away from scholastic Aristotelianism and thought through the philosophic implications of a new science of nature, Descartes is often called the founder of modern philosophy. Using six ideas—doubt, method, morality, certainty, mechanism, and mastery—he set the stage for modern science in a way that has had lasting impact while being subject to continuous debate.

Doubt and Method

Descartes's most famous book is the *Discourse on Method* (1637), which is divided into six parts, each developing one of the key ideas that run throughout his writing. In Part One, he presents the idea of doubt. He rejects all traditional thinking because it does not produce proven conclusions that can guide life. The traditional liberal arts education promotes philosophical disputes that are never resolved. Similarly, the moral customs of people around the world are contradictory, and there is no reliable way to resolve this confusion. So Descartes decides to turn inward, to seek within himself some source of conclusive knowledge.

Although modern science often seems to require doubting all traditional beliefs and customs, historians of science have noticed that modern science depends on intellectual traditions. Scientists tend to work within what Thomas S. Kuhn (1922–1996) called "paradigms," broad intellectual frameworks that organize research. To doubt everything received from one's society would deprive one of any starting point for inquiry. And insofar as science is a collective enterprise, it requires that scientists share social norms of thought and conduct. When scientists challenge a traditional belief, it is because they have found resources within their inherited traditions for doing so. Even Galileo's challenge to the traditional idea that the earth was the center of the universe arose from his appeal to an alternative, heliocentric theory that was thousands of years old.

In Part Two, Descartes presents the idea of method. He summarizes his method for scientific inquiry in four rules:

(1) accept only those ideas that are so clearly and distinctly present to the mind as to be self-evident,

(2) divide difficult problems into simple parts that are manageable,

(3) solve problems by moving in small steps from simple to complex,

(4) survey every part of the reasoning so that nothing is overlooked.

Descartes has formulated these rules of scientific method by generalizing from the procedures in geometrical demonstrations, in which one moves from self-evident principles (definitions and axioms) to solve complex problems by moving step by step from simple ideas to more complex propositions.

Many philosophers of science question the adequacy of the Cartesian method for explaining modern science. Michael Polanyi (1891–1976), for example, argued that there is always a personal judgment in scientific discovery that cannot be reduced to the formalized procedures demanded by such a method. The insight for grasping fruitful ideas in scientific research does not arise from an impersonal method. Jacques Hadamard (1865–1963) surveyed the lives of some famous mathematicians to show that even mathematical reasoning depends on personal, intuitive judgments that go beyond formal logic.

Morality and Certainty

In Part Three, Descartes presents the idea of morality. He admits that his scientific method could not give him moral knowledge to guide his conduct. So he had to adopt a "provisional morality" by which he could live while working to complete his intellectual project. His provisional moral code consists of four rules:

(1) accept whatever customs, laws, and religious beliefs prevail in one's country;

(2) act decisively according to the most probable opinions as if they were absolutely certain;

(3) change desires rather than the world;

(4) realize that the pursuit of truth is the best life for an intellectual person such as himself.

If Cartesian scientists cannot derive morality from their science, then they have to accept whatever moral and religious customs happen to be traditional in their society. This suggests a fundamental problem with modern science—that progress in scientific knowledge does not bring progress in moral knowledge. Cartesian scientists cannot even provide a scientific argument for the moral worth of a life devoted to science. The life of Cartesian science is incoherent. On the one hand, Cartesian scientists doubt everything and refuse to accept anything that is not proven true. On the other, they must accept the moral and religious prejudices of their society because their science cannot produce moral and religious knowledge. Ultimately, this could lead to moral nihilism with the thought that moral value is beyond scientific knowledge and must be left to unexamined prejudice. One must wonder, therefore, whether a scientifically grounded morality is possible.

In Part Four, Descartes presents the idea of certainty. "I think, therefore I am." This most famous claim of Descartes captures his thought that while doubting everything, he cannot doubt his existence, because this is confirmed by his very act of doubting. To doubt is to think, and to think presupposes his existence as a thinker. Beyond this, another idea comes to him—the idea of a perfect being—and this leads him to infer that God's existence is a self-evident certainty. From having the idea of God as a perfect being, Descartes concludes that God must exist, because if he did not exist, he would not be perfect. Descartes derives this ontological argument for God's existence from Anselm of Canterbury (1033 or 1034–1109).

Few people have found the ontological argument a persuasive proof for God's existence, and Descartes's restatement of the argument is weak. This has led some readers to suspect that he is not serious about the argument, and that it is part of his provisional morality to profess belief in the religion of his country to protect himself from persecution. Some readers see this as an indication that modern science as Descartes conceives of it is inherently atheistic.

"I think, therefore I am." Is this an immediately self-certifying truth? Or does it rather, as Friedrich Nietzsche (1844–1900) argued in *Beyond Good and Evil* (1886), illustrate "the prejudices of philosophers"? How does Descartes know that if there is thinking, there must be an "I" to do the thinking? How does he even know what thinking is? Has he perhaps confused thinking with feeling or willing? One could easily continue asking such questions to point out the numerous assumptions buried in Descartes's seemingly simple intuition, assumptions that are not self-evident, assumptions in need of proof if the Cartesian method is to be upheld. One might conclude that even the most rigorous science cannot attain complete certainty, because every proof depends ultimately on some fundamental assumptions that cannot themselves be proven.

Mechanism and Mastery

In Part Five, Descartes presents the idea of mechanism. He expresses reluctance to fully state his mechanistic view of the world, because it would be unpopular. He sketches his physics, explaining how the universe could have emerged through purely mechanical laws. He explains how all life, including the human body, can be explained as governed by mechanical causes. He declares, however, that the "rational soul" of a human being cannot be derived from the mechanical laws of nature, and therefore it must have been specially created by God.

Historians of science have identified Cartesian mechanism as fundamental for modern science. Prior to the seventeenth century, people generally understood nature through the metaphor of the world as a living organism. The Earth was a nurturing Mother. But modern Cartesian science understood nature through the metaphor of the world as a dead machine. The earth was matter in motion.

This mechanical view of the world was criticized as atheistic materialism, because it seemed to deny the immaterial and immortal reality of God and the soul. Descartes defended himself against such criticisms by affirming his belief in God and the soul. He insisted that material body and immaterial soul were two utterly different substances. In his *Treatise of Man* (1664), Descartes explained the physiology of the human body and brain as matter in motion determined by mechanical forces. This was not published until after his death, because he feared it would be too unpopular. Later, Julien Offray de La Mettrie (1709–1751) argued in his book *Man a Machine* (1748) that Descartes had shown that all living beings—including human beings—were merely machines. La Mettrie suggested that Descartes's dualistic separation between body and soul was only a trick to protect himself against persecution from the theological authorities.

The view of the human mind as a computational mechanism has been a powerful influence in the modern science of the brain. This has led some computer scientists to the thought that sufficiently complex computers will eventually replicate or surpass human intelligence. In some stories by Isaac Asimov (1920–1992), robots become Cartesian thinkers, declaring "I think, therefore I am!" But some prominent scientists such as John C. Eccles (1903–1997) argue that human self-conscious thought manifests the uniquely human power of an immaterial soul. So the debate continues over whether science can fully explain the human soul as a material mechanism.

In Part Six, Descartes presents the idea of mastery. The general aim of scientific research should be conquering nature for human benefit. The specific aim should be making such advances in medical science that human health would be improved dramatically, perhaps even to the point of prolonging life and thus conquering death. In this way, human beings would become "the masters and possessors of nature."

Descartes thus joins the project of Francis Bacon (1561–1626) for directing modern science and technology to the mastery of nature for relieving human suffering and enhancing human life. In support of this project, Descartes offers a distinctly modern vision of human beings scientifically constructing and technologically manipulating nature so that they can become like God.

LARRY ARNHART

SEE ALSO *Nature; Newton, Isaac; Scientific Revolution.*

BIBLIOGRAPHY

Asimov, Isaac. (1950). *I, Robot*. New York: Doubleday.

Descartes, René. (1988). *Descartes: Selected Philosophical Writings*, trans. John Cottingham, Robert Stoothoff, and Dugald Murdoch. Cambridge, UK: Cambridge University Press.

Descartes, René. (2003). *Treatise of Man*, trans. Thomas Steele Hall. Amherst, NY: Prometheus Books. Originally published, 1664.

Hadamard, Jacques. (1954). *An Essay on the Psychology of Invention in the Mathematical Field*. New York: Dover.

Kuhn, Thomas S. (1996). *The Structure of Scientific Revolutions*, 3rd edition. Chicago: University of Chicago Press.

Lachterman, David Rapport. (1989). *The Ethics of Geometry*. New York: Routledge. Study of Descartes' modern idea that mathematics is a god-like activity of construction.

La Mettrie, Julien Offray de. (1994). *Man a Machine*, trans. Richard A. Watson and Maya Rybalka. Indianapolis, IN: Hackett. Originally published, 1748.

Lampert, Laurence. (1993). *Nietzsche and Modern Times: A Study of Bacon, Descartes, and Nietzsche*. New Haven, CT: Yale University Press. Shows how Descartes contributed to modern break from Socratic philosophy and biblical religion.

Lange, Frederick Albert. (1925). *The History of Materialism*, 3rd edition, trans. Ernest Chester Thomas. London: Routledge and Kegan Paul. Demonstrates the importance of Cartesian mechanism in the history of materialism.

Merchant, Carolyn. (1980). *The Death of Nature: Women, Ecology, and the Scientific Revolution*. San Francisco: Harper and Row.

Nietzsche, Friedrich. (1968). *Basic Writings of Nietzsche*, trans. and ed. Walter Kaufmann. New York: Random House.

Polanyi, Michael. (1958). *Personal Knowledge*. Chicago: University of Chicago Press.

Popper, Karl R., and John C. Eccles. (1977). *The Self and Its Brain: An Argument for Interactionism*. New York: Springer International. Scientific and philosophical arguments for immaterial soul interacting with material brain.

Watson, Richard A. (2002). *Cogito, Ergo Sum: The Life of René Descartes*. Boston: David R. Godine.

DES (DIETHYLSTILBESTROL) CHILDREN

The scientific world was shocked by the 1971 discovery of the devastating effects in young women of a drug, diethylstilbestrol (DES), taken by their mothers twenty years earlier. The story of DES, from its discovery and widespread marketing without adequate testing or proof of efficacy, to the banning of its use by pregnant women, provides a good example of the serious harm that can result from inadequately protective regulation of new drugs and technologies.

Historical Development

In 1938, Sir E. Charles Dodd formulated DES, the first orally active, synthetic estrogen. This (nonsteroidal) estrogen, estimated to be five times as potent as estradiol, was very inexpensive and simple to synthesize. Because it was not patented, the developing pharmaceutical industry quickly began worldwide production; it was ultimately marketed under more than two hundred brand names for a wide range of indications. DES underwent very limited toxicological testing, a fate common to pharmaceutical products at that time.

Experiments with high doses of DES in women threatening to abort were conducted a few years later. The use of DES for prevention of miscarriage was promoted by the work of Drs. Olive and George Smith, who conducted multiple (uncontrolled) trials of DES for use in pregnancy throughout the 1940s. Despite limited evidence of safety or efficacy, the drug was deemed effective for this purpose and safe for mother and fetus. In 1947, DES obtained market approval in the United States for use in pregnancy in cases of threatened abortion and hormonal inadequacy.

Following the first poorly supported claims of the effectiveness of DES for the prevention of miscarriage, several studies were carried out to assess its efficacy, with mixed results. As these studies became more rigorous, support for the use of DES declined. In 1953, W.J. Dieckmann and colleagues demonstrated the lack of efficacy when DES was compared to a placebo in a randomized trial of pregnant women. Although the authors concluded that DES was ineffective, the drug continued to be prescribed even to women without previous pregnancy problems or evidence of threatened pregnancy. A reanalysis of Dieckmann's data in 1978, which showed that DES actually increased the risk of miscarriage, noted that had the data been properly analyzed in 1953, nearly twenty years of unnecessary exposure to DES could have been avoided.

The dangers of DES were not discovered, however, until 1971. Dr. A.L. Herbst and colleagues identified seven cases of a rare vaginal cancer (vaginal clear cell adenocarcinoma) in a single hospital. Using a case-control study they linked this rare cancer to the young women's prenatal exposure to DES. The results were so overwhelming that the Food and Drug Administration (FDA), in its November 1971 bulletin, declared that DES was contraindicated for use in pregnancy. Subsequent data demonstrated DES to be teratogenic as well as carcinogenic, and showed extensive damage to the reproductive systems of both men and women who had been exposed prenatally.

Elsewhere in the world, DES continued to be sold to pregnant women, in some countries into the 1980s. The fact that DES was prescribed for so long after its lack of efficacy had been demonstrated and dangers recognized illustrates a massive drug system failure.

In fact, it was not the lack of efficacy that triggered the end of marketing of DES for use in pregnancy, but a fortuitous accident. The cancer that DES caused in young women is extremely rare. It is estimated to have occurred in less than one in a thousand exposed daughters. If the cancer cases originally detected by Herbst and his colleagues had been diagnosed in several different medical centers, rather than at a single hospital (Massachusetts General Hospital, where DES use had been high as the site of the Smiths early experiments, the dangers of DES might well have gone unrecognized. Thus, this cancer, its link to DES, and other consequences of DES exposure might well have gone undetected.

DES Case Lessons

The DES story demonstrates that long-term and hidden effects of hormonal exposure may result from prenatal exposure, and that such consequences may be devastating. Could the mishap have been prevented? Where did science, society, and technology fail?

First, no long-term toxicity tests were ever carried out. Ironically, Dodds, the discoverer of DES, wrote in 1965, "I suppose we have to be very thankful that [DES] did prove to be such a non-toxic substance," referring to the minimal testing it underwent before marketing. Six years later the dangers of DES were identified.

Second, DES was put on the market without adequate proof of efficacy. Adequate pre-market testing would have shown that DES was never effective for the prevention of miscarriage. Therefore, a properly conducted and analyzed clinical trial might have avoided the entire episode. This accident is less likely in the early twenty-first century for pharmaceuticals, where thorough toxicity testing and evidence of efficacy are required prior to marketing.

Third, the widespread use of DES was furthered by the faith, prevalent at the time, in the advances of science and human abilities to control nature. DES was believed to be safe and effective, and both "modern and scientific." Its use became fashionable and there was pressure on physicians from peers and patients to prescribe DES. In the Netherlands, for example, the use of DES was aided by endorsement of the Queen's gynecologist.

Pharmaceutical retailers and advertising promoted the effectiveness and safety of DES to doctors and consumers. In fact, some manufacturers promoted it as a panacea for use in all pregnancies. The eagerness of the pharmaceutical companies to sell this profitable, unpatented product was compounded by the failure of medical and regulatory agencies to react rapidly to the emerging evidence.

Even prior to marketing for use in pregnancy, DES was a known animal carcinogen, a suspect human carcinogen, and a drug that had been shown to produce observable changes in the offspring of women exposed in pregnancy. Moreover, after DES was proven to be ineffective for use in pregnancy in 1953, a review of its risks and benefits should have resulted in immediate contraindication of this use. Had DES been withdrawn for use in pregnancy at that time, the unnecessary and tragic exposure of millions of mothers, sons, and daughters could have been avoided.

Regulatory authorities are also more alert in the early 2000s to reporting of adverse drug reactions and more inclined to take action than they were in the 1960s and 1970s. However, it should be remembered that regulation of non-pharmaceuticals is far from rigorous, and prenatal exposure to non-pharmaceuticals may also convey serious risk. The DES lesson can serve to raise consciousness about the dangers of inadequately identifying those risks.

DOLORES IBARRETA
SHANNA H. SWAN

SEE ALSO *Abortion; Drugs; Medical Ethics.*

BIBLIOGRAPHY

Giusti, Ruthann M.; Kumiko Iwamoto; and Elizabeth E. Hatch. (1995). "Diethylstilbestrol Revisited: A Review of the Long Term Health Effects." *Annals of Internal Medicine* 122: 778–788.

Ibarreta, Dolores, and Shanna H. Swan. (2002). "The DES story: Long-term consequences of prenatal exposure." In *The Precautionary Principle in the 20th Century: Late Lessons From Early Warnings*, ed. Poul Harremoës, David Gee, Malcolm MacGarvin, et al. London: Earthscan.

Swan, Shanna H. (2001). "Long term human effects of prenatal exposure to diethylstilbestrol." In *Hormones and Endocrine Disruptors in Food and Water: Possible Impact on*

Human Health, ed. Anna-Maria M. Andersson, Kenneth N. Grigor, Eva Rajpert de Meyts, et al. Copenhagen: Munksgaard.

INTERNET RESOURCE

National Cancer Institute. (1999). "DES Research Update 1999: Current Knowledge, Future Directions." Available from http://planning.cancer.gov/whealth/DES/.

DESERTIFICATION

SEE *Deforestation and Desertification*.

DESIGN ETHICS

Design ethics concerns moral behavior and responsible choices in the practice of design. It guides how designers work with clients, colleagues, and the end users of products, how they conduct the design process, how they determine the features of products, and how they assess the ethical significance or moral worth of the products that result from the activity of designing. Ethical considerations have always played a role in design thinking, but the development of scientific knowledge and technology has deepened awareness of the ethical dimensions of design. As designers incorporate new knowledge of physical and human nature as well as new forms of technology into their products, people are increasingly aware of the consequences of design for individuals, societies, cultures, and the natural environment.

The design arts are important because they are the means by which scientific knowledge and technological possibilities are converted into concrete, practical form in products that serve the needs and desires of individuals and communities. Design is difficult to define because of its breadth of application. One can discuss the design of scientific experiments, of theories of nature and society, of political systems and individual actions, of works of fine art, and of the everyday products created by engineering and the other useful or practical arts. In all of these examples, design may be described generally as the art of forethought by which society seeks to anticipate and integrate all of the factors that bear on the final result of creative human effort.

Descriptive definitions have a useful place in explaining the nature of design for a general audience—for example, "design is the art of forethought," "design is planning for action," "design is making things right." However a formal definition has the advantage of bringing together all of the causes or elements of design in a single idea so that their functional relationships are clear, and provides a framework for distinguishing and exploring the ethical dimensions of design. The following formal definition serves present purposes: *Design is the human power of conceiving, planning, and bringing to reality all of the products that serve human beings in the accomplishment of their individual and collective purposes*. There are four ethical dimensions represented in this definition, each identifying an area of ethical issues and potential moral conflict that often complicates the activity of designing but also enhances the value of the designer's work. These dimensions represent the web of means and ends that are the central concern of ethics and moral conduct in design.

Character and Personal Values

The first ethical dimension of design arises from the human power or ability to design. One may reasonably argue that design itself is morally neutral because the art is only an instrument of human action. However designers are not morally neutral. They possess values and preferences, beliefs about what is good and bad for human beings, and an array of intellectual and moral virtues or vices that constitute personal character. The power or ability to design is embedded in a human being, within the character of the designer. Personal accounts, written statements, manifestos, and biographies are the beginnings of the study of ethics in design. They provide direct and indirect evidence of individual character and personal values, and often include accounts of the moral dilemmas and decisions that individuals have made in the course of their careers. Thus the first ethical dimension of design is the character and personal morality of the designer.

Integrity of Performance

A second ethical dimension arises from the activity of conceiving, planning, and bringing products to reality. These activities are the immediate goal or purpose of design. The standard of performance demonstrates fidelity to the art of design itself and is a matter of personal and professional integrity. In the film *The Bridge on the River Kwai* (1957), a British colonel and his fellow prisoners of war are instructed by their Japanese captors to build a railway bridge for the transportation of troops and munitions. For the colonel, constructing the best bridge—*a proper bridge*— is a matter of personal and professional integrity, and he pushes his men harder than their captors to complete the work on schedule. The tragedy of his narrow commitment emerges at the end of the film when the colonel realizes that his obsession with achieving the immediate goal of professional performance in the prison camp conflicts profoundly with the ultimate goal of his service in the British army. Ultimate goals are another ethical dimension of design to be considered later, but this film, while a work of fiction, effectively illustrates the second ethical dimension of design.

Performing well raises other closely related ethical issues. Designers are responsible for relationships with others involved in performance of the art. In some cases the designer works alone and is responsible directly to a client. Ethical standards of fairness, honesty, and loyalty serve to guide the client relationship, as in any personal or business dealing. In most cases, however, the designer works with other individuals and has shared responsibility for maintaining those relationships according to ethical standards. For example because of the increasing complexity of products, technology, and other factors, designers work in teams with fellow designers or with technical specialists from a variety of disciplines and professions. There are also new practices of participatory design in which clients and even representatives of the end users of products participate directly in the design process. Finally there is an increasing emphasis in some forms of design on user research, requiring the ethical treatment of human subjects.

Guidance in these matters comes partly from personal morality, but also from professional codes of ethics formulated and established by professional societies. Because many of the branches of design are young—some were established as professions only in the early and middle decades of the twentieth century—designers turned to already established professional associations, such as those for medicine, law, business, engineering, and architecture, for guidance on many ethical issues, including how to formulate their codes. At the beginning of the twenty-first century, designers continue to look to those professions for sophisticated practical discussions of emerging ethical issues. The codes of ethics of national organizations such as the American Institute of Architects (AIA), the Industrial Designers Society of America (IDSA), and the American Institute of Graphic Arts (AIGA) and their international counterparts have evolved gradually. They began with issues of competence, integrity, and professionalism, emphasizing ethical standards in technical practice and education, in business matters, and in compliance with laws and regulatory codes associated with safety. They expanded to include intellectual property rights and the general area of service in the public interest, such as preservation of the cultural trust and sustainability of the human community. The evolution corresponds to the successive ethical dimensions of design.

Product Integrity

A third ethical dimension, product integrity, arises from the nature of the products created through the art of design. Product integrity should be distinguished from the end purpose or worth of products. It is the synthesis of form and materials by which one judges a product to be well or poorly designed. There are specific ethical issues of product integrity for each kind of design (engineering, communication, industrial, and architectural design), but in general the issues concern safety and reliability, compliance with laws and regulatory codes, sustainability in its various aspects, and service to the public good. Products are created to serve human beings in their various activities and pursuits. Anything that directly or indirectly harms a human being or harms someone or something for which a human being is responsible presents a serious problem of product integrity requiring both technical and ethical consideration.

Because of the complex nature of human-made products, it is important to distinguish three elements of form that identify design issues as well as their associated ethical considerations. These elements concern what is *useful*, *usable*, and *desirable* in all products. Their successful integration is one of the fundamental challenges of design thinking.

1. Structural Integrity of Form. This element involves technological reasoning that ensures the proper performance of a product so that it is useful in supporting an activity. In some products technological reasoning means employing mechanical and electrical principles in an efficient and safe relationship. In computer software the reasoning follows logical principles and best practices of program layout in order to create efficient and reliable computation and, increasingly, security of information. In graphic or communication design, the reasoning of form and content follows more general principles for the presentation of information and arguments about the subject that the designer seeks to communicate. Honesty and truth become serious ethical issues when communication design is employed in marketing, packaging, and instructional materials. Structural integrity of the physical form and of information is the frontline of safety and reliability.

2. Usability of Form. This element requires product features such as operating controls, control surfaces, information displays, seats, doors, and panels that allow human beings to access and operate a product—or deliberately prevent dangerous access or operation of a product—and maintain it in a safe and reliable condition. In design these are sometimes called *affordances*, because they afford a human being with access to the form in the way that doors provide access to a building. By analogy one can easily see the extension of the usability features of mechanical products into software and even products of visual and verbal communication. Software is accessed by means of a user interface, meaning all of the features presented on a computer screen that allow a human being to operate and control the software. In graphics and communication design, the size of fonts, the layout of information, and similar matters allow a person to understand what is being communicated. It is more than a technical matter when, for example, bus signs and timetables are printed in font sizes that are too small for elders to read. Unfortunately usability is often seen only in terms of the immediate use or functioning of a product. In reality usability issues affect the entire lifecycle of products. Can the product be produced efficiently and safely, can it be operated effectively, can it be maintained, and can it be disassembled and disposed of or recycled safely? These are technical issues with significant ethical implications for design thinking.

3. Aesthetics of Form. This element is sometimes a puzzling subject for scientists and engineers, but for the designer it is the final element in the creation of a complete product. The aesthetic element of form makes a product desirable to possess and use. Many products that are otherwise useful and even usable are incomplete and fail to be integrated into the everyday lives of human beings because the form is not aesthetically pleasing. This is a source of confusion and consternation to inventors and developers and sometimes to policy makers who seek to influence individual and social behavior through the adoption of certain products—for example, seat belts in automobiles or products that support recycling or sustainability.

Part of the misunderstanding of aesthetics rests with the term itself. In its original and broadest meaning, aesthetics refers to the pleasurable or painful sensations that human beings feel through their senses. In this meaning all products have an aesthetic element, by accident or by design. The sound of a door closing, the texture of a control surface, the visual appearance of information in a software interface, the smell of plastics and metals, the taste of medicine: All are examples of the aesthetic element of form. Over time aesthetics has taken on a second, more restricted meaning as the study and theory of beauty. The psychological, social, cultural, and philosophical significance of aesthetics is a complex and profound subject. One way to understand the place of aesthetics in design is how it leads a human being to identify with a product. Identification with a product—to imagine a product as a desirable part of one's lifestyle and a valuable extension of the user into the world—shows how important the aesthetic element of form may be in design thinking.

The complexity of aesthetics points toward several areas of ethical issues that the designer must consider. Aesthetics plays a subtle and important role in supporting the usability of products and, hence contributes to safety and accessibility. Aesthetics also concerns the social, cultural, and even political value placed on sensations of pleasure and pain. Economic necessity plays an important role in the degree of luxury that products provide, but local community values also influence what is acceptable in making products pleasurable. Adapting products to local values is an ethical consideration for the designer and the designer's client. It is closely related to the issue of *appropriate technology*, which concerns selecting the kind of technology for a product that is suited to the economic, environmental, and social or cultural conditions of people.

There are further ethical issues surrounding beauty: what it is, its value, its use as a political instrument to affect the development of society and culture, helping to achieve the goals of one or another cultural agenda. For some there is aesthetic delight in the intelligent working of a product such as a mechanical or electronic device. The beauty of an idea realized in concrete form may itself be captivating. However this and other forms of beauty often flow from individual delight into social and political movements, taking on further ethical and moral significance. For example the so-called *modernists* of twentieth-century design believed that creating a certain kind of formal beauty in their products would have a direct effect in improving the values and behavior of people. The *good design* movement of the 1950s is a specific example. In contrast the so-called *post-modernists* of the 1980s and early 1990s used other concepts of beauty and even anti-beauty to express cultural diversity and encourage alternative aesthetic values. In both cases the aesthetics of design was associated with moral values.

In addition to ethics of product form, there are ethical issues involved in the materials employed in bringing a form to reality. Traditional and new materials present hazards that the designer has a responsibility to understand and respect. The selection of proper materials literally supports structural integrity in engineering, industrial design, and architecture. There are also ethical implications when designers make excessive use of materials or of particularly precious materials, because this may be regarded as a waste of natural resources. Similarly there are ethical issues surrounding the long-term impact of materials on human beings and on the natural environment. Developments in science and technology are a source of the problem of sustainability, and play a role in society's efforts to create sustainable communities. Many people believe that the designer and the designer's client have a newly recognized responsibility for creating products that support the goal of sustainability.

The development of science and technology has had profound impact on products and product forms, an influence that will only grow through the development of designer materials by means of biotechnology, nanotechnology, and other methods. Perhaps most importantly it has broadened the understanding of what a product of design is. At the beginning of the twentieth century, a product was regarded simply as a tangible, physical artifact, whether a consumer good or industrial machinery or medical and scientific instruments or a building. At the beginning of the twenty-first century, these product categories remain but have been the object of much elaboration. The categories of the physical have also increased to include chemical and biological products as physical artifacts that result from design thinking. Furthermore people recognize that information products, visual communications, services and processes, and even organizations are products of design thinking, subject to forethought and requiring careful, responsible decision making in their creation.

The broadening of the general understanding of what a product is comes from several factors associated with the development of science and technology. One is the concept of a system, which depends on a rational ordering or relationship of parts to achieve some goal. Rationalization and standardization now play a fundamental role in design and product development, supporting mass production and mass communication. Another factor is the development of new materials and the machines to process and shape them. Closely related to both of these factors is the development of digital technology, with scientific and industrial applications as well as applications suited to the daily lives of human beings through personal devices as well as access to information and communication through the internet. Among the many factors that have changed the understanding of what a product is, perhaps the most important, from an ethical perspective, is assessment of the consequences of the product's creation on the lives of individuals, society, and the natural world. This has come through the application of the physical and biological sciences, tracing the impact of products far beyond the marketplace (Winner 1986). It has also come through the development and application of the psychological and social sciences. Base-line efforts in these sciences during the twentieth century have resulted in the gathering of information that allows informed discussion of social policy and the philosophical implications of science, technology, and design.

Ethical Standards and the Ultimate Purpose of Design

A fourth ethical dimension of design arises from the service nature of the design arts, and presents some of the most difficult ethical issues designers face. The design arts are fundamentally a practical service to human beings in the accomplishment of individual and collective purposes. That is, the end purpose of design is to help other people accomplish their own purposes. This is where the personal character and morality of the individual designer, as well as the other ethical dimensions of design, are inevitably placed in a larger social, political, religious, and philosophical context. What is the moral significance of the particular purposes that designers are asked to serve? What is the moral worth of particular products that seek to achieve these purposes? What consequences will products have for individuals, society, and the natural environment in the short and long terms? What ethical standards can designers employ in making decisions about the proper use of design?

Ethical guidance in these matters comes from several sources including personal morality, professional organizations, the institutions of government, religious teachings, and philosophy. The potential for moral conflicts and dilemmas is so great that in this fourth ethical dimension the ethical problems of design are essentially the same as the ethical problems of citizenship and practical living in general. It is difficult to distinguish design from politics, political science, and political philosophy. This reaffirms Aristotle's treatment of ethics and politics: They do not address different subject matters but the same subject matter from different perspectives.

Nonetheless there are grounds for continuing to treat design ethics as a distinct problem with a distinct perspective on individual and social life. For example the natural and social sciences study what already exists in the world, but design seeks to create what is possible and does not yet exist—design is concerned with invention and innovation and, generally, with matters that may be other than they are through human action. This is the basis for Herbert A. Simon's treatment of design as *the sciences of the artificial*. Whether one refers to design as an art or a science, most designers would agree with Simon that design is a systematic discipline involving choices that are "aimed at changing existing situations into preferred ones" (Simon 1981, p. 129). One implication has special significance for ethics. Following other philosophers, Caroline Whitbeck has observed that the traditional discourse of ethics tends to emphasize making moral judgments—the critique or evaluation of actions already taken. In contrast she argues that ethics may be considered from the perspective of the moral agent seeking to devise ethical courses of action (Whitbeck 1998). This argument—that ethics itself is a form of designing—is directed primarily toward the ethics of professional conduct, how designers relate to supervisors and clients, and how designers or any one else may respond creatively and responsibly to ethical and moral problems in their work.

The argument may be expanded in a direction that many designers would acknowledge: Not only is ethics a form of designing, but designing is a form of ethics. One aspect of the designer's creativity and responsibility is to devise ethical courses of action that navigate the moral dilemmas of practical life. This happens in the normal course of the design process when, for example, the designer studies the client's brief or charge and finds it inadequate or inappropriate for solving the problem that may be the real concern of the client. This leads to a rethinking and recasting of the initial purpose set by the client, often reached through negotiation over the nature of the product to be created.

In a broader sense, moral issues are addressed when the designer employs clear and well-articulated ethical standards in making decisions about the proper use of design in any particular situation. There is no single set of ethical standards in the field of design; the pluralism of the human community in general is mirrored in the design community in particular. However there are distinct ethical positions in the discussions of designers, and they bear a recognizable relationship to positions in the tradition of formal ethical theory. Two of these positions point toward a natural foundation of design ethics, and two others point toward conventional and arbitrary foundations established by human beings.

Designers whose ethical position is grounded on a natural foundation typically argue that the products of design should be *good*, in the sense that they affirm the proper place of human beings in the spiritual and natural order of the world. This position finds its strongest premises in spiritual teachings and some forms of philosophy (Nelson 1957). Alternatively they argue that products should be *appropriate and just*, in the sense that they are appropriate for human nature and the physical and cultural environment within which people live, and that they support fair and equitable relationships among all human beings. This position finds its strongest premises in human dignity and the development of human rights, encompassing civil and political rights, economic rights, and cultural rights (Buchanan 2001).

Designers whose ethical position is grounded on conventional and arbitrary foundations typically argue that products should satisfy the *needs and desires of human beings* within acceptable constraints. The constraints at issue are the simply conventional expectations of a community and what is considered normal in the physical, psychological, and social condition of human beings in a particular time and place. The strongest premises are drawn from the study of manners, taste, and prevailing laws, and by scientific study of what is normal and abnormal in the body and mind. Alternatively various designers argue that products are merely *instrumental*, in the sense that they are useful in enabling human beings to achieve any of their wants and desires, limited only by the power of individuals and the state to curb willfully destructive actions and turn creativity in acceptable directions. This position draws its strongest premises from the concept of the *social contract*, upon which it is argued that any state is created.

As observed earlier, the development of scientific knowledge and technology has had a profound effect on human understanding of the nature and consequences of the products created by the design arts, deepening consciousness of the ethical dimensions of design. Additionally the development of design thinking has made important contributions to discussions of science, technology, and ethics. Nowhere is this more evident than in the central concern of design to humanize technology and place the advancement of scientific knowledge in the context of practical impact on human life. The contributions are typically made through the concrete expression of design thinking in real products that influence daily life rather than through writing about design. As designers have ventured out from traditional products and product forms, their explorations and experiments in creating new products have provided the concrete cases that focus discussion of ethical issues and the limits of science and technology. In many instances, the design arts have been deliberately employed to provoke critical debate in the general public about the place of science and technology in community life.

Toward an Ethical History of Design

An ethical history of design would present the origins and development of design from the perspective of designers as moral agents, tracing the successive issues and ethical dimensions of design as they have arisen through individual and collective action. Such a history has not yet been written or even attempted because the formal study of ethics has received little attention among designers and scholars of design studies. Indeed there are grounds for arguing that the formal study of ethics in the philosophy of design began no earlier than the mid-1990s, with the publication of articles by authors such as Alain Findelli and Carl Mitcham. Mitcham's "Ethics into Design" draws from philosophical discussions of ethics, the philosophy of technology, and the development of ethics in engineering. He argues that the two traditions of design in the twentieth century—design as art and aesthetic sensitivity and design as science and logical process—"must be complemented by the introduction of ethics into design, in order to contribute to the development of a genuinely comprehensive philosophy of design" (Mitcham 1995, p. 174). Mitcham's essay is important because it gives disciplined philosophical focus to the many discussions of ethics, politics, and morality that have shaped design since the beginning of the twentieth century.

Several such discussions have made important contributions in opening up new lines of thinking. In the late-nineteenth century, the political writings of William Morris (1834–1896) introduced ideas about socialism that helped to shape the arts and crafts movement and questioned the value of industrialization. The documents of the Bauhaus in Germany—for example, the essays included in *Scope of Total Architecture* (1962) by Walter Gropius (1883–1969)—helped to set the moral agenda of modernism. Artist Laszlo Moholy-Nagy's (1895–1946) *Vision in Motion* (1947) developed these ideas further and contributed to a form of humanism in design. Work at the Ulm school of design, particularly under the influence of the *Frankfurt School* of social theory, showed a struggle between sociopolitical questioning and the introduction of scientific methods into the design process. The writings of George Nelson (1908–1986) elevated discussions of *good design* to a higher moral concern for the responsibilities of the designer and true good in products. Kenji Ekuan's *Aesthetics of the Japanese Lunchbox* (1998) offered a Buddhist perspective on issues of ethics and morality in product design. Victor Papanek's *Design for the Real World: Human Ecology and Social Change* (1984) and *The Green Imperative* (1995) introduced the ideas of appropriate technology and sustainability to design thinking. In *Cradle to Cradle* (2002), William McDonough and Michael Braungart extend the theory of sustainability in a controversial discussion of industrial design and architecture. Beginning in 1982, the journal *Design Issues: History, Criticism, Theory* provided a venue for some of the most important discussions of design ethics. Authors such as Alain Findelli, Richard Buchanan, Ezio Manzini, Tony Fry, and Victor Margolin addressed practical as well as philosophical issues surrounding design ethics, and their work poses a challenge for a new generation of students of design. The continuing pace of scientific and technological development and the growing sophistication of reflections on design, supported by new doctoral programs and research in many universities, suggest that design ethics will become a progressively more important subject.

RICHARD BUCHANAN

SEE ALSO *Architectural Ethics; Building Codes; Building Destruction and Collapse; Engineering Design Ethics; Engineering Ethics; Participatory Design.*

BIBLIOGRAPHY

Attfield, Judy. (1999). *Utility Reassessed: The Role of Ethics in the Practice of Design*. Manchester, England: Manchester University Press.

Borgman, Albert (1987). *Technology and the Character of Contemporary Life: A Philosophical Inquiry*. Chicago: University of Chicago Press.

Buchanan, Richard. (2001). "Human Rights and Human Dignity: Thoughts on the Principles of Human-Centered Design." *Design Issues* 17(3)(Summer): 35–39.

Ekuan, Kenji. (1998). *Aesthetics of the Japanese Lunchbox*, ed. David B. Stewart, trans. Don Kenny. Cambridge, MA: MIT Press.

Findelli, Alain. (1994). "Ethics, Aesthetics, and Design." *Design Issues* 10(2)(Summer): 49–68.

Gropius, Walter. (1962). *Scope of Total Architecture*. New York: Collier Books.

Harries, Karsten. (1997). *The Ethical Function of Architecture*. Cambridge, MA: MIT Press.

Lindenger, Herbert, ed. (1991). *Ulm Design: The Morality of Objects*, trans. David Britt. Cambridge, MA: MIT Press.

Manzini, Ezio. (1995). "Prometheus of the Everyday: The Ecology of the Artificial and the Designer's Responsibility," trans. John Cullars. In *Discovering Design: Explorations in Design Studies*, eds. Richard Buchanan and Victor Margolin. Chicago: University of Chicago Press.

Margolin, Victor. (2002). *The Politics of the Artificial: Essays on Design and Design Studies*. Chicago: University of Chicago Press.

McDonough, William, and Michael Braungart. (2002). *Cradle to Cradle: Remaking the Way We Make Things*. New York: North Point Press.

Mitcham, Carl. (1995). "Ethics into Design." In *Discovering Design: Explorations in Design Studies*, eds. Richard Buchanan and Victor Margolin. Chicago: University of Chicago Press.

Moholy-Nagy, Laszlo. (1947). *Vision in Motion*. Chicago: Paul Theobald.

Molotch, Harvey (2003). *Where Stuff Comes From*. London: Routledge.

Nelson, George. (1957). *Problems of Design*. New York: Whitney.

Papanek, Victor. (1984). *Design for the Real World: Human Ecology and Social Change*, 2nd edition. New York: Van Norstrand Reinhold.

Papanek, Victor. (1995). *The Green Imperative: Natural Design for the Real World*. London: Thames and Hudson.

"Responsible Design: Managing the Ethical Choices in the Design Process." (1991). *Design Management Journal* 2(4)(Fall): 6–84.

Simon, Herbert A. (1981). *The Sciences of the Artificial*, 2nd edition. Cambridge, MA: MIT Press.

van Toorn, Jan. (1994). "Design and Reflexivity." *Visible Language* 28(4)(Autumn): 317–325.

Whitbeck, Caroline. (1998). *Ethics in Engineering Practice and Research*. New York: Cambridge University Press.

Winner, Langdon (1986). *The Whale and the Reactor: A Search for Limits in an Age of High Technology*. Chicago: University of Chicago Press.

OTHER RESOURCE

Bridge on the River Kwai. (1957). Directed by David Lean. Columbia TriStar Pictures.

DESSAUER, FRIEDRICH

Friedrich Dessauer (1881–1963) was born in Aschaffenburg, Germany, on July 19, and died in Frankfurt am Main on February 16. He led an active life as an inventor, entrepreneur, politician, theologian, and philosopher who put forth a strong ethical justification of technology as being even more significant than science. On the basis of his experience with technological creativity Dessauer argued that the act of invention goes beyond appearance to provide contact with Kantian things-in-themselves and, in theological terminology, realizes the *imago dei* in which human beings have been created.

Early in his life Dessauer became fascinated with Wilhelm Röntgen's (1845–1923) discovery of X-rays (1895), which promised a penetration of appearances, and his design of high-energy X-ray power supplies earned him a doctorate in 1917. As an inventor and entrepreneur he developed techniques for deep-penetration X-ray therapy in which weak rays are aimed from different angles to intersect at a point inside the body where their combined energy can be lethal to a tumor while having less of an effect on the surrounding tissues. While continuing his work in biophysics, after 1924 Dessauer was a Christian Democratic member of the Reichstag until he was forced to leave Germany in 1933 because of his anti-Nazi stance. After World War II Dessauer returned to lead the Max Planck Institute for Biophysics until he died from cancer brought on by X-ray burns incurred during his experimental work.

Beginning in the 1920s, Dessauer also pursued a wide-ranging intellectual dialogue about the meaning of modern technology. Especially in *Philosophie der Technik* (1927) and *Streit um die Technik* (1956), Dessuaer defended a Kantian and Platonic theory of technology. In the *Critique of Pure Reason* Immanuel Kant (1724–1804) had argued that scientific knowledge is limited to appearances (the phenomenal world) and unable to grasp "things-in-themselves" (noumena). Subsequent critiques of moral reasoning and aesthetic judgment required the positing of a "transcendent" reality but precluded direct contact with it. In his "fourth critique" of technological making Dessauer argued for existential engineering contact with noumena:

> The Platonic idea descends into the imagination, recasting it. The airplane as thing-in-itself lies fixed in the absolute idea and comes into the empirical world as a new, autonomous essence when the inventor's subjective idea has sufficiently approached the being-such of the thing. . . .[And] it is possible to verify . . . [that] the thing-in-itself . . . has been captured [when] the thing works. (Dessauer 1927, p. 70)

Invention creates "real being from ideas," that is, engenders "existence out of essence" (Dessauer 1956, p. 234).

In conjunction with this metaphysics Dessuaer further articulated a moral assessment of technology that went beyond a simple consideration of practical benefits or risks. The autonomous, world-transforming consequences of modern technology bear witness to its transcendent moral value. Human beings create technologies, but the results, resembling those of "a mountain range, a river, an ice age, or a planet," extend creation.

> It is a colossal fate, to be actively participating in creation in such fashion that something made by us remains in the visible world, continuing to operate with inconceivable autonomous power. It is *the greatest earthly experience of mortals* (Dessauer 1927, p. 66).

For Dessauer invention is a mystical experience.

Although seldom stated as forthrightly as Dessauer put it, this view of technological activity as a supreme participation in the dynamics of reality arguably has influenced the ethos of cutting-edge engineering practice, as is discussed in David Noble's *The Religion of Technology* (1997). It is a view that merits more conscious examination in terms of both its strengths and its weaknesses than it has received.

CARL MITCHAM

SEE ALSO *Engineering Ethics; German Perspectives*.

BIBLIOGRAPHY

Dessauer, Friedrich. (1927). *Philosophie der Technik: Das Problem der Realisierung* [Philosophy of technology: the problem of realization]. Bonn: F. Cohen. Dessauer's most important book. Partial English version: "Philosophy in Its Proper Sphere," trans. William Carroll, in *Philosophy and Technology*, ed. by Carl Mitcham and Robert Mackey. New York: Free Press, 1972.

Dessauer, Friedrich. (1956). *Streit um die Technik* [The controversy of technology]. Frankfurt am Main: Klett. A revised and expanded edition of *Philosophie der Technik* (1927).

Noble, David. (1997). *The Religion of Technology: The Divinity of Man and the Spirit of Invention*. New York: Knopf. Criticizes religious faith in technology.

DETERMINISM

Philosophical questions about determinism involve the nature of the causal structure of the world. Given the occurrence of some factor or factors C that cause an effect E, could E have turned out otherwise than it did? Determinists answer *no*: In a strictly deterministic world all things happen by necessity, as a direct function of their causal antecedents. Indeterminists hold that E might not have occurred, even with exactly the same initial conditions, because of the possibility of true randomness or free will.

General Forms of Determinism

Early religious versions of determinism were based on the belief that people's lives are supernaturally ordained. As exemplified in the tale of Oedipus, even actions taken to try to avoid what the gods have in store turn out to be the means of sealing that destiny. Predestinarianism, a view held by some Christian sects, states that God controls and foreordains the events of human lives so that it is determined in advance whether one will go to heaven or hell. A related view holds that determinism follows from God's omniscience; if the future is undetermined, God cannot be said to be all-knowing. Modern forms of determinism dispense with supernatural beings and hold that invariable laws of nature fix events.

Determinism sometimes is defined in terms of predictability. The philosopher Karl Popper (1902–1994) called this "scientific" determinism. In a commonly performed thought experiment one imagines a Cartesian demon who knows all the laws of nature and the complete, precise state of the world at some time T; if the world is strictly determined, the demon can use that information to predict any future or past event with any degree of accuracy. Real scientists lack perfect theories and perfect data, and so imperfect prediction in practice does not by itself speak against predictability in principle. (Prediction is still possible in an indeterministic world, but only probabilistically.) Classical Newtonian physics typically is thought to describe a deterministic world—though John Earman (b. 1942) identifies a possible exception) as does relativistic Einsteinian physics.

How is determinism relevant to ethics? Some philosophers argue that if universal determinism is the case, morality is impossible because personal ethical responsibility requires the possibility of free action: One cannot be blamed or praised for doing something if one could not have done otherwise. Such incompatibilists hold that morality requires undetermined free will. Compatibilists argue that morality is possible even in a deterministic world. Some go further and hold that the kind of free will that is essential to morality actually requires determinism. If the world is indeterministic and people's actions result from mere chance, people are no more moral than a flipped coin.

Specific Forms of Determinism

Even if one sets aside such global issues, questions about determinism remain ethically significant at other levels of explanation. Various specific forms of determinism posit one or another causal factor as the driving force of change in human life and can be considered separately.

Is biology destiny? Explaining the social roles and behavior of men and women by reference to their sex, for example, is a common form of biological determinism. To specify further that genes are the ultimate biological determinant is genetic determinism. Are all human behaviors, thoughts, and feelings determined by basic characteristics of human nature and individual past experiences? Psychological determinism was a basic assumption of the psychologist Sigmund Freud's (1856–1939) psychoanalytic theory, which held that nothing that human beings do is ever accidental but instead is the result of the forces of the unconscious. The nature versus nurture debate (e.g., regarding the cause of sexual orientation) often is couched in terms of a choice between biological determinism and social determinism.

Other forms of social determinism include economic determinism: the view that economic forces are the fundamental determinants of social and political change. This thesis commonly is attributed to the political philosophers Karl Marx (1818–1883) and Friedrich Engels (1820–1895), though their thesis was more focused, stating that the mode of production determines social consciousness. They argued that because the material forces of production are given at a certain stage in history and people have no choice about whether to enter into such relations of production, the broad structure of people's social, political, and intellectual life is set by forces beyond their control.

Technological determinism tries to explain human history in terms of tools and machines. In a classic example a simple advance in cavalry technology—the stirrup—changed military and political history. However, many people consider this to be too narrow a conception, arguing that technology properly includes the entirety of material culture or even nonmaterial technologies such as knowledge and processes. In reaction against this view advocates of cultural determinism or the related view of social constructivism emphasize that technology itself is human-made and carries the imprint of the social and historical circumstances that formed it.

One could extend this list of midlevel determinist theses, with each thesis being distinguished by a claim that some causal factor determines some general, social effect. All such determinist theses come in stronger or weaker versions, depending on the claimed autonomy of the cause. A hard technological determinist, for example, would argue that technology develops by its own internal laws with a one-way effect on social structures, whereas a soft technological determinist would allow that the development and influence of technology could be mediated by other factors.

This issue sometimes is conflated with questions about reduction. Strictly speaking, reduction is the explanation of one thing in terms of another (typically though not necessarily its components) with no implication of exclusivity. However, one sometimes speaks derogatorily of an explanation as being "reductionistic" when a factor is claimed to determine something without acknowledging other causes.

Qualifications

With the accumulation of scientific evidence and the advance of technology it is possible to modify assessments of particular determinist theses. For instance, it is not a foregone conclusion that the world is fully deterministic. Indeed, evidence from quantum mechanics indicates that chance processes are a part of the causal structure of the world. Some ethicists, such as Robert Kane (b. 1938), have argued that quantum indeterminacy is what allows the possibility of human free will. By contrast, evidence from biology, psychology, and cognitive science that reveals causes of behavior, thoughts, and feelings may be taken to weaken the plausibility of free will. Even these very general issues can play a role in discussions of practical ethical matters, such as penal policy.

Midlevel determinist theses may have other ethical implications. For instance, as science identifies some causal factor as a determinant of social change or another ethically salient effect, people acquire (or lose) moral responsibility for such effects to the degree that they can control (or not control) the cause. Thus, to the degree that in (re)making technology people (re)make the world, people bear a responsibility to make ethical choices about what forms of technology to pursue or reject. The philosopher Herbert Marcuse (1898–1979), for instance, argued that technology dominates all other forms of control and that although people designed machines to free themselves, those machines often determine people's lives for the worse. If this is the case, their value should be reexamined. Similarly, people may have a responsibility to pursue technologies that would improve their lives. The debate over genetic engineering and other biotechnologies involves all these issues. If it is possible to reengineer human nature, should that be done?

The global questions about the relationship between universal determinism, indeterminism, free will, and morality remain paradoxical. However, advances in science and philosophy can help resolve questions about midlevel determinist hypotheses. For instance, one can sort out many issues by moving from a simple two-place parsing of the causal relation C causes E to a four-place analysis: C causes E in situation S, relative to some alternative *a* (CaSE). This analysis recognizes that there are always multiple causal factors that produce a given effect and places that people choose not to focus on for a particular question—a pragmatic matter—in "situation S." (The specified alternative does not contribute to the effect but provides a baseline against which to measure whether C's effect is positive or negative and to what degree.)

This model makes it clear that no single factor determines an effect by itself and that an effect can have multiple explanations, all equally legitimate and objective, depending on the (pragmatically delimited) situation. For instance, it is reasonable to say that a trait is determined by a gene only if specific environmental factors are taken as given. Thus, the thesis of genetic determinism is seen to be incorrect if it is taken in an exclusive reductionistic sense, though it can be correct in particular cases (that is, if scientific evidence shows that a particular gene causes effect E in a given environmental situation) in the same way that the environment can be said to determine the effect (if science shows that it is an explanatory causal factor of E, given a set genetic situation). This more fine-grained causal analysis allows a more precise assessment of determinist theses and thus a better moral evaluation.

ROBERT T. PENNOCK

SEE ALSO *Autonomous Technology; Evolutionary Ethics; Freedom; Free Will.*

BIBLIOGRAPHY

Dennett, Daniel C. (2003). *Freedom Evolves*. New York: Viking.

Earman, John. (1986). *A Primer on Determinism*. Dordrecht, The Netherlands, and Boston: D. Reidel.

Libet, Benjamin; Anthony Freeman; and Keith Sutherland, eds. (1999). *The Volitional Brain: Towards a Neuroscience of Free Will*. Thorverton, UK: Imprint Academic.

Kane, Robert. (1996). *The Significance of Free Will*. Oxford and New York: Oxford University Press.

Marcuse, Herbert. (2000). "The Problem of Social Change in the Technological Society." In *Towards a Critical Theory of Society: Collected Papers of Herbert Marcuse*, Vol. 2, ed. Douglas Kellner. New York: Routledge.

Marx, Karl and Frederick Engels. (1948 [1848]). *The Communist Manifesto*, ed. and annotated by Frederick Engels. New York Labor News Co.

Obhi, Sukhvinder S., and Patrick Haggard. (2004). "Free Will and Free Won't." *American Scientist* 92(4): 334–341.

Popper, Karl. (1991). *The Open Universe: An Argument for Indeterminism*. London: Routledge.

DEVELOPMENT

SEE *Change and Development.*

DEVELOPMENT ETHICS

Since the mid-twentieth century development has been promoted as the process of overcoming the condition of deprivation that prevails in many regions of the world. Underdevelopment is, correspondingly, a situation from which people and governments want to remove themselves, using science and technology to increase efficiency and generate innovations in the production of goods and services. Social science plays a crucial role in explaining the causes of and finding solutions to underdevelopment.

Development discourse often acts like an ideology, either as an uncritical recipe for all kinds of social ills or as a way of justifying policies that benefit the powerful while speciously purporting to aid the poor. In their 1992 work *The Development Dictionary: A Guide to Knowledge as Power* Wolfgang Sachs, Ivan Illich, Vandana Shiva, Arturo Esteva, and others recommend dropping development discourse altogether as being part of a project based on the quantitative and global instead of the qualitative and local. They also consider development to be an imposition from outside and above. As an example, they explain that the countries dominated by the United States after World War II only became *underdeveloped* when Harry S. Truman in his 1949 inaugural speech announced a program aimed at improving what he called underdeveloped areas. Before that the label did not exist.

But the distinction between the two kinds of countries was already in place. Some were rich, powerful, and dominant; others were—and continue to be—poor, weak, and dependent. By using the categories of imperialism and neocolonialism instead of development and underdevelopment, Marxists point to the historical roots of the difference, although political strategies to fight neocolonial relations are obviously not the same as development plans, and success in the first aspect does not guarantee success in the second.

There is no controversy as to the description of underdevelopment in terms of lack of food, shelter, education, health care, job opportunities, rule of law, good governance, and political power. Developing nations—formerly known as the Third World and sometimes as the South—share similar problems although to different degrees. The countries consistently listed at the bottom of the United Nations Development Programme (UNDP) annual report suffer acutely from an overall condition of deprivation, often aggravated by civil strife and corruption. It is not coincidence that many of the countries at the top of the list were colonial powers and that *all* the nations at the bottom were colonies of those at the top until the late-twentieth century.

Defining Development

It is more difficult to define a developed country for at least three reasons. First there are several models of development. The United States and Canada, for instance, are both developed countries in the usual definition of the term. But they are not developed in exactly the same way. Their social security and health care systems operate differently and do not cover similar percentages of the population.

Second it is not contradictory to state that there are varying degrees of underdevelopment but no real development so far in the world. There is room for improvement even in countries such as Norway and Sweden with a human development index close to 1 according to the 2001 UNDP report.

Third development create new problems. Homelessness is more of a problem in countries at advanced stages of change than in societies devoted to subsistence agriculture where family ties are stronger. The connection between mass consumption and clinical depression has been documented by Yale psychologist Robert E. Lane.

Moreover the very idea of development has experienced an evolution as a consequence of both a deeper theoretical understanding of what *developed* means and because of the practical problems encountered by governments and international agencies. An asymmetry can thus be found between development and underdevelopment. Whereas underdevelopment has referred to similar facts and conditions since the term began to be used, development has taken on different meanings, so that the notion itself shows a history of development. From development as economic growth, the notion became more complex to include world peace (Pope Paul VI; growth with equity [Amin 1977]); satisfaction of basic needs (Streeten 1981); sustainable development (Brundtland Report of the World Commission on Environment and Development 1987); and development as freedom (Sen 1999), and human security measured in the index used by the Global Environmental Change and Human Security (GECHS) Project, based at the University of Victoria in Canada.

Ethics of Development

Among the most important tasks of the ethics of development is to work out an evolved notion of development and to propose alternative models to governments, international agencies, non-governmental organizations (NGOs), and communities. Louis Joseph Lebret (1959) and Denis Goulet (1965, 1971) are considered pioneers in this endeavor, and as a critical examination of the values underlying plans for social change, development ethics reached maturity when the International Development Ethics Association (IDEA) was founded in Costa Rica in 1987. IDEA has been active in this work since its inception through conferences held in the Americas, Europe, India, and Africa. Another important task is to assess technological innovation from an ethical perspective. New technologies and their implications for the well-being of humans and nature pose urgent ethical questions. Experience demonstrates that technology is a necessary condition for the improvement of human well-being, but that it can also do harm.

Harmful technologies are scientifically unsound, wasteful, unsustainable, or inappropriate for their declared purposes. Trofim Denisovitch Lysenko's agricultural methods imposed by Stalin in the Soviet Union had no scientific basis and led to widespread famine. Those opposed to Lysenko's ideas and methods were persecuted and many died in prison. China's backyard iron furnaces during the period known as the Great Leap Forward (1958–1963) were a great failure, a cause of starvation for many millions, and led to the destruction of the precious few forests remaining in China at the time. Bad technologies in principle can be corrected or abandoned as soon as their inadequacies are clearly known, but some political regimes seem reluctant to do that.

Evil technologies are designed to enslave or eliminate individuals and groups. They respond to irrational hate, lust for power, or blind ideological commitments.

Adolph Hitler's use of technology in the so-called Final Solution is an example. Torture instruments are widely used by repressive regimes, and terrorists employ different destructive technologies to wreak havoc among civilians.

Given the fact that technology can be used to do harm, it is important to discuss how to ethically assess it. According to some, technology is ethically neutral, and ethics becomes relevant only when dealing with applications of objects and processes. Responsibility would thus lie only with the users of technologies, not with the engineers who designed them. But because the possible uses and abuses of technology are already present at the design stage, questions of aims and purposes, of good and evil, arise even before artifacts come into being. This is especially true of highly specific technologies. Although a hammer can be used to drive a nail or to commit murder, electric chairs have very few possible uses. It seems contradictory to justify building a torture chamber on the grounds that some other possible benign uses may be found for it.

How technology modifies the environment is another question that can and should be answered at the design stage. Any answer implies values held either by individuals, corporations, governments, or societies. Who makes the decisions, and on what grounds, are likewise ethical issues of great importance. The ethical principles of inclusion and participation are relevant here: As a general rule, the opinions of those affected by decisions should be taken into consideration.

Underdevelopment and Asymmetrical Relations between Countries

A particular problem is posed by the asymmetry in power between developed and developing nations. Two examples of asymmetrical relations are often mentioned in this connection: the patent system and subsidies. First the patent system internationally enforced in the early-twenty-first century and as interpreted by many in developing nations and by the UNDP's *Human Development Report 2001* is so rigid that it stifles possibilities of implementing changes necessary for the improvement of conditions in developing nations. One of the consequences of the strict imposition of the patent system is to give legal status and political power to huge monopolies that render it difficult for weak countries to develop their own technologies and protect their citizens from disease and death. In this connection, the Human Development Report 2001 mentions an emerging consensus on the unfair redistribution of knowledge as a consequence of intellectual property rights. It points out that since the late twentieth century the scope of patent claims has broadened considerably at the same time that the use of patents by corporations has become far more aggressive. Among those who may be interested in claiming patents, corporations are in the best position to do so because their focus on small improvements is geared to meet the required criteria for patenting. They also have the advantage of easy access to expensive legal advice in order to defend their patents under civil law. With such legal protection internationally enforced, companies use patent claims as a business asset to stake out their slice of the market. Although the report advocates fairness in international mechanisms for the protection of intellectual property, it also expresses concern because of the signals that the cards are stacked against latecomers. Another source of concern is the unequal relation between powerful corporations and the weak governments of developing countries. As pointed out by the UNDP report, advanced nations routinely issue compulsory licenses for pharmaceuticals and other products during national emergencies, and impose public, noncommercial use and antitrust measures. However by 2001 not a single compulsory license had been issued by a developing nation due to fear of the loss of foreign investments and the cost of possible litigation. Even the production of generic drugs is usually contested by advanced nations in trade negotiations with developing countries. Early-twenty-first century developed nations have profited enormously from the flow of information, discoveries, and inventions of previous eras and often have resorted to reverse engineering (procedures that are no longer available to developing nations because of the strict imposition of the patent system) to catch up with inventions. Yet they routinely oppose any such moves by developing nations.

Second the asymmetry among nations is also obvious in subsidies: In trade negotiations developed countries require developing nations to eliminate subsidies in the production of goods and services for export but refuse to abide by the same strictures. Marxists, dependency-theory scientists, and dependency-ethics theoreticians all denounce these unequal relations as an obstacle to the development of poor nations.

Ethics and Development Plans

Like technologies, development plans are designed for specific purposes and according to certain values, though implicit. Also as is the case in technologies, the selection of problems to be solved and the methods of solving them illustrate the values of decision makers. Those who formulate development plans often do so without consulting the people who may suffer the consequences of implementation of those plans.

Development ethics may follow two approaches. According to the first, which dates back to Plato and Aristotle and can also be found in the work of Hegel, justice is the main purpose of ethics and the state is the proper instrument by which to achieve a just society. Beyond commutative justice, in which personal differences are not taken into consideration in transactions between individuals, distributive justice aims at equality among people in unequal conditions. There must be an entity, which is greater than the individual, that is concerned with the interests of the many as opposed to the profits of the few; that entity is the state. Development ethics, in this perspective, is traditional ethics dressed in new clothes.

Some feel that a different approach is needed because there is little relation between public policies and distributive justice in modern states. They point out that politics is most often conceived of as the art of acquiring and keeping power. Rulers often stay in power by resorting to violence because they want to enrich themselves and their cronies or impose a particular ideology. Justice is the least of their concerns, and propaganda deflects the attention of the people from this fact. Consequently most people do not relate justice to the actions of the ruling classes and have many reasons to believe that governments are best described as instruments of injustice.

This view explains why ethics is often invoked against the rule of power and employed to overturn unjust laws. Because development plans in the hands of governments determined to impose a particular ideology or follow purely technocratic criteria often lead to suffering for the masses, development ethics, under this approach, is not simply traditional ethics in disguise. Rather development ethics is a critique of the unexamined ends and means that can form the basis of a new way of governing, a voice for the victims of development projects, and a call for accountability of those who consider themselves to be experts. Because development ethics risks placing too much importance on *development* and too little on *ethics*, it must have a strong theoretical foundation.

In light of the above discussion, an analysis of the connection between development and technology is useful. Development, in its social and economic sense and in the most general terms, is often conceived of as an increase in income or consumption per capita, plus social change. The first aspect is referred to as economic growth, which is easy to measure but can be used for purposes other than the improvement of conditions of the population, for instance, when a country fosters economic growth as a means to achieve military power. Social change is more difficult to define or measure, and has been described as the idea of development evolved.

The important role of technology in both aspects of development is obvious. W. W. Rostow (1987) argues that post-Newtonian science and technology are conditions for economic take-off, a means to break through the limits of per person output traditionally imposed on nontechnologically advanced societies. Technology applied to agriculture makes labor more productive, thereby preparing traditional societies for the transition to high consumption, and freeing large numbers of people for work in industry. Technology also makes possible large-scale industrial production. As an impetus for social change, advances in technology create new techniques, careers, jobs, opportunities, businesses, procedures, legislation, and even lifestyles. According to sociologist David Freeman in *Technology and Society* (1974), the social impact of technology follows four successive phases. First new technological products simplify daily tasks and chores. A pocket calculator is easier to handle than a slide rule; a word processor more versatile than a typewriter. Second job qualifications change. In the early-twenty-first century, secretaries are expected to use computers, instead of just type and file. Third allocation of authority and prestige also changes. Those who have expertise in cutting-edge technologies are in high demand and therefore make more money and enjoy greater social status than people working in older technologies. Finally values held in great esteem by society change. The values of traditional as opposed to industrial societies differ.

Thus changes in how human beings make things lead to cultural change. Even the valuation of change is subject to modification. As pointed out by Rostow, the value system of traditional societies ruled out major changes whereas modern societies incorporate the assumption that transformation and growth will occur. Commercial propaganda in high-consumption societies emphasize change as valuable in itself.

Because technology influences morality by changes in valuation, it is possible to perform an ethical analysis of social change brought about by technology. For example, a society that uses advanced technology to build weapons of mass destruction, and in which the military enjoys great prestige, is not morally the same as one that uses advanced technology to improve conditions for the poor. The fact that a technology is new, and even that it allows for greater productivity, does not mean that it is better. It may increase the gap between the rich and poor, or damage the environment. Increased productivity in agriculture due to new methods is usually associated with monoculture, whereas traditional agricultural practices, with their typical combination of different species, were safer both for human beings and for the environment.

One argument for preserving older technologies is that there is no way to tell when and how they may be needed as practical solutions in the future. In the event that certain technologies can no longer be used, knowing the old way of doing things may represent the difference between life and death. Each particular technology requires certain conditions for its functioning and more advanced technologies usually require more specific inputs. If such inputs (electricity, for instance) are not available, the ability to use alternative technologies is crucial. Because of the increasing dependency of technology on science, science is central to development. Government agencies dedicated to the promotion of scientific and technological research have existed in Latin America and other developing areas since the 1970s. The success of such agencies is not uniform, but the Latin American countries included in the 2001 UNDP report as countries with high human development (Argentina, Uruguay, Costa Rica, and Chile) also enjoy a long tradition of public support for science and technology.

Mastery of mathematics, physics, chemistry, and biology is the foundation of technological advancement. The social sciences also play an important role in developing nations. Because underdevelopment is a social condition, a scientific explanation could be found in social sciences. Development plans nevertheless tend to marginalize the importance of input from those disciplines.

Ethics of Science and Technology in Development

Before development economics existed, Francis Bacon (1561–1626) sought knowledge that could alleviate human misery. Gottfried Wilhelm Leibniz (1646–1716) struggled to develop a logical method to solve all kinds of theoretical and practical problems, which he employed in an attempt to alleviate the social ills he saw in Europe. David Hume (1711–1776) and Adam Smith (1723–1790) discussed the difference between rich and poor countries and whether it was morally desirable to bridge the gap. Their answer was affirmative.

After the Industrial Revolution in Great Britain in the late-eighteenth and early-nineteenth centuries, other countries experienced similar profound economic and social changes. In the nineteenth century, aspiration to better social conditions was summarized in the idea of *progress*. In the twentieth century, countries with different political regimes formulated and implemented far–reaching economic plans such as the Four-Year Plans in Germany and the Five-Year Plans in the Soviet Union in the 1930s, as well as Franklin D. Roosevelt's famous 100 Days, which included a number of measures designed to reverse the effects of the Great Depression. In the 1950s a clear distinction between the two kinds of countries entered the political arena, and plans were explicitly created to make change.

It became clear that development plans were not useful to large numbers of people forced to change their lives as part of the implementation of those plans. Several critics have examined the ends and means of development, the values implicit in plans, and the real beneficiaries of change. Denis Goulet (1965) devised a method to examine the choice of problems and solutions in light of values implicit and explicit. Because development ethics as conceived by authors such as Goulet and David A. Crocker aims at proposing alternative models to development, the question arises as to the feasibility of those models. Respect for cultural values is essential for these alternatives to succeed. Proponents hope that the social change brought about through such models will have a solid foundation and be, consequently, more sustainable for succeeding generations. The next generation should have at least the same natural, human-made and human capital than the previous one. If it has less than the previous generation, then development is not sustainable.

The connection of science and technology with development focuses on two questions: What, if any, is the relation between science and technology? and How do either or both relate to socioeconomic development? From the perspective of ethics, however, the basic question is not whether science and technology are subject to ethical analysis, but how science and technology can be used ethically for development.

A Development Ethics

At first glance, the answer to this question is simple. Development is morally justified when human beings are not mere *objects* in plans and projects but *subjects*, in the sense of being free agents who want to improve their condition. This position assumes that development plans are valid instruments by which to insure the universal right to an adequate standard of living, as expressed in Article of the Universal Declaration of Human Rights, and that each person is entitled to economic, social, and cultural entitlements as a member of society. Human development must be realized through national effort, but government plans and policies often ignore those who should benefit from them. Thus it is necessary to ground the legitimacy of plans and projects in the active role of development subjects. Without adequate living standards, human life cannot flourish, but an arbitrary imposition of change denies human beings the condition of being free agents.

Science and technology, whatever their relation to development, should be included in the process of making human beings actors instead of passive recipients. In addition to taking into consideration local knowledge, scientific theories must be relevant in the solution of the problems of the dispossessed. An economic approach that fails to appreciate the importance of unemployment and asymmetrical relations in trade is morally defective. An economics of development able to explain the difference between developed and developing regions of the world is needed. But, in addition, an economics *for* development must be created. The same is true for other social sciences, especially psychology and anthropology. Also, obviously, the resources of natural science should be harnessed in the effort to increase productivity and reduce poverty.

A second stage in the move from passive recipient to actor concerns the formulation of development plans and projects. Local knowledge, techniques, and technologies are usually more efficient and appropriate than imported ones, a point often made in Latin American fiction, for example in Jorge Amado's novel *Gabriela, Clove and Cinnamon* (1974). Local values embedded in cultural practices must respectfully be taken into account; mere lip service to those values, which is typical of political and social manipulation, should be condemned. When respect for a culture and its values is genuine, development plans are not arbitrary but are the outcome of consideration of the aspirations and desires of those who will be affected. Values that are deeply ingrained in cultures may be inimical to development and thus pose a challenge to development ethics. An ethics that includes not only values but also duties and obligations may counter antidevelopment sentiment.

However it is not enough for people to realize themselves as actors in development. Even when a project is rooted in local values and is the result of negotiation among individuals and groups, it may be morally indefensible or technically defective. Democracy guarantees public participation, but this in turn does not insure a morally correct result. Hence the interplay between insiders and outsiders in development is important, a point often made by Crocker.

Insiders are in a good position to incorporate local values into the process, whereas outsiders are not influenced by such values when assessing the rights and wrongs of plans and projects. Local experiences may be relevant but limited; outside expertise may be less relevant but wider in scope. For a fruitful collaboration to occur, insiders and outsiders must share some basic values and be committed to similar goals in connection with the improvement of human conditions. Thus development ethics can be conceived as a dialogue among cultures aimed at sharing valuable experiences in the struggle to overcome obstacles in the path of free social agents.

LUIS CAMACHO

SEE ALSO *Alternative Technology; Bhutan; Change and Development; Colonialism and Postcolonialism; Mining; Progress; Sustainability and Sustainable Development.*

BIBLIOGRAPHY

Adas, Michael. (1989). *Machines as the Measure of Men: Science, Technology and Ideologies of Western Dominance*. Ithaca, NY: Cornell University Press.

Amado, Jorge. (1974). *Gabriela, Clove and Cinnamon*. New York: Avon/Bard Books.

Aman, Kenneth, ed. (1991). *Ethical Principles for Development: Needs, Capacities or Rights. Proceedings of the IDEA / Montclair Conference* Montclair, NJ: Institute for Critical Thinking.

Amin, Samir. (1977). *Imperialism and Unequal Development*. Hassocks, England: Harvester Press.

Camacho, Luis. (1993). *Ciencia y Tecnología en el Subdesarrollo* [Science and technology in developing countries]. San Jose, Costa Rica: Editorial Tecnológica de Costa Rica.

Crocker, David A. (1991). "Insiders and Outsiders in International Development Ethics." *Ethics and International Affairs* 5: 149–174.

Crocker, David A. (1998). *Florecimiento Humano y Desarrollo Internacional* [Human flourishing and international development]. San Jose, Costa Rica: Editorial de la Universidad de Costa Rica.

Crocker, David A., and Toby Linden, eds. (1998). *Ethics of Consumption*. Lanham, MD: Rowman & Littlefield Publishers.

Escobar, Arturo. (1995). *Encountering Development: The Making and Unmaking of the Third World*. Princeton, NJ: Princeton University Press.

Freeman, David. (1974). *Technology and Society*. Chicago: Rand McNally.

Goulet, Denis. (1965). *Etica del Desarrollo* [Ethics of development]. Barcelona: Estela/IEPAL.

Goulet, Denis. (1971). *The Cruel Choice: A New Concept in the Theory of Development*. New York: Atheneum.

Goulet, Denis. (1989). "Tareas y métodos en la ética del desarrollo" [Tasks and methods in ethics of development]. *Revista de Filosofía de la Universidad de Costa Rica* 27(66): 293–306.

Goulet, Denis. (1995). *Development Ethics: A Guide to Theory and Practice*. New York: Apex Press.

Lane, Robert E. "The Road Not Taken: Friendship, Consumerism and Happiness." In *Ethics of Consumption*, eds. David A. Crocker and Toby Linden. Lanham, MD: Rowman and Littlefield.

Lebret, Louis Joseph. (1959). *Dynamique concrète du développement* [Concrete dynamics of development]. Paris: Les Éditions Ouvrières.

Rapley, John. (2002). *Understanding Development: Theory and Practice in the Third World*. Boulder, CO: Lynne Rienner Publishers.

Robinett, Jane. (1994). *This Rough Magic: Technology in Latin American Fiction*. New York: Peter Lang.

Rostow, W. W. (1960). *Stages of Economic Growth*. Cambridge, England: Cambridge University Press.

Rostow, W. W. (1987). *Rich Countries and Poor Countries: Reflections on the Past, Lessons for the Future*. Boulder, CO: Westview Press.

Sachs, Wolfgang, et al., eds. (1992). *The Development Dictionary: A Guide to Knowledge as Power*. London; Atlantic Highlands, NJ: Zed Books.

Sen, Amartya. (1999). *Development as Freedom*. New York: Anchor Books.

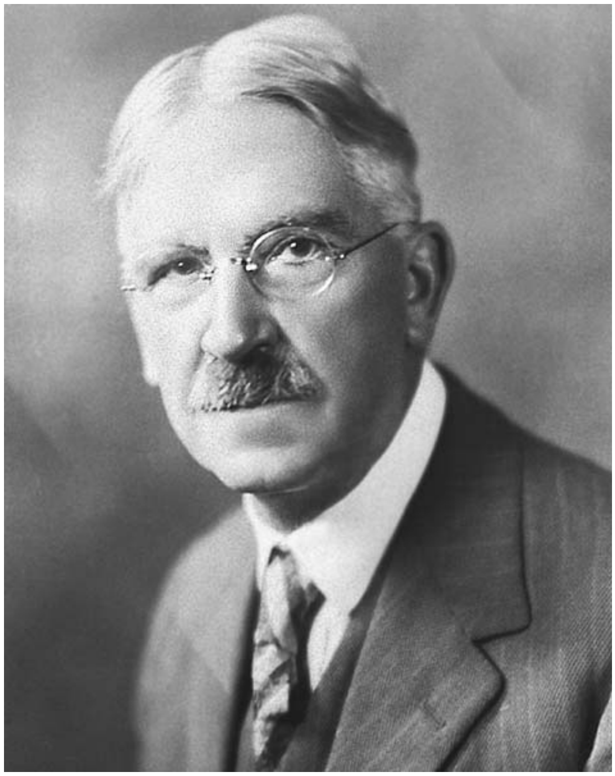
Streeten, Paul. (1981). *First Things First*. Oxford: Oxford University Press.

United Nations Development Programme. (2001). *Human Development Report 2001: Making New Technologies Work for Human Development*. New York: Oxford University Press.

United Nations Development Programme. (2003). *Human Development Report 2003: Millenium Development Goals: A Compact among Nations to End Human Poverty*. New York: Oxford University Press.

DEWEY, JOHN

Born in Burlington, Vermont, on October 20, John Dewey (1859–1952) lived a long and productive life as a psychologist, social activist, public intellectual, educator, and philosopher. Educated at the University of Vermont and Johns Hopkins, Dewey taught philosophy at the universities of Michigan, Minnesota, and Chicago, and Columbia University. He initiated the progressive



John Dewey, 1859–1952. During the first half of the 20th century, Dewey was America's most famous exponent of a pragmatic philosophy that celebrated the traditional values of democracy and the efficacy of reason and universal education. *(The Library of Congress.)*

laboratory school at the University of Chicago, where his reforms in methods of education could be put into practice. He was instrumental in founding the American Association of University Professors (AAUP), helped found the National Association for the Advancement of Colored People (NAACP), and was active in the American Civil Liberties Union (ACLU). Dewey remained active until shortly before his death in New York City on June 1.

Dewey's philosophical pragmatism, which he called "instrumentalism," is both an extended argument for and an application of intelligence-in-action. Intelligence-in-action, human reasoning understood as fallible and revisable, aims to ameliorate existing problems (ethical, scientific, technical, social, aesthetic, and so on). It is rooted in the insights and methodologies of modern science and technology.

Intellectual Influences

At Vermont, Dewey studied the work of Charles Darwin (1809–1882) and evolutionary theory, from which he learned the inadequacy of static models of nature, and the importance of focusing on the interaction between an organism and its environment. For Darwin, living organisms are products of a natural, temporal process in which lineages of organisms adapt to their environments. These environments are significantly determined by the organisms that occupy them. At Johns Hopkins, Dewey studied the organic model of nature in German idealism, the power of scientific methodology, and, with Charles Sanders Peirce (1839–1914), the notion that the methods and values of the natural sciences and technology (technosciences) should serve as a model for all human inquiry. Strongly influenced also by William James (1842–1910), Dewey became a proponent of philosophical naturalism. For Dewey, knowledge and inquiry develop as adaptive human responses to environing conditions which aim at reshaping those conditions.

Inquiry as Scientific and Technological

Along with Peirce and James, Dewey took the open, experimental, and practical nature of technoscientific inquiry to be the paradigmatic example of all inquiry. For Dewey, all inquiry is similar in form to technoscientific inquiry in that it is fallibilistic, resolves in practice some initial question through an experimental method, but provides no final absolute answer. In *Studies in Logical Theory* (1903), Dewey identifies four phases in the process of inquiry. It begins with the *problematic situation,* a situation in which one's instinctive or habitual responses to the environment are inadequate to fulfill needs and desires. Dewey stresses throughout his work that the uncertainty of the problematic situation is not inherently cognitive, but also practical and existential. The second phase of the process requires the *formulation of a question* that captures the problem and thus defines the boundaries within which the resolution of the initial problematic situation must be addressed. In the third, *reflective phase* of the process, the cognitive elements of inquiry, such as ideas and theories, are evaluated as possible solutions. Fourth, these solutions are *tested in action.* If the new resulting situation resolves the initial problem in a manner conducive to productive activity, then the solution will become part of the habits of living and thus a part of the existential circumstances of human life.

This method of inquiry works because, as Dewey points out in *Experience and Nature* (1925), human experience of the world includes both the stable, patterned regularity that allows for prediction and intervention and the transitory and contingent aspects of things. Hence, although for Dewey people know the world in terms of causal laws and mathematical relationships, such instrumental value of understanding and controlling their situations should not blind them to the sensuous characteristics of everyday life. Thus, not surprisingly, the value of technoscientific understanding and practice is most significantly realized when humans have sufficient and consistent control over their circumstances that they can live well.

Science, Technology, and the Good Life

Dewey rejects the distinction between moral and nonmoral knowledge because all knowledge has possibilities for transforming life, and arises through inquiry into a problematic situation. Thus, all knowledge has moral dimensions. Throughout his more explicitly aesthetic, ethical, and social writings, Dewey stresses the need for open-ended, flexible, and experimental approaches to problems, approaches that strive to identify means for pursuing identifiable human goods ("ends-in-view") and that include a critical examination of the consequences of these means.

For Dewey, people live well when they cultivate the habits of thinking and living most conducive to a full flourishing life. In *Ethics* (1932) he describes the flourishing life as one in which individuals cultivate interests in goods that recommend themselves in the light of calm reflection. In works such as *Human Nature and Conduct* (1922) and *Art as Experience* (1934), he argues that a good life is one characterized by (a) the resolution of conflicts of habit and interest within the individual and within society; (b) the release from rote activity in favor of enjoying variety and creative action; and (c) the enriched appreciation of human culture and the world at large. Pursuing these ends constitutes the central issue of individual ethical concern. The paramount goal of public policy is nurturing the collective means for their realization. Achieving these goals requires intelligence in action, best cultivated through democratic habits in everyday life, and education and practice in technoscientific modes of inquiry.

In the late twentieth and early twenty-first centuries, Dewey's ideas have had increasing influence in areas of applied philosophy such as philosophy of technology, bioethics, and environmental ethics. Nonetheless, Dewey has often been criticized as a mere apologist for the status quo and for a narrow straight-line instrumentalism that leaves no room for reflection on, or critical evaluation of, ends. Others criticize his work by noting that technoscience has unleashed great horrors on the world (such as nuclear weapons and environmental degradation), and increased the possibilities of social control and manipulation (Taylorism, mass media, surveillance, and so on). Dewey does not deny that technoscience has sometimes failed, but this has not been due to something intrinsic to science and technology. Failures in the use of science and technology are rather failures to consistently employ intelligence-in-action; failures of inquiry, failures to be sufficiently experimental, reflective, and open.

Among the influential interpreters of Dewey's work, especially as it applies to science, technology, and ethics, are Paul Durbin (b. 1933) and Larry A. Hickman. For some years Durbin has argued what has come to be known as the "social worker thesis," that philosophers dealing with science, engineering, and medicine have obligations similar to social workers not simply to analyze problems but to become socially and politically engaged in their solution. Hickman, director of the Center for Dewey Studies (Southern Illinois University at Carbondale), argues that Dewey's pragmatism offers the best account of how to develop moral intelligence and then bring it to bear in the context of an advancing technoscientific culture.

J. CRAIG HANKS

SEE ALSO *Expertise; Pragmatism; Social Engineering.*

BIBLIOGRAPHY

Campbell, James. (1995). *Understanding John Dewey: Nature and Cooperative Intelligence.* Chicago: Open Court.

Dewey, John. (1967–1991). *The Collected Works of John Dewey,* 37 volumes, ed. Jo Ann Boydston. Carbondale: Southern Illinois University Press.

Dewey, John. (1981). *The Philosophy of John Dewey,* ed. John J. McDermott. Chicago: University of Chicago Press.

Dewey, John. (1998). *The Essential Dewey,* 2 vols., ed. Thomas M. Alexander and Larry A. Hickman. Bloomington: Indiana University Press.

Durbin, Paul T. (1992). *Social Responsibility in Science, Technology, and Medicine.* Bethlehem, PA: Lehigh University Press.

Eldridge, Michael. (1998). *Transforming Experience: John Dewey's Cultural Instrumentalism.* Nashville, TN: Vanderbilt University Press.

Hickman, Larry A. (1990). *John Dewey's Pragmatic Technology.* Bloomington: Indiana University Press.

Hickman, Larry A. (2001). *Philosophical Tools for Technological Culture: Putting Pragmatism to Work.* Bloomington: Indiana University Press.

Hickman, Larry A., ed. (1998). *Reading Dewey: Interpretations for a Postmodern Generation.* Bloomington: Indiana University Press.

DIAGNOSTIC AND STATISTICAL MANUAL OF MENTAL DISORDERS

• • •

The Diagnostic and Statistical Manual of Mental Disorders (DSM) represents the most influential effort in the field of mental health to identify psychological and psychiatric abnormalities for the purposes of treatment. The extent to which this effort has been pursued in a rigorously scientific manner, and the ethical issues surrounding the distinction between normal and abnormal mental functioning, are important questions for clarification and debate.

The DSM, which has been compiled and published by the American Psychiatric Association (APA) since its first publication in 1952, is intended to serve as a standard tool for mental health professionals in the diagnosis of mental illness. In addition to providing the field with a definition of the term *mental disorder,* the fourth edition of the manual (DSM-IV-TR; APA 2000) contains a catalog of the clinical symptoms of 365 different mental disorders (for example, obsessive–compulsive disorder, borderline personality disorder), which are organized into sixteen major diagnostic classes (such as anxiety disorders, personality disorders, and so on).

With each subsequent edition, the classifications provided by the DSM have become more widely referenced in the field of psychopathology. In addition, the DSM system of diagnosis has become increasingly central to the communication between mental health professionals and those outside the field, such as lawyers, insurance companies, and the media. Nevertheless, the system remains highly controversial, even among those who have contributed to its development. Some of this controversy surrounds the general issue of whether or not the diagnosis of mental illness is a scientific endeavor at all. More specific criticism has also been leveled, however, at the specific approaches the DSM has taken over its history to describe or explain mental disorders. In both cases, the debate over the DSM has often raised fundamental questions about the nature and diagnosis of mental illness.

The Origins and History of the DSM

As Gerald N. Grob (1991) has detailed, psychiatrists of the early 1900s were largely uncomfortable with the idea that the symptoms of mental illness could be broken down into any meaningful classification scheme. The professionals of this period tended to view the individual case as highly unique and subject to a wide variety of interrelated personal and environmental variables. Various classification schemes were proposed between 1900 and 1920, including a collaborative effort of the U.S. Bureau of the Census and the existing version of the American Psychiatric Association that produced a taxonomy of twenty-two categories of mental disorder, most of which were predicated on a particular form of biological abnormality. Such systems, however, were largely irrelevant in clinical practice or research. Instead, they served primarily to provide gross survey categories for hospitals and local governments to use in the compilation of statistics on rates of mental illness among different demographic and ethnic groups and on standards of care across different communities.

During World War II, however, mental health professionals began caring for large numbers of patients (i.e., soldiers) who did not require long-term confinement in a hospital. These patients showed psychophysical, personality, and acute stress disorders that were not well documented and that added significant variety to the existing classifications of mental illness. Inspired by these circumstances, the APA formed a committee of experts to establish a diagnostic system that expanded upon systems developed for the U.S. armed forces and adapted the international statistical classification of diseases, injuries, and causes of death, developed by the World Health Organization, for use in the United States. This process involved a significant expansion and reorganization of the existing systems and culminated in the publication of the first DSM (DSM-I) in 1952. The DSM-I (and the subsequent DSM-II, published in 1968) represented a major turning point in the nature and purpose of a taxonomy of mental disorders. For one thing, it was the first attempt to standardize psychiatric diagnoses according to a particular theory of mental illness (that is, psychoanalytic theory). Moreover, the DSM was proposed to advance the science, and not just the administration, of mental health services. By providing mental health professionals with a common diagnostic language and by grounding the descriptions of the disorders in the prevailing psychoanalytic theory, the DSM was intended to further stimulate and synthesize research into the nature of mental illness.

These first two editions of the DSM, however, were not received with unequivocal support. The two primary complaints mental health professionals voiced against the DSM concerned the lack of evidence for the distinctions it made among various disorders and the small number of experts involved in determining the classification scheme. The reliance on psychoanalytic concepts was also increasingly questioned given the rise of more empirical and behavioral approaches in clinical settings. In response the APA took a distinctively different approach to developing the third (DSM-III, 1980) and fourth (DSM-IV, 1994) editions. For each of these editions, expert researchers and clinicians were organized into work groups for each category of disorders (e.g., anxiety disorders, substance-abuse disorders). These groups conducted reviews of the available literature to determine whether or not the criteria for each disorder and the distinctions among disorders were supported by empirical evidence. Although the findings from the work groups continued to be compiled and reviewed by committee, the emphasis on research increased both the objectivity of the decision-making process and the number of professionals who could influence the final product. The manual also became accessible to a wider range of professionals by abandoning a central theoretical perspective and adopting a focus on clinically observable symptoms such as thoughts of suicide or repetitive behaviors.

Current Issues in the Development and Application of the DSM

The primary purpose for the development of the DSM has always been its use as a clinical tool for guiding the assessment and treatment of mental disorders. Perhaps the greatest strength of the DSM is its usefulness in differential diagnosis. For example, a patient's complaint of feeling down or depressed can be evaluated in light of other clinical symptoms that are present and compared with the criteria for disorders such as Major Depressive Episode and Adjustment Disorder with Depressed Mood. Although disorders such as these share some common features, distinctions among them with regard to etiology (cause) and prognosis may provide important guidance for treatment planning. In fact, some clinicians argue that the future of mental health as a science depends heavily on the ability of professionals to distinguish among treatments that are or are not effective for specific diagnoses. Such an approach ultimately leads to the matching of treatment with diagnosis based on support from available research.

An important problem with such an approach, however, is that patients with distinctly different symptoms and clinical presentations can receive the same diagnosis. In the DSM-IV, for example, each disorder is characterized by a set of equally weighted criteria. Patients need not meet all criteria for a given disorder in order to fit the diagnosis. This flexibility allows for more reliable diagnosis across clinicians, but it can also lead to minimal overlap in symptoms between any two patients with the same diagnosis. Often, symptoms that these patients do not share play a major role in treatment planning and clinical management.

A similar problem concerns the frequency with which patients meet criteria for more than one disorder at a given time (known as comorbidity). As Lee Anna Clark, David Watson, and Sarah Reynolds (1995) have noted, more than half of all individuals with a DSM diagnosis also meet criteria for another disorder. In many cases, the presence of a second disorder is a significant issue that has a dramatic effect on a patient's response to a given treatment.

A third problem with the use of the DSM in treatment planning is the lack of a coherent theoretical framework for understanding the causes and progressions of the various disorders. This limitation is ironic, given that a descriptive, symptom-focused approach was deliberately adopted in the DSM-III and DSM-IV to make the manual accessible to a range of professionals with different theoretical orientations. Clinicians inevitably rely on a particular theoretical framework in assessment and treatment planning, however, and so a purely descriptive manual cannot help but appear removed from reality in clinical settings.

Beyond its clinical utility, the DSM has also been developed to facilitate research and communication among professionals regarding the nature of mental illness. Prior to the development of the DSM, clinicians developed colloquial classification schemes that did not generalize far beyond their immediate setting. Although many professionals of the time considered such an approach to be unavoidable, they also recognized the difficulties this posed for efforts to increase or disseminate their base of knowledge. The DSM has certainly increased systematic research into mental illness and placed that research in a framework that is accessible to a broader scientific community. A prominent example is the dramatic increase of research in personality disorders that has occurred because these disorders were given special emphasis in the DSM-III (Widiger and Shea 1991).

The question remains, however, whether this proliferation in research has resulted in any real increases in scientific knowledge concerning mental illness. For instance, critics have noted that as the DSM classifications have become more widely adopted, they have begun to take on the nature of assumptions rather than scientific problems to be investigated. Thus, researchers may rely on DSM criteria instead of independent, theoretically driven criteria in selecting research participants. In this way, the DSM has become a somewhat self-perpetuating framework.

In addition, it is important to keep in mind that the ultimate decisions about making changes to the manual are not purely empirical exercises. Such decisions must appeal to fundamental assumptions about principles concerning the nature of mental illness and the goals of the system itself. Along these lines, Arthur C. Houts (2002) has argued that it is unlikely that the continual expansion of the DSM from 106 disorders in 1952 to 365 disorders in 1994 represents real scientific advance in the ability to detect and diagnose mental illness. In particular, this expansion of labels has not occurred alongside the necessary solidification of a limited number of "covering" or "synthesizing" laws that would explain how all these new disorders relate to one another. A more specific and highly publicized example of this problem concerns the removal of homosexuality as a mental disorder in the third edition of the DSM. Regardless of whether or not homosexuality should be included in the DSM as a mental disorder, even the leadership of the revision process has admitted that the decision was ultimately based more on social pressures than on the weight of scientific evidence (Spitzer, Williams, and Skodol 1980).

A third central purpose for the development of the DSM concerns the justification of professional services and judgments. Particularly in the arenas of insurance reimbursement and legal proceedings, mental health professionals are expected to demonstrate that their evaluations and treatment plans meet some standard of common practice in the profession. With respect to insurance, however, it continues to be difficult to justify treatment decisions based on a particular diagnostic picture. Because of the heterogeneity of patients who can share a given diagnosis and because the DSM continues to explicitly require clinical judgment in assigning a diagnosis and planning treatment, the assignment of a particular diagnosis to a patient can have very little impact on the clinical services provided to that patient. Furthermore, clinicians often use DSM diagnoses for purely instrumental reasons (e.g., to promote or protect the relationship with the patient, to obtain services from a resistant insurance provider). In a common example, clinicians, in order to avoid stigmatizing or scandalizing a patient, will often diagnose the person with adjustment disorder (which connotes a more transient and normative reaction to stress) instead of a more serious disorder even though the patient meets the criteria for the latter. With regard to the courts, mental health professionals cannot assume that a particular DSM diagnosis of mental illness bears any correspondence to the legal definition of "mental disease" or "mental defect." Thus, questions of diagnosis are often abandoned altogether in the courtroom in favor of more straightforward comparisons of symptoms and states of mind with legal definitions of sanity.

Future Directions for the DSM

Shortly after publication of the DSM-IV, clinicians began expressing hopes that future editions would address several fundamental flaws in the current classification scheme, in addition to those mentioned above. Perhaps the most common desire is to move away from categorical (i.e., yes or no) diagnosis of mental disorders and toward a system of rating patients on a small number of basic, personological dimensions (e.g., personality traits). Proponents argue that such a system would have greater value in guiding differential diagnosis, would help consolidate the growing number of disorders, and would more validly reflect the dynamic nature of the individual. A less radical revision that, presumably, would also reduce the degree of disparate diagnoses is John F. Kihlstrom's (2002) proposal that the current phenomenological groupings of symptoms be replaced with diagnoses based on laboratory findings such as characteristic cognitive or affective deficits. Finally, Thomas A. Widiger and Lee Anna Clark (2000) recommend that greater attention be paid to the most basic element of the diagnostic system: the establishment of meaningful boundaries between normal and abnormal psychological functioning. Common to all these proposals is a need for the DSM to develop a more unified and coherent framework of mental illness that is more validly rooted in the fundamental nature of the human person.

Central to the ongoing debates surrounding the DSM, then, is the role of values and metaphysical assumptions in defining psychological normality and, thus, providing a foundation for the identification and treatment of abnormality. Whereas empirical science may be invaluable in describing the mental, emotional and physical processes underlying psychological disorders, interpretation of these descriptions inevitably proceeds from a framework containing statements about the nature of human abilities, the kind of life worth living, and the ideal form of relationships among persons or between persons and their environment. As Daniel Robinson (1997) has argued, any theory of psychological disorder and therapy that is divorced from these questions fails to answer the question, "therapy for what?" because it will fail to account for the kind of healing or remediation that is necessary. These kinds of metaphysical issues, which are also assuming an increasingly central role in the ethics of the biological and genetic sciences, bring into clearer relief the nature and limits of a scientific attempt to identify problems or deficiencies in the psychological life of persons.

CARLETON A. PALMER

SEE ALSO *Homosexuality Debate; Psychology.*

BIBLIOGRAPHY

American Psychiatric Association (APA). (2000). *Diagnostic and Statistical Manual of Mental Disorders: DSM-IV-TR,* 4th edition, text revision. Washington, DC: Author. This most recent revision updates the text of the DSM-IV to include the results of research conducted after 1992. The revision is intended to maintain the usefulness of the DSM as an educational resource between major editions.

Clark, Lee Anna, David Watson, and Sarah Reynolds. (1995). "Diagnosis and Classification of Psychopathology: Challenges to the Current System and Future Directions." *Annual Review of Psychology* 46: 121–153. The authors review the purposes of a diagnostic taxonomy and consider alternatives to the current, descriptive approach. Research failing to support categorical diagnosis of psychopathology is highlighted.

Grob, Gerald N. (1991). "Origins of DSM-I: A Study in Appearance and Reality." *American Journal of Psychiatry* 148(4): 421–431. Examines the social and political context in which the DSM-I was developed.

Houts, Arthur C. (2002). "Discovery, Invention, and the Expansion of the Modern Diagnostic and Statistical Manuals of Mental Disorders." In *Rethinking the DSM: A Psychological Perspective,* ed. Larry E. Beutler and Mary L. Malik. Washington, DC: American Psychological Association. Analyzes the assumption that the proliferation of DSM diagnostic labels across editions represents actual scientific progress in the assessment and differentiation of psychological disorders.

Kihlstrom, John F. (2002). "To Honor Kraepelin . . . : From Symptoms to Pathology in the Diagnosis of Mental Illness." In *Rethinking the DSM: A Psychological Perspective,* ed. Larry E. Beutler and Mary L. Malik. Washington, DC: American Psychological Association. Argues that a taxonomy based on laboratory observations would advance the science of psychopathology and return the practice of psychological diagnosis to its historical roots.

Robinson, Daniel N. (1997). "Therapy as Theory and as Civics." *Theory and Psychology* 7(5): 675–681. The author suggests that fitness for the moral and civic aspects of human life provides the grounding for any theories of mental disorder and any attempts at psychotherapy.

Spitzer, Robert L., Janet B. W. Williams, and Andrew E. Skodol. (1980). "DSM-III: The Major Achievements and an Overview." *American Journal of Psychiatry* 137(2): 151–164. Leaders from the task force on DSM-III describe the origins of its development and the reasons for the major transition toward an atheoretical approach to defining and classifying mental disorders.

Widiger, Thomas A., and Lee Anna Clark. (2000). "Toward DSM-V and the Classification of Psychopathology." *Psychological Bulletin* 126(6): 946–963. Discusses the more significant issues of disagreement and debate surrounding the DSM-IV and recommends continued exploration of alternatives to the current perspective.

Widiger, Thomas A., and Tracie Shea. (1991). "Differentiation off Axis I and Axis II Disorders. *Journal of Abnormal Psychology* 100(3): 399–406. Suggests that the distinction between personality and symptomatic disorders first introduced in DSM-III ignores important relationships between them and instances of significant overlap in symptomatology.

DIGITAL DIVIDE

The *digital divide* refers to the gap between those who can effectively benefit from information and computing technologies (ICTs) and those who cannot. The term is a social construction that emerged in the latter half of the 1990s, after the Internet came into the public domain and the World Wide Web (Web) exploded into the largest repository of human knowledge that has ever existed. For those who can both contribute and retrieve information from the Web, ICTs hold the promise of broad collaborations in science and technology, transparency in government, rationality of markets, and shared understandings between peoples. Sadly this utopian promise applies only to an elite few. As of 2003, less than ten percent of the world's 6.4 billion people have had access to the Web (NielsenNetRatings, February 2003). While information poverty is rarely blamed as a direct cause of human suffering, the digital divide raises ethical questions of universal access. Like access to food or clean water, access to essential information has moral and ethical implications that merit consideration in the formation of public policy.

Differing Divides

The digital divide is a problem of multiple dimensions. In 1999 Rob Kling summarized the problem from (a) a technical aspect referring to availability of the infrastructure, the hardware, and the software of ICTs, and (b) a social aspect referring to the skills required to manipulate technical resources. Pippa Norris (2001) described (a) a global divide revealing different capabilities between the industrialized and developing nations; (b) a social divide referring to inequalities within a given population; and (c) a democratic divide allowing for different levels of civic participation by means of ITCs. And Kenneth Keniston (2004) distinguished four social divisions:

1. those who are rich and powerful and those who are not;
2. those who speak English and those who do not;
3. those who live in technically well-established regions and those who do not;
4. those who are technically savvy and those who are not.

From a global perspective, a high concentration of access to ICTs is observed in North America, Europe and the Northern Asia Pacific while access is noticeably sparse in the southern regions of the globe, particularly in Africa, rural India, and the southern regions of Asia. The poorer nations, plagued by multiple burdens of debt, disease, and ignorance are those least likely to benefit from Internet access.

The entry costs to secure equipment and to set up services are far beyond the means of most poor communities. Startup costs and expenses of technical maintenance compete with resources needed for essential human survival. Policy makers are challenged to find justification for investment in ICTs when local and national resources are limited and where the urgent needs of people for basic nutrition, health care, and education remain unsatisfied. If ICT development is justified in these countries, it is on the belief that ICTs are instruments to be wielded in order to meet essential human needs.

Overcoming Divides

One formidable obstacle to ICT diffusion is language. There is a self-perpetuating cultural hegemony associated with ICTs (Keniston 2004). By the year 2000, only 20 percent of all Web sites in the world were in languages other than English, and most of these were in Japanese, German, French, Spanish, Portuguese, and Chinese. But in the larger regions of Africa, India, and south Asia, less than 10 percent of people are English-literate while the rest, more than 2 billion, speak languages that are sparsely represented on the Web. Because of the language barrier the majority of people in these regions have little use for computers. Those who do not use computers have little means to drive market demands for computer applications in their language. Left simply to the market, this Anglo-Saxon hegemonic cycle will continue unhindered.

If the digital divide is viewed purely as a technical problem, the solution is within reach. European and North American capitalism has the means to intervene where market forces lack the power to bridge the divide. It is not an unrealistic task to tie every nation, every tribe, and every community, no matter how isolated, into a common interconnected information infrastructure. It is within technical means to manufacture low-cost, durable computers for wide distribution. It is within fiscal means to distribute these devices to places where computers are most lacking. Gifted programmers and translators can be recruited to convert existing online resources into many different languages.

Beyond Technical Issues

While such technical solutions can be conceived, the problem of the digital divide is not primarily a technical problem. Expenditure of monies for ICTs comes with no guarantee that problems that plague the poor of the world will be addressed. Policy makers cannot simply thrust technology into people's hands with any expectation that it will be used. Experimentation has shown that new initiatives tend to fail unless they are built from existing social and economic structures (Warshauer 2003). ICT projects must be conceived from an assessment of actual needs defined locally by target populations. Planners must pay attention to existing human networks and social systems, taking into account local language and cultural factors, literacy and educational levels of users, and institutional and social structures of the community.

M. S. Swaminathan, one of India's best-known scientists, suggests that if technological and information empowerment is to reach the unreached, then policy makers must focus their "attention to the poorest person" (Swaminathan 2001, p. 1). This concept, coined by Gandhi as *antyodaya*, provides a model for technical development using a bottom-up approach. Digital initiatives of the Swaminathan Research Foundation have demonstrated how ICTs can change the lives of the poor in remote villages by strategies that enlist local involvement from their inception. Projects begin from assessments of specific local needs and by instituting practices that rely entirely on local villagers rather than distant agencies and technical experts. Including the excluded in the empowerment brought by knowledge and skills is the most effective approach to harnessing technologies in the interests of the poor. The divide may never be fully closed, but where a bridge is to be spanned, it will be constructed by active participants from both sides.

MARTIN RYDER

SEE ALSO *Information Society; Internet; Networks; Poverty.*

BIBLIOGRAPHY

Keniston, Kenneth (2004). "Introduction: The Four Digital Divides." In *IT Experience in India: Bridging the Digital Divide*, ed. Kenneth Keniston and Deepak Kumar. Delhi: SagePublishers, pp. 11–36. This book examines the history of the "digital divide" as seen from observers on both sides of the abyss. A collection of essays from social scientists, policy analysts, and technologists, the book lends special focus to the social and technical problems that emerge with introduction of new technologies in remote and impoverished regions. It reviews the fundamental issues facing policy makers whose decisions impact the balance between expert direction and local control, between modern goals and traditional values, and between future hopes and immediate needs.

Kling, Rob. (1999). "Can the 'Next Generation Internet' Effectively Support 'Ordinary Citizens'?" *The Information Society* 15: 57–63. Rob Kling (1944–2003) was professor of information systems at the School of Library and Information Science at Indiana University. This article was originally delivered as a white paper in 1988 to the Clinton Presidential Advisory Committee on High Performance Computing and Communications, Information Technology, and the Next Generation Internet (NGI). Kling advocated a focus on social value in planning and resource allocation for the NGI. Policies should privilege methods of Internet access for ordinary people over exotic media advances that benefit only technological elites. NGI initiatives should seek to reduce cost and improve value for ordinary citizens and strengthen IT infrastructures for the public commons.

Norris, Pippa. (2001). *Digital Divide: Civic Engagement, Information Poverty, and the Internet Worldwide*. New York: Cambridge University Press. Pippa Norris is Associate Director of Research at the Shorenstein Center on the Press, Politics and Public Policy at Harvard University. This book examines the digital divide from case studies involving Internet access of users from 179 countries. Norris describes the ways in which people in different cultures make use of the Internet for information and civic engagement and she attempts to provide a descriptive model to explain patterns of participation on the Internet. Norris reviews the manner that institutional entities have created or enabled opportunities for public engagement and she analyzes how the various publics have responded to these opportunities.

Warschauer, Mark. (2003). "Demystifying The Digital Divide." *Scientific American* 289(2): 42–48. Mark Warschauer teaches Informatics in the Department of Education at the University of California at Irvine. He has

conducted qualitative research on technology adoption in Egypt, China, India, Brazil, Singapore. In a three-year longitudinal case study in Egypt, Warschauer examined the steps that governmental agencies took to introduce ICTs in the schools and he observed the various impacts that were manifested from those initiatives. From his observations, Warschauer concluded that policies which promote the mere presence of new technologies in schools without a corresponding emphasis on social mobilization and transformation can squander limited resources while leaving problems of sociotechnical inequities in tact.

INTERNET RESOURCES

NielsenNetRatings. (2003). "Global Internet Population Grows an Average of Four Percent Year-Over-Year"" Available from http://www.nielsen-netratings.com/pr/pr_030220.pdf. Nielsen NetRatings provide ongoing measurement of Internet usage. Detailed information collected by Nielsen is intended primarily for commercial use, however summaries are published monthly and may be accessed at http://www.nielsen-netratings.com/news.jsp?section=dat_gi.

Swaminathan, Monkombu Sambasivan. (2001). "Antyodaya Pathway of Bridging the Digital Divide." Available from http://www.worldbank.org/wbi/B-SPAN/docs/antyoday.pdf. (Lecture delivered before the Tilak Smarak Trust, Pune, India, August 1, 2001.) Through his involvement in hybrid grain research in the 1960s, geneticist Monkombu Sambasivan Swaminathan played a principle role in the introduction of high-yielding wheat varieties that significantly contributed to India's "Green Revolution" (1967–1978). In 1987 the celebrated scientist created the Swaminathan Foundation, with the aim of supporting fledgling technological development projects that directly address hunger, poverty and environmental concerns. The foundation is known for its emphasis on bottom-up participatory approaches to economic development where local control is the key element to the introduction of new technologies.

DIGITAL LIBRARIES

Digital libraries are organized collections of information resources and associated tools for creating, archiving, sharing, searching, and using information that can be accessed electronically. Digital libraries differ from traditional libraries in that they exist in the "cyber world" of computers and the Internet rather than in the "brick and mortar world" of physical buildings. Digital libraries can store any type of information resource (often referred to as documents or objects) as long as the resource can be represented electronically. Examples include hypertexts, archival images, computer simulations, digital video, and, most uniquely, real-time scientific data such as temperature readings from remote meteorological instruments connected to the Internet.

The digitization of resources enables easy and rapid access to, as well as manipulation of, digital library content. The content of a digital library object (such as a hypertext of George Orwell's novel, *1984*) includes both the data inherent in the nature of the object (for example, the text of *1984*) and metadata that describe various aspects of the data (such as creator, owner, reproduction rights, and version). Both data and metadata may also include links or relationships to other data or metadata that may be internal or external to any specific digital library (for instance, the text of *1984* might include links to comments by readers derived from a literary listserv or study notes provided by teachers using the novel in their classes).

The concepts of organization and selection separate digital libraries from the Internet as a whole. Whereas information on the Internet is chaotic and expanding faster than either humans or existing technologies can trace accurately, the information in a digital library has been organized in some manner to provide the resource collection, cataloging, and service functions of a traditional library. In addition, the resources in digital libraries have gone through some sort of formal selection process based on clear criteria, such as including only resources that come from original materials or authoritative sources. Digital libraries are thus an effort to address the problem of information overload often associated with the Internet.

Origins

Although the concept of digital libraries has been traced back to nineteenth-century scientific fiction writers such as H. G. Wells, most library historians credit Vannevar Bush's description of the memex in the July 1945 edition of *Atlantic Monthly* as the original source. Despite being limited to analog technologies such as microfilm that seem crude in the early twenty-first century, Bush anticipated several key features of digital libraries, including rapid and accurate access to scientific and cultural information.

Contemporary conceptions of digital libraries developed in tandem with the rapid growth of the Internet and especially the widespread, flexible access to digital information afforded by the development of World Wide Web browsers in the early 1990s. For example, in the United States, Phase One of the Digital Libraries Initiative was launched in 1993 when the National Science Foundation (NSF), the Defense Advanced Research Projects Agency (DARPA), and the National Aeronautics and Space Administration (NASA) provided six universities with nearly $25 million to develop digital library test-beds. Another pioneer digital library effort was the U.S. Library of Congress's American Memory project. This groundbreaking digital collection of historical artifacts was first made available on interactive videodiscs, later on CD-ROMs, and most recently via the Internet. Related digital library projects have been underway in Europe, Canada, and elsewhere since the mid-1990s.

In 1998 Phase Two of the Digital Libraries Initiative (DLI2) was launched with funding from NSF, DARPA, NASA, the Library of Congress, the National Library of Medicine, the National Endowment for the Humanities (NEH), and the Federal Bureau of Investigation (FBI). The seemingly strange bedfellows supporting DLI2 suggests some of the ethical issues surrounding digital libraries. These include privacy (who can find out about the resources someone has accessed via digital libraries?), security (who decides what information should or should not be freely accessible?), intellectual property (who owns what information?), hegemony (who controls the access to information?), and globalization (who assures that cultural identity is not weakened or even destroyed by digital libraries?).

Challenges: Technical and Ethical

The technical challenges confronting librarians, computer scientists, cognitive psychologists, and others working on the frontiers of digital libraries are formidable. These include interoperability (what protocols and standards are needed to ensure that distributed digital libraries will provide widespread interconnected access?), access (what types of user interfaces are most effective in providing easy access to diverse communities of users seeking information for different reasons?), preservation (what technologies are needed to assure the long-term survival of digital information resources?), and sustainability (what financial resources are needed to support the maintenance of digital libraries, and how can they be procured?).

In a manner similar to the science of genetics and the Human Genome Project, ethical debates about the ultimate status and value of information science and digital libraries may be even more complex than the technological challenges. It is inevitable that much information will be primarily available through digital technologies in the foreseeable future, a result that leads to complex social and ethical questions that must be addressed. How can traditional library values such as providing all people with free access to high-quality information be upheld when large corporations increasingly seek to profit by selling the information they control? Will the "digital divide" (that is, the unequal access to information technologies currently inherent in the growth of the Internet, which is largely controlled by Western powers such as the United States and the European Union) be decreased or increased by the development of digital libraries? How can the validity of information resources be established when increasingly sophisticated technologies threaten fundamental concepts such as authorship and copyright? How can digital libraries be designed to improve education at all levels?

In his 2000 book *Digital Libraries*, William Y. Arms concludes that "a dream of future libraries combines everything that we most prize about traditional methods with the best that online information can offer. In some nightmares, the worst aspects of each are combined" (p. 272). Although the future of digital libraries is unclear, digital libraries will nevertheless influence the future.

THOMAS C. REEVES

SEE ALSO *Education; Hypertext; Information.*

BIBLIOGRAPHY

Arms, William Y. (2000). *Digital Libraries*. Cambridge, MA: MIT Press. This volume remains the definitive description of digital library concepts and structures.

Bush, Vannevar. (1945). "As We May Think." *Atlantic Monthly* 176(1): 101–108. This article has influenced several generations of the designers of hypertext, hypermedia, and digital libraries.

INTERNET RESOURCES

Arms, William Y. *Digital Libraries*. Available from http://www.cs.cornell.edu/wya/.

Bush, Vannevar. (1945). "As We May Think." *Atlantic Monthly* 176(1): 101–108. Available from http://www.theatlantic.com/unbound/flashbks/computer/bushf.htm.

"Digital Libraries Initiative Phase Two." National Science Foundation. Available from http://www.dli2.nsf.gov/.

U.S. Library of Congress. "American Memory: Historical Collections for the National Digital Library." Available from http://memory.loc.gov/.

DIGNITY

Dignity in modern Europe and North America is that quality of an individual human person that warrants treating him or her as an end, never merely as a means to some further end. Many things have a price; they are exchangeable for something of equal or greater value.

A human person has no price and is not exchangeable; nothing has more value. Philosopher Immanuel Kant (1724–1804) gave voice to the Enlightenment view by saying that dignity is "an intrinsic, unconditioned, incomparable worth or worthiness" (Kant, p. 36). In a context of expanding technological ability to treat many topics, including persons, as means, the concept of dignity has been associated with the setting of boundaries on such treatments.

In common parlance society distinguishes between expressing dignity and having dignity. To *express dignity* is to behave in a dignified manner, to retain composure and a sense of self-worth in a difficult situation. To *have dignity* is a status independent of any behavior. It is to be treated by others as a person of worth or with respect. It is the second of these, having dignity, that carries moral weight. Every person has dignity regardless of his or her wealth, class, education, age, gender, or demonstrated abilities. Dignity is said to be inherent, inborn.

What is the warrant for the assumption that each person has dignity? The capacity to reason or to make moral judgments are Enlightenment criteria by which human beings are distinguished from other sentient creatures. The theological tradition shared by Jews and Christians locates the ground of dignity in the *imago dei*, the image of God within the human race; and Christians add the incarnation, according to which God enters into the humiliation of becoming human in order to exalt the human race. These provide justification for belief in dignity plus modern commitments to human rights and social equality.

Metaphysically dignity is innate or inborn—that is, dignity applies universally to all human beings regardless of distinctive personal characteristics. Phenomenologically, however, dignity is relational—that is, dignity is first conferred and then claimed. When a family treats infants and young children as persons of worth, these children grow up to see themselves as worthy, as valuable in themselves. Then they are able to express dignity by claiming their rights in society. One way to view the ethical task of persons in free societies is to affirm our responsibility to confer dignity upon persons who are marginalized politically or economically or socially, so that they will be able to rise up and claim equal rights. To be treated by others as having dignity enables one to rise up and express that dignity.

Societal Threats to Dignity

Human dignity today faces four threats. First, quite obviously, totalitarian governments and repressive religious regimes deny a sense of final value to their citizens. Problems of how to deal with such governments or religious traditions, especially in a world increasingly linked by technological means of communication and scientific research, remains a serious political issue.

Second, animal rights groups accuse European and North American society of *speciesism* and seek to confer dignity on nonhuman creatures and, in some cases, on the environment. The extent to which dignity applies to animals, plants, or even certain artifacts such as works of art, remains a debated issue.

Third, modern industrial economics appears to treat individuals impersonally, as part of a mass. Karl Marx (1818–1883) reflected this threat when describing factory workers as flesh and blood appendages to machines of steel. Science and technology also are frequently seen as the instruments whereby bureaucratized industry is given the power to destroy traditional family values and undermine the personal relationships necessary for dignity to enjoy a conferring context.

In recent years the Roman Catholic Church has become one of the world's champions of human dignity against this third threat. Social forces enhanced by biomedical technologies appear to compromise social commitments to protect human life at all costs. Abortion—both therapeutic and elective—seems to threaten life at the beginning; and certain forms of euthanasia seem to threaten life at the end. Ethical debates over pregnancy termination and end-of-life medical practices appear to Vatican eyes as a hardening of hearts against those who cannot protect themselves from the economics of an increasingly technology-dependent civilization. Pope John Paul II referred to this as the *culture of death*. The Pope believes that at conception God places a newly created immortal soul in the conceptus; and the presence of this soul establishes morally protectable dignity. This translates into an ethics that will not allow society to put to death a person with a soul, whether prior to birth or when suffering from a terminal illness. In our culture of death "the criterion of personal dignity—which demands respect, generosity and service—is replaced by the criterion of efficiency, functionality and usefulness: others are considered not for what they are, but for what they have, do and produce. This is the supremacy of the strong over the weak" (Pope John Paul II, p. 42).

The fourth threat, at least in the eyes of the public, comes from genetic research and biotechnology. This is because DNA has become associated with the essence of a human person. DNA is said to be the so-called *blueprint*. Manipulation of one's genes, then, appears to subordinate one's essence to some further end. Proposals for *designer children* or *perfect children* through genetic selection and genetic engineering appear to subordinate the welfare of the children to the images and ends of the parents. Proposals for human reproductive cloning, resulting in two persons with identical genomes, appear to violate the individuality of both for purposes exacted by those making the cloning decision. Such proposals elicit public anxiety over the possible loss of dignity.

This fourth threat to human dignity is more apparent than real. It is a mistake to identify DNA with human essence. No matter how significant one's genome may be, genes alone do not constitute a person. Even identical twins, who share the same genome, develop their own private self-awareness and express their own individual claims to worth. Dignity is not lodged in DNA. Any person coming into the world having been influenced by genetic technologies will enter into the same sets of relationships that confer or deny dignity. Metaphysically no amount of genetic manipulation will reduce a person's dignity

As a belief held by a culture, dignity is a conviction that must be rearticulated in the face of threats. Even though built into this conviction is the idea that human worth is innate or inborn, social ethics requires that it be conferred, cultivated, enhanced, and fought for. The doctrine that each person already has dignity is actually a hope that some day all people will realize—and express—dignity.

TED PETERS

SEE ALSO *Abortion; Embryonic Stem Cells; Euthanasia; Freedom; Genetic Research and Technology; Holocaust; Human Cloning; Humanization and Dehumanization; Human Nature; Human Rights; Posthumanism.*

BIBLIOGRAPHY

Kant, Immanuel. (1953). *Groundwork of the Metaphysic of Morals*, trans. H. J. Paton. New York: Harper.

Peters, Ted. (1996). *For the Love of Children: Genetic Technology and the Future of the Family.* Louisville, KY: Westminster/John Knox Press.

Pope John Paul II. (1995). Encyclical letter *Evangelium Vitae* (March 25, 1995). Vatican City: Vatican.

DIRECT DEMOCRACY

The modern, mainstream democratic ideal has been republican or representative democracy, but the original Greek ideal was direct democratic participation in all major decisions by all citizens. To some extent even administrative actions were directly democratic, insofar as various executive and judicial functions were determined by lot. Along with direct democracy, two general terms around which efforts to theoretically and practically promote such broad contemporary involvement of citizens in their own governance are those of participatory and anticipatory democracy. In as much as both are argued to be especially facilitated by advanced telecommunications technologies such as television and the Internet, terms of choice range from digital and e-democracy to teledemocracy.

Background

The modern roots of contemporary direct democracy ideals are nineteenth-century anarchist experiments in Europe and populous and progressive movements in the United States. Populism, which reflected agrarian interests, and progressivism, more urban based, sought to institutionalize the citizen legislative initiative, the referendum, and the recall. The participatory democracy movement itself has been closely associated with theories of strong, radical, grass roots, deliberative, and consensus democracy. Anticipatory democracy gives direct democracy a futurist spin. Bioregional democracy is a related notion stressing environmental or ecological issues. Cyberdemocracy stresses virtual reality both as means and as end.

The unifying thread in such diverse direct democracy movements is that all citizens, not just their periodically elected representatives, have rights and responsibilities to contribute to collective decision making. Independent of arguments for such rights and responsibilities, and analyses of the strengths and weaknesses of participatory democracy, one of the most well-developed efforts to promote citizen participation through advanced telecommunications is the Direct Democracy Campaign (DDC) in Great Britain. Using the motto *Let the people decide*, the DDC has advanced a number of specific proposals. The popular initiative would require the government to hold a binding referendum on an issue if 2 percent of the electorate submitted a petition to this effect. The popular veto would allow 1 percent of the electorate to challenge any existing legislation and call for a binding referendum. Moreover according to the DDC web site, "the era of pencil crosses on paper must give way to an age of secure electronic communication."

In the United States, although the theory of participatory democracy emerged in left-wing political circles during the 1960s, proposals for the utilization of advanced telecommunications technologies were promoted more in right-wing political circles during the 1970s. Post 1960s left-wing work moved in the direction of trying to get citizens directly involved in processes of scientific and engineering design decision making, using such means as consensus conferences and by often questioning the adequacy of electronic or virtual participation (Sclove 1995).

Liberal theorists have on occasion utilized measurement theory, especially as applied in psychology by S. S. Stevens (1946), to make some critical assessment of representative democracy and propose reforms that might serve to attract more citizen involvement or enhance the justice of decision making. Among various mathematical or scientific models for enhancing the influence of minority viewpoints or interests are, for example, possibilities for proportional representation, which again might be facilitated by technological means.

Right-wing work, by contrast, has been more populist and positive about electronic democracy. Indeed conservative futurist Alvin Toffler has argued that technological change at once demands intensified, anticipatory democracy as a "continuing plebiscite on the future" (Toffler 1970, p. 422) and provides the "imaginative new technologies" (Toffler 1970, p. 424) to make this possible. Clem Bezold (1978) further advanced the idea of anticipatory democracy. Brian Martin (demarchy) and Robin Hanson (futarchy) have proposed other related ideas appealing to or utilizing market theory.

Outside Great Britain and the United States, efforts to promote and practice participatory democracy utilizing advanced telecommunications technologies exist in, among other countries, Switzerland, Canada, Australia, and New Zealand. Often these efforts exist most vigorously at the local or regional levels. As expected, they have also sponsored numerous web sites.

Questions

Historically there have been three main objections to direct democracy. One is that it provides for no check on emotional responses to complex situations. Another is that most people do not have time or interest enough to become sufficiently educated in the issues to participate intelligently. A third is that there is simply no technical means by which it could work in a modern, large-scale nation-state.

According to Toffler (1980) all three objections can be met. There could be structural or constitutional requirements for a cooling-off period or a second vote on certain issues. Increased affluence and leisure give people more time for politics, and in fact when offered the chance many citizens take advantage of opportunities to become informed about an issue. Social learning generally takes place through trial and error. Finally contemporary communications technologies, especially the Internet, make direct electronic democracy realistically feasible.

More specific questions about the utilization of advanced technological means of communication have also been raised. Has C-SPAN improved democratic intelligence? To what extent can the Internet promote critical reflection and engagement with the nonvirtual world in which political action ultimately takes place?

CARL MITCHAM

SEE ALSO *Democracy; Participation.*

BIBLIOGRAPHY

Bezold, Clem, ed. (1978). *Anticipatory Democracy*. New York: Random House.

Sclove, Richard E. (1995). *Democracy and Technology*. New York: Guilford Press. Widely influential work in liberal circles.

Stevens, S. S. [Stanley Smith]. (1946). "On the Theory of Scales of Measurement." *Science* 103: 677–680.

Toffler, Alvin. (1970). *Future Shock*. New York: Random House.

Toffler, Alvin. (1980). *The Third Wave*. New York: William Morrow. Influential in conservative political circles.

DISABILITY

Science and technology are pursued for human benefit. But the particular benefits of scientific research and technological development are the result of human activities embodying various cultural, economic, and ethical frameworks as well as the perspectives, purposes, and prejudices of any given society and of powerful groups within it. One group that should benefit includes disabled people. But such benefit will in large measure depend on the governance of science and technology, the involvement of disabled people themselves in their governance, and on the very concept of disability, an issue that is more contentious than commonly recognized. With regard to science, technology, and disability, there are at least two ethical issues that deserve more consideration than they are usually given: What perception of disabled people guides scientific research and technological development? What role do disabled people play in this process?

Solutions Follow Perceptions

Science and technology for disabled people depend on how so-called *disabilities* and disabled people are perceived. Definitions of disability range from the biomedical and economic to the liberal, social-political, minority rights, and universalist models (Penney 2002). These may nevertheless be reduced to three main perspectives:

The *medical individualistic perspective* (MP) sees disabled people as patients in need of being treated so that their level of functioning and appearance approaches that of the so-called non-disabled people (the norm). It assumes that disabled people perceive themselves as patients, and their own biological reality as defective or subnormal. It promotes the use of science and technology for the development of normative therapies for disabled people.

The *transhumanist perspective* (TP) is similar to the medical perspective with the modification that it sees both disabled and non-disabled people as patients. The human body in general is judged to be defective and in need of indefinite enhancement. Even normally existing abilities are subject to being raised above the norm or complemented with new abilities. The transhumanist (or *posthumanist*) perspective does not accept a given norm, and thus does not accept the subnormal/normal distinction between the disabled and non-disabled. The human body in general is seen as subnormal and in need of scientific-technological enforcement. It is no accident that Ray Kurzweil, inventor of the computer voice synthesizer the Kurzweil Reader for the blind, is also a strong proponent of transhumanist technological transformations for everyone.

The *social justice perspective* (SP) does not see disabled people as patients in need of treatment or enhancement so much as society in need of transformation. It assumes that most problems faced by disabled people are not generated by their non-normative bodies or capabilities but by the inability of society to fully integrate, support, and accept individuals with different biological realities and abilities. The social justice perspective encourages the use of science and technology to alter the physical environment so that disabled people may more easily interact with non-disabled people. The focus is on social, not medical, cures.

The social perspective also allows *able-ism* to be seen as analogous to racism or sexism, with able-ism constituting a network of beliefs and practices that yield a particular kind of self and body (the corporeal standard) that is then projected as the perfect, species-typical, and therefore essential and fully human. From the viewpoint of able-ism, disability becomes a diminished state of being human.

The social perspective on disability does not deny that disabled people possess certain biological realities (such as having no legs), which make them different in their abilities and cause them to deviate from a norm. However, it views the "need to fit a norm" as the main problem, and questions whether all deviations from the norm require a medical solution (adherence to the norm). Maybe in some cases a social solution (change or elimination of norm) would be just as appropriate. Neither does the social perspective deny the existence of symptomatic acute medical problems that should be treated. It simply questions the increasing medicalization of non-normative characteristics and sees many so-called diseases, defects and impairments not as acute medical problems but as societal constructions (Wolbring 2003b). It questions whether medical solutions are always the best response.

Scientific research and technological development may emphasize fixing the disabled (on an MP basis); science and technology may also seek to enhance the disabled (on a TP basis). Or technology especially can be used to reconstruct the world in ways that allow the disabled to interact freely with others without altering their biological identity/reality (on an SP basis). "Barrier-free access" is, for example, an SP program.

Society has a long history of adopting the MP approach to seeing disabilities. Many legal instruments describe a disabled person as someone with subnormal or diminished functioning in need of *special* care. They do not see disabled people as having a biological reality leading to *different* sets of abilities, *different* ways of functioning and *different* needs. The medical understanding of disabilities is essential for the acceptance and marketability of many scientific and technological applications such as genetic and non-genetic prebirth testing and genetic and non-genetic therapies and enhancements.

However, this traditional focus is being replaced by a transhumanist focus on science and technology as a means to not just meet norms but to enhance existing abilities and add new ones. It is becoming increasingly difficult to draw a line between therapy and enhancement. If one believes someone is defective without legs, and finds it acceptable to develop artificial legs that function like normal biological legs restoring the normative characteristics of walking (medical cure), one has a hard time justifying the denial of artificial that improve on the natural capabilities of biological legs (running faster, jumping higher) and that might add capabilities beyond the scope of normal biological legs such as climbing walls (transhumanist enhancements).

Scientific and technological research with an SP justification to develop software and hardware that allows the usage by clients with the widest range of abilities is rare. This reflects the fact that most product development is geared toward the largest common denominator in the market so as to ensure the highest profit. Products are seldom developed for disabled people because their numbers are not big enough to make a profit. Without a change in social policies and dynamics, this will not change significantly. In the United States, the Americans with Disabilities Act (ADA), which resulted from the lobbying of the disabled as a public interest group, created a new market for barrier free access and other technological developments.

Roles For Disabled People

Can disabled people influence the indicated dynamics? Do they have to accept the medical or transhumanist perspectives on disabilities? Is it possible for them to promote the social justice perspective?

The disabilities rights movement and emergence of disability activism in the early 1980s provides one kind of answer to such questions (see Shapiro 1994). Disabled persons, no matter how they are defined, worked together in ways that led, in the United States for instance, to passage of the Americans with Disabilities Act (ADA) of 1990, the focus of which was on changing the environmental parameters of the lives of disabled people. However the ADA has been siege ever since its passing, and although it was somewhat successful with access issues, the ADA does not sufficiently cover emerging technologies; nor has it decreased the development of technologies that focus on the medical perception of disability. An increase of the presence of disabled persons among the ranks of scientists, engineers, and ethicists would be another means of more specifically influencing scientific and technology policy.

Certainly some negative consequences of science and technology can be avoided by integrating ethics into the governance of science and technology. But what kind of ethics? Ethical guidelines are not always free from biases that reflect the perspectives, purposes, and prejudices of the most powerful social groups. Much debate about science policy and the legal regulation of technology appears to accept the medical perspective of disability, with some qualified influence of the transhumanist perspective, but little appreciation of the social justice perspective (see, e.g., Harris 2000; Singer 2001; UNESCO 2003; and Wolbring 2003a and 2003c). One of the most effective ways for disabled persons who might object to this situation to counter it is to themselves become involved in policy national and international formation.

At the same time, disabled persons need not shy from inviting non-disabled people of power to ask themselves the following questions:

- Does scientific and technological decision making lead to further marginalization of disabled people?
- Does scientific and technological practice allow disabled people to freely choose their self-identity?
- Do science and technology by themselves have similar impacts on disabled and non-disabled people?
- Does the transhumanist perspective force non-disabled people to enhance their abilities and does it encourage society to make these new abilities eventually the new norm ("normative creep") that makes society less accepting of differences?
- What policy guidelines are needed to promote science and technology for the common good in an inclusive society?
- How the governance of science and technology be made more inclusive and diverse?

GREGOR WOLBRING

SEE ALSO *Bioethics; Informed Consent; Medical Ethics.*

BIBLIOGRAPHY

Albrecht, Gary L.; Katherine D. Seelman, and Michael Bury, eds. (2001). *Handbook of Disability Studies*. Thousand Oaks, CA: Sage. A collection of thirty-five articles on the shaping of disabilities studies, experiencing disability, and disability in context.

Barton, Len, ed. (2001). *Disability Politics and the Struggle for Change*. London: David Fulton. Twelve essays on disability, mostly in the British context.

Harris, John. (2000). "Is There A Coherent Social Conception of Disability?" *Journal of Medical Ethics* 26(2): 95–100. Harris denounces the social justice model of disability and the claim that disability is a medical issue.

Johnston, David. (2001). *An Introduction to Disability Studies*, 2nd edition. London: David Fulton. A synoptic overview of disability studies in both the United Kingdom and United States.

Shapiro, Joseph P. (1994). *No Pity: People with Disabilities Forging a New Civil Rights Movement*. New York: Three Rivers Press. A journalistic account of the disabilities civil rights movement in the United States that led to the passage of the Americans with Disabilities Act (1990).

Singer, Peter. (2001). "Response to Mark Kuczewski." *American Journal of Bioethics* 1(3): 55–57. Singer denounces the social jusice model of disability and a disability rights aproach to bioethics issues.

Wolbring, Gregor. (2003a). "Disability Rights Approach to Genetic Discrimination." In *Society and Genetic Information: Codes and Laws in the Genetic Era,* ed. Judit Sándor. Budapest: Central European University Press. Uses the three models (MP, SP, TP) together for the first time and shows that anti-genetic discrimination laws are discriminating against disabled people. Provides examples of disability discrimination within the usage of advances of human genetic interventions .

Wolbring, Gregor. (2003b). "The Social Construct of Health and Medicine." *Health Ethics Today* 13(1): 5–6. Looks at the social construction of health and medicine.

Wolbring, Gregor. (2003c). "Disability Rights Approach towards Bioethics." *Journal of Disability Policy Studies* 14(3): 154–180. Shows that the ethical divide that approves the prohibition of sex selection while allowing disability (MP) deselection is untenable. Questions the two-tiered ethical approach of medical versus social reasons

INTERNET RESOURCES

Harris, John. (2000). "Is There A Coherent Social Conception of Disability?" *Journal of Medical Ethics* 26(2): 95–100. Available from http://www.ncbi.nlm.nih.gov.

Penney, Jonathan. (2002). "A Constitution for the Disabled or a Disabled Constitution? Toward a New Approach to Disability for the Purposes of Section 15(1)." *Journal of Law and Equality* 1: 83–94. Available from http://www.jle.ca/files/v1n1/JLEv1n1art3.htm.

Penney, Jonathan. (2002). "A Constitution for the Disabled or a Disabled Constitution? Toward a New Approach to Disability for the Purposes of Section 15(1)." *Journal of Law and Equality* 1: 83–94. Describes different possible models and perception of disability and disabled people. Available from http://www.jle.ca/files/v1n1/JLEv1n1art3.htm

UNESCO. (2003). "Report of the IBC on Pre-implantation Genetic Diagnosis and Germ-line Intervention." *UNESCO Publication SHS-EST/02/CIB-9/2 (Rev. 3) Paris,* 24 April 2003. Available from http://portal.unesco.org./shs/en/file_download.php/1f3df0049c329b1f8f8e46b6f381cbd1ReportfinalPGD_en.pdf. This report sees disability totally within a medical framework. It advances the notion that preimplantation genetic diagnostic and germ-line interventions are ethically permissible if done for medical reasons. It denounces sex selection on the grounds that intervention is done for social reasons.

DISCOURSE ETHICS

Discourse ethics (DE) has two aims: to specify the ideal conditions for discourse, and to ground ethics in the agreements reached through the exercise of such discourse. DE thus instantiates the intuition that if people discuss issues in fair and open ways, the resulting conclusions will be morally binding for those appropriately involved in the conversation. Such a view of ethics has special relevance in a scientific and technological world characterized by expanding means of communication. DE may also arguably provide the best framework for understanding the ethics of scientists and engineers operating within their professional communities.

Theoretical Framework

Discourse ethics is primarily associated with the work of Karl-Otto Apel (1980) and Jürgen Habermas, who conjoins his own theory of communicative rationality and action (1981) with Apel's insights (Habermas 1983, 1989). Apel and Habermas root DE in Immanuel Kant's emphasis on the primacy of moral autonomy for both the individual and the moral community (Apel 2001) and in Aristotle's understanding of the importance of human community praxis as the crucible in which all theory must be tested. More broadly DE includes the work of John Rawls (1971), Stephen Toulmin (Jonsen and Toulmin 1990), and Richard Rorty (1989). As Robert Cavalier notes, each of these thinkers argues for "widening reflective equilibrium by embedding empathy and detailed reciprocity into moral reflection and by placing the deliberative process within the intelligent conduct of communal inquiry" (Cavalier Internet site). DE has deeply influenced not only philosophy and sociology—but also, in keeping with its praxis orientation, such applied fields as business ethics (Blickle et al. 1997) and nursing (Marck 2000).

Apel-Habermasian DE seeks to circumscribe—and justify—the *ideal speech situation* in which members of a *democratic* community, free of domination (*herrschafts-freie*), engage in a rational dialogue or debate in order to achieve consensus about the fundamental rules of the community. Drawing on the Kantian understanding that rules are morally legitimate only as free human beings consent to follow them, Habermas argues that such community rules may emerge from discourse that meets certain necessary (but not sufficient) conditions—the first of which is freedom and equality for participants. In his essay "Justice and Solidarity" (1989), Habermas summarizes the basic intuition of discourse ethics with the statement that "under the moral point of view, one must be able to test whether a norm or a mode of action could be generally accepted by those affected by it, such that their acceptance would be rationally motivated and hence uncoerced" (Habermas 1989, p. 6).

In "*Diskursethik: Notizen zu einem Begründungsprogram*" [Discourse Ethics: Notes on Philosophical Justification] (1983), Habermas further emphasizes the importance of *perspective-taking* on the part of all discourse participants: Possible norms for a community can be legitimate only if they emerge from a discourse setting that "constrains all affected to adopt the perspectives of all others in the balancing of interests" (Habermas 1990, p. 65). These conditions of free but rational debate, shaped by such perspective-taking, issue in legitimate *universal norms*—meaning that (a) all who are affected by a proposed norm are willing to accept the consequences and side effects likely to follow from observing that norm, and (b) these consequences are preferred over those of other possible norms under consideration.

Seyla Benhabib notes that such norms are better characterized as *quasi*-universal. They are morally legitimate for the specific discourse community whose debate and dialogue generates them. But diverse communities, shaped by different histories, traditions, and contexts, may come to agree upon a range of possible norms rather than a single monolithic set (Benhabib 1986). In this way, consistent with its Aristotelian and Kantian roots, DE establishes an *ethical pluralism*—in contrast with both monolithic ethical *dogmatism* (asserting that only a single set of norms can be right) and *relativism* (asserting that any set of values and norms is as acceptable as any other).

To circumscribe such discourse more carefully, Habermas refines a set of rules first proposed by Robert Alexy (1978). According to Habermas (1990, p. 86), these are:

1. Every subject with the competence to speak and act is allowed to take part in a discourse.

2a. Everyone is allowed to question any assertion whatever.

2b. Everyone is allowed to introduce any assertion whatever into the discourse.

2c. Everyone is allowed to express his (or her) attitudes, desires, and needs.

3. No speaker may be prevented, by internal or external coercion, from exercising his (or her) rights as laid down in (1) and (2).

Finally, partly in response to feminist and postmodernist critiques that his discourse ethics exhibits a masculine form of rationalism, especially because of the exclusion of emotion, Habermas argues that a sense of *solidarity* is also required between participants.

In short the conditions for the practical discourse out of which (quasi-) universally valid norms may emerge include the free participation and acceptance of all who are affected by such norms, as such norms meet their interests—where such participation is shaped by rational debate, perspective-taking, and solidarity.

Discourse Ethics in Technology and Science

Discourse ethics thus intends to define the conditions of a free and democratic discourse concerning important norms that affect all members of a community. It aims to do so in ways that are directly *practical* for the real and pressing problems facing both local and more comprehensive communities. In this light, DE would seem well-suited for circumscribing discourse concerning pressing issues provoked by science and technology.

Indeed DE can be seen to be implicitly at work in a first instance in the Technology Assessment (TA) movement. Beginning in the 1970s in the United States, and then developing further in Europe, TA seeks to develop ways for programmatically assessing the risks and benefits of proposed or emerging technologies, in order to determine whether the technology *ought* to be developed and deployed in light of central social values, such as protecting both human life and the larger environment. Rather than having decisions regarding new technologies made solely by a relatively narrow circle of scientists and market-dependent corporations, one version of TA has sought to *democratize* technology development by enlarging the circle of decision-makers to include non-technical citizens' representatives. One dramatic instantiation of such democratic technology assessment emerged in the consensus conferences developed by the National Institutes of Health (NIH) in the United States in the 1970s (Jacoby 1985) and then expanded upon, initially in Denmark in 1985 (Klüver 1995). Such consensus conferences were occasioned by the issues raised by the Human Genome Project and genetically modified (GMO) foods, and were composed of carefully structured dialogues involving scientific and technological experts, policy experts, political representatives, and lay or non-technical citizens. Subsequently held throughout Scandinavia and Europe, they have also been applied to issues raised by emerging information technologies (for example, see Anderson and Jæger 1997).

Although not explicitly developed as such, consensus conferences are clearly consistent with the goals and sensibilities of DE, beginning with the intuition that democratic control of science and technology depends on citizens' discourse intended to generate consensus on those values and norms affecting the members of a community—in this case, with regard to the possible development and implementation of technologies with both obvious and not-so-obvious benefits and risks for human beings and their environment. Indeed Barbara Skorupinski and Konrad Ott (2002) have argued that the European consensus conferences, as efforts to develop what they call *participatory Technology Assessment* (pTA), are rooted not only in basic notions of democratic governance, but also precisely in the work of Habermas. They review six examples of such consensus conferences from the 1990s—including a Danish conference on GMO food, as well as Swiss and German conferences on genetic technology—to argue that these represent a sometimes imperfect implementation of DE. Similarly Richard Brown (1998) has argued that the environmental justice movement, including the specific history of Love Canal, can be evaluated in DE terms. To make his case, however, Brown develops a notion of science as narration in order to fit science more directly into the rhetorical and communicative DE frameworks.

Along with its ability to provide a framework for promoting the external democratic discussion of technology, DE may in a second instance also illuminate the internal structure of the scientific and technical communities—especially in terms of professional ethics. Robert Merton, the mid-twentieth-century founder of the sociology of science, analyzed the ethos of the scientific community as producing knowledge that is universal, commonly owned, not tied to special interests, and fallible (Merton 1942). Since Merton there has been considerable debate about the status of these norms, especially insofar as detailed case studies in the history and sociology of science have revealed the often parochial, egotistic, self-interested, and dogmatic behavior of scientists. Using DE, however, it might be possible to reconstruct the norms of professional science as precisely those principles that promote technical communication, and thus properly articulated and taught by means of professional ethics codes.

Pragmatic Discourse Ethics

Although discourse ethics has not been applied explicitly to analyzing or interpreting professional ethics in science or engineering, the explicit work in relation to TA has been carried forward in special areas. For example, Matthias Kettner (1999) has elaborated additional conditions for moral discourse, such as *bracketing of power differentials* and *nonstrategic transparency* (that is, avoiding lies of omission), especially as applied to issues in bioethics. Similarly Jozef Keulartz and his colleagues, in *Pragmatist Ethics for a Technological Culture* (2002), sought to bridge Habermasian DE and pragmatism to deal with issues in agricultural ethics. In particular Paul Thompson (2002) draws on the American pragmatist tradition to avoid what he argues is a crucial failure of DE in Habermas—namely, that the emphasis on ideal speech situations tends to focus on debate *about* ethics (meta-ethics), rather than, as needed, move forward consensus-building about pressing issues.

DE has further played both a theoretical and practical role in connection with the Internet and the World Wide Web. For example, DE has been used to structure online dialogues regarding important but highly controversial social issues such as abortion. These dialogues in fact realize the potential of DE to achieve consensus on important community norms, insofar as they bring to the foreground important normative agreements on the part of those holding otherwise opposed positions, agreements that made a *pluralistic* resolution of the abortion debate possible (Ess and Cavalier 1997). In 2002 DE served as the framework for the ethics working committee of the Association of Internet Researchers (AoIR), as they sought to develop the first set of ethical guidelines designed specifically for online research—and with a view toward recognizing and sustaining the genuinely *global* ethical and cultural diversity entailed in such research. The guidelines stand as an example of important consensus on ethical norms achieved by participants from throughout the world.

The Future of Discourse Ethics?

Despite its promotion of a pluralistic universalism—namely, one that recognizes a wide range of possible discourse resolutions as shaped, for example, by diverse cultural traditions—discourse ethics is more prominent on both theoretical and practical levels in the Germanic cultures of Northern Europe than elsewhere. This regionalized predominance reflects a still larger cultural divide between the United States and Europe in terms of how to take up important ethical issues in science and technology. Thus Jeffrey Burkhardt, Paul Thompson, and Tarla Peterson (2000) note that European analysis and discussion of agricultural and food ethics is marked by a strong preference for *deontological* approaches to ethics, in contrast with the U.S. preference for *utilitarian* approaches. This same contrast can be seen in European approaches to data privacy protection and research ethics (as more deontological) versus American approaches (as more utilitarian).

That is, deontological approaches are associated with Kant and his emphasis on duties to individuals, which is required by their status as rational, autonomous beings. Kantian deontology is a central influence in DE. By contrast, utilitarian approaches—long associated with the Anglo-American philosophical tradition shaped by Jeremy Bentham and John Stuart Mill—seek instead to determine *the greatest good for the greatest number* through a kind of moral calculus that prefers those acts which maximize benefits and minimize costs. Markets, in particular, are justified on utilitarian grounds: While individuals and groups will inevitably lose out in market competition, such competition is justified as leading to greater economic efficiency and thus greater good for at least the greater number. Deontologists are wary of such strictly utilitarian approaches, precisely because they can result in the rights and interests of a minority being sacrificed for the ostensible benefit of the majority.

The Germanic reliance on DE in consensus conferences is thus consistent with the larger preference for deontological approaches. Indeed the European Commission continues to fund important initiatives concerning the ethical dimensions of emerging technologies such as GMO foods, human cloning, stem cell research, and therapeutic cloning research. By contrast the United States abolished the Office for Technology Assessment in 1995. Paul Riedenberg's observation about data privacy protection appears more generally true: The United States pursues a market-oriented (and thus more utilitarian) approach, in contrast with the European reliance on "socially-protective, rights-based governance"—an emphasis on the role of government to protect deontological rights and values (Reidenberg 2000, p. 1315).

In particular the success of consensus conferences in Europe—especially Scandinavia—appears tied to a well-defined set of conditions, beginning with the commonly held value that "democracy is only possible in a society where all citizens are enlightened enough to make an informed and conscious choice" in electing their representatives and voting—where such enlightenment further requires high levels of general education (Anderson and Jæger 1997, p. 150). Moreover the frameworks for Danish consensus conferences explicitly note that "market forces should not be the only forces involved" in deciding the design and deployment of information technology, which should further serve such fundamental deontological values as "free access to information and exchange of information" and "democracy and individual access to influence" (Anderson and Jæger 1997, p. 151). Consensus conferences thus exemplify what Reidenberg describes as the European emphasis on socially-protective, rights-based governance, in contrast with the U.S. utilitarian preference for market-oriented approaches.

Insofar as consensus conferences approximate DE ideals, societies must be committed to citizen enlightenment, as fostered by a strong educational system, and to citizen involvement in democratic processes, including those such as consensus conferences, as fostered by free access to information. In the twenty-first century, however, budgets for education systems continue to shrink and countries around the world are increasingly influenced by the U.S. emphasis on market forces alone to resolve important social issues. This is clearly a move away from socially-protective, rights-based governance in general, and from a belief that government should foster citizen assessment and possible regulation of technological development and deployment in particular. Spending taxpayers' funds on consensus conferences for the assessment of emerging technologies is explicitly criticized. Such circumstances are hardly promising for the application of DE to pressing issues in science and technology.

Nevertheless more promising conditions for DE as applied to democratic procedures for assessing science and technology may emerge in the future. Indeed such conditions are necessary for the sake of democratic procedures in TA. In addition the human, social, ethical, and financial resources required for DE and consensus conferences are the resources needed to realize and further more broadly the Enlightenment project of liberation and democracy.

CHARLES ESS

SEE ALSO *Consensus Conferences; Constructive Technology Assessment; Democracy; Deontology; Habermas, Jürgen; Internet; Kant, Immanuel; Rhetoric of Science and Technology; Technology Assessment: Germany and Other European Countries; Office of Technology Assessment.*

BIBLIOGRAPHY

Alexy, Robert. (1978). "Eine Theorie des praktischen Diskurses" [A Theory of Practical Discourse]. In *Normenbegründung–Normendurchsetzung*, ed. Willi Oelmüller. Paderborn, Germany: Schöningh. An English translation by

David Frisby is included in *The Communicative Ethics Controversy*, eds. Seyla Benhabib, and Fred Dallmayr (Cambridge, MA: MIT Press [1990]).

Anderson, Ida-Elisabeth, and Birgit Jæger. (1997). "Involving Citizens in Assessment and the Public Debate on Information Technology." In *Technology and Democracy: Technology in the Public Sphere—Proceedings from Workshop 1,* eds. Andrew Feenberg, Torben Hviid Nielsen, and Langdon Winner. Oslo: Center for Technology and Culture. A seminal discussion of consensus conferences as applied to information technology: Co-author Anderson remains a leader in organizing consensus conferences both in Denmark and abroad, including the United States.

Apel, Karl-Otto. (1980). "The A Priori of the Communication Community and the Foundations of Ethics." In *Towards a Transformation of Philosophy*. London: Routledge.

Apel, Karl-Otto. (2001). *The Response of Discourse Ethics to the Moral Challenge of the Human Situation as Such and Especially Today*. Leuven, Belgium: Peeters. Mercier Lectures, Louvain-la-Neuve, March 1999. A recent and accessible overview of Apel's understanding of discourse ethics and its contemporary relevance.

Benhabib, Seyla. (1986). *Critique, Norm, and Utopia: A Study of the Foundations of Critical Theory*. New York: Columbia University Press. A magisterial study of and central feminist contribution to critical theory from Hegel and Kant through Habermas.

Blickle, Gerhard; Sabine Hauck; and Wolfgang Senft. (1997). "Assertion and Consensus Motives in Argumentations." *International Journal of Value-Based Management* 10: 193–203.

Brown, Richard Harvey. (1998). *Toward a Democratic Science: Scientific Narration and Civic Communication*. New Haven, CT, and London: Yale University Press.

Burkhardt, Jeffrey; Paul B. Thompson; and Tarla Rae Peterson. (2002). "The First European Congress on Agricultural and Food Ethics and Follow-up Workshop on Ethics and Food Biotechnology: A U.S. Perspective." *Agriculture and Human Values* 17(4): 327–332.

Ess, Charles, and Robert Cavalier. (1997). "Is There Hope for Democracy in Cyberspace?" In *Technology and Democracy: User Involvement in Information Technology*, ed. David Hakken and Knut Haukelid. Oslo, Norway: Center for Technology and Culture.

Fixdal, Jon. (1997). "Consensus Conferences as Extended Peer Groups." In *Technology and Democracy: Technology in the Public Sphere—Proceedings from Workshop 1,* eds. Andrew Feenberg, Torben Hviid Nielsen, and Langdon Winner. Oslo: Center for Technology and Culture.

Habermas, Jürgen. (1981). *Theorie des Kommunikativen Handelns* [The Theory or Communicative Action], 2 vols. Frankfurt: Suhrkamp. English translation: *The Theory of Communicative Action,* Vol. 1: *Reason and the Rationalization of Society* and *The Theory of Communicative Action;* Vol. Two: *Lifeworld and System: A Critique of Functionalist Reason,* both translated by Thomas McCarthy (Boston: Beacon University Press [1984/1987]). Habermas's central effort to develop a systematic theory of communicative rationality that might resolve the "legitimation crisis" of enlightenment reason in the twentieth century—an effort further elaborated in the following two works.

Habermas, Jürgen. (1989). "Justice and Solidarity: On the Discussion Concerning Stage 6." In *The Moral Domain: Essays in the Ongoing Discussion Between Philosophy and the Social Sciences,* ed. Thomas Wren. Cambridge, MA: MIT Press.

Habermas, Jürgen. (1990). "Discourse Ethics: Notes on Philosophical Justification." In *Moral Consciousness and Communicative Action,* trans. Christian Lenhardt and Shierry Weber Nicholson. Cambridge, MA: MIT Press. Published in Germany as "Diskursethik: Notizen zu einem Begründungsprogram," in *Moralbewusstsein und kommunikatives Handeln* (Frankfurt: Suhrkamp [1983]).

Jacoby, Itzhak. (1985). "The Consensus Development Program of the National Institutes of Health." *International Journal of Technology Assessment in Health Care* 1: 420–432.

Jonsen, Albert R., and Stephen E. Toulmin. (1990). *The Abuse of Casuistry: A History of Moral Reasoning*. Berkeley: University of California Press.

Keulartz, Jozef; Michiel Korthals; Maartje Schermer; and Tsjalling Swierstra, eds. (2002). *Pragmatist Ethics for a Technological Culture*. Dordrecht, The Netherlands: Kluwer. A central collection of important contributions towards ethical frameworks for technology that include discourse ethics.

Kettner, Matthias. (1999). "Discourse Ethics: A Novel Approach to Moral Decision Making." *International Journal of Bioethics* 19(3): 29–36. One of several significant extensions and revisions of discourse ethics by a contemporary German philosopher.

Klüver, Lars. (1995). "Consensus Conferences at the Danish Board of Technology." In *Public Participation in Science: The Role of Consensus Conferences in Europe*, eds. Simon Joss, and John Durand. London: Science Museum.

Lagay, Faith L. (1999). "Science, Rhetoric, and Public Discourse in Genetic Research." *Cambridge Quarterly of Healthcare Ethics* 8(2): 226–237.

Marck, Patricia B. (2000). "Recovering Ethics After *Technics*: Developing Critical Text on Technology." *Nursing Ethics* 7(1): 5–14.

Merton, Robert. (1942). "Science and Technology in a Democratic Order." *Journal of Legal and Political Sociology* 1: 115–126. Reprinted as "The Normative Structure of Science" in *The Sociology of Science: Theoretical and Empirical Investigations* by Robert K. Merton (Chicago: University of Chicago Press [1973]).

Rawls, John. (1971). *A Theory of Justice*. Cambridge, MA: Belknap Press. One of the most significant contributions to political philosophy in the twentieth century—one that shares with Habermasian discourse ethics an emphasis on consensus procedures as the means of developing legitimate moral norms.

Reidenberg, Joel R. (2000). "Resolving Conflicting International Data Privacy Rules in Cyberspace." *Stanford Law Review* 52(May): 1315–1376.

Rorty, Richard. (1989). *Contingency, Irony, and Solidarity*. Cambridge, UK: Cambridge University Press.

Skorupinski, Barbara, and Konrad Ott. (2002). "Technology Assessment and Ethics." *Poiesis & Praxis: International Journal of Technology Assessment and Ethics of Science* 1(2)(August): 95–122.

Thompson, Paul B. (2002). "Pragmatism, Discourse Ethics and Occasional Philosophy." In *pragmatist Ethics for a Technological Culture*, eds. Josef Keulartz, Michiel Korthals, Maartje Schermer, and Tsjalling Swierstra. Dordrecht, The Netherlands: Kluwer.

INTERNET RESOURCES

Association of Internet Researchers. "Ethical Decision-making and Internet Research: Recommendations from the Aoir Ethics Working Committee." Available from www.aoir.org/reports/ethics.pdf. The first interdisciplinary, international ethical guidelines for Internet research, developed through an explicit application of discourse ethics.

Cavalier, Robert. Academic Dialogue on Applied Ethics. Carnegie-Mellon. Available from http://caae.phil.cmu.edu/Cavalier/Forum/ethics.html. See in particular "Abortion: Religious Perspectives," available from http://caae.phil.cmu.edu/Cavalier/Forum/abortion/abortion.html.

DISEASE

SEE *Health and Disease*.

DISTANCE

One of the well-recognized benefits of science and technology is that they reduce distance across both space and time. Science looks back in time toward the origins of the cosmos and provides information about microscopic phenomena and distant planets. Technologies of transportation and communication reduce the significance of distance limitations on human travel and personal interaction, making globalization a commonplace experience. But while celebrating the ways in which science and technology bring the far near, some thought must also be given to the ways science and technology can make the near far.

The social critic Ivan Illich (1973) was among the first to note some cultural and political implications of distance reversal. The automobile, for instance, brings the suburbs within a daily commuting distance of the central city, while simultaneously placing a living interaction with the city itself outside the bounds of a simple stroll. Illich argued that automobiles "can shape a city into its image," practically ruling out other forms of locomotion. He coined the term *radical monopoly* to designate this type of exclusivity in rendering a service. Something analogous occurs when the telephone, the Internet, and cell phone enhance interactions with distant relatives and friends, while tending to situate immediate neighbors in other worlds. Such technologies invite people to virtually traverse distances at the same time that they might be contributing decisively to the impoverishment of local collectives, communities, and urban spaces. The advent of online education likewise tends to obscure the importance of nearness in knowledge acquisition (Huyke 2001).

As science attaches to the knowledge of distant places and times a kind of exotic glamour, one has to work hard to pay attention to what is immediately at hand. As people get used to online education, for instance, the illustrations brought forth by distant experts may outshine local experience and events. With the advent of biotechnology, high-yielding herbicide-resistant plants of major commodity crops become available throughout the world, shackling farmers to the patented plants and herbicides of a few multinational conglomerates, while also diverting them from local forms of agriculture and a more diverse produce.

Other commentators highlight the positive potential of such transformations in the character of distance. From the perspective of critical social theory, Andrew Feenberg (2002) calls for the democratic design and control of systems that facilitate self-organizing, nonterritorial communities throughout the globe. He likewise defends online education (which used to be called "distance education"), as long as it is "shaped by educational dialogue rather than the production-oriented logic of automation" (p. 130). The phenomenologist Don Ihde (1990) acknowledges an inevitable overwhelming of near "monocultural lifeworlds"—that is, ingrown German or Italian cultures, and especially indigenous cultures—but argues that independent of political efforts to limit the damage, such lifeworlds will become "pluricultural" through selective adoptions and incorporations. With the use of image-technologies, future traditions will inevitably be characterized by multiplicity and abundance, or what Ihde calls plurality. The local adaptation of global trends, a bringing of the far near sometimes known as "glocalization," can free individuals from the limitations of too specifically conceived traditions.

A third response seeks to identify those conditions that allow for personal, political, and cultural flourishing in the context of sciences and technologies that will continue to bring the far close and make the near distant. One insightful representative of this approach is the philosopher Albert Borgmann. In his 1984 book, *Technology and the Character of Contemporary Life,* Borgmann argued that the key to the good life is engagement with what he calls "focal things and practices" that order and intensify human experience, such as playing music or cross-country running. Contemporary technology, however, exhibits a guiding pattern, which he terms the "device paradigm," that is at odds with such experiences. Rather than needing to be played, music is able to be consumed by CDs and other devices, and running easily becomes an activity that takes place on a running machine rather than in nature.

The abstract problem of distance reversal is made concrete in the technological device itself, which increasingly hides its own near inner workings in favor of unhindered delivery of some commodity. The traditional hearth called forth ordered engagement in cutting wood and tending fire, and how it produced heat was transparent for all to see. The central heating system reduces engagement to a maintenance contract and is more or less mysterious to the consumer. Other examples permeate contemporary life: Few people know how digital clocks work, but such devices unambiguously state the time. Without the burdens of cooking, processed food is everywhere and available at any time. Humans progressively construct a world monopolized by the prominent availability of goods and a parallel disappearance of things and practices that might engage and challenge. Genuine nearness that could lead to "the unity of achievement and enjoyment, of competence and consummation" is replaced by the easy consumption of commodities that in the past would have required the expenditure of time or the traversing of space (Borgmann 1984, pp. 202–203). In the case of virtual reality, the line between the real and the virtual gets blurred in the context of "a deceptive sense of ease and expertise" that comes with digitalized cultural information about things (Borgmann 1999, p. 176).

Borgmann argues for a distinctive reform of technology. He has repeatedly called for the design of technologies that engage people bodily, socially, and politically. In opposition to Illich before him, Borgmann believes that more appropriate or enabling technologies will not constitute the deciding difference for a reformed future, because technological devices exhibit their own perfections and attractiveness. Instead he calls for a two-sector economy that would limit production with devices and of devices, leaving room for and encouragement of focal things and practices. To what extent such a project is politically feasible remains at issue. How it might help meet the challenges of time and space displacements found in scientific knowledge and technological tendencies is yet to be explored.

HÉCTOR JOSÉ HUYKE

SEE ALSO *Material Culture; Place; Space.*

BIBLIOGRAPHY

Borgmann, Albert. (1984). *Technology and the Character of Contemporary Life: A Philosophical Inquiry.* Chicago: University of Chicago Press. A comprehensive inquiry and critique of the technological pattern that prevails in contemporary life.

Borgmann, Albert. (1992). *Crossing the Postmodern Divide.* Chicago: University of Chicago Press. A reflection on the importance of the local and the communal for articulating a vision of postmodern culture.

Borgmann, Albert. (1999). *Holding On to Reality: The Nature of Information at the Turn of the Millennium.* Chicago: University of Chicago Press. A reflection on the history and limits of technological information or information as reality

Borgmann, Albert. (2001). "Opaque and Articulate Design." *International Journal of Technology and Design Education* 11(1): 5–11. A philosophical discussion of technological design from the perspective of the things and practices people value the most.

Feenberg, Andrew. (2002). *Transforming Technology: A Critical Theory Revisited.* Oxford: Oxford University Press. An inquiry on the social values that frame contemporary technology and the possibility of a change in direction based on genuine democratic values.

Huyke, Héctor José. (2001). *Anti-profesor: Reflexiones contra el profesor y su estudiante, con particular atención en la sociedad, el conocimiento y las tecnologías que se promueven en el salón de clases* [Anti-professor: Reflections against the professor and the student with particular attention to the society, the knowledge, and the technologies that are promoted in the classroom]. Río Piedras: Editorial de la Universidad de Puerto Rico. A critique of the university professor's role in reproducing some of the most troubling predicaments of contemporary conditions of life.

Ihde, Don. (1990). *Technology and the Lifeworld: From Garden to Earth.* Bloomington: Indiana University Press. An exploration of some of the most crucial cultural issues presented by the tools and instruments of the contemporary age.

Illich, Ivan. (1973). *Tools for Conviviality.* Berkeley, CA: Heyday. A critical examination of the institutions that dominate modern life and obstruct creativity and joy.

DOMINANCE

For students of animal behavior, *dominance* refers to the phenomenon by which individuals of a social species organize themselves with regard to access to resources. Although some social species appear to be egalitarian in many respects, close observations reveal differential access among individuals in nearly all cases, especially when resources are in short supply. These resources may include food, nest sites, mates, or any other considerations that have consequences for evolutionary success, or fitness; a dominance hierarchy is one of the most common patterns whereby access to these resources is established.

Dominance Hierarchies and Relationships

Although dominance relationships have in the past been seen as a species characteristic in themselves, they most importantly reflect differences in size, aggressiveness, and/or motivation among individuals, with these differences generating, in turn, a hierarchy of access to fitness-enhancing opportunities. It also appears to be beneficial to individuals to recognize their competitive relationship with respect to others, because without such recognition considerable time and energy might be wasted re-establishing priority, not to mention risking injury if a confrontation results in actual fighting. A signal characteristic of dominance hierarchies is that despite their aggressive underpinnings, animal societies characterized by rigid dominance relationships tend to experience relatively little actual fighting.

Most specialists maintain that—as with other biological phenomenon—there are no ethical implications of animal dominance relationships per se. While human observers may be inclined to deplore the *unfairness* whereby some individuals achieve disproportionate access to resources while others are comparatively excluded, dominance relationships, by definition, are not egalitarian. Indeed, during the late-nineteenth and early-twentieth centuries, when social Darwinism was especially influential, dominance relationships among human beings were considered admirable, as a working out of natural law. In the early twenty-first century, biologists acknowledge that dominance relationships among animals do indeed reflect the working out of natural tendencies and inclinations, as do predator-prey relationships, or the patterns of energy flow among different levels of natural communities. Just as neither eagles nor decomposing bacteria are good or bad, the same is true of dominance hierarchies. They are part of natural life, and as such, ethically neutral.

From an evolutionary perspective, dominance relationships among individuals develop because individuals are selected to maximize their fitness, their success in projecting copies of their genes into the future. Natural selection rewards those who succeed in doing so, and, in certain cases, this success is achieved by establishing one's self in a clearly defined situation of social superiority over others.

This is not to say that dominance relationships develop by some sort of intentional decision process on the part of the animals themselves, in which the latter get together and agree to establish a hierarchy. Rather, individuals who are somewhat larger, more aggressive, smarter, or who may have enjoyed such advantages in the past, simply assert themselves and, by virtue of that circumstance, succeed in gaining priority. Natural selection, in turn, supports those who achieve this success insofar as priority to food, mates, and nesting sites, among other things, correlates positively with ultimate reproductive success. Gene combinations that lead to success in such competition are favored in succeeding generations.

In some cases—barnyard chickens are the classic example—individuals end up establishing a *pecking order* whereby individual 1 dominates individual 2 and all those below, individual 2 dominates individual 3 and all those below, with that pattern continuing. However, dominance relationships are not always linear, nor are they always transitive: In many territorial species, for example, individual 1 may dominate individual 2, and individual 2 dominates individual 3, but individual 3 may dominate individual 1! In others—harem-keeping or polygynous species, such as elk, for example—there may be a single dominant individual (the dominant bull), who is clearly *number one*, with a less clear hierarchy among the remaining subordinate males.

Dominance relationships among animals depend upon an often tacit acknowledgment of the existing situation, on the part of dominants and subordinates alike. Thus once a dominance relationship is established, it is typically unnecessary for the various participants to fight—or even, in most cases, to engage in elaborate threat and subordination behavior—in order to maintain the pattern. When a dominance pattern is well established, individuals promptly respond to their mutual relationships by recognizing each other as individuals. (Indeed, this rapid, tacit response can be taken as powerful evidence of the participants' capacity to recognize individuals in the first place.)

Traditionally, dominance hierarchies have been seen as relatively immutable. More recent studies, however, have shown that they are not. Even though hierarchical relationships among animals tend to be resistant to change, they are subject to modification, as when a dominant male harem-keeper among langur monkeys is overthrown by one of the previously subordinate bachelors. Similarly, dominance hierarchies among female animals commonly vary as a function of hormonal and reproductive state: Breeding females and those in estrous often experience a temporary increase in their dominance status.

Correlation to Human Dominance Patterns

There is considerable variation in the nature of dominance relationships among different animal species, even some that are closely related. Chimpanzee social behavior, for instance, is generally oriented along lines of male dominance whereas the dominance system of bonobos (formerly known as pygmy chimpanzees) is primarily structured by the interactions of females. This, in turn, leads to question as to which animal system—if any—is most appropriate for understanding social dominance among human beings. Nonetheless biologists as well as increasing numbers of social scientists believe that in some complex way the biological nature of human beings underlies the nature of human politics just as that of other species underlies their pattern of social interactions.

Status signaling has also received considerable research attention. Although it seems legitimate to distinguish between physical characteristics (such as elaborate crests, ruffles, and antlers) used to achieve success in sexual selection by generating greater attractiveness to members of the opposite sex, such traits often also contribute to success in same-sex competition, and thus, with regard to dominance relationships. Would-be competitors are themselves more fit if they respond appropriately to indicators of probable physical or even mental superiority rather then subject themselves to possible injury or time wastage finding out *who is successful relative to whom*. Additionally it is probably adaptive for potential mates to employ the same traits that are used to establish and maintain same-sex dominance relationships as signals that generate success in between-sex courtship. This is because such traits—if genuinely connected to health and vitality—would lead to more successful offspring and hence be appropriate signals for an individual of one sex to employ in choosing a potential mate, and also because any offspring of such a union, insofar as they possessed these characteristics, would likely to be attractive to the next generation of *choosers*.

Among human beings dominance is a function of many things, including physical characteristics, intellectual qualities, and the control of material resources. Social dominance typically goes beyond the merely physical ability to intimidate a would-be rival, and carries with it signifiers of social rank such as clothing, make of automobile, speech patterns, and self-confidence. As in the case of animals, it is difficult —and perhaps impossible—to separate intrasexual from intersexual aspects of dominance. There is evidence that mastery of technology contributes to social dominance, and moreover, that the pursuit of technological and scientific success is generated, albeit unconsciously, by an underlying pursuit of social dominance (which itself is pursued because of its ultimate connection with reproductive success). The fact that such connections and motivations—if they exist—are not consciously pursued, does not make them any less genuine. At the same time, even as biologists are agreed that dominance and the pursuit of dominance is *natural,* there is no evidence that it is either ethically privileged or, by contrast, to be disparaged.

DAVID P. BARASH

SEE ALSO *Ethology; Selfish Genes; Social Darwinism.*

BIBLIOGRAPHY

Ardrey, Robert. (1971). *The Social Contract.* New York: Doubleday. An early and rather speculative attempt to examine the role of dominance hierarchies in human beings.

De Waal, Frans B. M., and Peter Tyack, eds. (2003). *Animal Social Complexity: Intelligence, Culture, and Individualized Societies.* Cambridge, MA: Harvard University Press. A technical work that examines the inter-relationships of animal social behavior—including but not limited to dominance relationships—and aspects of culture and intelligence.

Masters, Roger D. (1989). *The Nature of Politics.* New Haven, CT: Yale University Press. A political scientist considers the likely role of biological considerations in influencing complex patterns of human behavior.

Schein, Martin W. (1975). *Social Hierarchies and Dominance.* New York: Dowden, Hutchinson & Ross. A technical consideration of how dominance hierarchies form among animals and how they can be measured.

Smuts, Barbara. (1999). *Sex and Friendship in Baboons.* Cambridge, MA: Harvard University Press. A primatologist examines prosocial behavior among free-living baboons, showing that dominance relationships allow for benevolent interactions.

DOUBLE EFFECT AND DUAL USE

In moral philosophy the principle of double effect traditionally refers to conflict situations in which an action or series of actions will result in multiple effects, some good and some bad. It parallels the contemporary policy concept of dual use: the idea that scientific knowledge or technological artifacts can serve multiple purposes, depending on the context. Dual use targeting and dual use research are areas that sometimes raise ethical dilemmas about the production and use of scientific knowledge and technologies but on other occasions provide multiple justifications for a single policy. Double effect seldom is referred to explicitly in those situations, but its general conditions may provide conceptual clarity with regard to moral permissibility. However, at the level of practical political decision making activities such as risk assessment, technology assessment, and scenario building provide better guidance for handling the ethical problems posed by dual use situations than does double effect reasoning.

Double Effect

Still widely discussed in the bioethics literature, the principle of double effect originated in Catholic scholastic moral philosophy, specifically in the discussion by the theologian Thomas Aquinas (1224–1274) of killing in self-defense:

> A single act may have two effects, of which only one is intended, while the other is incidental to that intention. But the way in which a moral act is to be classified depends on what is intended, not what goes beyond such an intention. Therefore, from the act of a person defending himself a twofold effect can follow: one, the saving of one's own life; the other the killing of the aggressor. (*Summa theologiae,* IIaIIae, q.64, a.7)

This raises the central distinction in double effect reasoning between intention and foresight (Aulisio 1995). In a morally acceptable case of killing in self-defense, the death of the aggressor is a foreseeable effect but the intention is to preserve one's own life. If, however, the killing was intended and not merely foreseen, it is considered homicide.

Originally formulated in slightly more complex terms, the principle of double effect commonly is stated as follows: An action with multiple effects, good and bad, is permissible if and only if (1) one is not committed to intending the bad effects either as the means or the end and (2) there is a proportionate reason for bringing about the bad effects (Bole 1991). The proportionality clause arises from Thomas's insistence that one should not use more violence than necessary in defending oneself: "An act that is properly motivated may, nevertheless, become vitiated, if it is not proportionate to the end intended" (*Summa theologiae,* IIaIIae, q. 64, a. 7). Subsequent interpreters saw this condition as referring more broadly to the overall balance of good and bad effects.

Paradigm applications of double effect in Catholic bioethics pertain to cases of maternal-fetal conflict and distinctions between palliative care and euthanasia. Double effect also has been used in debates about the use of embryos in medical research. Many theorists question the relevance of double effect reasoning outside the Catholic moral framework (Boyle 1991). Some have argued that although the distinction between intention and foresight is difficult to apply practically, double effect nonetheless applies in any of the multiple moral frameworks that incorporate deontological constraints (in the form of intention) on consequentialist considerations (Kagan 1989). (Deontology asserts that certain acts are intrinsically right or wrong, whereas consequentalism asserts that the rightness or wrongness of an act depends on its consequences.) Traces of double effect reasoning can be seen even in Anglo-American law, for example, in the distinction between first-degree murder and manslaughter.

Double Effect and Dual Use

The concept of dual use is not well formulated for general use but can be understood in light of the principle of double effect as referring to any activity, artifact, or body of knowledge that is intended to bring about good effects but also has foreseeable negative consequences. This definition, however, excludes one of its most common applications: cost-sharing research programs involving industry and the military. For example, the U.S. Department of Defense operates a Dual Use Science and Technology Program to fund jointly with industry partners technologies that can be of use both on the battlefield and in the market. Defined in this sense, dual use is somewhat difficult to consider under the principle of double effect because there is no admitted or foreseen bad result, only multiple good ones. It merely refers to basic research with the potential for positive benefits in more than one sector of the economy and thus offers multiple justifications for governmental support. It is often the case that if political support for a research program cannot be marshaled with one argument (knowledge production alone), scientists have few qualms about appealing to others, such as military or health benefits and economic competitiveness. However, in this case ethical questions arise about whether both uses are equally sound or valid and whether rhetorical appeals to one may contaminate the other.

Insofar as dual use implies both good and bad outcomes, the concept presents even more fundamental challenges for social policies in regard to public support of science and technology. Stanley Rosen introduces the problem by noting that "all fundamental aspects of the natural sciences . . . may lead to the destruction of the human race. . . . Whereas no one would argue the wisdom of attempting to prevent a nuclear holocaust or the biochemical pollution of the environment, not many are prepared to admit that the only secure way in which to protect ourselves against science is to abolish it entirely" (Rosen 1989, p. 8). Security requires not only the abolition of science but also the destruction of all children because it is impossible to be certain who eventually may produce knowledge that threatens human existence. Rosen calls this the "ultimate absurdity of the attack against the enlightenment" (Rosen 1989, p. 9).

This absurdity follows from the notion of dual use because nearly all knowledge and artifacts, despite good intentions, could produce foreseeable bad effects. Examples can be as exotic as the "grey goo" (uncontrolled replication of nanotechnology) envisioned by Bill Joy (2000), as mundane as using a pen as a stabbing instrument, or as horrifying as the deadly use of commercial airplanes by terrorists on September 11, 2001. Rosen's point is that the only way to guarantee safety is to ban science and its technological products entirely.

Of course, society does not follow this absurd logic because most people feel that the benefits provided by science and technology (the intended good effects) make it worthwhile to risk some of the foreseeable bad effects. People seek a judicious regulation of scientific inquiry and technological progress, and it is in this middle ground that the major ethical questions are raised by dual use phenomena: Do the foreseeable bad effects outweigh the intended positive ones? Are there ways to minimize the negative effects without compromising the positive ones? Are there some foreseeable consequences that are so appalling that people should ban the production or dissemination of knowledge in a certain area altogether?

These questions show the importance of the proportionality condition of the principle of double effect. In fact, proportionality is disclosed through activities such as risk assessment, technology assessment, and scenario building. Those activities involve processes of weighing the good and bad effects of research and technology in light of uncertainty about their relative probabilities. The distinction between intention and foresight is less difficult to apply, at least in theory, because if someone is attempting intentionally to bring about bad effects, say, by engineering a supervirulent pathogen, it seems obvious that there should be intervention to end that work. Indeed, in the realm of biotechnology dual use situations are difficult to deal with precisely because bad effects are not intended (cures, vaccines, and other good effects are intended) but nonetheless are foreseeable. Dual use situations present practical challenges to regulate research and ensure the proper use of technology in cases in which double effect analysis provides some insight and conceptual clarity. Dual use can be conceived of more broadly than can the conditions of double effect, however, because some bad effects of science and technology may be unforeseeable, let alone unintended.

Conduct of War and Biological Research

Precision-guided munitions and satellite-aided navigation have enhanced the accuracy of aerial bombardment. Although this has improved the ability of military planners to minimize collateral damage, it has raised an ethical dilemma: Military leaders are faced with questions of the legitimacy of dual use targeting, or the destruction of targets that affect both military operations and civilian lives. An example of such dual use targeting was the destruction of Iraqi electrical power facilities by the U.S. military in Operation Desert Storm in 1991.

Under the principle of double effect such activity would be deemed morally acceptable if the intention was not to harm or kill civilians (a bad effect that is foreseen but unintended) and the good effects outweighed the bad. This application of the principle of double effect relates to the idea of the just war that can be traced back to the theologian Augustine 354–430). Thomas expanded Augustine's idea that one cannot be held accountable for unintended effects caused by chance by applying that principle to include even foreseeable unintended effects that are not due entirely to chance. Like all versions of morality in terms of principles or formulas, however, the principle of double effect only establishes basic guidelines, and the majority of the work lies in deciding how and by whom such judgments about good and bad effects should be made.

Nuclear science provides the paradigmatic case of dual use summarized in the tension between physicists' initial hopes of "atoms for peace" and the grim reality of international proliferation of nuclear weapons. The dual nature of civilian and military use of nuclear science and technology poses grave problems in international relations, as witnessed by suspicions that Iran and other nations were developing nuclear weapons while claiming that such research was intended for civilian use only. The added possibility that terrorists could acquire weapons-grade nuclear material raises the stakes even higher.

The same concerns have surfaced around nanotechnology but have taken on a more mature form in regard to biological research. In 2004 the U.S. National Research Council (NRC) issued a report titled *Biotechnology Research in an Age of Terrorism*. Presenting recommendations to minimize the misuse of biotechnology, the authors warned: "In the life sciences . . . the same techniques used to gain insight and understanding regarding the fundamental life processes for the benefit of human health and welfare may also be used to create a new generation of [biological warfare] agents by hostile governments and individuals" (U.S. National Research Council 2004, p. 19). Attention was paid to the risk that dangerous research agents could be stolen or diverted for malevolent purposes and the risk that research may result in knowledge or techniques that could facilitate the creation of novel pathogens. The report characterizes the central tension as one of reducing the risks of the foreseeable unintended bad effects while allowing for the continuation of the good effects yielded by biomedical research. One major dilemma is the trade-off between national security and scientific freedom of inquiry.

The distinction between intention and foresight and the proportionality condition are reasonable concepts for understanding the nature of this dual use situation. Clearly, mechanisms must be in place to ensure that researchers are not working intentionally toward bad effects either directly in the laboratory or covertly by sharing information with terrorists or other enemies. The more difficult questions, however, are left even when the assumption is made that no malevolent intentions exist.

The U.S. government established the National Science Advisory Board for Biosecurity (NSABB) to provide advice to federal departments and agencies on ways to improve biosecurity, which refers to practices and procedures designed to minimize the bad effects of biological research while maximizing the good effects. The U.S. Patriot Act of 2001 and the Bioterrorism Preparedness and Response Act of 2002 established the statutory and regulatory basis for protecting biological materials from misuse. The NSABB develops criteria for identifying dual use research and formulates guidelines for its oversight and the public presentation, communication, and publication of potentially sensitive research. It works with scientists to develop a code of conduct and training programs in biosecurity issues. NSABB rules apply only to federally funded research. A possible avenue for the oversight of dual use research is Institutional Biosafety Committees (IBCs) for case-by-case review and approval.

The mechanisms fashioned by the NSABB for the regulation of dual use research are a good example of how the general spirit of double effect analysis is manifested in specific actions, raising political issues such as the proper balance of self-regulation by the scientific community and outside intervention. Members of IBCs and those involved in implementing other NSABB rules face the challenge of interpreting and applying the general guidelines provided by the principle of double effect in the sense that they must wrestle with difficult ethical dilemmas posed by good intentions and their foreseeable bad effects.

ADAM BRIGGLE

SEE ALSO *Consequentialism; Cultural Lag; Normal Accidents; Unintended Consequences.*

BIBLIOGRAPHY

Aulisio, Mark P. (1995). "In Defense of the Intention/Foresight Distinction." *American Philosophical Quarterly* 32(4): 341–354. Defends the distinction against challengers who claim that foresight of a probable consequence of one's actions is sufficient to consider that consequence part of one's intentions.

Bole, Thomas J. (1991). "The Theoretical Tenability of the Doctrine of Double Effect." *Journal of Medicine and Philosophy* 16: 467–473. Contends that the principle of double effect is relevant to different moral frameworks.

Boyle, James. (1991). "Further Thoughts on Double Effect: Some Preliminary Responses." *Journal of Medicine and Philosophy* 16: 467–473.

Joy, Bill. (2000). "Why the Future Doesn't Need Us." *Wired* 8(4): 238–262. Also available from http://www.wired.com/wired/archive/8.04/joy.html. A pessimistic outlook on the impending loss of human control as genetics, nanotechnology, and robotics become integrated research programs.

Kagan, Shelly. (1989). *The Limits of Morality*. New York: Oxford University Press. Argues that the ordinary understanding of limits imposed by morality and limits on what morality can demand of people cannot be defended adequately. Contains a section on intending harm.

Rosen, Stanley. (1989). *The Ancients and the Moderns: Rethinking Modernity*. London: Yale University Press.

U.S. National Research Council: Committee on Research Standards and Practices to Prevent the Destructive Application of Biotechnology. (2004). *Biotechnology Research in an Age of Terrorism*. Washington, DC: National Academies Press.

DRUGS

Drugs are notoriously difficult to define and yet present some of the most difficult ethical issues for the science and technology on which they are based. At the simplest level, drugs are molecules whose biochemical effects have been classified as socially desirable or undesirable in different times and places. *Dorland's Medical Dictionary* defines a drug as a "chemical compound that may be used on or administered to humans or animals as an aid in the diagnosis, treatment, or prevention of disease or other abnormal condition, for relief of pain or suffering, or to control or improve any physiologic or pathologic condition" (p. 510). But this ignores so-called *recreational drugs*, which may be described as substances used mainly for their psychoactive properties and pleasurable effects.

Historically drugs have been derived from plants and other natural materials and thus their production relied on indigeneous forms of knowledge and premodern techniques, often appropriated for modern applications. Over half of drugs in clinical use today continue to be derived from natural sources—including the excretions of insects, animal organisms, or microbes—from which they are extracted through direct or indirect processes (Aldridge 1998). The other half is synthesized through chemical processes that are now industrialized.

International Regulation

Ethical issues relating to human exploitation of indigenous knowledge and resources—sometimes called *bio- prospecting*—became central with the rise of a multinational pharmaceutical industry in the mid- to late-twentieth century. International treaties now provide safeguards that guarantee countries sovereign right over their genetic resources and a share of pharmaceutical profits derived from them. Yet such treaties also make national drug policy inflexible, inhibit innovation, and do not necessarily guarantee that indigenous groups that provide genetic materials are fairly compensated.

Given the high profit margins and relatively recession-proof nature of the pharmaceutical industry, drug production, marketing, distribution, and consumption are tightly regulated through a complex series of legal protocols and social controls that start from a set of international treaties that are coordinated through the United Nations Single Convention (1961), still the foundational document of international drug control (McAllister 2000). Prior to 1961 nine separate international treaties governed illicit or addictive drugs, primarily narcotics (opium and its derivatives), coca and its derivatives, and marijuana/hashish. The Single Convention defined the boundary between licit and illicit drugs, as well as legitimate medical and illegitimate, nonmedical, or recreational use, granting expert committees of the World Health Organization (WHO) authority for adding or altering *drug schedules*, which define how strictly drugs are regulated according to the level of their abuse liability. The Single Convention also mandated that national governments create and maintain drug-control agencies, and otherwise required signers to conform their domestic drug policies to its international mandate.

Regulation in the United States

Regulatory regimes are divided in the United States between illicit drugs, regulated by the Federal Bureau of Narcotics (FBN), the Treasury Department unit responsible for enforcing the Volstead Act (alcohol prohibition) and the Harrison Act, which transmuted into the Drug Enforcement Administration (DEA) in 1973; and licit drugs, regulated by the Food and Drug Administration (FDA) following the Food, Drug, and Cosmetic Act (1938). The 1938 Act granted the FDA authority to designate which drugs would be available only with a physician's prescription (Swann 1988). The liberalization of prescription laws in the 1960s and 1970s culminated in direct-to-consumer (DTC) advertising briefly becoming legal in the United States in the early 1980s prior to an FDA-imposed moratorium finally lifted in 1997. Supranational organizations such as the European Union have limited the spread of direct-to-consumer advertising (DTC) of prescription drugs. New Zealand is currently the only other country besides the United States that allows DTC, although it is under consideration elsewhere.

Well into the twentieth century, *proprietary medicines* were unregulated in terms of production, advertising, marketing, or distribution. Heavy advertising of commercial compounds emerged in the mid-nineteenth century United States, as patent medicine manufacturers were among the first to market their products nationally. Total advertising expenditures for proprietary medicines soon exceeded those of all other products combined; it was not unusual for nineteenth-century advertising budgets to exceed $100,000 per year, and some reached the million-dollar mark.

Narcotic drugs were restricted to prescription by the Harrison Act (1914), an outcome of growing international concern about widespread use and abuse of opiates, which were one of the few effective drugs then considered part of the medical armamentarium. An ongoing search for a non-addicting analgesic mounted by the National Research Committee propelled early-twentieth century innovation in the U.S. pharmaceutical industry in the context of concerns about addiction liability (Acker 2002). Addiction remains a classically public problem to which a coordinated federal response is understood as necessary, despite disagreement over the form that it should take. The United States remains the largest consumer of illicit drugs and has continued to struggle against what has proven a largely intractable problem. Basic research efforts into the neurobiochemistry of addiction led to the visualization of multiple opiate receptors, long hypothesized to exist, in the early 1970s. Federally funded studies of drug addiction have shifted away from the social and health consequences of abuse, and toward the use of molecular and animal models in establishing the basic neurobiological and now biogenetic mechanisms of drug action.

Drug Evaluation

Classified according to what is known about their mechanism of action, as well as their predominant effects on human and animal populations, both prescription and over-the-counter drugs must now be evaluated for safety, efficacy, abuse liability, and therapeutic effects. First their metabolic effects must be determined in animal models. Clinical trials in healthy human volunteers take place after pharmacokinetic studies in animals. Trials are divided into four phases, three of which take place before licensing and one of which occurs once patients are prescribed the drug by participating physicians. The large-scale clinical trials system in place in the United States since the 1960s is complex, lengthy, and expensive. Both the FDA and the National Institutes of Health (NIH) reluctantly became involved in regulating and coordinating the testing and licensure system for new drugs (Hertzman and Feltner 1997). Ethical concerns relevant to clinical trials include determinations of the capacity for informed consent of experimental human subjects; balancing rights to privacy and confidentiality with public access to information; the design and execution of double-blind, placebo-controlled studies; and how to go about occasionally halting a trial as adverse effects become clear.

Ethical questions are raised both in terms of the type of drug development, production, marketing, and distribution being promoted; and the conditions of use. Drugs play a different role depending upon whether they are administered within allopathic or homeopathic therapeutic regimes. Homeopathy involves the administration of minute dosages of drugs designed to produce symptoms in healthy persons that mimic the symptoms of the disease for which the person is being treated. Developed by Samuel Hahnemann (1755–1843), homeopathy has been the target of many conflicting claims concerning its safety and efficacy in the face of the dominant practice in western medicine, allopathic treatment, which seeks to produce conditions that are incompatible or antagonistic to the disease. Many aspects of complementary and alternative medicine (CAM) are now being explored through large-scale clinical trials, since tremendously high percentages of U.S. patients now seek alternative practitioners in conjunction with allopathic practitioners, leading to a vast and less regulated market for so-called nutraceuticals, off-label use of pharmaceutical drugs, and herbal remedies untested by scientific regimes.

One of the major events in twentieth century history of drugs was the coincidence between the trend toward deinstitutionalization of mental hospitals that began in the 1940s with the psychopharmacological revolution that occurred upon introduction of a major tranquilizer, chlorpromazine (CPZ, marketed as Thorazine in the United States and Largactil in Europe), in the 1950s. This was followed by the first popular use of pep pills (amphetamines) and the mass marketing of minor tranquilizers such as Miltown in the late 1950s, which brought advances in psychopharmacology to popular attention (Smith 1991). Since that time periodic concerns have surfaced as to the social value of drugs used for performance enhancement or marketed widely as lifestyle drugs in ways that have changed the meaning of *medical use*. Pfizer Pharmaceutical's introduction of Viagra, a drug used to temporarily correct erectile dysfunction and targeted toward relatively affluent male consumers, brought to light disparities in insurance coverage of lifestyle drugs such as the lack of insurance coverage for female contraceptives, whose coverage has been restricted due to the abortion controversy. This *Viagra gap* illustrates one of the persistently troubling ethical issues in the domain of drugs, namely that of research and development targeted toward developing or widening markets among the affluent through lifestyle or look-alike drugs that are simply a means for drug companies to gain market share, compared to the relative lack of attention to drugs for treating orphan diseases that seriously affect small numbers of individuals, or those diseases—such as malaria or schistosomiasis—that mainly affect individuals in the developing world.

While the FDA is often regarded as an agency that largely serves the needs of the pharmaceutical industry, three major reproductive health controversies of the 1960s and 1970s propelled the FDA into taking a somewhat proactive regulatory role. These were the development of hormonal methods of contraception; widespread prescription of Thalidomide to pregnant women in Europe, while the drug was still experimental in the United States when it was demonstrated to cause severe birth defects; and prescription of diethylstilbestrol (DES), which caused *in utero* defects and increased rates of cancer in the children of women who took it. These controversies arose simultaneously with interrelated social movements that targeted health and physician-patient relationships, including the patients' rights movement, the consumer rights movement, the women's health movement, and, later, the HIV/AIDS movement. These social movements sought to limit the use of certain classes of therapies such as electroshock (ECT) and drugs such as the major tranquilizers or benzodiazepines (Valium) among certain populations. They also agitated for increased inclusion in clinical trials, earlier and more democratic access to experimental drugs, and expanded patients' rights including privacy, confidentiality, and informed consent.

Pharmacogenomics

Pharmacogenomics is the attempt to identify individual, genetic variation in drug response—metabolism, transport, and receptors—and to extend those findings to population genetics through a variety of information and visualization technologies. Pharmacogenomics promises individually tailored medications that would likely decrease adverse drug reactions, currently the fourth leading cause of death in the United States.

Projects in this research arena raise novel ethical and legal issues related to the creation of sample repositories or banks of genetic materials that would enable hypothesis-driven research on statistically significant differences in the phenotypes of human subjects. Such research could help establish the safety, efficacy, and compatibility of certain classes of drugs for particular individuals or populations; and could be used to create a complex set of biomarkers that describe the particular complement of different neuroreceptors that an individual has that may make him or her more or less responsive to a range of addictive substances (tobacco, opiates, and others) or prescribed medications. Pharmacogenetic databanking is potentially useful for avoiding adverse consequences but could also create a rationale for genetic and health-related discrimination. As with previous advances in the field of pharmacology, pharmacogenetics presents a double-edged sword, and its meaning and ethical value will be determined by the social contexts in which it is deployed.

NANCY D. CAMPBELL

SEE ALSO *Bioethics; Clinical Trials; Complementary and Alternative Medicine; DES (Diethylstilbestrol) Children; Food and Drug Regulatory Agencies; HIV/AIDS; Medical Ethics; Sports.*

BIBLIOGRAPHY

Acker, Caroline. (2002). *Creating the American Junkie: Addiction Research in the Classic Era of Narcotic Control*. Baltimore, MD: Johns Hopkins University Press. Thorough historical study of addiction research up to the 1940s, including the ongoing search for a non-addicting analgesic.

Aldridge, Susan. (1998). *Magic Molecules: How Drugs Work*. Cambridge, England: Cambridge University Press. Highly accessible general introduction to drugs.

Balance, Robert, Janos Pogany, and Helmut Forstner. (1992). *The World's Pharmaceutical Industries*. Brookfield, VT: Edward Elgar.

Campbell, Nancy D. (2000). *Using Women: Gender, Drug Policy, and Social Justice*. New York: Routledge. Social and cultural history of the representation of different populations of women who have used illicit drugs in the twentieth-century United States.

Courtwright, David T. (2001). *Dark Paradise: A History of Opiate Addiction in America*, enlarged edition. Cambridge, MA: Harvard University Press. Classic historical demography on opiate addiction in the United States.

Cozzens, Susan E. (1989). *Social Control and Multiple Discovery in Science: The Opiate Receptor Case*. Albany: State University of New York Press.

Dorland's Medical Dictionary. 1980. Philadelphia: Saunders Press.

Healy, David. (2002). *The Creation of Psychopharmacology*. Cambridge, MA: Harvard University Press.

Hertzman, Marc, M.D., and Douglas E. R. Feltner, M.D. (1997). *The Handbook of Psychopharmacology Trials: An Overview of Scientific, Political, and Ethical Concerns*. New York: New York University Press.

Liebenau, Jonathan, Gregory J. Higby, and Elaine C. Stroud, eds. (1990). *Pill Peddlers: Essays on the History of the*

Pharmaceutical Industry. Madison, WI: American Institute of the History of Pharmacy.

McAllister, William B. (2000). *Drug Diplomacy in the Twentieth Century*. New York: Routledge. Detailed diplomatic history of the global regulation of drugs.

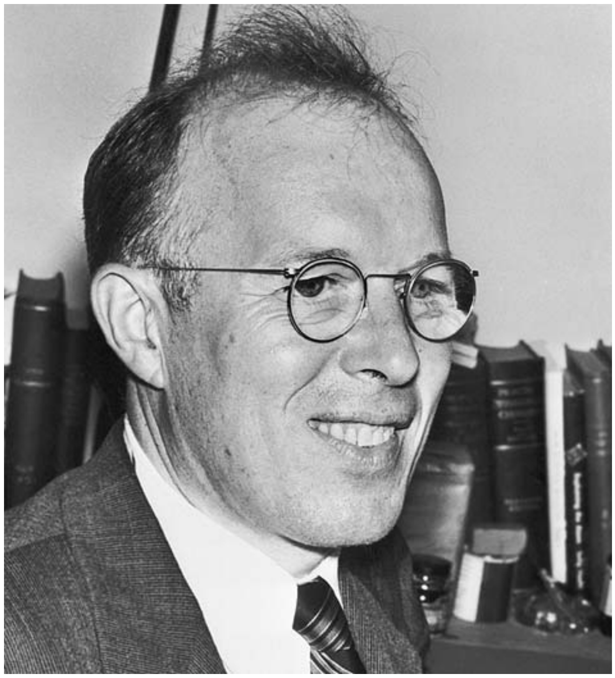
Musto, David F. (1999). *The American Disease: Origins of Narcotic Control Policy*, 3rd edition. New York: Oxford University Press. Foundational text in the field of drug policy history.

Smith, Mickey C. (1991). *A Social History of the Minor Tranquilizers*. New York: Haworth Press.

Swann, John P. (1988). *Academic Scientists and the Pharmaceutical Industry: Cooperative Research in Twentieth-century America*. Baltimore, MD: Johns Hopkins University Press.

Terry, Charles, and Mildred Pellens. (1970 [1928]). *The Opium Problem*. New York: Bureau of Social Hygiene. Reprinted by special arrangement with The American Social Health Association, Montclair, NJ: Patterson Smith. Fascinating compendium of over 4,000 nineteenth- and early twentieth-century studies on the effects of opiates.

White, William L. (1998). *Slaying the Dragon: The History of Addiction Treatment and Recovery in America*. Bloomington, IL: Lighthouse Institute. The best of very few historical works on drug treatment regimens.



René Dubos, 1901–1982. Dubos pioneered in the development of antibiotics and was an important writer on humanitarian and ecological subjects. *(© Bettmann/Corbis.)*

DUBOS, RENÉ

René Jules Dubos (1901–1982), the French-American microbiologist and Pulitzer Prize-winning author, was born in Saint-Brice-sous-Forêt, France, on February 20. At the age of twenty-three, after completing his undergraduate training in agronomy, he used the money he made from translating scientific writings to travel to the United States. There he spent the rest of his prolific career, making groundbreaking contributions to antibiotic development, tuberculosis research, and environmental philosophy. René Dubos died in New York City on his eighty-first birthday.

Dubos's early work as a translator exposed him to the research of the Russian microbiologist Sergei Winogradsky, who stressed the importance of studying soil microbes in their natural setting, not just the sterile conditions of the laboratory. As Dubos reminisced late in life, "I have been restating that idea in all forms ever since. The main intellectual attitude that has governed all aspects of my professional life has been to study things, from microbes to man, not per se but in their complex relationships" (quoted in Kostelanetz 1980, p. 195). He earned his doctorate in agricultural microbiology from Rutgers University in 1927, and soon after won a fellowship from the Rockefeller Institute for Medical Research to find a way to disarm the microbe that causes pneumonia by destroying its protective polysaccharide coating. His unconventional approach entailed collecting dozens of soil samples in search of a bacterium that could decompose the material in question. Dubos's success led to his 1939 discovery of gramicidin, the first commercially produced antibiotic, which in turn stimulated efforts by other researchers to develop the antibacterial drugs that revolutionized medicine during the mid-twentieth century.

Dubos's ecological approach enabled him to predict the development of bacterial resistance to antibiotic drugs in the early 1940s, decades before antibiotic drug failure became a global health crisis. His subsequent research on the bacterium that causes tuberculosis, which killed his first wife, sharpened his appreciation of the social determinants of the disease, and his growing conviction that controlling microbial diseases required much more than eradicating the responsible microbes. In *The Mirage of Health* (1959) and *Man Adapting* (1965), Dubos challenged the dominant paradigm of scientific medicine by emphasizing the environmental determinants of disease, and the impossibility of vanquishing infectious diseases due to the constant flux of environmental conditions. A colleague at the Rockefeller University, Walsh McDermott, later hailed Dubos as "the conscience of modern medicine."

During the late 1960s and 1970s, Dubos's long career studying the links between environment, health, and disease facilitated his transformation into "the philosopher of the earth," as the *New York Times* called him near the end of his life. Dubos won the Pulitzer Prize for his book *So Human an Animal* (1968), in which he presents a holistic critique of modern civilization:

> Most of man's problems in the modern world arise from the constant and unavoidable exposure to the stimuli of urban and industrial civilization, the varied aspects of environmental pollution, the physiological disturbances associated with sudden changes in ways of life, the estrangement from the conditions and natural cycles under which human evolution took place, the emotional trauma and the paradoxical solitude in congested cities, the monotony, boredom and compulsory leisure—in brief, all the environmental conditions that undisciplined technology creates. (Dubos 1968, p. 216–217)

In later publications, Dubos elaborated his philosophy that humans can overcome such problems by creating what he called humanized environments that meet modern physiological, emotional, and esthetic human needs. His argument that humans can improve on nature by applying ecological insights to the built environment set him apart from the prominent pessimists of the burgeoning environmental movement, attracting widespread attention. The United Nations commissioned Dubos to chair a group of experts for the landmark 1972 United Nations Conference on the Human Environment, and to coauthor its influential background report, *Only One Earth* (1972).

Dubos's experience with the environmental megaconferences of the 1970s convinced him that solving global environmental problems requires dealing with them at the regional level, with respect to their unique physical, technological, economic, and cultural contexts. His practical approach spawned the famous phrase *Think globally, act locally,* which continues to inspire environmental activists around the world. He linked the maxim with his ecological insights and ethical concerns in *The Wooing of Earth* (1980): "Global thinking and local action both require understanding of ecological systems, but ecological management can be effective only if it takes into consideration the visceral and spiritual values that link us to the earth." Therefore "ecological thinking must be supplemented by humanistic value judgments concerning the effect of our choices and actions on the quality of the relationship between humankind and earth, in the future as well as in the present" (Dubos 1980, p. 157).

To promote such ideas in the policymaking arena, in 1975 he cofounded what later became the internationally recognized René Dubos Center for Human Environments. For reasons that include his prescient warnings against the overuse of antibiotics to his humanistic perception of environmental problems, Dubos deserves a central place among the foremost twentieth-century scholars of science, technology, and ethics.

CHRISTINE KEINER

SEE ALSO *Environmental Ethics.*

BIBLIOGRAPHY

Dubos, René. (1968). *So Human an Animal.* New York: Scribner. A reissue of Dubos's Pulitzer Prize-winning 1968 analysis of technologically-induced dehumanization.

Dubos, René. (1976). "Symbiosis of the Earth and Humankind." *Science* 193: 459–462.

Dubos, René. (1980). *The Wooing of Earth.* New York: Scribner.

Eblen, Ruth A. (1990). "Preface." In *The World of René Dubos: A Collection from His Writings,* eds. Gerard Piel and Osborn Segerberg Jr. New York: Holt.

Eblen, Ruth A. (1994). "René Jules Dubos." In *The Encyclopedia of the Environment,* eds. Ruth A. Eblen and William R. Eblen. Boston: Houghton Mifflin. This reference work embodies Dubos's humanistic approach to environmental concepts.

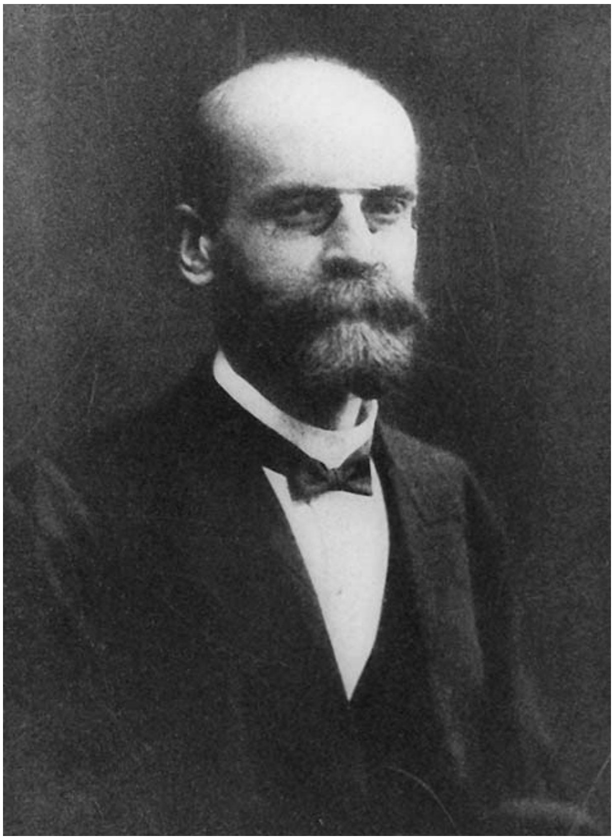
Kostelanetz, Richard. (1980). "The Five Careers of René Dubos." *Michigan Quarterly Review* 19: 194–203. A brief overview of Dubos's multifaceted career.

Moberg, Carol L. (1999). "René Dubos, A Harbinger of Microbial Resistance to Antibiotics." *Perspectives in Biology and Medicine* 42: 559–581. An analysis of Dubos's prophetic warnings of antibiotic overuse.

Piel, Gerard. (1980). "Foreword." In *The World of René Dubos: A Collection from His Writings,* eds. Gerard Piel, and Osborn Segerberg Jr. New York: Holt. A compilation of excerpts from Dubos's numerous publications regarding science, medicine, civilization, microbiology, ecology, and environmental management.

DURKHEIM, ÉMILE

Émile Durkheim (1858–1917), the son and grandson of rabbis, was born in the Alsatian town of Épinal, Vosges, France, on April 15. In 1887 he married Louise Julie Dreyfus, and the death of their son in World War I hastened Durkheim's own premature end in Paris on November 15.



Émile Durkheim, 1858–1917. Durkheim was one of the founders of 20th-century sociology. *(The Library of Congress.)*

In 1870, when Durkheim was twelve, German troops occupied his home during the Franco-Prussian War, forcing him to confront a normless, anomic (unstable) social environment and loss of collective well-being that was later to figure as a theme in his sociological research. He attended the École Normale Superieure (1879–1882), France's best teachers' college, and formed an early friendship with Jean Jaurès (1859–1914), later a leading socialist, which broadened Durkheim's academic and political interests to include philosophy and political action. In 1887 he was named professor at the University of Bordeaux, where he became the first person to teach social sciences in France, and from which he moved to the University of Paris in 1902. As a youth he had been schooled in the traditional education of male Jews, but when still young found himself attracted to Catholic mysticism, eventually dispensing with formal religion altogether. Nevertheless, a deeply religious and ethically alert sensibility shaped virtually all his mature scholarship, though skillfully recast in secular, scientific terms.

Durkheim's central sociological argument, which extends from his earliest to his final works, holds that a scientifically crafted theory of societal morality could prevent the sort of "anomie" that he thought afflicted citizens within France's Third Republic (1870–1940), and that extended as well to all rapidly industrializing nations. He treated this topic in his dissertation, *The Division of Labor in Society* (1893), a book with now almost biblical significance in sociology. Durkheim posed this question: How might morally binding norms be promulgated within a secularized and diversified society? His answer was that such norms would have to be shaped through professional groups, each of which would be responsible for guiding and monitoring the behavior of its members.

Other important works include *Suicide* (1897), which demonstrates that killing oneself is as much a sociological as a psychological event, and *The Rules of Sociological Method* (1895), which points to the "social fact" as the foundation of social research, thus separating sociology from the work of the other social sciences. The book he regarded his masterpiece, *The Elementary Forms of the Religious Life* (1912), is an exhaustive study of aboriginal religious practices compared with their modern progenies. With his nephew Marcel Mauss (1872–1950), Durkheim also cowrote *Primitive Classification* (1903), an innovative study in what came to be called "the sociology of knowledge." Highlighting as examples Australian aboriginals, the Zuni, Sioux, and Chinese, the two authors showed that the contrasting ways different societies arrange knowledge is a direct reflection of their particular forms of social organization; that is, they concluded, mental categories repeat social configurations. This was a direct attack on conventional epistemology, which held that all humans comprehend and analyze their environment in roughly the same way.

What gives Durkheim a unique status in the living tradition of classical social theory is his ability to blend science with ethics, as part of his lifelong effort to create what he called a "science of morality." To twenty-first-century ears this seems a quixotic venture, because science and ethical maxims have been severed one from the other (at least since Max Weber wrote "Science as a Vocation" in 1917, if not before), particularly among researchers whose principal allegiance is to scientific procedure. Yet even in his *Rules of Sociological Method* (still a key text for apprentice sociologists), he showed that identifying "social facts" is never an end in itself, but rather a realist propaedeutic (preparatory study) to understanding how norms operate in various societies, and how deviant behavior is curtailed or controlled.

In a famous essay, "The Dualism of Human Nature and Its Social Conditions," Durkheim invoked "the old formula *homo duplex*," explaining that "Far from being simple, our inner life has something that is like a double center of gravity. On the one hand is our individuality—and more particularly, our body in which it is based; on the other is everything that is in us that expresses *something other than ourselves*" (1973 [1914], p. 152; emphases added). Durkheim's deeply ambivalent relation to "pure" science originates in his divided loyalties as expressed in this essay: On one side stands the scientist looking for "laws" of social life; on the other is the ethicist and philosopher of culture, whose main goal is to identify, albeit via strictly scientific methods, the "something other" that encourages people to lay aside their natural egocentricity and embrace values that often conflict with their own best, individualized interests.

From his earliest work in *Division of Labor* and *Suicide* up through his masterly *Elementary Forms*, Durkheim always sang the praises of modern science and insisted that sociology be imbued with rigorous positivism. Yet never far away from his gaze were the "larger questions" that had troubled ethicists since Plato and Confucius, culminating in Leo Tolstoy's famous question: "What constitutes a life worth living?" To this pressing query, science has no answer, as Durkheim well knew.

In addition to his virtuosic sociological research, Durkheim also established the first scholarly journal of sociology in France, trained an entire generation of anthropologists and sociologists (many of them, along with his son, slaughtered in World War I), and wrote a posthumously published history of education in France that remains a standard work. Given all these scholarly achievements, many argue that Durkheim is indeed the father of modern sociology and the first to lay out in exact terms how the sociological viewpoint differs from that of its allied disciplines.

ALAN SICA

SEE ALSO *Communitarianism; French Perspectives; Parsons, Talcott; Professions and Professionalism; Sociological Ethics.*

BIBLIOGRAPHY

Durkheim, Émile. (1915 [1912]). *The Elementary Forms of the Religious Life*, trans. Joseph Ward Swain. London: Allen and Unwin.

Durkheim, Émile. (1933 [1893]). *The Division of Labor in Society*, trans. George Simpson. New York: Free Press.

Durkheim, Émile. (1938 [1895]). *The Rules of Sociological Method*, 8th edition, trans. Sarah A. Solovay and John H. Mueller, and ed. George E. G. Catlin. Chicago: University of Chicago Press.

Durkheim, Émile. (1951 [1897]). *Suicide*, trans. John A. Spaulding and George Simpson. Glencoe, IL: Free Press.

Durkheim, Émile. (1973 [1914]). "The Dualism of Human Nature and Its Social Conditions." In *Émile Durkheim on Morality and Society*, ed. Robert Bellah. Chicago: University of Chicago Press.

Durkheim, Émile, and Marcel Mauss. (1963 [1903]). *Primitive Classification*, trans. and ed. Rodney Needham. Chicago: University of Chicago Press.

LaCapra, Dominick. (1972). *Emile Durkheim: Sociologist and Philosopher*. Chicago: University of Chicago Press.

Lukes, Steven. (1972). *Emile Durkheim: His Life and Work*. San Francisco: Harper and Row.

Poggi, Gianfranco. (2000). *Durkheim*. New York: Oxford University Press.

INTERNET RESOURCE

Weber, Max. (1917). "Science as a Vocation." In *From Max Weber: Essays in Sociology*, ed. H. H. Gerth and C. Wright Mills. New York: Oxford University Press (1946). Available from http://www2.pfeiffer.edu/~lridener/DSS/Weber/scivoc.html.

DUTCH PERSPECTIVES

In the Netherlands, various styles of applied ethical research can be distinguished. They have resulted in "best practices" that formerly regarded each other as competitive, but tend to see themselves as complementary in the early twenty-first century.

Two Preliminary Observations

A first general observation is historical. Twenty centuries ago, the border of the Roman Empire followed the Rhine, thus dissecting the area that later was to become the Netherlands into a southern part (inside the empire) and a northern and western part (outside the empire). This division has written itself into the Dutch cultural landscape in an astonishingly obstinate manner. It is still noticeable today, in terms of dialect, culture, manners, ethics, and religion. Whereas before the onset of secularization the south was predominantly Catholic (that is, oriented toward "Rome"), the north and west were predominantly Protestant.

This difference in cultural geography continues to be visible in the domain of ethics. In the south, ethical research tends to be oriented toward and influenced by

Continental (notably German and French) intellectual developments and trends. Thus, ethicists from this area are influenced mainly by hermeneutical or phenomenological approaches. Ethicists from the northern and western part, however, are more likely to be influenced by analytical approaches and debates. They often subscribe to theories and views that dominate the Anglo-American spheres of influence. Although the difference has become less obvious than it was in the 1980s, the two ethical profiles remain distinguishable.

A second observation has to do with the international status of Dutch ethics. It has been said that Dutch philosophy is the philosophy of the country that possesses the largest harbor in the world, namely Rotterdam (Nauta 1990). And because ethics is a special discipline within the broader field of philosophy, this goes for ethics as well. What does it mean? One might say that Dutch ethicists are better at importing and exporting than at producing philosophy. In terms of style, the Dutch are neither as "profound" as the Germans nor as sensitive to new trends as the French. They do have a special talent, however, for intellectual transfer. Their mastery of international scholarly languages such as English, German, and French also plays a role here. Dutch philosophers often serve as intellectual intermediaries. This is, of course, a generalization, but a systematic review of academic performance will show that as a rule the Dutch tend to focus on assessing, processing and connecting ideas rather than on originating them.

Three Styles of Ethical Research

Three styles of ethical research exist in the Netherlands. They start from different understandings of what ethics is.

(1) ethics = analyzing and solving moral problems

(2) ethics = intellectual reflection

(3) ethics = moral conflict management

According to the first option, which is based on a more or less Anglo-American approach, an ethicist is someone who analyzes moral problems and formulates possible solutions, usually by applying a set of moral principles (ethical input) to problem cases (solutions as output).

The second option reflects a more hermeneutical or Continental way of thinking. An ethicist is seen as someone who tries to interpret certain forms of moral discourse by situating them in a broader cultural and historical perspective. The focus is on understanding, rather than on solving, problems. The philosophical ethicist works toward a "diagnosis" rather than a "solution."

The third option entails a more pragmatic approach. The ethicist identifies stakeholders and value perspectives, and works toward consensus formation, based on stakeholder participation, by means of interviews, workshops, and similar techniques.

These three ways of doing ethical research entail different views on the relationship between expert knowledge and public knowledge. According to the first option, ethicists are experts, perhaps even "ethical engineers" (Van Willigenburg 1991). They have learned to analyze moral problems in a professional manner. Consistency is important, even if this means that ethicists distance themselves from common intuitions and conventional morality.

According to the second option, however, the ethicist's expert knowledge is knowledge of moral traditions, of types of discourse, or of fundamental cultural attitudes that are noticeable in the ways in which moral debates evolve and problem cases are being framed and presented (Van Tongeren 1994). The ethicist relies on erudition rather than analytical tools. The attention is directed toward fundamental issues rather than concrete problems. In other words, the problem cases at hand are regarded as exemplifications of broader, cultural issues.

According to the third option, it is not the ethicist's job to add new insights, but rather to build on the knowledge, values, and intuitions of the stakeholders involved. Rather than performing desk research, the ethicist enters into dialogue with others, inviting them to articulate and clarify their (tacit) views. The ethicist's expertise is of a pragmatic and intermediary nature (Keulartz et al. 2002). Ethicists have at their disposal a toolbox for moral deliberation and moral conflict management. Their input in the decision-making process does not come from ethics as such, but from the views and experiences of stakeholders themselves.

Through the late 1990s, the first style of doing ethical research dominated (the public image of) institutionalized ethics in the Netherlands, whereas the second style was more prevalent in academic circles. Since the early 2000s, the pragmatist approach is gaining ground. In fact, Dutch ethicists tend to be flexible when it comes to method in the early twenty-first century. To some extent, they are willing and able to use all three models, depending on context. Congenial with the pragmatist turn, but not exactly identical with it, is the *empirical turn* in ethics. More and more often, research in applied ethics involves the collection of empirical data and the use of tools borrowed from the social sciences such as interviews, questionnaires, and participant observation.

Ethics of Science and Technology: Examples

In the Netherlands, as elsewhere, moral disputes tend to arise in response to technological changes. Initially, the growing interest in ethical research was associated with medical or clinical ethics. An interesting case is the famous Dutch euthanasia debate that started around 1970 in response to the dramatic increase of medical technology and therefore of treatment options with which many lives, that previously would have had no chance of survival, could now be saved, or at least prolonged. The debate was triggered by Jan Hendrik van den Berg (1978), a physician who was also trained as a phenomenologist, and therefore a representative of Continental philosophy. Moral problems involved in end-of-life decision were interpreted as indications that something was fundamentally wrong with current views and attitudes toward life and death *as such*. Soon, however, the debate was taken over by applied ethicists who subscribed to an analytical approach. On the basis of the principle of autonomy, they argued in favor of the patients' right to refuse treatment or even to request that physicians end their lives. Eventually, the ethical debate over euthanasia shifted toward a more pragmatic and empirical approach: How are end-of-life decisions actually taken, and by whom, how often, and on what grounds? Last but not least, what kind of technical contrivances co-influence decisions of this type?

During the 1990s, the attention of professional ethicists in the Netherlands drifted away from euthanasia. Reproductive technologies, biotechnology, genetic modification of organisms, and animal research became important items of concern. Even more so than in the case of medical ethics, moral disputes arose in response to technological change. These debates thus exemplified the ways in which technological developments influence ethical controversies. After the introduction of recombinant DNA techniques in the 1970s and 1980s, the genetically modified research animal became an important object of research, and knockout experiments (deleting genes) became an important research tool.

This new technology had a major impact on ethical debates concerning laboratory animals. It caused the focus of the debate to shift away from traditional concerns (animal suffering and animal welfare) to issues involved in the recently acquired power of biologists to modify—to *change*—their laboratory animals, and to adapt them to research requirements. Concepts such as integrity and intrinsic value, borrowed from medical and environmental ethics, respectively, were used to articulate new moral concerns over genetic engineering.

Furthermore, the three styles of ethical research distinguished above are recognizable here as well, although demarcations are somewhat less rigid than before. The majority of contributions to animal ethics and biotechnology ethics since 2000 adhere to a more or less analytical approach. Their usual aim is to enrich a traditional, consequentionalist view (focusing on animal welfare and animal suffering) with deontological elements, using concepts such as integrity and intrinsic value (Heeger and Brom 2001). A more Continental and phenomenological approach, however, is represented here as well. Its aim is to elucidate the different ways in which animals are perceived. Thus, the scientific understanding of animalhood is confronted with life-world perspectives and artistic perspectives. In other words, this line of research studies the various conditions under which relationships with animals (notably in the context of research practices) evolve (Zwart 2000). Finally, promising examples of empirical and pragmatic approaches have begun to enter the animal ethics scene as well.

Early Twenty-First-Century Developments

Genomics, the most recent chapter in the history of the life sciences and their technological applications, is what occupies the majority of ethicists in the Netherlands in the early twenty-first century. The basic trend is toward establishing large, multidisciplinary programs in the domain of ethical, legal, and social issues (ELSI) research. In the context of such programs, ethicists (of various styles and backgrounds) collaborate, not only together, but also with experts coming from various other disciplines, such as the social sciences, psychology, cultural studies, communications, economics, and law. This trend is sometimes referred to as the "elsification" of science and technology.

During the 1990s, the focus of applied ethicists tended to be on the individual or institutional level (the micro- and meso-level) rather than on the societal (or macro-) level. The empirical turn in ethics likewise tended to restrict itself to research on a relatively small scale. But in the early 2000s it became clear that the most challenging issues involved in so-called "enabling technologies," such as genomics, will present themselves on a much broader, cultural, and societal scale. Rather that providing information on discrete monogenetic defects (relevant for specific target groups), for example, genomics is expected to inundate the public realm with genetic information on multifactorial health risks that will be relevant for virtually everybody.

Although the ethics of science and technology in the Netherlands tends to focus on the life sciences and biotechnology, and on genomics in particular, this is but one example of "enabling technologies" that are emerging in research laboratories in the early twenty-first century. Other technologies, notably Information and Communication Technologies (ICT) and nanotechnology, are items of concern as well (Van den Hoven 1999; De Mul 1999). They are regarded as enabling technologies in the sense that they will give birth to a wide variety of applications. As ethical debates tend to reflect technological developments, the agenda of ethics will no doubt continue to orient itself toward these three major scientific and technological breakthroughs of the past and coming decades.

Genomics, ICT and nanotechnologies will give birth to a wide variety of new and yet unanswered questions. How will new technologies in these fields change existing roles and responsibilities of professionals and citizens? How can the knowledge and information that is generated in these fields be evaluated and used; how can abuse be prevented? In answering these questions, ethicists will find themselves no longer alone, but in the company of (in particular) scholars from Science and Technology Studies (STS) and from the Philosophy of Technology (who often are members of the STS community in a broader sense).

STS scholars study the ways in which science and technology are intertwined (in terms of content and organization, but also socially) with the development of modern societies and cultures. Science and technology are regarded not as the producers or influencers of society and culture, but both science and technology on the one hand and society and culture on the other are seen as interacting with one another and as *co-producing* one another. While STS formerly focused on the deconstruction of epistemological claims, thereby underpinning the idea that there are different ways to perceive nature or reality, the field in the early 2000s tends to move towards a more normative and hence ethically oriented approach. Constructive Technology Assessment (CTA) for example, geared towards the "management of technology in society," aims at early feedback and learning cycles in the development of new technologies, particularly with respect to the societal use and entrenchment of new technologies (Rip et al. 1995, Schot et al. 1997).

The ambition of STS scholars to put on the agenda the political question "how to help shape the technological culture we live in" has influenced the landscape of STS into a more normative direction (Bijker 1995 among others). Large technological "projects," and the transformations they are expected to induce, such as nanotechnology, genomics, and ICT, thus have increased the interest for ethical and normative questions from different fields and disciplines. Ethical questions have become the domain of an interdisciplinary research field. Put differently, "elsification" (entrenchment of ethical, legal and social projects in large technological programs) has enhanced new forms of ethical research, characterized by interdisciplinary collaboration, proximity to scientific consortia, and sensitivity to social change. The development of new interdisciplinary modes of doing ethical research also gives rise to new networks and institutions. Interesting examples are Nanonet and the establishment of the Centre for Society and Genomics (CSG) at the University of Nijmegen.

Institutionalization

It is to be expected that in the near future collaboration between philosophers and ethicists on the one hand and social science researchers on the other will continue to increase. At the moment, they still can be seen as separate domains. Research in the Netherlands is organized on the basis of research schools that assemble experts from various universities into common programs. With regard to research into the societal aspects of science and technology, two research schools are particularly relevant: the Onderzoekschool Ethiek (the Netherlands School for Research in Practical Philosophy) and the Onderzoeksschool Wetenschap, Technologie en Moderne Cultuur (the Netherlands Graduate Research School Science, Technology, and Modern Culture, WTMC). Both research schools were established in 1994. In the Netherlands School for Research in Practical Philosophy the analytical style is dominant, but pragmatic and Continental approaches are represented as well. Methodology and epistemology of ethics have been important issues from the very outset, and the "empirical turn in ethics" is a major item of concern. The Netherlands Graduate Research School Science, Technology, and Modern Culture brings together researchers from the interdisciplinary field of science and technology studies (STS). In the Netherlands, STS emerged in the late 1960s as a result of new interactions between history, philosophy and sociology of science. The focus of WTMC is on the interrelatedness and interpenetration of science, technology, and society. The membership list of WTMC indicates that the school recruits scholars from the sociology of science, history of technology, philosophy of technology, philosophy of science, arts and culture, psychology, political sciences, science dynamics and policy and innovation studies.

Although demarcations in terms of style have become less obvious than in the past, the Netherlands School for Research in Practical Philosophy is dominated by ethicists who come from an analytical background, although Continental and phenomenological approaches to technology are present as well. The Netherlands Graduate Research School Science, Technology, and Modern Culture is oriented more toward pragmatism and constructionism. Yet, as was already noticed, within the Dutch STS community, interest in normative (ethical) issues has increased in the past five years. See for example Verbeek (2003), who analyzes the ways in which artifacts influence human experience, while new technologies are interpreted as material answers to ethical questions.

The Future

Until recently, bioethics and the philosophy of technology were seen as separate fields. As has been indicated, this will no longer hold in the near future. Bioethics increasingly will have to regard itself as an ethics of science and technology. A broader understanding of the coevolution of science and technology thus will have to become an integral part of bioethics. The emphasis (within applied ethics and bioethics) on the micro-level will shift towards the development of science and technology *at large* and towards ethical and philosophical questions concerning the role of science and technology in modern societies. The focus on (and the interest for) the moral aspects of (for example) the interaction between physicians and patients, or between laboratory researchers and laboratory animals, will be increasingly overshadowed by the need to address the social dynamics of technological change. These broader issue will dominate the future agenda of bioethics, applied ethics and—as it often does already—the philosophy of technology.

Ethics can be expected to broaden its perspective and become an increasingly interdisciplinary endeavor. And while ethicists will "discover" the importance of the broader social and cultural impact of technological innovations, social scientists already working on these questions will increasingly acknowledge the importance of the normative issues they tended to avoid in the past.

HUB ZWART
ANNEMIEK NELIS

SEE ALSO *Applied Ethics; Engineering Ethics; European Perspectives.*

BIBLIOGRAPHY

Bijker W. E. (1995). *Democratisering van de Technologische Cultuur Inaugurale rede* [Democratisation of technological culture: inaugural lecture]. Maastricht: University of Maastricht.

De Mul, Jos. (1999). "The Informatization of the Worldview." *Information, Communication, and Society* 2(1): 69–94.

Heeger, Robert, and Frans Brom. (2001). "Intrinsic Value and Direct Duties: From Animal Ethics towards Environmental Ethics." *Journal of Agricultural and Environmental Ethics* 13(1): 241–252.

Keulartz, Jozef; Michiel Korthals; Maartje Schermer; and Tsjalling Swierstra, eds. (2002). *Pragmatist Ethics for a Technological Culture*. Dordrecht, Netherlands: Kluwer Academic.

Nauta, Lolle. (1990). "De subcultuur van de wijsbegeerte: Een privé-geschiedenis van de filosofie" [The subculture of philosophy: a private history of philosophy]. *Krisis* 38: 5–19.

Rip, Arie; Thomas Misa; and Johan Schot, eds. (1995). *Managing Technologies in Society: The Approach of Constructive Technology Assessment*. London: Printer Publishers.

Schot, Johan and Arie Rip. (1997). "The past and Future of Constructive Technology Assessment. *Technological Forecasting and Social Change* 54(1997): 251–268.

Van den Berg, Jan Hendrik. (1978). *Medical Power and Medical Ethics*. New York: Norton. Originally published in Dutch, 1969.

Van den Hoven, M. J. (1999). "Ethics, Social Epistemics, Electronic Communication, and Scientific Research." *European Review* 7(3): 341–349.

Van Tongeren, Paul. (1994). "Moral Philosophy as a Hermeneutics of Moral Experience." *International Philosophical Quarterly* 34(2): 199–214.

Van Willigenburg, Theo. (1991). *Inside the Ethical Expert: Problem Solving in Applied Ethics*. Kampen, Netherlands: Kok Pharos.

Verbeek, Peter-Paul. (2003). *De daadkracht der dingen* [The activity of things]. Amsterdam: Boom.

Zwart, Hub. (2000). "The Birth of a Research Animal: Ibsen's *The Wild Duck* and the Origin of a New Animal Science." *Environmental Values* 9(1): 91–108.

DYING

SEE *Death and Dying.*

DYSTOPIA

SEE *Utopia and Dystopia.*

E

EARTH

In science and philosophy earth (German *Erde,* Greek *ge*) can refer to one in a set of primordial material elements (earth, air, fire, and water, for the Greeks; wood, fire, earth, metal, water, for the Chinese) and to the physical body on which humankind lives. As physical home, the Earth serves as the reflective horizon or framework for human self-awareness and as a contingent unity among the array of individual entities they encounter. The Earth, defined by an elemental earthiness of rock and soil, is that which grounds the identity of humans in both physical and psychological senses, independent of wherever they may venture in information networks or outer space, while serving as a fund of resources available for exploitation. The tensions between these various approaches are imaged in the diagrammatic icon of the atom and the photo of the blue planet taken from space: matter that is mostly space and a life-giving sphere that appears more water than rock and calls perhaps for technological management.

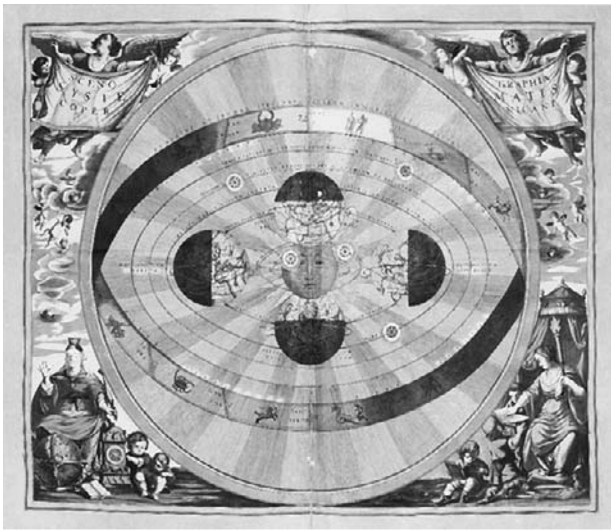
Earth Science and Engineering

As soil and matter, earth has become a distinctive object for science and technology. The material out of which all things are made has itself become subject to chemical processing, synthesis, and nuclear engineering. The scientific study of matter existing independent of humans has expanded to examining those new forms of matter intentionally and unintentionally designed by humans and the interactions between the two, especially insofar as they may impact on humans themselves. As a planet the Earth is a body in space with a stable orbit at a distance from the sun suitable for the origin and evolution of life. During its 4.56 billion years the Earth has given rise to an abundance of organisms, first in the sea, and then diversifying and evolving to occupy land and air. As recipient of heat energy from both the sun and its own core, the Earth is a site of dynamic terrestrial behavior. The seven major tectonic plates comprising its rocky outer crust diverge and then compensate through convergence; its land masses, ocean basins, islands, and other prominent features such as volcanoes, mountains, plains, and valleys have gone through continual development—producing new materials essential of life and humans. Hominids appeared on the Earth 7 million years ago and Homo sapiens about 200,000 years ago. Humans began to till the Earth about 10,000 years ago.

This early-twenty-first-century perspective on earth and the Earth sees them as dynamic complexities inviting examination and provoking manipulation. Especially with regard to the Earth, it is now perceived as a nexus of interactions between the solar system and its own atomic and subatomic foundations, as well as of exchanges between its own landmasses, oceans, atmosphere, and living organisms. Through earth system science these have in turn become, because of human technological powers and their commercial development, also subject to speculative engineering management. Earth system science is complemented by the possibilities of earth systems engineering and thus challenged to reflect ethically on both ends and means.

Philosophies of the Earth

The Earth has throughout human history been a focus of philosophizing, central to ethics, and a framework for self-understanding. For the Greeks, the Earth was implicated



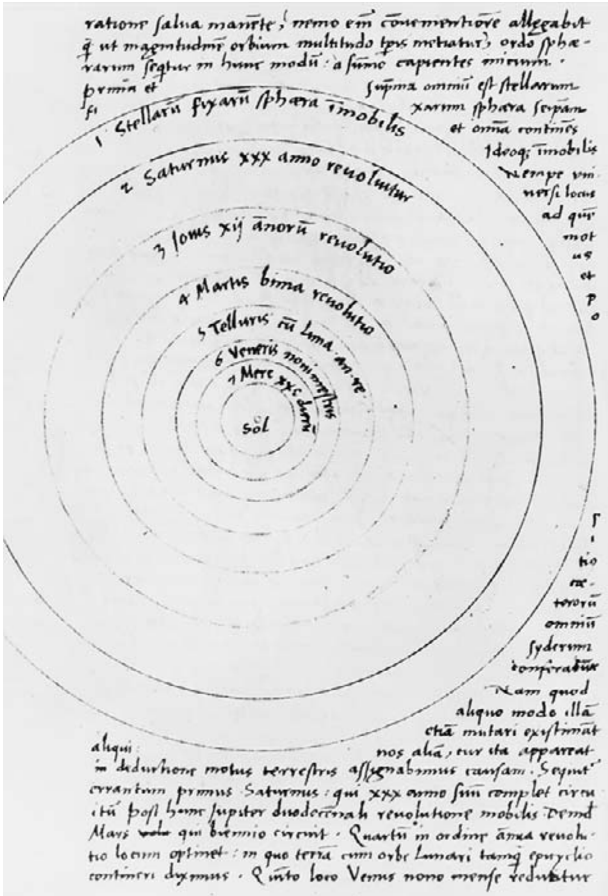
A print by Andea Cellario entitled "Harmonia Macrocosmica," showing the Ptolemaic system. Proposed by Claudius Ptolemy in the 2nd century A.D., the system postulated that the earth was at the center of the universe, and was accepted for more than 1000 years. *(© Enzo & Paolo Ragazzini/Corbis.)*

in their cosmology not only as planet and home of humanity, as focus of the gods who lived above its plane, and in relation to the heavens; its core constituent, earth, was also one of the four elements, earth, water, air, and fire. The Earth itself was a compound of the four elements. For the Chinese, the earth and heaven are the two forces responsible for engineering and completing nature and all its aspects. Earth and heaven also work together to create the five Chinese elements: wood, fire, earth, metal, and water. As an element, the Earth is located at the center and is the cauldron, with the other four elements located in the four outer directions, east, west, north and south. Earth is also the element of the "naked" animal, the human, of the actions is representative of "thought." The element earth is also associated with the sense of touch, the sound of singing, the organ of the spleen, and the virtue of good faith. There have been two related controversies about the place of the Earth within cosmological, metaphysical, and ethical visions: whether the Earth is the center of a given scheme of existence or is only an element in a vaster cosmos, and whether the earth is a site of corruption at a distance from a purer realm or is a unique locus of corporeal and spiritual development.

Plato approaches both issues in his atypical dialogue, the *Timaeus*. He describes an original Demiurge who takes the elements of earth, fire, air, and water and "out of such elements which are four in number, the body of the world was created, and it was harmonized by proportion, and therefore has the spirit of friendship; and having been reconciled to itself, it was indissoluble by the hand of any other than the framer" (33, c). This picture of the Earth as a model of balance, harmony, and fairness is complemented by a *world soul* infusing the world with a vitality and rationality of fair proportion: "The world became a living creature truly endowed with soul and intelligence by the providence of god" (30, c). The Earth as an entity in the cosmos is described as located at the center and surrounded by the moon, the sun, and five planets in circular orbits. This picture from the *Timaeus* is opposed by another from the *Phaedo*. There Plato writes of the "earth and the stones and all the places [as] corrupted and corroded, as things in the sea are by brine so that nothing worth mention grows in the sea, and there is nothing perfect there, one might say, but caves and sand and infinite mud and slime wherever there is any earth, things worth nothing" (110, b). He condemns the passions and senses for "nailing" people to the Earth that, by its attractive power, can "drunkenly" estrange human souls from their true home in the aether beyond (83, d). His emphasis on the immaterial nature of the soul and its kinship with the intelligible structure underlying reality leads to a condemnation of the earthly as tempting snare.

Aristotle, by contrast, observes the Earth and catalogues its differences in beings—animate and inanimate—embracing "the delight we take in our senses," especially the sense of sight as indicating that "this, most of all the senses, makes us know and brings to light many differences between things" (980, a). His vision of the Earth as a nexus of beings defined by their *for sake of which*—their purpose as fully actualized—working in concert with other beings' drive to actualization, renders a grandeur to the dynamism and wholeness of the Earth and the totality of its excellences fully realized. His cosmological vision in *On the Heavens* further emphasizes this foundation status because "the earth does not move and does not lie elsewhere than at the center." Aristotle's placing of the Earth at the center of the cosmos around which the sphere of the fixed stars daily rotates, carrying with it the spheres of the sun, moon, and planets, is the authority cited by Ptolemy (85–165 C.E.) in working out his plan of the Earth in relation to the heavens.

The shift in perspective known as the Copernican Revolution began when the Polish astronomer Nicolaus Copernicus (1473–1543) wrote his *Little Commentary* (1514). He argued that there was no one center to the universe, the Earth's center is not the center of the universe, the rotation of the Earth accounts for the apparent daily rotation of the stars, and the Earth revolves in a vast space. These ideas helped inaugurate the thinking that Galileo Galilei (1564–1642) would confirm a



Page from Copernicus's *De Revolutionbus Orbium Coelestium*, showing a sun-centered solar system. This conception of the universe represented a historical shift in thinking from an earlier view in which the Earth was seen as the center of the cosmos. *(© Hulton/Archive. Reproduced by permission.)*

century later. This philosophy not only displaced the Earth from its central position in religious cosmologies, but made the planet itself into a composite of more basic materials to be analyzed and manipulated.

The Cartesian method of analysis led several European scientists in the 1860s to articulate how the basic constituents of all chemical compounds could be broken down into their simplest components. These elements, as measured and compared by their atomic weight, were arrayed in a chart, the periodic table, that both presented them sequentially (giving them an atomic number based on their atomic mass) and grouped them according to their electron configuration, which gives them similar chemical behavior such as the group of inert gases or that of alkali metals, for example. The table as presented in 1869 by the Russian chemist Dmitrii I. Mendeleev is still used with little revision other than filling in spaces left blank for predicted new elements.

Earths and Ethics

The approach to earth as a composite or collection of discrete units has informed one dominant modern philosophical perspective. Seen in terms of external relations among material constituents, this perspective tends toward a utilitarian approach to ethical problems. If the greatest number of people benefit from some alteration or use of an environment, or if some part of the environment which occurs naturally can be functionally replaced through technological advance, then utilitarianism allows for these alterations of the earth, even if they might involve a diminution in its diversity or degradations in its ecological viability. This approach has nevertheless promoted the rights of excluded social groups in arguments for environmental justice, as well as suggested that animals have rights as part of the earth (Singer 1990).

A contrasting philosophical perspective contends that the Earth has a distinct holistic identity, perhaps inseparably intertwined with the collective identity of humanity. Explorations of this option often rely on James Lovelock's *Gaia: A New Look at Life on Earth* (1979), in which he posited the Earth is an evolving, self-regulating organism. In this view, the planet through its temperature, gaseous constituents, minerals, acidity, and many other factors maintains a homeostasis by active feedback processes operating in the biota. Other philosophical views, while not seeing the planet itself as a living being, do envision human identity as internally related to aspects of the earth in such a way that these relationships themselves constitute the identity of both, such as in the work of Arne Ness, Dave Abram, Glen Mazis, or Freya Matthews. From such a perspective a utilitarian ethics fails to adequately safeguard either the Earth or humanity and all those parts of the biosphere due respect for their intrinsic work.

Returning to the question of the Earth as the horizon for humanity's sense of meaning and purpose, one path in philosophy is that first proposed by Friedrich Nietzsche in *Thus Spoke Zarathustra* (1883) and its claim that the nihilism of modern culture can only be undercut by a reevaluation of values and a reidentification of humanity as no disembodied spirit but as an animal of passion, body, sensuality, *and* reason—whose greatest challenge is to create value and meaning while obeying the injunction to "remain faithful to the earth." Edmund Husserl called the Earth the *foundation* [*Boden*] of the sense of being human and likened the planet to an ark that would always be with humanity as its abiding sense of identity no matter where humanity ventured.

For Martin Heidegger, humans open up a horizon for meaning and purpose through the way that art and other institutions open "the strife between earth and world," as he articulated in "the Origin of the Work of Art." The artist, like other creators, must initiate a dynamic struggle between the context of meaning and value, which makes up the "world" of various epochs and cultures with the opacity and resistance of the sheer materiality of the earth. The earth both anchors and occludes this birth of meaning, so it is literally "grounded" and yet never fully fathomable, but suggestive. In his analysis of the elements fire, water, air, and earth, Gaston Bachelard saw the Earth as the dimension which gives humanity a *rootedness,* and a sense of infinite depth, as well as a resistance against which meaning is forged in action. The resistance of the earth is the "partner of the will." Humans are motivated to create and shape in response to the earth. Differing visions and temperaments respond to the continuum of earth in its span from hardness to softness. Humanity is motivated to forge the earth into creations as well as struggle against earth's gravity towards flight.

Increasingly, too, there is a growing interchange of Western philosophy with global philosophical perspectives that suggests the inseparability of humanity and earth. These ideas include the Buddhist emphasis on the ontological interdependence of all living and nonliving beings expressed through the concept of "emptiness," which might be better evoked as the relativity among all beings, as well as the depiction of the Buddha's original inspiration to seek enlightenment after shedding tears at seeing the worms and insects cut up by the plows making furrows in the fields with the same grief he would have had for the death of his family. There is the Daoist sense of *nonacting* [Wu wei] in which the beings of the Earth act through humans or as the Way [Dao] itself is the dynamic interplay of the entities of the Earth—"the ten thousand things"—as well as the Earth itself as a larger field of energy. Within North America, there is the Native American sense that all beings are part of Mother Earth or the Great Spirit, living on *turtle island,* the community of two-legged, four-legged, and all other beings of the four directions.

A challenge ahead is whether these philosophical perspectives can integrated with earth system science and engineering at the micro and macro scales in which they are now being practiced in order to give some basis for ethical decision making and a coherent perspective.

GLEN A. MAZIS

SEE ALSO *Air; Earth Systems Engineering and Management; Environmental Ethics; Fire; Gaia; Green Ideology; Nature; Water; Wilderness.*

BIBLIOGRAPHY

Abram, Dave. (1996). *The Spell of the Sensuous*. New York: Random House.

Aristotle. (1941). *The Basic Works of Aristotle*. New York: Random House.

Bachelard, Gaston (2002). *Earth and Reveries of Will.* Dallas: Dallas Institute.

Connelly, Dianne M. (1994). *Traditional Acupuncture: The Law of the Five Elements*. Columbia: Traditional Acupuncture Institute.

Feng, Gia-Fu, and Jane English. (1972). *Tao Te Ching*. New York: Alfred A. Knopf.

Heidegger, Martin. (1971). *Poetry, Language, Thought*. New York: Harper and Row.

Luhr, James F. (2003). *Earth*. New York: DK Publishing.

Matthews, Freya. (2005). *Rehabilitating Reality*. Albany: State University of New York Press.

Mazis, Glen A. (2002). *Earthbodies*. Albany: State University of New York Press.

Naess, Arne. (1989). *Ecology, Community and Lifestyle*. Cambridge: Cambridge University Press.

Plato. (1961). *The Collected Dialogues of Plato,* ed. Edith Hamilton and Huntington Cairns. Princeton: Princeton University Press.

Singer, Peter. (1990 [1975]). *Animal Liberation: A New Ethics for Our Treatment of Animals*, 2nd edition. New York: New York Review.

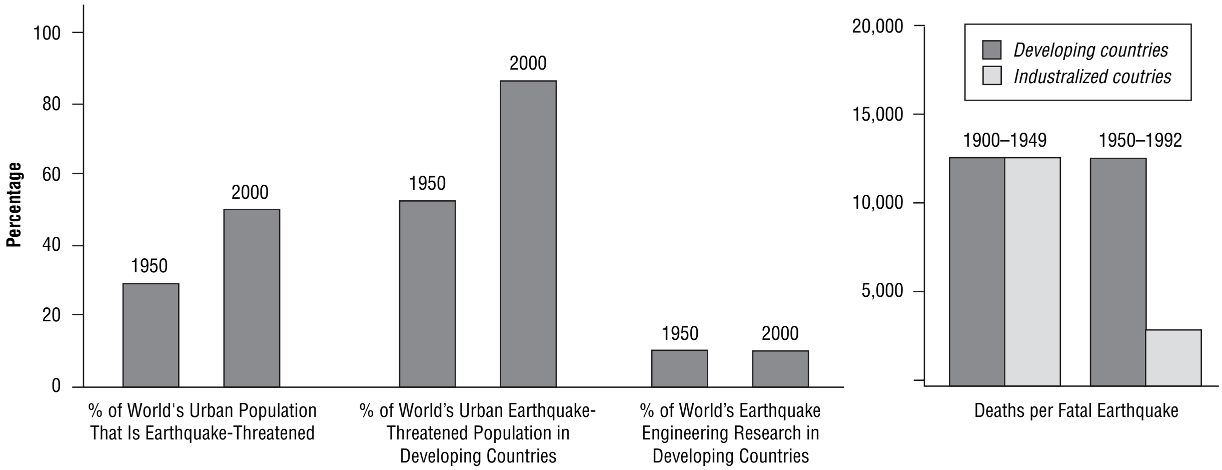
Ward, Peter, and Donald Brownlee. (2003). *Rare Earth: Why Complex Life is Uncommon in the Universe*. New York: Copernicus Books.

EARTHQUAKE ENGINEERING

Earthquake engineering is the collective effort of earth scientists, geotechnical engineers, structural engineers, and public policymakers to provide a built environment that is safe in the event of an earthquake. A significant part of this effort and the focus here is related to structural engineering, which involves the design and construction of structures and the anchorage of nonstructural building contents. Additionally structural evaluations and targeted retrofit of existing structures can be utilized to mitigate the risk of human and economic loss from an expected maximum probabilistic earthquake at a given site due to building collapse, loss of building contents, or economic downtime. Earthquake engineering thus constitutes a case study in specific relations between science, technology, and ethics.

FIGURE 1

Impact of Earthquakes in Developing Countries vs. Industrialized Countries



SOURCE: Courtesy of GeoHazards International, http://www.geohaz.org

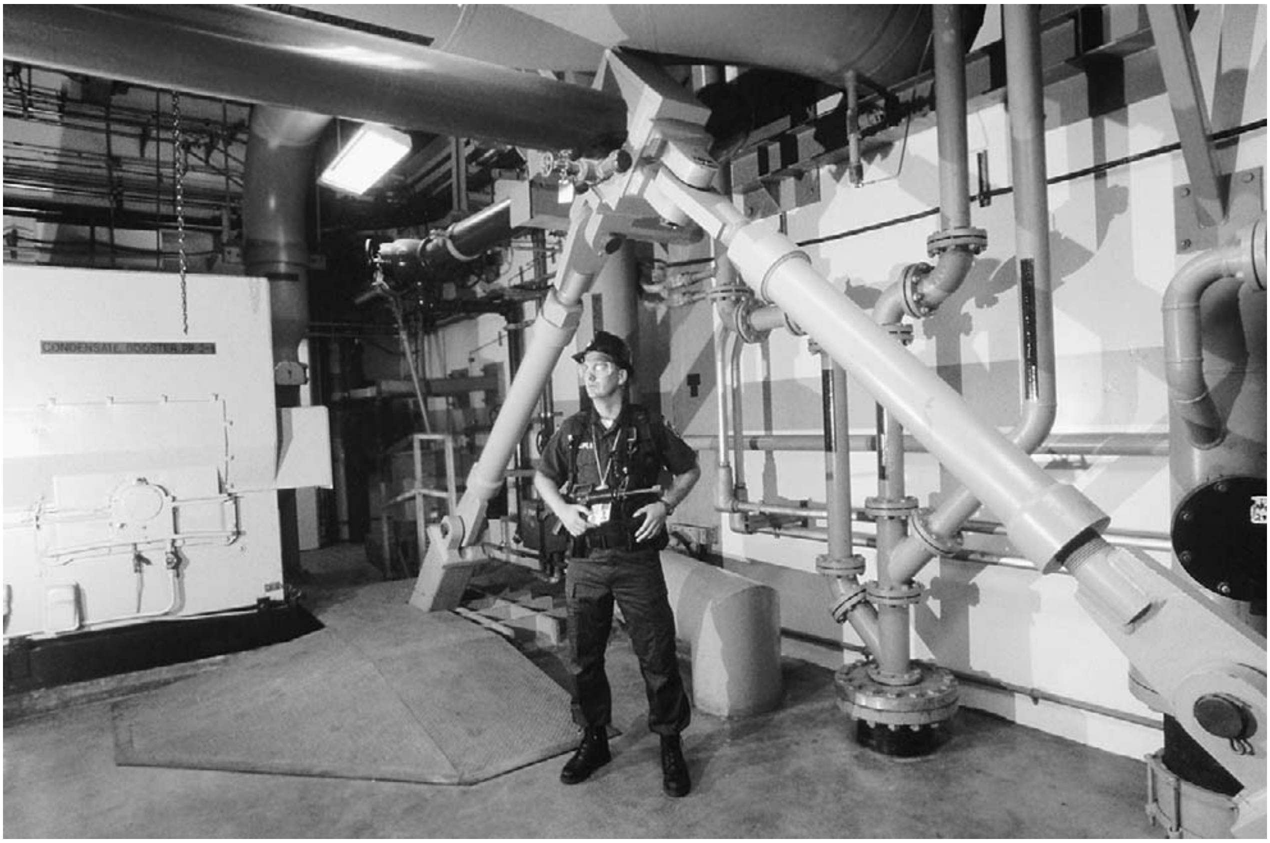
Historical and Technical Background

Interest in constructing buildings to provide greater resistance to earthquakes arose in association with the scientific and professional development of engineering, especially from the late 1800s and early 1900s, in response to large earthquake damages that occurred in Japan, Italy, and California. For instance, the earthquake near San Francisco, in April 1906 (magnitude M = 7.8 on the Richter scale, 3,000 fatalities) destroyed structures in an area 350 miles long by 70 miles wide, and was the most expensive natural disaster in U.S. history until hurricane Andrew in 1992, with $500 million in damages (equivalent to $10 billion in 2004 dollars).

In order to defend investments and continue growth, initial press reports from San Francisco minimized the quake itself and focused instead on the fires started by downed electrical wires, cracked gas lines, and broken stoves (Geschwind 2001). Yet shaken by this and related events, California has become one of the most progressive states in the public reduction of earthquake risk through engineering design. More recent major losses in August 1999 in Izmit, Turkey (M = 7.6, 17,000 fatalities); January 2001 in Gujarat, India (M = 7.7, 20,000 fatalities); and December 2003 in Bam, Iran (M = 6.6, 43,000 fatalities) have promoted recognition of the need to deal systematically with earthquakes in the regions affected.

Despite the length of time since public attention was first drawn to earthquake risks, earthquake engineering remains a young science because of the relative infrequency of large quakes and the tremendous number of variables involved. Since the 1960s, earthquake-engineering development has made important progress by moving to incorporate knowledge from the pure geosciences with structural engineering, moving even toward multidisciplinary efforts to include sociology, economics, lifeline systems, and public policy (Bozorgnia et al. 2004). The scientific study of earthquakes or *seismology* is also relevant (see Bolt 1993).

Complete or partial structural collapse is the major cause of fatalities from earthquakes worldwide; earthquakes themselves seldom kill people, collapsing buildings do. Earthquake energy causes structures not sufficiently designed to resist earthquakes to move laterally. At this point, a building may lose its load carrying capacity and collapse under its own weight. Portions of buildings (such as roof parapet walls) or the interior nonstructural contents (refrigerators, bookshelves, and so on) can topple onto inhabitants inside or outside the building. Directly adjacent buildings can pound into each other, serving sometimes to stabilize each other when neighboring structures are on both sides (termed bookends) or to cause additional damage if a neighboring structure is on one side only or the floors do not align. Buildings on corners of city blocks are known to perform poorly, being pushed into the street due to one-sided pounding. Tsunamis, or tidal waves triggered by seafloor seismic movements, are another source of damage. Fires can be initiated from broken gas or electrical lines. Water saturated soil can lose its strength during dynamic shaking, and landslides or soil liquefaction may cause buildings to slide, be buried, or sink as if into quicksand.



A security officer stands next to a seismic brace inside the Diablo Canyon Nuclear Power Plant. Braces like these are representative of the technological advances in earthquake engineering. *(© Roger Ressmeyer/Corbis.)*

To affect a structure, earthquake energy must first transmit through the bedrock from the *epicenter*, or the fault rupture location, through the soil above the bedrock (if any), through the foundation system, and then up through the building itself. All of these elements between the epicenter and building structure affect the level of lateral force (termed *base shear*) used for structural design. Frequency of ground motion can vary with distance from the epicenter, directivity, type of fault rupture, and magnitude. In the United States, the U.S. Geological Survey (USGS) maintains probabilistic earthquake demand topography maps based on statistical analyses of seismicity, referenced by building codes and design standards and used by structural engineers for design.

Engineering judgment, based on experience and observation of damage during past earthquakes, is relied on heavily in approximating earthquake demand, structural analysis, and overall structural design. Geotechnical engineers determine site soil conditions and site-specific seismic hazard. Structural engineers model the structural mass and stiffness, or how much a building moves when pushed laterally, based on the earthquake-resisting structural system used in design. Dynamic force and displacement limits are assumed based on structural detailing of connections and experimental testing results. Though material standards are used to set minimum criteria for material properties, there still exists some variability in material strength and ductility, requiring designing for a range of properties. Due to these many variables, two identical structures at different locations may require quite different earthquake-resisting systems.

After an earthquake, it is often difficult to know immediately if a building is severely damaged. The structure is typically covered by finishes, suspended ceilings, and fireproofing that need to be removed for visual investigation of connections, cracking, and other damage. In the United States, structural engineers may travel thousands of miles to aid in the initial building tagging and reconnaissance efforts, to quickly assign a red (no entry, evacuate), yellow (limited entry), or green (functional) placard at the entrance points. Developments in instrumentation have allowed for real-time building motions to be streamed over the Internet, which facilitates accuracy in initial tagging, but visual observation remains the primary basis for evaluation. In the case of a large office building, red tagging means the loss of weeks or months of revenue. In the case of hospitals and emergency response centers, a decision to evacuate means disruption of critical care during an emergency situation, increasing the death rate. For such reasons, engineers have an ethical responsibility to be extremely careful about a recommendation to evacuate a damaged building.

As architecture, construction materials, technology, and economics of construction evolve, seismic engineering evolves as well. Assumptions made during design are put to the test in future earthquakes, both validating previous thinking and exposing flaws. After the January 1994 earthquake in Northridge, California (M = 6.7, 60 fatalities, $40 billion in damage), it was found that many steel beam-to-column connections in relatively new structures had fractured at yield stress in buildings across the city, much different than the ductile behavior assumed in design. The structural engineering community initiated a six-year research project funded primarily by the U.S. Federal Emergency Management Agency (FEMA) to determine the cause of the poor performance, devise repair schemes, determine new design procedures that would produce desired ductile behavior, and modify building codes to avoid similar failures in future earthquakes (SAC 2000).

Building Codes, Economics of Construction, and Seismic Loss

In general the purpose of building codes is to protect public safety. But building codes and design standards, like the structures and societies in which they exist, are not permanent static entities, but dynamic and evolving to meet the demands and knowledge of changing times.

To minimize construction costs, building codes function as minimum requirements to permit damage from an earthquake but prevent collapse of the main structure, structural attachments, or contents. New buildings are expected to be repairable after a major earthquake, but some may be too costly to repair. Engineers have a responsibility to inform clients that building codes are not intended to preserve a structure, but do provide opportunities to increase the structural capacity or add special elements such as supplemental energy dissipation devices (viscous dampers and friction dampers, among others) or base isolation to reduce damage permissible by design codes.

Building owners are thus able to increase a building's earthquake *performance level* if they are willing to pay the additional construction and design costs. Generally, however, it is difficult to sell higher performance engineering and construction costs to owners in the United States. In Japan and New Zealand, by contrast, higher performance structural elements are more frequently used. Building codes increase earthquake demand for critical structures, such as hospitals, schools, and communications hubs, with the intent that less damage occur during a major earthquake allowing the structure to remain operational afterward. In capitalist societies, history has shown that either economic incentives (tax breaks) or the threat of a facility being closed are often required to make building owners decide to retrofit. Both tactics are used in California (Geschwind 2001).

It is cheaper by far to allow for seismic forces during initial design than to incur damage or to retrofit later. Considering seismic forces initially may increase construction costs by 2 to 5 percent. Retrofit costs are typically on the order of 20 to 50 percent of original construction costs, excluding design fees and business interruption costs (Conrad 2004). Though seemingly inexpensive in comparison with the potential loss of the entire structure, there is major resistance to a 5 percent increase in construction cost from building owners, developers, and engineers not familiar with seismic design, especially in areas where the earthquake return period is longer than 100 years, when building codes (as in the United States) assume the typical building life to be fifty years. The area along the Mississippi River between St. Louis, Missouri, and Memphis, Tennessee, experienced three magnitude 7.8 to 8.1 earthquakes in 1811 and 1812, which reportedly moved furniture in James Madison's white house and rang church bells in Boston, yet many in the local communities maintain that designing for earthquakes is too costly. Money not spent on seismic retrofit for public facilities could theoretically be spent on the salaries of police and teachers, better hospital care, highway upgrades, and social programs. However probabilistic risk analysis demonstrates that ignoring earthquakes in design is often much more costly in the long run than short-term benefits of construction savings or budget reallocations.

In addition to loss of life, earthquake damages can significantly affect the local and world economies. The January 1995 earthquake in Kobe, Japan (M = 6.9, 5,502 fatalities) caused more than $120 billion in economic loss. It is estimated that a similar earthquake in a major metropolitan area in the United States could result in a comparable loss (House Committee on Science, Subcommittee on Research, 2003). In the United States, earthquakes pose significant risk to 75 million Americans in 39 states. Averaging single event losses over the time between events, total annualized damages in the United States have been estimated at approximately $4.4 billion (House Committee on Science, Subcommittee on Research, 2003). When industrial transportation and utility losses are considered,

TABLE 1

Magnitude and Intensity of Significant Earthquakes

Date	Time (GMT)	Place	Latitude	Longitude	Fatalities	Intensity	Magnitude
January 23, 1556		Shensi, China	34.5	109.7	830,000	–	~8
November 1, 1755	10:16	Lisbon, Portugal	36.0	−11.0	70,000	–	~8.7
December 16, 1811	08:00	New Madrid, MO, USA	36.6	−89.6		–	~8.1
January 23, 1812	15:00	New Madrid, MO, USA	36.6	−89.6		12	~7.8
February 7, 1812	09:45	New Madrid, MO, USA	36.6	−89.6		12	~8
August 31, 1886	02:51	Charleston, SC, USA	32.9	−80.0	60	–	~7.3
June 15, 1896	19:32	Sanriku, Japan	39.5	144.0		–	~8.5
June 12, 1897	11:06	Assam, India	26.0	91.0	1,500	–	~8.3
April 18, 1906	13:12	San Francisco, CA, USA (San Andreas fault from Cape Mendocino to San Juan Bautista)			3,000	11	7.8
August 17, 1906	00:40	Valparaiso, Chile	−33.0	−72.0	20,000	11	8.2
December 16, 1920	12:05	Ningxia-Kansu, China	36.60	105.32	200,000	–	8.6
September 1, 1923	02:58	Kanto, Japan	35.40	139.08	143,000	–	7.9
May 22, 1927	22:32	Tsinghai, China	37.39	102.31	200,000	–	7.9
March 2, 1933	17:31	Sanriku, Japan	39.22	144.62	2,990	–	8.4
March 11, 1933	01:54	Long Beach, CA, USA	33.6	−118.0	115	–	6.4
December 26, 1939	23:57	Erzincan, Turkey	39.77	39.53	32,700	11	7.8
May 22, 1960	19:11	Chile	−38.24	−73.05	5,700	11	9.5
March 28, 1964	03:36	Prince William Sound, AK, USA	61.02	−147.65	125	–	9.2
February 9, 1971	14:00	San Fernando, CA, USA	34.40	−118.39	65	11	6.7
July 27, 1976	19:42	Tangshan, China	39.61	117.89	255,000*	10	7.5
September 19, 1985	13:17	Michoacan, Mexico	18.44	−102.36	9,500	9	8.0
October 18, 1989	00:04	Loma Prieta, CA, USA	37.14	−121.76	63	9	6.9
January 17, 1994	12:30	Northridge, CA, USA	34.18	−118.56	60	9	6.7
January 16, 1995	20:46	Kobe, Japan	34.57	135.03	5,502	11	6.9
August 17, 1999	00:01	Izmit, Turkey	40.77	30.00	17,118	–	7.6
January 26, 2001	03:16	Gujarat, India	23.39	70.23	20,085	–	7.7
December 26, 2003	01:56	Bam, Iran	29.00	58.34	26,200	9	6.6
December 26, 2004	00:58	offshore Sumatra, Indonesia	3.31	95.85	225,000 (est.)	–	9.0

*Fatalities estimated as high as 655,000.

SOURCE: U.S. Geological Survey, Earthquakes Hazards Program. Available from http://earthquake.usgs.gov; National Geophysical Data Center. Available from http://www.ngdc.noaa.gov/seg/.

Earthquake Intensity is a measure of earthquake size based on observed damage of buildings and other structures on the earth's surface. Intensity is measured on a scale of 1 to 10+, with 10+ representing the most damage. Intensity is a different measurement than earthquake Magnitude, a measure of the strain energy released over the area of fault rupture. Magnitude is not a linear scale; each 1.0 increase in magnitude number represents greater than a factor of 30 times total energy released. Values of Intensity and Magnitude do not numerically correlate between different earthquake events due to local geology, depth of fault rupture, existing construction, and many other factors.

the estimated annual damage approaches $10 billion (Bonneville 2004). The September 11, 2001, terrorist attacks in the United States caused approximately 3,000 deaths and $100 billion in losses, roughly the same proportions as a major earthquake. Just as insurance, travel, and security measures have been increased throughout the world in response to the attacks of September 11, 2001, preparing for the next major earthquake would lessen the worldwide economic effects of future events.

Seismic Risk Analysis and Societal Response

Since 1990 financial risk management analysis has been increasingly utilized by various levels of government, large corporations, and universities to understand and work toward reducing the financial impacts of major earthquakes. For example, a small one-story structure storing landscaping equipment may not be as important to a client as a one-story structure that houses emergency generators and an essential communications antenna. If the one-story structure is a collapse hazard, the owner may decide to strengthen the structure or move essential components to reduce risk.

Risk analyses use various loss estimating measures. The most common is the probable maximum loss (PML) due to a major earthquake, presented as a percentage of the building value. A 50-percent PML anticipates that half of the building will be damaged beyond repair in a major earthquake. Risk assessments need to be periodically updated to show progress and to reevaluate a client's portfolio with the ever-improving tools available to structural engineers produced through new research, analysis software, code developments, and observed damage. Values of PML studies need to be defined and investigated carefully as each methodology or computer program assumes slightly different parameters (Dong 2000).

Three requirements must be satisfied for a successful earthquake resistant design protocol. First, there must be practical structural design standards that reflect current observations and research, standards that are used by engineers and legally enforced as minimum requirements. Second, there must be thorough structural engineering performed by qualified and licensed engineers that leads to clear and explicit construction drawings. Third, construction must be monitored by qualified inspectors or by the designing engineers to ensure that the intended materials are used and construction proceeds as shown in the drawings and specifications. In case of unforeseen construction difficulties, the structural engineer must be involved in a solution that meets the intent of the design without compromising the structure, but also is as economic as possible.

If one or two of these three requirements are satisfied, the protocol is not successful. For example, after the 1999 earthquake in Izmit, Turkey, reports focused on shoddy construction and unenforceable building codes. Building codes are quite good in Turkey, closely following the standards published in the United States. However, for cultural reasons the building codes are frequently not enforced when a design is reviewed, and the contractor is held neither to building to the design standard nor to having an engineered design (EERI 1999).

Due to the Izmit earthquake, efforts to mitigate current and future earthquake risk in Europe are underway in Turkey, as well as Greece, Portugal, Italy, and the rest of the European Union (Spence 2003). All countries with moderate or high earthquake risk have their own cultural, financial, and political barriers toward earthquake risk mitigation. However, as has been demonstrated in the United States, Japan, and elsewhere when the three requirements of practical codes, sound structural design, and construction monitoring work together, earthquake risk is decreased as new buildings replace older ones.

It is extremely difficult for developing countries to mitigate seismic risk. Priorities are on more immediate needs such as food, clean water, and disease prevention and on the effects of poverty and war. Construction uses available materials and follows traditional methods without structural calculations. While economic losses in developing countries may not be as high as in the United States, loss of life is much more severe, potentially approaching the proportions of the July 1976 earthquake in Tangshan, China ($M = 7.5$), where between 250,000 and 655,000 people were killed and more injured when nearly the entire city was razed.

Population expansion, and hence the rate of construction using traditional (seismically unsafe) methods, is at a much higher rate in countries such as India or Nepal than in the United States, exponentially increasing the earthquake risk in these countries. It is estimated that the risk of fatalities in developing countries compared to industrialized countries is 10 to 100 times greater—and increasing. This trend is the largest ethical and functional difficulty worldwide with regard to earthquake risk. In addition to moral obligations to reduce earthquake risk in developing countries, there are financial reasons as well. Due to economic globalization, a major disaster in a developing country has direct immediate and long-term financial impact on the world economy.

JAMES P. HORNE
DAVID R. BONNEVILLE

SEE ALSO *Earth; Earth Systems Engineering and Management; Safety Engineering.*

BIBLIOGRAPHY

Bolt, Bruce A. (1993). *Earthquakes,* newly revised and expanded. W. H. New York: Freeman. Contains information about seismology, structural engineering, and public response to historical earthquakes.

Bonneville, David. (2004). "Securing Society Against Earthquake Losses." *Structural Engineers Association of Northern California Newsletter* 59(2004): 1–3.

Bozorgnia, Yousef, and Vitelmo V. Bertero, eds. (2004). *Earthquake Engineering: From Engineering Seismology to Performance-Based Engineering.* Boca Raton, FL: CRC Press. Describes the current knowledge of practicing engineers' and researchers' techniques in structural engineering for earthquake resistance.

Earthquake Engineering Research Institute (EERI). (2000). *Financial Management of Earthquake Risk/EERI Endowment Fund White Paper.* Oakland, CA: EERI. An excellent description of the key aspects of seismic risk analysis techniques after a decade of development and private practice.

Geschwind, Carl-Henry. (2001). *California Earthquakes: Science, Risk, and the Politics of Hazard Mitigation.* Baltimore, MD: Johns Hopkins University Press. An extremely well developed text from start to finish of seismic legislation and public policy related to curbing seismic loss in California.

SAC Joint Venture. (2000). Federal Emergency Management Agency (FEMA) Publication 354. The SAC joint venture is a very thorough research project that employed a great deal of coordination and cooperation between academia and practicing engineers, in an effort to better understand the poor behavior that was observed after the 1994 Northridge earthquake, which was exactly the opposite of the intention of the building codes which produced the results. Engineers and researchers took it upon themselves to publicize the problem, obtain funding, and publish these documents to avoid the poor behavior in future buildings, as well as publish ways to retrofit existing structures with similar characteristics.

Spence, Robin. (2003). "Earthquake Risk Mitigation in Europe: Progress towards Upgrading the Existing Building Stock." In *Proceedings of the Fifth National Conference on Earthquake Engineering*. Istanbul, Turkey: Fifth National Conference on Earthquake Engineering. A discussion on the European view of earthquake engineering, the cultural resistance, and potential for future progress.

INTERNET RESOURCES

Applied Technology Council. Available from www.atcouncil.org. Organization web site.

Conrad, Katherine. (2004). "Seismic Retrofit May Limit Bomb Damage." *East Bay Business Times*. Available from http://eastbay.bizjournals.com/eastbay/stories/2004/04/05/focus1.html

Consortium of Universities for Research on Earthquake Engineering. Available from www.curee.org. Organization web site.

Earthquake Engineering Research Institute (EERI). "Learning From Earthquakes: The Izmit (Kocaeli), Turkey Earthquake of August 17, 1999." Available from: http://www.eeri.org/lfe/pdf/turkey_kocaeli_eeri_preliminary_report.pdf.

House Committee on Science, Subcommittee on Research. *The National Earthquake Hazards Reduction Program: Past, Present and Future*. 108th Cong, 1st sess. May 8, 2003, 108–114. Available from http://commdocs.house.gov/committees/science/hsy86870.000/hsy86870_0.HTM. An interesting interpretation of where and how funds in the United States are appropriated, and the information this is based on.

Structural Engineers Association of California. Available fromwww.seaoc.org. Organization web site.

EARTH SYSTEMS ENGINEERING AND MANAGEMENT

The biosphere, at levels from the landscape to the genome, is increasingly a product of human activity. At a landscape level, islands and mainland regions are affected by agriculture, resource extraction, human settlement, pollution, and invasive species transported by humans. Few biological communities can be found that do not reflect human predation, management, or consumption. At the organism level, species are being genetically engineered by humans to increase agricultural yields; reduce pesticide consumption; reduce demand for land for agriculture; enable plant growth under saline conditions and thereby conserve fresh water resources; produce new drugs; reduce disease; and support a healthier human diet. At the genomic level, the human genome has been mapped, as has that of selected bacteria, yeast, plants, and other mammals.

Moreover too little of the discussion about the potential effects of advancements in cutting-edge fields, such as nanotechnology, biotechnology, and information and communication technology (ICT), is focused on their global impacts on integrated human-natural systems. Major human systems, from urban to economic to philosophic systems, increasingly are reflected in the physical behavior and structure of natural systems, yet there is little study and understanding of these subtle but powerful interactions.

A planet thus dominated by the activities, intentional and unintentional, of one species is a new historical phenomenon. This species is affecting a complex, dynamic system of which it is a part. Changes in such systems cannot be predicted by linear causal models; witness the continuous debate over the extent global warming is occurring, and its likely consequences. Probabilistic models and continuous data collection can help human beings enter into a dialogue with these coupled human-technological-environmental systems.

Appropriate data-gathering, modeling and dialogue is impeded by the absence of an intellectual framework within which such broad technological trends, and their cumulative impact on global human-natural systems, can be conceptualized. The current base of scientific and technical knowledge, governance institutions, and ethical approaches are inadequate to this challenge (Allenby 2001). Managing these highly complex systems requires an integration of the physical and social sciences that is difficult for both cultural and disciplinary reasons, and the institutional structures that would foster this understanding, and enable its implementation, do not yet exist.

Emergence of Earth Systems Engineering and Management

The challenge of the anthropogenic Earth drove Brad Allenby to propose Earth Systems Engineering and Management (ESEM), an interdisciplinary framework for perceiving, understanding, and managing complex, coupled human-natural-technological systems. It reflects not just the need to respond to, and manage, systems at scales of complexity and interconnection that current practices cannot cope with, but also to minimize the risk and scale of unplanned or undesirable perturbations in coupled human or natural systems. It does not replace traditional scientific, engineering, and social science disciplines or study; rather it draws on and integrates them to enable responsible, rational, and ethical response to the relatively new phenomenon of the anthropogenic Earth. Therefore, ESEM draws heavily on related work in multiple fields (Clark 1989, Turner et al. 1990).

ESEM is a response to a broad set of multidisciplinary questions that are relatively intractable to twenty-first-century disciplinary and policy approaches: How, for example, will people cope with the potential ramifications for environmental systems of nanotechnology, biotechnology, and ICT? How can they begin to redesign human relationships with complex ecosystems such as the Everglades; engineer and manage urban centers to be more sustainable; or design Internet products and services to reduce environmental impact while increasing quality of life?

The Ethics of ESEM

Dealing responsibly with the complex web of interconnections between human and natural systems will thus require experts skilled in new approaches and frameworks, capable of creating policy and design options that protect environmental and social values while providing the desired human functionality. Such an ESEM approach requires both a rigorous understanding of the human, natural, and technological dimensions of complex systems, and an ability to design inclusive strategies to address them, all the while recognizing that no single approach or framework is likely to be able to capture the true complexity of such systems.

Even at this nascent stage, it is possible to begin to establish a set of principles applicable to ESEM (Allenby 2002):

(a) Try to articulate the current state of a system and desired future states, consulting with multiple stakeholders. Establish a process for continuous sharing of knowledge and revision of system goals, based on continuous monitoring of multiple system variables and their interactions. Anticipate potential problematic system responses to the extent possible, and identify markers or metrics by which shifts in probability of their occurrence may be tracked.

(b) The complex, information dense and unpredictable systems that are the subject of ESEM cannot be centrally or explicitly controlled. ESEM practitioners will have to be reflective, seeing themselves as an integral component of the system, closely coupled with its evolution and subject to many of its dynamics.

(c) Whenever possible, engineered changes should be incremental and reversible. In all cases, scale-up should allow for the fact that, especially in complex systems, discontinuities and emergent characteristics are the rule, not the exception, as scales change. Lock-in of inappropriate or untested design choices, as systems evolve over time, should be avoided.

(d) ESEM projects should support the evolution of system resiliency, not just redundancy. In a tightly coupled complex system, a failure of one component can be fatal, and it is virtually impossible to build in sufficient redundancy for every component (Perrow 1984). The space shuttle is an example. Resilient systems are loosely coupled; the system as a whole can adapt to failures in one component. The Internet is an example, as are many natural systems. However, even in resilient systems, there are tipping points where the amount of disruption exceeds the ability of the system to adapt, and a major transformation occurs. Therefore, even resilient systems require monitoring and management.

To succeed, ESEM depends on the development of an Earth Systems Engineer (ESE) who would have a core area of expertise, perhaps environmental science or systems engineering or social psychology, and be able to take a global systems view of environmental problems. The ESE would have to be what Collins and Evans call an interactional expert, capable of facilitating deep, thoughtful conversations across disciplinary boundaries (Collins and Evans 2002) that enable productive trading zones (Galison 1997) for managing complex environmental systems (Gorman and Mehalik 2002). The ESE would also be involved in the creation of new data monitoring and modeling tools that would add rigor to ESEM. To assess its value, the ESEM approach needs to be piloted on several complex systems, and the results described in detailed case-studies from which others can learn. The ESEM framework has the potential to facilitate intelligent management of trading zones centered on converging technologies: nanotechnology, biotechnology, information technology and cognition (Gorman 2003).

BRADEN R. ALLENBY
MICHAEL E. GORMAN

SEE ALSO *Engineering Ethics; Environmental Ethics; Environmentalism; Management: Models.*

BIBLIOGRAPHY

Allenby, Braden R. (2001). "Earth Systems Engineering and Management." *IEEE Technology and Society Magazine* 19(4): 10–21.

Clark, William C. (1989). "Managing Planet Earth." *Scientific American* 261(3): 46–54. This article introduces and gives an overview of an issue of *Scientific American* that points the way toward ESEM.

Collins, H. M., and Robert Evans. (2002). "The Third Wave of Science Studies." *Social Studies of Science* 32(2): 235–296.

Galison, Peter Louis. (1997). *Image and Logic: A Material Culture of Microphysics*. Chicago: University of Chicago Press.

Gorman, Michael E. (2003). "Expanding the Trading Zones for Convergent Technologies." In *Converging Technologies for Improving Human Performance: Nanotechnology, Biotechnology, Information Technology and Cognitive Science*, ed. Mihail C. Roco and William S. Bainbridge. Dordrecht, Netherlands: Kluwer.

Gorman, Michael E., and Matthew M. Mehalik. (2002). "Turning Good into Gold: A Comparative Study of Two Environmental Invention Networks." *Science, Technology and Human Values* 27(4): 499–529.

National Academy of Engineering. (2000). *Engineering and Environmental Challenges: A Technical Symposium on Earth Systems Engineering*. Washington, DC: National Academy Press.

Perrow, Charles. (1984). *Normal Accidents: Living With High-Risk Technologies*. New York: Basic Books.

Turner, B. L., William Clark; Robert W. Kates; et al., eds. (1990). *The Earth as Transformed by Human Action*. Cambridge: Cambridge University Press.

INTERNET RESOURCE

Allenby, Braden R. (2002). "Observations on The Philosophic Implications of Earth Systems Engineering and Management." Available from http://www.darden.virginia.edu/batten/pdf/WP0010.pdf. This is the most comprehensive account of ESEM, including its relationship to multiple disciplines, perspectives and precursors.

ECOLOGICAL ECONOMICS

Economics is frequently defined as the science of the allocation of scarce resources among alternative desirable ends. The first question this implies—What are the desired ends?—is ultimately a question of values and ethics. Most economists would agree that while the ultimate desired end is too difficult to define, increasing social welfare serves as a reasonable placeholder. Seeking to establish itself as an objective, value-free science, mainstream (neoclassical) economics strives to maximize welfare as measured by the dollar value of market goods plus the imputed dollar value of nonmarket goods and services produced. Therefore neoclassical economists, including natural resource and environmental economists, devote most of their attention to markets, which under certain strict conditions efficiently allocate resources toward uses that maximize dollar values. Taking an explicitly ethical position, ecological economics asserts that ecological sustainability and just distribution take priority over efficient allocation as prerequisites to increasing social welfare. Markets cannot be relied upon unless these first two priorities have been met.

Once the desired ends have been determined, ecological economists rely on insights from physics and ecology to assess the nature of the scarce resources. Only then do they seek appropriate allocative mechanisms, drawing from mainstream economics as well as other social sciences. Ecological economics embraces the full complexity of the economic question, and the full range of inquiry necessary to answer it. It lays no claim to being a value-free science, but rather works to be a transdisciplinary field, integrating knowledge and skills from both the humanities and sciences. (Costanza, Daly, and Bartholomew 1991; Norgaard 1989).

As an emerging transdiscipline, ecological economics has an exceptionally broad scope of inquiry, and has not yet achieved the level of consensus that characterizes an established science. This overview leaves out much brilliant work, and not all ecological economists will agree with all it says.

The Resources of Nature and the Nature of Resources

An understanding of scarce resources begins with hard science and the laws of thermodynamics. The first law states that the quantity of matter-energy cannot be created or destroyed and remains constant in a closed system. Everything produced by humans (human-made capital) must come from raw materials supplied by nature (natural capital). Any waste produced by the economy must return to the ecosystem. In contrast, most standard microeconomics textbooks argue that through specialization and trade, society can "increase production with no change in resources" (Parkin 2003, p. 42).

The second law of thermodynamics states that entropy never decreases in an isolated system. From the perspective of economics, entropy can be thought of as a measure of used-up-ness, or the extent to which the capacity of matter-energy to perform work or be useful has been exhausted. When oil is burned to run an engine or heat a house, the energy it contains is not destroyed in performing this work, but it cannot be used again for the same purpose. When the steel in cars rusts and flakes off, it does not disappear but is scattered about the ecosystem so randomly one cannot gather it back up. The quantity of matter-energy is constant in a system, but the quality is constantly deteriorating. These laws suggest that human-made capital will inevitably be used up or worn out and return to the ecosystem as high entropy waste. A constant flow of low entropy natural capital is required simply to maintain the economy.

Fortunately the Earth is not an isolated system, because the sun provides a daily source of low entropy energy. But it is this solar inflow that limits the physical size of the economy in the long run, not the nonrenewable stock of fossil fuels. While fossil fuels can be used up as quickly as one chooses, solar energy comes at a fixed rate. People can therefore use fossil fuels to achieve rapid physical growth of the economic system, but not to create a sustainable system (Georgescu-Roegen 1971).

Humans depend not only on raw materials provided by nature, but like all other species on the planet, are sustained by the solar-powered life support functions of healthy ecosystems. All of human technology simply cannot provide the climate stability, waste absorption capacity, water regulation, and other essentials that more than 6 billion people require to survive. In other words, natural capital has two components. Ecosystem goods are the raw materials provided by nature, as well as the structural components of the ecosystem. Ecosystem services are the valuable functions that emerge when those structural components interact in a complex ecosystem to create a whole greater than the sum of the parts. When humans remove low entropy raw materials from nature to build the economy and return high entropy waste, they must pay an opportunity cost measured in both ecosystem goods and services lost.

These laws of thermodynamics are responsible for the core vision of ecological economists: The human system is sustained and contained by the global ecosystem. When the physical size of the economic system increases, it does not expand into a void, but must instead consume and displace the natural capital on which humans depend for survival (Daly and Farley 2003).

Scale, Distribution, and Allocation

As a consequence of the ecological economists' core vision, their primary concern is with *scale*—the physical size of the human economy relative to the ecosystem that contains and sustains it. The scale of the economy cannot exceed the capacity of the ecosystem to sustain it. This priority emerges from an understanding of the laws of physics combined with an ethical responsibility to future generations.

Sustainable scale is necessary, but inadequate. Virtually all economists accept the law of diminishing marginal utility—the more one has of something, the less an additional unit is worth. As human-made capital increases, its marginal utility diminishes. A corollary is the law of increasing opportunity costs—as natural capital dwindles, the opportunity costs of continued losses increase. Increasing opportunity costs must eventually surpass diminishing marginal utility. At this point, an economic system has reached its optimal scale, and the physical growth of the economy should stop—though economic development, as measured by improvements in social welfare, can still continue.

Two hundred years ago when market economies were emerging, human-made capital was relatively scarce and natural capital abundant. Economists logically focused on allocating the former. In the early twenty-first century, however, it is natural capital that constrains economic development. If people need more fish or timber, the problem is depleted fish stocks and forests, not a shortage of boats or chainsaws. It is likely that humans have exhausted nearly half the planet's supply of conventional petroleum in less than 150 years (Campbell and Laherrère 1998), threatening to destabilize the global climate in the process. Yet natural capital does not increase in fecundity or quantity in response to an increase in price—the driving force behind markets.

However while natural capital does not respond to price signals, technology does: As a resource becomes scarce, its price goes up, and people can either use it more efficiently or create a substitute, leading many conventional economists to conclude that resource scarcity imposes no limits on economic growth. At one extreme, economists such as Julian Simon deny that natural resources are finite and argue that a growing human population brings more brainpower to solve society's problems (Simon 1996). Similar claims from statistician Bjørn Lomborg (2001), supposedly based on evaluation of empirical data, have received considerable publicity, but the quality of his scholarship raises serious concerns (Rennie 2002). For example, he accepts without question a doubling and even tripling of estimated oil reserves in several member states of the Organization of the Oil Exporting Countries (OPEC) that took place shortly before their quota negotiations in 1988, while rejecting as implausible four out of five scenarios for climate change from an intensively peer-reviewed report by leading scientists working with the International Protocol on Climate Change (Schneider 2002). Nonetheless more credible technological optimists such as Amory Lovins are actively creating pollution reducing, resource and energy efficient technologies such as the hydrogen powered *hyper-car*.

While not denying its importance, ecological economists are leery of undue faith in technological advance for both practical and ethical reasons. In practical terms few ecosystem services even have a price to signal market scarcity and thus induce technological innovation, and even imputed prices cannot capture the fact that most ecosystem services do not have clear substitutes (Gowdy 1997). While there is a greater capacity to develop substitutes for ecosystem goods than for services, efficiency improvements have physical limits, and continued economic growth must eventually lead to more resource use, more waste output, and diminishing marginal utility—a growing fleet of hyper-cars will still require more roads and parking lots and induce more traffic jams. The fact is that efficiency in resource use rarely stimulates frugality, but frugality quite often stimulates efficiency (Daly and Farley 2003). From the viewpoint of ethics, no one can say for certain what technologies will emerge and when, and the gamble is whether or not future technologies will create substitutes for critical resources before they are exhausted. Ecological economists weigh the gains from winning against the costs of losing. If the technological optimists are wrong, continued increases in the rate of resource use could lead to the irreversible loss of vital ecosystem life support functions. If the optimists are right, then limiting resource extraction and waste emissions will impose only short term costs to standards of living while technological innovation develops substitutes.

Thus ecological economists operate on the assumption that natural capital has become the scarcest resource required to achieve the desired ends, and recognize that markets fail to respond to this scarcity and cannot be relied on as a mechanism for determining desirable scale. Environmental economists in contrast believe markets can determine desirable scale if they calculate the dollar value of ecosystem services then feed this information back into the market system. However all economic production degrades ecosystem services through resource extraction and again through waste emissions. Two prices must be calculated for every price the market detects. This defeats the whole purpose of a market whose virtue is its reliance on decentralized information. Ecological economists believe scale should be determined by a participatory democratic process informed by appropriate experts and the ethical values of citizens. Stakes are high, decisions are urgent, and facts are uncertain. Society must act quickly, but should err on the side of caution and leave room to adapt as it learns more (Funtowicz and Ravetz 1992; Prugh, Costanza, and Daly 2000). The Endangered Species, Clean Air, and Clean Water acts in the United States and the Montreal Protocol on ozone depleting substances are only a few examples of this approach. In sum, while environmental economists in contrast strive to calculate prices first, and then allow scale to adjust, ecological economists strive to determine the desirable scale first, and then allow prices to adjust.

The second priority for ecological economists is just distribution, which emerges in part from their concern with scale. What ethical system would allow a concern for the welfare of people not yet born, and ignore the welfare of those alive and suffering today? If a finite planet imposes finite limits on the size of the economy, then society cannot grow its way out of poverty, and alleviating poverty requires redistribution. On practical grounds, no one living in poverty can really afford to think about the future—hungry people around the world will sacrifice essential natural capital for immediate needs. Unjust distribution is therefore incompatible with ecological sustainability.

How markets allocate resources depends on the initial distribution. For example, a society with highly unequal distribution will allocate resources toward both slums and yachts, while one with more equal distribution will allocate resources toward neither. A given market allocation is therefore no more desirable than the initial distribution that produced it. Nonetheless the tradition in neoclassical economics is to leave the distribution question to other disciplines or policymakers, while ecological economists consider just distribution a prerequisite to desirable allocation.

Distribution should also be decided by a participatory democratic process. Three principles can guide the decision. Wealth created by nature and society as a whole should be equally distributed. Those who degrade that wealth, through pollution or resource depletion, for example, should compensate society for its loss. Those who benefit from society should provide compensation in proportion to their gains.

The third priority for ecological economists is efficiency. Once society has ensured the preservation of enough natural capital to sustain the system, and that remaining resources are justly distributed, those resources should be allocated toward uses that generate as much welfare as possible. Markets can be an efficient allocative mechanism when resources are privately owned, use by one person precludes used by another, and production and consumption have minimal impacts on others. When these conditions do not hold, markets alone will fail to generate efficient outcomes, and society must again rely on participatory democratic decision making to allocate resources, complemented when appropriate by market mechanisms.

JOSHUA C. FARLEY

SEE ALSO *Environmental Economics; Environmental Ethics; Sustainability and Sustainable Development.*

BIBLIOGRAPHY

Campbell, Colin J., and Jean H. Laherrère. (1998). "The End of Cheap Oil." *Scientific American* March: 78–83. This article offers a solid, multi-tiered analysis predicting that oil production will peak within the next few years, leading to a dramatic increase in oil prices.

Costanza, Robert; Herman Daly; and Joy Bartholomew. (1991). "Goals, Agenda and Policy Recommendations for Ecological Economics." In *Ecological Economics: The Science and Management of Sustainability*, ed. Robert Costanza. New York: Columbia University Press. This chapter is an excellent brief introduction to the field of ecological economics.

Daly, Herman, and John J. Cobb, Jr. (1989). *For the Common Good: Redirecting the Economy Toward Community, the Environment, and a Sustainable Future*. Boston: Beacon Press. This award winning book remains one of the best and most complete introductions to ecological economics, and the first description of the index of sustainable economic welfare.

Daly, Herman H., and Joshua Farley. (2003). *Ecological Economics: Principles and Applications*. Washington, DC: Island Press. Textbook that provides a comprehensive and readable introduction to ecological economics, suitable for upper level undergraduates and graduate students.

Funtowicz, Silvio O., and Jerome R. Ravetz. (1992). "Three Types of Risk Assessment and the Emergence of Post-Normal Science." In *Social Theories of Risk*, ed. Sheldon Krimsky and Dominic Golding. Westport, CT: Praeger. This chapter describes a general approach for solving ecological economic problems when facts are uncertain, decisions are urgent, stakes are high and values matter.

Georgescu-Roegen, Nicolas N. (1971). *The Entropy Law and the Economic Process*. Cambridge, MA: Harvard University Press. A classic work in ecological economics; the first comprehensive analysis of the importance of the entropy law to economics.

Gowdy, John. 1997. "The Value of Biodiversity: Markets, Society, and Ecosystems." *Land Economics* 73: 25–41. Presents a fine analysis of different types of value and clarifies the limits to monetary valuation.

Heilbroner, Robert, and Lester Thurow. (1981). *The Economic Problem*. Englewood Cliffs, NJ: Prentice-Hall.

Lomborg, Bjørn. (2001). *The Skeptical Environmentalist: Measuring the Real State of the World*. New York: Cambridge University Press. An influential but poorly researched example of the cornucopian world view that natural resources and waste absorption capacity are limitless, and the laws of thermodynamics are essentially irrelevant to economics.

Norgaard, Robert. (1989). "The Case for Methodological Pluralism." *Ecological Economics* 1(1): 37–58. Explains why complex ecological economic problems demand a transdisciplinary approach.

Parkin, Michael. (2003). *Microeconomics*, 6th edition. Boston: Addison Wesley. A standard microeconomics textbook.

Prugh, Thomas T.; Robert R. Costanza; and Herman H. E. Daly. (2000). *The Local Politics of Global Sustainability*. Washington, DC: Island Press. This short, readable book describes participatory democratic processes, and presents them as an effective mechanism for the sustainable and just allocation of resources.

Rennie, John. (2002). "Misleading Math about the Earth: Science Defends Itself against *The Skeptical Environmentalist*." *Scientific American* 286(1): 61. A brief editorial that introduces a series of articles describing the factual and analytical errors in Lomborg's *The Skeptical Environmentalist*.

Schneider, Stephen. (2002). "Global Warming: Neglecting the Complexities." *Scientific American* 286(1): 60–63. One in the series of articles introduced by John Rennie (see above).

Simon, Julian Lincoln. (1996). *The Ultimate Resource 2*, revised edition. Princeton, NJ: Princeton University Press. One of the first, best written and most influential descriptions of the cornucopian world view (see annotation following *The Skeptical Environmentalist*).

ECOLOGICAL FOOTPRINT

In the early 1990s, Dr. William Rees and a graduate student, Mathis Wackernagel, developed and quantified the first "ecological footprint" for the city of Vancouver, Canada. Fundamental to this research was answering the question, "how large an area of productive land is needed to sustain a defined population indefinitely, wherever on earth that land is located?" Ecological footprints build on earlier studies, all designed to quantify the natural resources used by humans and compare that to those that are available. However, footprints are distinguished, according to leading practitioners, by the many categories of human activity included in the ana-

TABLE 1

Ecological Footprint Results 1999

	Total Footprint [global hectares/pers] (1999)	Biocapacity [global hectares/pers] (1999)	Ecological Deficit [global hectares/pers] (if negative)	Total Footprint [global acres/pers] (1999)	Biocapacity [global acres/pers] (1999)	Ecological Deficit [global acres/pers] (if negative)
World	**2.3**	**1.9**	**−0.4**	**5.6**	**4.7**	**−0.9**
Argentina	3.0	6.7	3.6	7	16	9
Australia	7.6	14.6	7.0	19	36	17
Austria	4.7	2.8	−2.0	12	7	−5
Bangladesh	0.5	0.3	−0.2	1.3	0.7	−0.6
Belgium & Luxembourg	6.7	1.1	−5.6	17	3	−14
Brazil	2.4	6.0	3.6	6	15	9
Canada	8.8	14.2	5.4	22	35	13
Chile	3.1	4.2	1.1	8	10	3
China	1.5	1.0	−0.5	4	3	−1
Colombia	1.3	2.5	1.2	3	6	3
Costa Rica	2.0	2.3	0.4	5	6	1
Czech Republic	4.8	2.3	−2.5	12	6	−6
Denmark	6.6	3.2	−3.3	16	8	−8
Egypt	1.5	0.8	−0.7	4	2	−2
Ethiopia	0.8	0.5	−0.3	1.9	1.1	−0.8
Finland	8.4	8.6	0.2	21	21	0
France	5.3	2.9	−2.4	13	7	−6
Germany	4.7	1.7	−3.0	12	4	−7
Greece	5.1	2.3	−2.8	13	6	−7
Hungary	3.1	1.7	−1.3	8	4	−3
India	0.8	0.7	−0.1	1.9	1.7	−0.2
Indonesia	1.1	1.8	0.7	3	5	2
Ireland	5.3	6.1	0.8	13	15	2
Israel	4.4	0.6	−3.9	11	1	−10
Italy	3.8	1.2	−2.7	9	3	−7
Japan	4.8	0.7	−4.1	12	2	−10
Jordan	1.5	0.2	−1.4	4	0	−3
Korea (Republic of)	3.3	0.7	−2.6	8	2	−6
Malaysia	3.2	3.4	0	8	8	1
Mexico	2.5	1.7	−0.8	6	4	−2
Netherlands	4.8	0.8	−4.0	12	2	−10
New Zealand	8.7	23.0	14	21	57	35
Nigeria	1.3	0.9	−0.4	3.3	2.2	−1.1
Norway	7.9	5.9	−2.0	20	15	−5
Pakistan	0.6	0.4	−0.2	2	1	−1
Peru	1.2	5.3	4.2	3	13	10
Philippines	1.2	0.6	−0.6	2.9	1.4	−1.5
Poland	3.7	1.6	−2.1	9	4	−5
Portugal	4.5	1.6	−2.9	11	4	−7
Russia	4.5	4.8	0.4	11	12	1
South Africa	4.0	2.4	−1.6	10	6	−4
Spain	4.7	1.8	−2.9	12	4	−7
Sweden	6.7	7.3	0.6	17	18	2
Switzerland	4.1	1.8	−2.3	10	4	−6
Thailand	1.5	1.4	−0.2	4	3	0
Turkey	2.0	1.2	−0.7	5	3	−2
United Kingdom	5.3	1.6	−3.7	13	4	−9
United States	9.7	5.3	−4.4	24	13	−11

SOURCE: World Wildlife Fund (2002).

Ecological footprint and biocapacity figures for representative countries around the world. Ecological deficit refers to the extent that a country's footprint exceeds its biocapacity.

lysis, and by the measure's ability to compare current demand with current ecological limits (biocapacity).

The ecological footprint is an environmental accounting tool that measures human impact on nature, based on the ability of nature to renewably produce the resources that humans use and absorb the ensuing waste. Footprinting provides a way to aggregate into a single composite measure many of the ecological impacts associated with built-up land (i.e., roads and buildings), food, energy, solid waste, and other forms of waste or consumption. The result represents the impact or footprint. Using an area-based measure, such as hectares or acres, the size of a footprint can be compared to the renewable services the Earth's biocapacity can produce in a given year. The footprint methodology can be used to evaluate a population's progress toward ecological sustainability.

The footprint has been criticized on a variety of fronts, primarily related to the complex methodology that underlies the measure, as well as the applications for which it is appropriate. Along with other aggregate indicators, the footprint has been criticized for obscuring the components and assumptions that comprise the measure. While the methodology behind the measure is readily available, it is complicated and therefore not approachable without some technical background. Other critics argue that the premise of living within resource limitations can be overcome with technological innovation. It is true that in many ways the footprint is a worst-case scenario because it describes the situation if there are no technological improvements; but the converse, counting on improvements, could be risky in the long run as well.

When a country or community uses more renewable resources than are available, it has exceeded ecological limits. It will not be sustainable over an indefinite period of time. Such a situation can occur over a relatively short time-span because natural capital can be depleted to fill the renewable resource gap. Imports can also meet society's needs, but may simply shift depletion of natural capital around the globe. Over time, global stocks may be depleted to the point where they cannot regenerate or require significant human intervention to do so.

The *Living Planet Report 2002* contains footprints of countries with populations greater than one million. Estimates for the year 1999 show that the average American required approximately 9.6 hectares (24 acres) of ecologically productive land to sustain his or her lifestyle. In comparison, the average Canadian lived on a footprint that was nearly one-third smaller (6.9 global hectares or 17 acres), while the average Italian lived on an ecological footprint that was less than half the size (3.8 global hectares or 9 acres) of the American's. Each of these footprints can be compared to the amount of ecologically productive land area available locally or to the amount available globally on per person basis (1.9 hectares or 4.7 acres). See Table 1.

Footprint Methodology

The basic procedure for the footprint methodology is to determine annual global productivity and assimilation capacity (biocapacity) of major land areas. Then, this biocapacity is compared to the demands placed on it by human consumption and waste production. Productive lands are aggregated as cropland, pasture, forest, fisheries, and built-up land. Built-up land is generally assumed to occupy former cropland, as this is the predominant settlement pattern in human history. The present footprint methodology holds that less than one quarter of the Earth's surface provides sufficiently concentrated biomass to be considered biologically productive—leaving out deep ocean areas, deserts, frozen tundra, and other less productive parts of nature. Biocapacity can change: both negatively, due to land alterations such as desertification; and positively, due to improvements in technology that result in higher yields.

Ecological footprints can be calculated using two basic approaches: component and compound. Component footprinting is a bottom-up approach consisting of calculating the ecological footprints of individual parts of a system and then adding them up. Compound footprinting, on the other hand, is a top-down approach using aggregate figures such as production, imports, and exports of agriculture, energy, and other commodities, usually for nations.

Using either methodology, human consumption and waste components of a footprint are attributed to the final point of utilization (where a product is used up and enters the waste stream), regardless of where the output is actually assimilated. For example, some waste products, such as carbon dioxide, may be assimilated well outside the boundaries of the place where they are actually emitted, either because the wastes are carried away from the point of use or because the wastes are generated at a remote production site.

The final footprint results from the comparison of global biocapacity to consumption and waste. High available biocapacity allows for more or larger footprints, and higher levels of consumption require more biologically productive land. Consumption beyond renewable levels of biocapacity requires the depletion of natural capital and is considered unsustainable if it draws resources down to the point at which they cannot regenerate.

Measuring the ecological footprint of energy is a particularly significant and complex challenge that can be addressed in a variety of ways. A primary question that arises concerns the type of energy that is being used. Highly renewable forms of energy production, such as wind and solar power, typically have footprints equivalent to the land area they occupy plus the materials embodied in the collection mechanism. At the other extreme, nuclear energy is inherently unsustainable both because the resources it utilizes are non-renewable and extremely toxic, and because the potential destruction from nuclear accidents produces a dramatic increase in footprint area. The current approach is to convert nuclear energy to the equivalent fossil fuel impact. The footprint of fossil fuels can be calculated as either the amount of land area that would be required to grow and harvest an equivalent amount of fuelwood, or as the amount of land area required to assimilate associated carbon dioxide emissions. The latter approach is the most typically used in footprint accounts.

Footprint calculations through the beginning of the twenty-first century have assumed optimistic yield factors for foods and forests (making them conservative) and have left unmeasured many of the impacts associated with pollution, water use, and habitat and species decline. Though improvements are being made in the methodology, the ecological footprint cannot be considered a definitive measurement of humanity's ecological impact without significant additions.

Applications

Footprinting provides a methodology to evaluate potential tradeoffs among alternative actions, designs, energy sources, policies and products. It can be used as a yardstick for measuring humanity's impact on the earth in terms of ecological sustainability. Research in the field has provided the stimulus and foundation for academics at universities throughout the world. The ecological footprint has informed discussions and debates from the global to local level in national governments, meetings of the United Nations, research institutes, and municipal sustainability initiatives.

Footprints change over time, as populations change, consumption patterns shift, and biocapacity increases or decreases. The changes allow humanity to see its progress toward sustainability, at a global, national, state, and local level.

DAHLIA CHAZAN
JASON VENETOULIS

SEE ALSO *Ecology; Ecological Economics; Ecological Restoration; Sustainability and Sustainable Development.*

BIBLIOGRAPHY

Chambers, Nicky; Craig Simmons; and Mathis Wackernagel. (2000). *Sharing Nature's Interest: Ecological Footprints as an Indicator for Sustainability*. London: Earthscan.

Costanza, Robert. (2000). "Commentary Forum: The Ecological Footprint. The Dynamics of the Ecological Footprint Concept." *Ecological Economics*, 32: 341–345.

Rees, William. (1992). "Ecological Footprints and Appropriated Carrying Capacity: What Urban Economics Leaves Out." *Environment and Urbanization* 4(2): 121–130.

Rees, William, and Mathis Wackernagel. (1994). "Ecological Footprints and Appropriated Carrying Capacity: Measuring the Natural Capital Requirements of the Human Economy." In *Investing in Natural Capital: The Ecological Economics Approach to Sustainability*, ed. AnnMari Jansson et al. Washington, DC: Island Press.

Venetoulis, Jason. (2001). "Assessing the Ecological Impact of a University: The Ecological Footprint for the University of Redlands." *International Journal of Sustainability in Higher Education* 2(2): 180–196.

Wackernagel, Mathis, and William E. Rees. (1996). *Our Ecological Footprint: Reducing Human Impact on the Earth*. Gabriola Island, BC: New Society Publishers.

Wackernagel, Mathis et al. (2002). "Tracking the Ecological Overshoot of the Human Economy." *Proceedings of the National Academy of Sciences of the United States of America* 99(14): 9266–9271.

INTERNET RESOURCES

"The Ecological Footprint Project." Sustainable Sonoma County. Available from http://www.sustainablesonoma.org/projects/scefootprint.html.

"Living Planet Report 2002." World Wildlife Fund. Available from http://www.panda.org/news_facts/publications/general/livingplanet/index.cfm.

ECOLOGICAL INTEGRITY

Ecological or biological integrity originated as an ethical concept in the wake of Aldo Leopold (1949) and has been present in the law, both domestic and international, and part of public policy since its appearance in the 1972 U.S. Clean Water Act (CWA). Ecological integrity has also filtered into the language of a great number of mission and vision statements internationally, as well as being clearly present in the Great Lakes Water Quality Agreement between the United States and Canada, which was ratified in 1988.

The generic concept of integrity connotes a valuable whole, the state of being whole or undiminished, unimpaired, or in perfect condition. Integrity in common usage is thus an umbrella concept that encompasses a variety of other notions. Although integrity may be developed in other contexts, wild nature provides paradigmatic examples for applied reflection and research.

Because of the extent of human exploitation of the planet, examples are most often found in those places that, until recently, have been least hospitable to dense human occupancy and industrial development, such as deserts, the high Arctic, high-altitude mountain ranges, the ocean depths, and the less accessible reaches of forests. Wild nature is also found in locations such as national parks that have been deemed worthy of official protection.

Among the most important aspects of integrity are the autopoietic (self-creative) capacities of life to organize, regenerate, reproduce, sustain, adapt, develop, and evolve over time at a specific location. Thus integrity defines the *evolutionary and biogeographical processes* of a system as well as its parts or elements at a specific location (Angermeier and Karr 1994). Another aspect, discussed by James Karr in relation to water and Reed Noss (1992) regarding terrestrial systems, is the question of what spatial requirements are needed to maintain native ecosystems. Climatic conditions and other biophysical phenomena constitute further systems of interacting and interdependent components that can be analyzed as an open hierarchy of systems. Every organism comprises a system of organic subsystems and interacts with other organisms and abiotic elements to constitute larger ecological systems of progressively wider scope up to the biosphere.

Ecological Integrity and Science

Finally ecological integrity is both "valued and valuable as it bridges the concerns of science and public policy" (Westra et al. 2000, pp. 20–22). For example, in response to the deteriorating condition of our freshwaters, the CWA has its objective: "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (sec. 101[a]). Against this backdrop, Karr developed the multimetric Index of Biological Integrity (IBI) to give empirical meaning to the goal of the CWA (Karr and Chu 1999). Karr defines ecological integrity as "the sum of physical, chemical, and biological integrity." Biological integrity, in turn, is "the capacity to support and maintain a balanced, integrated, adaptive biological system having full range of elements (genes, species, and assemblages) and processes (mutation, demography, biotic interactions, nutrient and energy dynamics, and metapopulation processes) expected in the natural habitat of a region" (Karr and Chu 1999, pp. 40–41). Scientists can measure the extent to which a biota deviates from integrity by employing an IBI that is calibrated from a baseline condition found "at site with a biota that is the product of evolutionary and biogeographic processes in the relative absence of the effects of modern human activity" (Karr 1996, p. 97)—in other words, wild nature. Degradation or loss of integrity is thus any human-induced positive or negative divergence from this baseline for a variety of biological attributes (Westra et al. 2000). Noss's Wildlands Project, which aims to reconnect the wild in North America, from Mexico to Alaska (Noss 1992, Noss and Cooperrider 1994) utilizes the ecosystem approach to argue the importance of conserving areas of integrity.

But the most salient aspect of ecosystem processes (including all their components) is their life-sustaining function, not only within wild nature or the *corridor surrounding wild areas* although these are the main concerns of conservation biologists. The significance of life-sustaining functions is that ultimately they support life everywhere. Gretchen Daily (1997), for instance, specifies in some detail the functions provided by *nature's services*, and her work is crucial in the effort to connect respect for natural systems integrity and human rights.

Arguments against the value of ecological integrity for public policy have identified the concept as *stipulative* rather than fully scientific (Shrader-Frechette 1995). In a similar vein even the concept of ecology as such has been criticized as *not robust* enough to guide public policy (Shrader-Frechette and McCoy 1993). But ecological integrity is already a part of public policy, thus requiring consideration of its meaning and the role its inclusion should play in policy, rather than arguing for its rejection. Further to maintain that "we need a middle path—dictated in part by human not merely biocentric theory" (Shrader-Frechette 1995, p. 141) ignores how humans do not exist apart from other organisms: Biocentrism is life-oriented, and this principle is increasingly accepted not only by science, but in the law.

The routine use of Karr's IBI to reach general conclusions illustrates the ethical effectiveness of the scientific concept of ecological integrity in public policy. The law analyzes a crime or victim under a particular set of circumstances. But public policy must abstract from specifics. Disintegrity (or lack of integrity) and *environmental crime* (Birnie and Boyle 2002) are global in scope and need international fora and broad concepts to ensure that they will be proscribed and possibly eliminated.

In addition, there is mounting evidence to connect disintegrity or *biotic impoverishment* (Karr 1993) in all its forms, from pollutions, climate change, toxic wastes, and encroachment into the wild (Westra 2000) to human morbidity, mortality, and abnormal functioning. International law has enacted a number of instruments to protect human rights (Fidler 2001) and the World Health Organization (WHO) invited the Global Ecological Integrity Project (1992–1999) to consult with it. This collaboration eventually produced a document titled "Ecological Integrity and Sustainable Development: Cornerstones of Public Health" (1999) (Soskolne and Bertollini).

The Ethics of Integrity

Because of this global connection between health and integrity, and the right to life and to *living* (Cançado Trindade 1992), a true understanding of ecological integrity reconnects human life with the wild, and the rights of the latter with those of the former. The ethics of integrity primarily involves respect for *ecological rights* (Taylor 1998) without limiting these to the human rights that are the primary focus of the law. The main point of an ethic of integrity is that it is a *new* ethic (Karr 1993), one founded on recent science demonstrating the interdependence between humankind and its habitats. Environmental ethicists may prefer to focus on one or the other aspect of this interconnected *whole*—biocentrism or anthropocentrism. While biocentrists accept the presence of humankind as such within the rest of nature, anthropocentrists attempt to separate the two, in direct conflict with ecological science.

If, as argued, human health and function are both directly and indirectly affected by disintegrity (Soskolne and Bertollini Internet article), then no theory can properly separate one from the other. The strength of the proverbial canary-in-the-mine example is based on the fact that the demise of the canary anticipates that of the miner. Hence it is necessary to accept a general imperative of respect for ecological integrity. Onora O'Neill makes this point well:

> The injustice of destroying natural and man-made environments can also be thought of in two ways. In the first place, their destruction is unjust because it is a further way by which others can be injured: systematic or gratuitous destruction of the means of life creates vulnerabilities, which facilitate direct injuries to individuals. . . . Secondly, the principle of destroying natural and man-made environments, in the sense of destroying their reproductive and regenerative powers, is not universalizable. (O'Neill 1996, p. 176)

In addition, the *vulnerability* that follows the destruction of integrity links this concept to environmental justice. The *principle of integrity* together with appropriate second order principles would ensure (a) the defense of the *basic rights* of humankind (Shue 1996) as well as (b) the support of environmental justice globally, because it would ensure the presence of the *preconditions* of agency and thus the ability of all humans to exercise their rights as agents (Gewirth 1982, Beyerveld and Brownsword 2001).

Ecological integrity is thus not an empty metaphor or a grand theory of little utility. It is a concept robust enough to support a solid ethical stance, one that reinstates humans in nature while respecting the latter, thus permitting clear answers in cases of conflicts between (present) economic human interests and (long-term) ecological concerns.

Ecological Integrity and the Law

It is reasonable to conceive of humanity as being morally responsible to protect the integrity of the whole ecosystem, and for that responsibility to be translated into such mechanisms as standard setting in a manner that is cognizant of ecological thresholds (Taylor 1998). Insofar as such responsibility is justified as a protection of human life and health, breaches of environmental regulations deserve not just economic penalties but criminal ones. Nevertheless there is a growing parallel movement to recognize the intrinsic value of both the components and the processes of natural systems, not only in philosophy (Westra 1998, Callicott 1987, Stone 1974, Leopold 1949), but also in the law (Brooks et al. 2002).

A number of international legal instruments also reflect the emerging global ecological concerns, and thus include language about respect for the intrinsic value of both natural entities and processes. This point is illustrated by a project involving the justices of the world's highest courts, which is funded by the United Nations Environment Programme (UNEP). The project's biocentric goal, as outlined by Judge Arthur Chaksalson of South Africa, is one of the most important results of the Johannesburg meeting (also known as "Rio+10"). The 2000 Draft International Covenant on Environment and Development incorporates the mandates of the Earth Charter, which was adopted by a United Nations Economic, Scientific, and Cultural Organization (UNESCO) resolution on October 16, 2003, in its language, and includes articles on ecological integrity and the intrinsic value of nature.

Although the positions advanced in these international initiatives are present in law, economic interests often obscure the opposition between the basic rights of persons and peoples and the property rights of legal entities and institutions. In the process courts tend to weigh these incommensurable values as though they were equal. But the right to life and the survival of peoples is not comparable to economic benefits or even the survival of corporate and industrial enterprises.

An additional connection arises from a consideration of *ecological integrity* a complex concept that, after several years of funded work, the Global Ecological Integrity Project eventually defined in 2000 (Westra et al. 2000). The protection of basic human rights through recognition of the need for ecological integrity, as Holmes Rolston (1993) acknowledges, is a step in the emerging awareness of humanity as an integral part of the biosphere (Westra 1998, Taylor 1998).

On the basis of the biocentric foundation for ecological integrity, it is necessary to move toward the twin goals of deterrence and restraint, as is done in the case of assaults, rapes, and other violent crimes. Laws that restrain unbridled property rights represent a first target; but efforts should not be limited to action within the realm of tort law. The reason is obvious: Economic harms are transferable, thus acceptable to the perpetrators of such harms, although the real harms produced are often incompensable. As Brooks and his colleagues indicate in reference to U.S. law, science is now available to support appeals to interdependence. "Not only has conservation biology as a discipline and biodiversity as a concept become an important part of national forest and endangered species management, but major court cases reviewing biodiversity determinations have been decided" (Brooks et al. 2002, p. 373). In addition, Earth System Science increasingly provides "multidisciplinary and interdisciplinary science framework for understanding global scale problems," including the relations and the functioning of "global systems that include the land, oceans and the atmosphere" (Brooks et al. 2002, p. 345). In essence, the ecosystem approach and systematic science of ecological integrity have contributed support to what Antonio A. Cançado Trindade terms "the globalization of human rights protection and of environmental protection" (Cançado Trindade 1992, p. 247).

As noted these ideals are contained in the language and the principles of the Earth Charter. The global reach of these ethics and charters, to be effective, must be supported by a supranational juridical entity such as the European Court of Human Rights. As the case for environmental or, better yet, ecological rights, becomes stronger and more accepted in the international law, the best solution as suggested by Patricia Birnie and Adam Boyle could be to empower the United Nations (UN). It might be desirable "to invest the UN Security Council, or some other UN organ with the power to act in the interests of 'ecological security,' taking universally binding decisions in the interests of all mankind and the environment (Birnie and Boyle 2002, p. 754). Empowering the United Nations in this way would foster support for programs based on the abundant evidence linking ecology and human rights and could become the basis for a new global environmental/human order (Westra 2004).

LAURA WESTRA

SEE ALSO *Ecology; Research Integrity.*

BIBLIOGRAPHY

Angermeier, Paul L., and James R. Karr. (1994). "Protecting Biotic Resources: Biological Integrity versus Biological Diversity as Policy Directives." *BioScience* 44(10): 690–697.

Beyleveld, Derek, and Roger Brownsword. (2001). *Human Dignity in Bioethics and Biolaw*. Oxford and New York: Oxford University Press.

Birnie, Patricia, W., and Adam E. Boyle. (2002). *International Law and the Environment,* 2nd edition. Oxford: Oxford University Press.

Brooks, Richard; Ross Jones; and Ross A. Virginia. (2002). *Law and Ecology*. Aldershot, Hants, UK: Ashgate Publishing.

Brunnée, Jutta. (1993). "The Responsibility of States for Environmental Harm in a Multinational Context—Problems and Trends." *Les Cahiers de Droit* 34: 827–845.

Brunnée, Jutta, and Stephen Toope. (1997). "Environmental Security and Freshwater Resources: Ecosystem Regime Building." *American Journal of International Law* 91: 26–59.

Cançado Trindade, Antonio A. (1992). "The Contribution of International Human Rights Law to Environmental Protection, with Special Reference to Global Environmental Change." In *Environmental Change and International Law,* ed. Edith Brown-Weiss. Tokyo: United Nations University Press.

Daily, Gretchen C., ed. (1997). *Nature's Services: Societal Dependence on Natural Ecosystems*. Washington, DC: Island Press.

Fidler, David, P. (2001). *International Law and Public Health*. Ardsley, NY: Transnational Publishers.

Gewirth, Alan. (1982). *Human Rights Essays on Justification and Applications*. Chicago: University of Chicago Press.

Hurrell, Andrew, and Benedict Kingsbury, eds. (1992). *The International Politics of the Environment*. New York: Oxford University Press.

Karr, James R. (1993). "Protecting Ecological Integrity: An Urgent Societal Goal." *Yale Journal of International Law* 18(1): 297–306.

Karr, James R. (1996). "Ecological Integrity and Ecological Health Are Not the Same." In *Engineering Within Ecological Constraints*, ed. Peter C. Schulze. Washington, DC: National Academy Press

Karr, James R. (2000). "Health, Integrity and Biological Assessment: The Importance of Whole Things." In *Ecological Integrity: Integrating Environment, Conservation and*

Health, ed. David Pimentel, Laura Westra, and Reed F. Noss. Washington, DC: Island Press.

Karr, James R. (2003). "Biological Integrity and Ecological Health." In *Fundamentals of Ecotoxicology*, 2nd edition, ed. Michael C. Newman and Michael A. Unger. Boca Raton, FL: CRC Press.

Karr, James, R., and Ellen W. Chu. (1999). *Restoring Life in Running Waters*. Washington, DC: Island Press.

Kiss, Alexandre Charles. (1992). "The Implications of Global Change for the International Legal System." In *Environmental Change and International Law*, ed. Edith Brown-Weiss. Tokyo: United Nations University Press.

Leopold, Aldo. (1949). *A Sand County Almanac, and Sketches Here and There*. New York: Oxford University Press.

Noss, Reed F. (1992). "The Wildlands Project: Land Conservation Strategy." *Wild Earth*, Special Issue: *The Wildlife Project:* 10–25.

Noss, Reed F., and Allen Y. Cooperrider. (1994). Saving Nature's Legacy: Protecting and Restoring Biodiversity. Washington, DC: Island Press.

O'Neill, Onora. (1996). *Towards Justice and Virtue*. Cambridge, MA: Cambridge University Press.

Pogge, Thomas. (2001). "Priority of Global Justice." In *Global Justice*, ed. Thomas Pogge. Oxford: Blackwell Publishers.

Rolston, Holmes, III. (1993). "Rights and Responsibilities on the Home Planet." *Yale Journal of International Law* 18(1): 251–275.

Shrader-Frechtte, Kristin. (1995). "Hard Ecology, Soft Ecology, and Ecosystem Integrity." In *Perspectives on Ecological Integrity*, ed. Laura Westra and John Lemons. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Shrader-Frechette, Kristin, and Earl D. McCoy. (1993). *Method in Ecology: Strategies for Conservation*. New York: Cambridge University Press.

Shue, Henry. (1996). *Basic Rights: Subsistence, Affluence and American Public Policy*. Princeton, NJ: Princeton University Press.

Sterba, James. (1998). *Justice Here and Now*. Cambridge, MA: Cambridge University Press.

Stone, Christopher. (1974). *Should Trees Have Standing?: Towards Legal Rights for Natural Objects*. Los Altos, CA: W. Kaufmann.

Taylor, Prudence. (1998). "From Environmental to Ecological Human Rights: A New Dynamic in International Law?" *Georgetown International Environmental Law Review* 10: 309–397.

Westra, Laura. (1998). *Living in Integrity Toward a Global Ethic to Restore a Fragmental Earth*. Lanham, MD: Rowman and Littlefield.

Westra, Laura. (2000). "Institutionalized Violence and Human Rights." In *Ecological Integrity: Integrating Environment, Conservation and Health*, ed. David Pimentel, Laura Westra, and Reed F. Noss. Washington, DC: Island Press.

Westra, Laura. (2004). *Ecoviolence and the Law (Supranational, Normative Foundations of Ecocrime)*. Ardsley, NY: Transnational Publishers, Inc.

Westra, Laura; Peter Miller; James R. Karr, et al. (2000). "Ecological Integrity and the Aims of the Global Ecological Integrity Project." In *Ecological Integrity: Integrating Environment, Conservation and Health*, ed. David Pimentel, Laura Westra, and Reed F. Noss. Washington, DC: Island Press.

INTERNET RESOURCE

Soskolne, Colin, and Roberto Bertollini. "Global Ecological Integrity and 'Sustainable Development': Cornerstones of Public Health." World Health Organization, Regional Office for Europe. Available from http://www.euro.who.int/document/gch/ecorep5.pdf.

ECOLOGICAL RESTORATION

Ecological restoration (hereafter restoration) is "the process of assisting the recovery of an ecosystem that has been damaged, degraded or destroyed" (Society for Ecological Restoration Science & Policy Working Group). *Restoration ecology* and ecological restoration are terms often interchanged: The former is the scientific practice that is contained within the broader embrace of the latter, which incorporates both science *and* many varieties of technological and political practice.

Restoration refers to an array of salutary human interventions in ecological processes, including the elimination of weedy species that choke out diverse native assemblies, prevention of harmful activities (such as excess nutrient loads), rejuvenation of soil conditions that foster vigorous plant communities, reestablishment of extirpated species, and rebuilt webs of social participation that foster ecologically rich and productive ecosystems. The metaphor of healing is often used to describe what restorationists do.

However not everyone regards restoration as a fully positive practice. Some view it as a technological response to ecological damage, while others worry that restoration deflects attention from avoiding harm in the first place. There is also concern that restored ecosystems may be simply pale imitations of nature, and that ecosystems are always more complicated than those seeking to restore them can truly understand. Restoration practice is driven by the tension between a technological approach to restoration—technological restoration—and a participatory, humble, culturally aware approach, or what this author terms "focal restoration." The furious debates among practicing restorationists regarding these issues and others provide particular perspectives on relations between science, technology, and ethics. Moreover, conceptual clarity offers practitioners a guide to pitfalls and opportunities for good restoration.

Concept and Origins

Restoration is practiced in all regions of the world, although what counts as restoration varies according to cultural perspective and socioeconomic condition. This has complicated the creation of a precise definition of this relatively new field, especially because international conversation and cooperative projects have become more common in the early-twenty-first century. In North America, the aim is typically to restore an ecosystem to its predisturbance condition under the presumption that reversion to a pristine, original state is the ideal end point. In Europe and other regions, long and continuous human occupation has resulted in landscapes that present a distinctively cultural benchmark. In many regions of the southern hemisphere, and especially in areas where poverty and civil disruption prevail, the focus is on restoration of productive landscapes that support both ecological and cultural ideals.

No comprehensive history of restoration is available, especially one that treats diverse international perspectives. North Americans often claim to be the founders of restoration, in part because of a tradition in the twentieth century of supporting scientific and practical restoration capacity including the formation of the premier organization devoted to restoration, the Society for Ecological Restoration International (founded 1987). Prairie restoration projects at the University of Wisconsin Arboretum under the direction of Aldo Leopold, Theodore Sperry, and Henry Greene in the 1930s are often cited as inaugural moments in modern restoration. Important as these efforts are, there were prior influential developments in applied ecology, rehabilitation (the recovery of a landscape to productive capability), revegetation, and naturalistic gardening that made the Wisconsin projects possible (Perrow and Davy 2002; Mills 1995; Jordan, Gilpin, and Aber 1987). Restoration was being practiced under different guises in North America, Europe, and other regions of the world prior to the twentieth century, and, as historical accounts of these efforts are written, a tangled and interconnected lineage will undoubtedly be revealed.

Points at Issue

A spate of articles written since the 1980s has positioned restoration as one of the most hotly contested issues in environmental philosophy. Why is this? Philosophers, many environmentalists, and some restorationists are uneasy about claims that ecosystems can in fact be restored. Much turns on the standards set for restoration, most prominently the demands for historical accuracy. If the aim is to reset ecosystems to some prior time or sequence, then restoration is by definition an austere and limited practice, depending on a limited ranges of options and choices.

If the demands for historical fidelity are relaxed, the practice opens up, although enlargement of scope creates other problems. What are appropriate boundaries on restoration? How much history is necessary? How precise ought be the demands for ecological integrity? (Ecological integrity is an umbrella term that describes the capacity of an ecosystem to adjust to change—resiliency, elasticity, stress response, and so on [Kay 1991]). How much should human agency matter? How much should human participation in ecological processes matter? Without much digging, restoration turns into a conceptual quagmire, which is occasionally vexing for practitioners and always intriguing for philosophers (Throop 2002).

Arguably what has proved most contentious is the instrumental character of restoration. At worst, some would argue, restoration is a mere technological fix, that is a forgery of nature, and deflects attention from pressing and underlying environmental problems (Eliot 1997). While few hold such a dim view and most acknowledge that restoration creates value, there is a fundamental concern that restoration is a practice that grew up and thrives in a technological culture. Indeed restoration is always a series of deliberate interventions in ecological processes. As restorative capacity rises, so does the risk that such capacity will be used as a justification for destruction or careless modification of ecosystems. The challenge is to keep restoration from becoming an apologia for environmental destruction while manifesting a powerful will to repair the damage that continues to be done. Hence most restorationists operate under the belief that their actions benefit nonhuman species and enrich the social engagement between people and ecosystems. Limiting human will and ensuring that restoration does not become an end in itself is a central challenge.

The Future of Restoration

The tendency to think of restoration in technological terms is abetted by increasingly large projects—restoration megaprojects such as Florida's Everglades restoration—that are driven by typically top-down imperatives and serve primarily as emblems of environmental responsibility. The dominant tradition in restoration encompasses relatively small-scale projects that depend on bottom-up participation; these projects are deeply embedded in locality and enliven human communities. While the appearance to some observers that restoration is a set of prescriptions imposed on nature, in fact most restoration projects to date are modest in intention, self-reflexive, and tentative; exactly the opposite of what one might think of as large-scale technologically constituted practices.

Restoration practitioners are approaching a crossroads at which they will have to choose between *technological* and *focal* restoration, which focuses on community and participation (Higgs 2003). Focal restoration is one term for describing the alternative or antidote to technological restoration, and derives from Borgmann's (1984) formulation of "focal practice," in which the relations between "things" and practices are brought to the center and given priority. When focusing on something that truly matters to a community—an ecosystem to be restored for instance—the values of that community and the integrity of the thing are given heightened respect. Other terms such as "ecocultural" restoration are found in the restoration literature with roughly the same intention, but this author prefers the identification of focal restoration with its robust commentary about, and philosophy of, technology. The choice between technological and focal restoration may not be exclusive or stark, but reflective practitioners must decide which vision of restoration is appropriate. Scholarly and popular criticism has raised awareness of the risks that restoration will become thoroughly enmeshed in technological culture. The challenge is to steer along the road of participation, with respect for ecological process, modesty, and humility.

Ecological restoration has stirred profound debates about the constitution of nature in a technological society and human relations with ecosystems. Perhaps as much as any other practice, restoration has brought a conceptual spotlight to issues that arise in environmental management, conservation biology and other related endeavors. In particular, restoration demands attention to the social, economic and political relationships people have with places, which inspires a broader perspective on the scientific and technical dimensions. It is, therefore, insufficient to discuss "restoration ecology" without "ecological restoration; both matter to achieving the socially constituted goal of good restoration. The dynamic character of ecosystems also poses some fascinating challenges to other uses of the term restoration, such as those found in art, architecture, and literature.

ERIC HIGGS

SEE ALSO *Acid Mine Drainage; Ecological Footprint; Ecology; Environmental Economics; Rain Forest; Sierra Club; Wilderness.*

BIBLIOGRAPHY

Borgmann, Albert. (1984). *Technology and the Character of Contemporary Life*. Chicago: University of Chicago Press. Borgmann's original book on technology—he has since published two others—has become a foundation for contemporary philosophy of technology.

Eliot, Robert. (1997). *Faking Nature: the Ethics of Environmental Restoration*. London: Routledge. The title derives from Eliot's oft-cited paper from 1982 that assailed restoration practice and sparked a significant portion of the philosophical debate about restoration.

Higgs, Eric. (2003). *Nature By Design: People, Natural Process, and Ecological Restoration*. Cambridge, MA: MIT Press. Sets ecological restoration in a technological culture, and identifies the perils and responses to those perils that restorationists should follow.

Higgs, Eric; Andrew Light; and David Strong. (2000). *Technology and the Good Life?* Chicago: The University of Chicago Press.

Jordan, William R., III; Michael E. Gilpin; and John D. Aber, eds. (1987). *Restoration Ecology: A Synthetic Approach to Ecological Research*. New York: Cambridge University Press. Among the first synthetic accounts of restoration theory and practice.

Kay, James J. (1991). "A Non-Equilibrium Thermodynamics Framework for Discussing Ecosystem Integrity." *Environmental Management*. 15(4): 483–495.

Mills, Stephanie. (1995). *In Service of the Wild: Restoring and Reinhabiting Damaged Landscapes*. Boston: Beacon Press. A heartfelt and lyrical discussion of restoration.

Perrow, Martin R., and Anthony J. Davy, eds. (2002). *Handbook of Ecological Restoration*, 2 Vols. Cambridge, UK: Cambridge University Press. A good initial if limited attempt at summarizing restoration practice internationally.

Throop, William, ed. (2002). *Environmental Restoration: Ethics, Theory, and Practice*. Amherst, NY: Humanity Books.

INTERNET RESOURCE

Society for Ecological Restoration Science & Policy Working Group. "The SER Primer on Ecological Restoration." Available from www.ser.org/content/ecological_restoration_primer.asp.

ECOLOGY

The word *ecology* is derived from the Greek *oikos*, "household," and *logos*, "reason," thus indicating the logic of living creatures in their homes. Although *oikos* originally indicated only human households, as a term coined in 1866 by Ernst Haeckel, ecology names a biological science such as molecular biology or evolutionary biology, though often thought to be less mature, that studies organism–environment relations. Closely related to ecology in this sense are conservation biology and environmental science. Ecology, the science, studies ecosystems at multiple levels and scales in space and time. Ecosystems have proved to be often quite complicated and resist analysis. Experiments in the field are difficult, and the systems may be partly chaotic.

In part because of such complications ecology has become the focus of a particular set of discussions related to science, technology, and ethics. The term *ecological ethics* may, for instance, call for doing ethics in the light of what ecologists have found in their studies of the world. Perhaps it is appropriate, at times, for humans to imitate the way ecologies themselves function, or look toward ecosystems as fundamental goods to be appreciated and preserved. Given these associations, ecology can also feed into a worldview or philosophy.

What has been called the environmental or ecological crisis seems to rest on assumptions about or commitment to the goodness of ecosystems in the face of threats to their continuing vitality from pollution or other phenomena. Ecology thus becomes mixed with ethics in urging that humans ought to find a lifestyle more respectful or harmonious with nature. As the founder of wildlife management, Aldo Leopold, argued: "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise" (Leopold 1968 [1949], pp. 224–225). More recently, since the United Nations Conference on Environment and Development (1992), the focus has been a sustainable economy based on a sustainable biosphere.

Leading Concepts

Leading concepts in ecology involve ecosystems (a term coined by Arthur G. Tansley in 1935), a succession of communities rejuvenated by disturbances, energy flow, niches and habitats, food chains and webs, carrying capacity, populations and survival rates, diversity, and stability. A main claim is that every organism is what it is where it is, its place essential to its being, the "skin-out" environment as vital as "skin-in" metabolisms. Early ecologists described organism–environment relations in terms of homeostasis, equilibrium, and balance. Contemporary ecologists give a greater role to contingency, flux, dynamic change, or even chaos. Others emphasize self-organizing systems (autopoiesis).

As subsequent studies have shown, any ecological stability is not simply homeostatic but quite dynamic, and may differ with local systems, the level of analysis, and over time. There are perennial processes—wind, rain, soil, photosynthesis, competition, predation, symbiosis, trophic pyramids, and networks. Ecosystems may wander or be stable within bounds. When unusual disturbances come, ecosystems can be displaced beyond recovery of their former patterns. Then they settle into new equilibria. Ecosystems are always on a historical trajectory, a dynamism of chaos and order entwined.

Ecology, Technology, Management

How far can human environmental policy be drawn from ecology? The question raises classical is/ought concerns about moving from facts to values, and worries about the naturalistic fallacy. Perhaps ecology, a "piecemeal" science, can offer no more than generalizations of regional or local scope, and supply various concepts (such as eutrophication of lakes, keystone species, nutrient recycling, niches, and succession) for analyzing particular circumstances. Humans could then step in with their management objectives and reshape ecosystems consonant with cultural goals.

Certainly humans have always had to rest their cultures upon a natural life-support system. The human technosphere is constructed inside the biosphere. In the future this could change; the technosphere could supersede the biosphere. The natural sciences would be increasingly replaced by the sciences of the artificial, as in computer science, or materials science (as with Teflon), or engineered biotas. Edward Yoxen (1983) has celebrated the prospect: "The living world can now be viewed as a vast organic Lego kit inviting combination, hybridisation, and continual rebuilding. . . . Thus our image of nature is coming more and more to emphasise human intervention through a process of design" (pp. 2, 15).

Ecosystem management (if not more global, planetary management) appeals alike to scientists, who see the need for understanding ecosystems objectively and for applied technologies, as well as to landscape architects and environmental engineers, who see nature as redesigned home, and finally to humanists, who desire benefits for people. A good thing in nature may not be a good in culture, and vice versa. Viruses kill people; people's cities kill wild animals. The combined ecosystem/management policy promises to operate at systemwide levels, presumably to manage for indefinite sustainability, alike of ecosystems and their outputs. Such management sees nature as "natural resources" at the same time that it has a "respect nature" dimension. Christian ethicists note that the secular word *manager* is a stand-in for the earlier theological word *steward*, and also that the biblical "dominion" involves more cultivating a garden Earth than conquering and controlling it.

At the same time, ecosystem management has been criticized as an umbrella idea under which different managers can include almost anything they wish, because what one is to manage ecosystems for is left unspecified. They might be managed for maximum sustainable yield, for equal opportunity in the next generation, for maximum biodiversity, or for quick profit. Nevertheless there usually is the idea of fitting human uses into ongoing ecosystem health or integrity. There is less overconfidence than with those who view nature as a vast Lego kit and seek to redesign the planet. This is often a matter of managing human uses of their ecosystems with as much care as one is managing, or revising, wild nature.

Editing a 1989 *Scientific American* issue on "Managing Planet Earth," William C. Clark identified two central questions: "What kind of planet do we want? What kind of planet can we get?" (Clark 1989, p. 47). Over great stretches of Earth, evolutionary and ecosystemic nature has been diminished in favor of engineered design. Nature is at an end. The principal novelty of the millenium is that Earth will be a managed planet. Humans will make it a better home for themselves.

Ecological Limits?

Such claims raise concerns about how far nature can and ought to be transformed into humanized nature. Ecologists are likely to fear the arrogance rather than to celebrate the expertise of such planetary engineers. Much transformation is the positive result of human managerial successes: widespread irrigation, agricultural production, electric power. But just as often there are unintended, undesired results: The seeds of exotic weeds are carried afar on ships and trains; the landscape is increasingly weedy. Toxic, nondegradable agricultural chemicals seep into the nooks and crannies of all nature. Industrial production and mass consumption produces global climate change. The "dominion" mentality is what led to the ecological crisis; more clever dominion, the ultimate technological fix, is a dangerous myth. Rather people should think of humans as fitting themselves into a sustainable biosphere, as members of a larger community of life on Earth, as a better logic of our being at home on Earth.

But, critics rejoin, the community of life on Earth is already human-centered; this is the fact of the matter. The end of nature may be, in its own way, a sad thing; but it is inevitable, and the culture that replaces nature has many compensating values. Humans too belong on the planet. With the arrival of humans, and their technologies, pristine nature vanishes. Nature does not vanish equally and everywhere, but there has been loosed on the planet such a power that wild nature will never again be the dominant determinant of what takes place on the inhabited landscapes.

Should this rebuilding of humanity's Earth home be thought of as a sort of dialectic: nature the thesis, culture the antithesis, and the synthesis a humanized nature? Possibly, but there is a still better ecological model: that of an ellipse with two foci. Some events are generated under the control of a culture focus: society, its economics, its politics, its technologies. Under the other focus, nature, some events take place in the absence of humans—wild, spontaneous, ecological, evolutionary nature (in parks, reserves, and wilderness areas).

From a larger ecological perspective, a domain of hybrid or synthetic events is generated under the simultaneous control of both foci, the result of integrated influences from nature and culture. Human labor and craft put natural properties to use in culture, mixing the two to good effect in agricultural, industrial, scientific, medical, and technological applications. *Symbiosis* is a parallel biological word.

Lest technologists become too arrogant, there is a sense in which nature has not ended and never will. Humans stave off natural forces, but the natural forces can and will return, if one takes away the humans. Nature is forever lingering around. Nature bats last. In, with, and under even the most technologically sophisticated culture, there is always this once and future nature.

Ecological Is and Ought

Scientists and ethicists alike have traditionally divided their disciplines into realms of the is and the ought, facts and values. No study of nature, it has been argued, will tell humans how they ought to behave. But this neat division is challenged by ecologists and their philosophical and ethical interpreters. There may be goods (values) in nature that humans ought to consider and care for. Animals, plants, and species, integrated into ecosystems, may embody values that, though nonmoral, count morally when moral agents encounter them. Ecology invites human beings to open their eyes and to appreciate realities that are valuable in ways humans ought to respect.

Ecological or environmental science may thus inform environmental technology and environmental ethics in subtle ways. Scientists describe the order, dynamic stability, and diversity in biotic communities. They analyze interdependence, or speak of health or integrity, perhaps of resilience or efficiency. Scientists describe the adapted fit that organisms have in their niches. They analyze an ecosystem as flourishing, as self-organizing. Strictly interpreted, these are only descriptions; and yet they embody already quasi-evaluative terms, perhaps not always but often enough that by the time the descriptions of ecosystems are in, some values are already there, putting constraints on what we think might be appropriate human technological development of such areas.

Ethicists can with considerable plausibility also claim that neither conservation, nor a sustainable biosphere, nor sustainable development, nor a well-managed planet, nor any other harmony between humans and nature can be gained until persons learn to use Earth both justly and charitably. These twin concepts are found neither in wild nature nor in any science that studies nature, nor in any technology as such. One needs human ecology, humane ecology, and this requires insight more into human nature than into wild nature. True, humans cannot know the right way to act if they are ignorant of the causal outcomes in the ecosystems they modify. And they cannot act successfully without technology. But there must be more, and here ethics is required to keep science, technology, and life human and humane on this, humanity's home planet.

HOLMES ROLSTON III

SEE ALSO *Biodiversity; Deforestation and Desertification; Ecological Economics; Ecological Footprint; Ecological Integrity; Ecological Restoration; Environmental Ethics; Rain Forest; Sustainability and Sustainable Development; United Nations Environmental Program.*

BIBLIOGRAPHY

Barbour, Ian G. (1980). *Technology, Environment, and Human Values*. New York: Praeger Publishers. Older study, but remains a useful analysis.

Clark, William C. (1989). "Managing Planet Earth." *Scientific American* 261(3): 46–54. Introduces a theme issue on managing the planet.

Cooper, Gregory J. (2003). *The Science of the Struggle for Existence: On the Foundations of Ecology*. Cambridge, UK, and New York: Cambridge University Press. Examines the philosophical foundations of ecosystem science.

Golley, Frank B. (1998). *A Primer for Environmental Literacy*. New Haven, CT: Yale University Press. Presents leading themes in ecology and how understanding these might change individual lifestyles.

Gotelli, Nicholas J. (2001). *A Primer of Ecology*, 3rd edition. Sunderland, MA: Sinauer Associates.

Grumbine, R. Edward. (1994). "What Is Ecosystem Management?" *Conservation Biology* 8(1): 27–38. Discusses ecosystem management and whether it is feasible.

Leopold, Aldo. 1968 (1949). *A Sand County Almanac*. New York: Oxford University Press.

Odum, Eugene P. (1997). *Ecology: A Bridge between Science and Society*, 3rd edition. Sunderland, MA: Sinauer Associates. Ecology and its social implications.

Real, Leslie A., and James H. Brown, eds. (1991). *Foundations of Ecology: Classic Papers with Commentaries*. Chicago: University of Chicago Press. The classic papers in the founding of ecology as a science.

Yoxen, Edward. (1983). *The Gene Business: Who Should Control Biotechnology?* New York: Harper and Row. Examines genetic modification of foods for human benefit and who makes what kind of choices.

Zweers, Wim, and Jan J. Boersema, eds. (1994). *Ecology, Technology, and Culture*. Cambridge, UK: The White Horse Press. Essays from a European perspective.

ECONOMICS AND ETHICS

Economics often is regarded as the most successful of the social sciences in developing a scientific theory of social behavior. Therefore, economics is a science with manifest ethical implications.

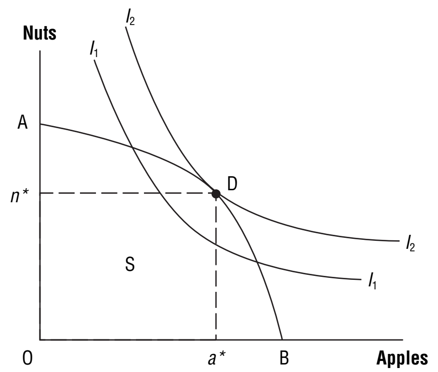
General Equilibrium Theory

Contemporary economic theory is based on the *general equilibrium model* first outlined by the nineteenth-century Swiss economist Léon Walras (1834–1910) and perfected in the post–World War II era by Kenneth Arrow (b. 1921; winner of a Nobel Prize in economics in 1972) and others. The Walrasian general equilibrium model includes firms, which transform production inputs (land, labor, natural resources, capital goods such as buildings and machines, and intermediate goods produced by other firms) into outputs (including consumer goods and services) by using a technologically determined production function that summarizes the most technically efficient way to transform a specific array of inputs into a particular output or array of outputs. The only other actors in the general equilibrium model are individuals and government. Individuals supply labor to firms and own the land, natural resources, and capital, which they supply to firms, and also are consumers who use the income they derive from supplying inputs to production to purchase goods and services that they then consume. The government enforces property rights and contracts and intervenes to alter economic outcomes that are considered inefficient or inequitable.

The general equilibrium model assumes that there are many firms competing to supply each good desired

FIGURE 1

Individual Welfare Maximization



SOURCE: Courtesy of Herbert Gintis.

by consumers. Equilibrium takes the form of a set of prices for the production inputs and outputs so that supply equals demand for each good as well as for labor, land, capital, and natural resource inputs. General equilibrium theory shows that once the equilibrium prices are known, if individuals and firms are allowed to trade in competitive markets, the equilibrium allocation of production inputs and outputs will emerge. This process often is called *market clearing*.

General equilibrium theory assumes that each individual has a *preference function* that reflects that individual's labor supply and consumption rankings, as described by *rational choice theory* and *decision theory*. The central property of preferences in the theory is that they are self-regarding; this means that individuals care only about their personal labor supply and commodity consumption. It also means that individuals are completely indifferent to the welfare of others and never willingly sacrifice on behalf of other market participants. To make this assumption more palatable, the individuals in general equilibrium theory often are described as families, thus allowing for nonmarket altruistic interactions among nuclear family members.

Consumer Sovereignty

The most important ethical judgment in general equilibrium theory is that involving *consumer sovereignty*: A state of affairs A is normatively better than a state of affairs B for individuals if, with everything else being equal, these individuals prefer the labor and consumption bundles they have in state A over those they have in state B. For a graphic illustration, assume that there are only two goods, Apples (*a*) and Nuts (*n*). Suppose the consumer is restricted to choosing from the Apples-Nuts bundles depicted by region *S* in Figure 1, bounded by OADB.

In this figure I_1I_1 *and* I_2I_2 *represent indifference curves*, which are sets of points along which the consumer is equally well off. These curves exhibit *diminishing marginal rates of substitution*; this means that the greater the ratio of nuts to apples is, the more the individual values apples over nuts, and vice versa. Note that the indifference curve I_1 intersects the interior of region S, and so an agent may increase his or her consumption of both Apples and Nuts. Thus, that individual can shift out his or her indifference curve, and hence increase his or her utility, as long as that indifference curve continues to intersect region S. The consumer is thus best off with indifference curve I_2, which intersects S at the single point D, at which point the indifference curve is tangent to the constraint set S. Consumer sovereignty judges consumption point D, at which the individual consumes a^* units of Apples and n^* units of Nuts, to be a welfare optimum for the individual.

Consumer sovereignty is a problematic ethical judgment in at least three ways. First, it ignores the distribution of economic benefits across individuals. If individual I_1 is very rich and all the other individuals in the economy are very poor, it can be said that society as a whole is normatively better if I_1 is made even richer as long as this is not done at the expense of the other individuals. Assuming that individuals are self-regarding, this is a plausible ethical statement, but if the poor care about equity and are hurt when their relative deprivation is exacerbated, the consumer sovereignty judgment will be flawed. In fact, it appears that individuals do care not only about their own consumption but about how it compares with that of others as well, and so improving the consumption opportunities of one group can hurt another group (Lane 1993).

A second problem with the consumer sovereignty principle lies in its failure to recognize that individuals may prefer things that are not in their own interest. For instance, it is in the nature of the addiction that a cigarette smoker prefers smoking to abstaining, but even smokers recognize that they would be better off if they abstained. Consumer sovereignty at one time was an inviolable article of faith for economists, who considered evaluating people's preferences an insulting and socially undesirable form of paternalism. Widespread phenomena such as obesity, recreational drug use, and substance addiction have convinced many economists that there is a role for government intervention to curb consumer sovereignty in such spheres. However, these sentiments are restricted to a few well-defined areas.

The values promoted by economic theory are generally hostile to the notion that scientists and the educated elite (e.g., teachers, preachers, and social workers) know best what is good for everyone else.

The third problem is that consumer sovereignty implies that individuals care only about their own well-being, whereas people often care about each other. In fact, people often positively value contributing to the welfare of the less well off and to the punishment of social transgressors.

Pareto Efficiency

Consumer sovereignty leads to a very simple but powerful means of comparing the normative worth of two economic situations. One says that state A is *Pareto superior* to state B if at least one person is better off in state A than in state B and no one is worse off in state A than in state B, where *better off* and *worse off* are synonyms for *higher up* and *lower down* on one's preference ordering according to consumer sovereignty. It then can be said that state A is *Pareto efficient* if there is no other state that is Pareto superior to it. These conditions are named after the nineteenth-century Italian engineer and sociologist Vilfredo Pareto (1848–1923).

The important point here is that the Pareto efficiency condition expresses the very weak ethical judgment that society is better off when one member is better off and none worse off, and an individual is better off when he or she has more of what he or she prefers. Any maximally ethically desirable state of the economy will be Pareto efficient because otherwise, by definition, there would be a normatively superior state. Thus, one can separate the normative question "Who deserves to get what?" completely from the positive, nonethical question "What are the conditions for Pareto efficiency?"

The relationship between Pareto efficiency and the normative question of the distribution of welfare among individuals was diagramed by the English economist Francis Ysidro Edgeworth (1845–1926) in what has come to be known as the Edgeworth Box diagram (see Figure 2). One can consider a simple economy with two individuals (I_1 and I_2), two goods (Apples and Nuts), no labor, and no firms—the two individuals simply trade with each other. The width of the rectangle represents the total amount of Apples, and the height represents the amount of Nuts.

Suppose point C represents the initial wealth of the two individuals so that I_1 has FG Apples and 1E Nuts and I_2 has G2 Apples and EF Nuts. The curve

$$I_1^c$$

represents an indifference curve for I_1, a locus of points (combinations of Apples and Nuts) among which I_1 is indifferent, preferring all the points to the northeast to points on the curve and preferring all points on the curve to points to the southwest of the curve. Similarly,

$$I_2^c$$

is an indifference curve for I_2. Note that point D lies on both curves, and it is easy to see that D is Pareto efficient because any move away from it will make either I_1 or I_2 worse off. Clearly, the initial point C makes both agents worse off than they are at D, and so it would benefit them to trade, with I_1 increasing the amount of Apples in his bundle by getting them from I_2 and I_2 increasing the amount of Nuts in her bundle by getting them from I_1.

The locus of points 1ADB2 is called the *contract curve* and is the set of Pareto efficient points for this economy. Note that at point 1 individual 2 gets everything, whereas at point 2 individual 1 gets everything. The points between represent different distributions of the benefits of the total supply of Apples and Nuts in the economy. Of course, I_1 prefers C to most of the points on the contract curve below C and I_2 prefers C to most of the points on the contract curve above C. To find out exactly which point or points each individual prefers, one can draw the indifference curves for the two agents that go through C and see where they hit the contract curve. Suppose they hit at C_1 and C_2 (not shown in the figure). Then the two agents will be willing to trade at any point on the contract curve between C_1 and C_2.

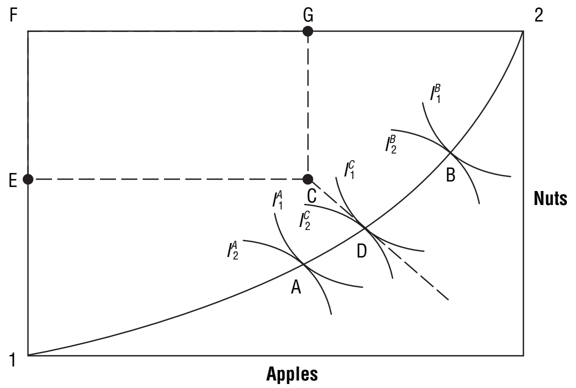
Implications for Ethics

The general equilibrium model has several important implications for ethical theory. The First Fundamental Theorem of Welfare Economics states that any equilibrium of the market economy is Pareto efficient. Note that this conclusion depends on the assumption of self-regarding preferences. If, for instance, above a certain income level people care only about their relative position in the distribution of material benefits, a market-interfering law that prohibited people from working more than a certain number of hours per week could increase the welfare of all people.

Suppose that the various production sectors have production functions that do not depend on one another and that efficient firm size is sufficiently small that there

FIGURE 2

The Edgeworth Box



SOURCE: Courtesy of Herbert Gintis.

can be many firms producing each good in equilibrium. Then a Second Fundamental Theorem of Welfare Economics holds. This theorem states that if the economy satisfies the conditions stated above and a few technical conditions, any Pareto efficient allocation can be supported by a suitable initial distribution of ownership rights in land, natural resources, capital goods, and labor. This theorem successfully separates the positive (technical, scientific) issues of Pareto efficiency from the normative issue of who deserves to get what.

Perhaps the most distinctive normative characteristic of the Walrasian general equilibrium model is its strong commitment to separating considerations of technical efficiency from considerations of normative distribution. This separation is completely justified only if there is a mechanism to distribute initial ownership rights in a way that achieves an ethically desired distribution of welfare. The separation nevertheless often is defended by saying that if the economy attends to the efficiency side of the dichotomy rather than sacrificing efficiency in the name of equity, in the long run most individuals will be better off. This is doubtless a defensible position, although there are often government interventions that promote efficiency and satisfy egalitarian goals as well (Bowles and Gintis 1996).

Several aspects of the general equilibrium model render it an imperfect basis for making judgments about social policy and ethics. First, people are not entirely self-regarding. Rather, they are what may be called strong reciprocators who prefer to reward those who help them and contribute to social goals and to punish those who hurt them or act in an antisocial manner (Gintis, Bowles, Boyd, and Fehr 2003). Strong reciprocators prefer to redistribute resources to the needy if the recipients are considered worthy but not otherwise. This leads to social policies that would not be envisioned under the assumption of the general equilibrium model that people are self-regarding (Fong, Bowles, and Gintis 2004).

In addition, the idea of achieving social equity by means of an initial distribution of wealth among individuals in society followed by market exchange ignores the problem that with incomplete knowledge of the future the process of egalitarian redistribution away from the wealthy and toward the needy will have to be repeated time and time again as the economy moves away from a condition of basic equality to one of severe inequality. That type of redistribution may be infeasible because of the ensuing individual disincentives to accumulate wealth and income-earning capacity.

To see this one must remember that the general equilibrium model assumes that all goods and services are marketable and can be the subject of contracts that are enforced costlessly by a third party such as the judicial system. For instance, several behaviors that are critical to high levels of productivity—hard work, maintenance of productive equipment, entrepreneurial risk taking, and the like—are difficult to monitor and thus cannot be specified fully in any contract that is enforceable at a low cost. As a result key economic actors, namely, employees and managers, must be motivated by incomplete contracts in which monetary rewards are contingent on their performance. However, when incentive rewards are necessary to motivate behavior, egalitarian redistribution works against those who supply a high level of effort, leading to a dampening of the incentive system. Hence, it may be impossible in practice to separate efficiency from equity issues.

Another problem with periodic egalitarian redistribution is that it may violate the principles of justice that many people hold. According to the English philosopher John Locke,

> every man has a property in his own person. . . . The labour of his body, and the work of his hands, we may say, are properly his. Whatsoever then he removes out of the state that nature hath provided, and left it in, he hath mixed his labour with, and joined to it something that is his own, and thereby makes it his property (*Second Treatise on Government* (*Of Property* Chapter 5, Section 27).).

Such values would preclude the involuntary redistribution of wealth even if it furthered widely approved egalitarian ends.

In short, technical efficiency and normative issues concerning justice and equality cannot be separated in the manner intended in the Walrasian general equilibrium model. Moreover, because individuals are not completely self-regarding, social policies based on this model will fail to tap the genuine egalitarian motives of voters and citizens. This said, it would be folly to use these shortcomings to override completely the assumption in the Walrasian model that in the long run economic efficiency and efficiency-oriented technical change are more likely to help the less well off. Insofar as this is the case, issues of egalitarian reform should be biased as much as possible toward efficiency-enhancing redistributions such as education, training, and the financing of small business and small-scale farming.

Contracts

Another important set of issues arises when it is recognized that the neoclassical assumption that contracts can be written and enforced costlessly generally does not hold for either labor or capital. In the case of labor an employer can offer workers a legally binding wage, but a worker cannot offer the employer a legally binding amount of effort and care. This is the case because effort and care are not sufficiently measurable that a violation would hold up in a court of law. Therefore, employers generally enter into long-term agreements with their employees, using the threat of termination and the promise of promotion to elicit a high level of performance. However, this practice will motivate employees only if dismissal is costly to an employee, and this will be the case generally only if it is difficult to obtain comparable employment with another firm. That will be the case only if there is *equilibrium unemployment* in the economy. It can be shown that if employers follow this strategy of worker motivation, there indeed will be unemployment in equilibrium (Gintis 1976, Shapiro and Stiglitz 1984, Bowles 1985, Gintis and Ishikawa 1987, Bowles and Gintis 2000).

This situation accounts for the fact that employers generally have power over their employees in the sense that employers can use the threat of dismissal to induce employees to bend to their will, whereas the converse is not true. Although this power may be used benignly, it also may be used in an unethical manner, as occurs when employers force employees to accept unhealthy working conditions or subject them to sexual harassment and other forms of personal humiliation and discrimination.

In the case of capital the difficulty in contract enforcement arises because the borrower cannot make an easily enforced promise to repay a loan. Of course, a wealthy borrower can offer collateral in the form of valuable assets that the lender has the right to seize if the borrower defaults. Nonwealthy borrowers who lack collateral thus are frozen out of many capital markets. Special credit institutions have arisen to give nonwealthy individuals access to credit for home and automobile ownership as well as credit cards for consumer purchases. In the case of home and automobile purchases the asset itself provide collateral, and requiring the buyer to provide a sizable down payment assures the lender against sustaining a loss. In the case of credit cards the threat of a loss of one's credit rating and hence future access to consumer credit serves to protect lenders against loss (Bowles and Gintis 2000).

The absence of costlessly enforced contracts in capital markets has several important social implications. First, demand generally exceeds supply, leading to credit rationing (Stiglitz and Weiss 1981) in which wealthy agents have access to loans whereas nonwealthy agents do not. Second, banks and other lending agencies have the same sort of power over borrowers that employers have over employees by virtue of their superior "short-side" market position. This power is subject to abuse by lenders, although large borrowers have a counterbalancing power to injure lenders so that in effect it is only the small borrower who must be protected against the arbitrary actions of lenders (Bowles and Gintis 2000).

HERBERT GINTIS

SEE ALSO *Consequentialism; Efficiency; Political Economy; Rational Choice Theory.*

BIBLIOGRAPHY

Bowles, Samuel. (1985). "The Production Process in a Competitive Economy: Walrasian, Neo-Hobbesian, and Marxian Models." *American Economic Review* 75(1):16–36.

Bowles, Samuel, and Herbert Gintis. (1996). "Asset Based Redistribution: Improving the Tradeoff between Allocative Gains and Dynamic Inefficiency Losses." MacArthur Economics Initiative Working Paper, University of California at Berkeley.

Bowles, Samuel, and Herbert Gintis. (2000). "Walrasian Economics in Retrospect." *Quarterly Journal of Economics*, November, pp. 1411–1439.

Fong, Christina M.; Samuel Bowles; and Herbert Gintis. (2004). "Reciprocity and the Welfare State." In *Moral Sentiments and Material Interests: On the Foundations of Cooperation in Economic Life*, eds. Herbert Gintis, Samuel Bowles, Robert Boyd, and Ernst Fehr. Cambridge, MA: MIT Press.

Gintis, Herbert. (1976). "The Nature of the Labor Exchange and the Theory of Capitalist Production." *Review of Radical Political Economics* 8(2): 36–54.

Gintis, Herbert, and Tsuneo Ishikawa. (1987). "Wages,Work Discipline, and Unemployment." *Journal of Japanese and International Economies* 1: 195–228.

Gintis, Herbert; Samuel Bowles; Robert Boyd; and Ernst Fehr. (2003). "Explaining Altruistic Behavior in Humans." *Evolution & Human Behavior* 24: 153–172.

Lane, Robert E. (1993). "Does Money Buy Happiness?" *The Public Interest* 113: 56–65.

Locke, John. (1965 [1690]). *Two Treatises of Government*, ed. Peter Laslett. New York: New American Library.

Shapiro, Carl, and Joseph Stiglitz. (1984). "Unemployment as a Worker Discipline Device." *American Economic Review* 74(3): 433–444.

Stiglitz, Joseph, and Andrew Weiss. (1981). "Credit Rationing in Markets with Imperfect Information." *American Economic Review* 71: 393– 411.

ECONOMICS: OVERVIEW

In economics, issues of science, technology, and ethics are more diverse than in any other scientific or technological discipline. In the first instance, like all the sciences, economics is both dependent on and independent of ethics. Its methods involve internal commitments of an ethical character (e.g., truth telling) but are subject to external ethical oversight (e.g., with regard to the proper treatment of human participants in empirical research). At the same time, as the entry on "Economics and Ethics" points out, the content of the science may have ethical implications in ways that physics, for instance, does not.

In the second instance, insofar as economics constitutes a technique or technology, it may provide guidance for how to achieve externally determined ends. As such it exhibits multiple interactions with various ethical, legal, and policy perspectives. Such interactions are referenced in entries such as those on "Capitalism," "Market Theory," "Political Economy," and "Science Policy."

Modern Economics

Economics in the modern sense (also called "neoclassical economics") is the science of the allocation and utilization of resources under conditions of scarcity, that is, when there are not enough resources or goods to satisfy all human needs or wants. In a widely adopted definition, for example, the British economist Lionel Robbins (1932) describes economics as "the science which studies human behavior as a relationship between ends and scarce means which have alternatives uses" (p. 16). Insofar as economics assumes that most goods and services are scarce or insufficient to satisfy human wants, and that by and large all human wants are legitimate, economics places the free satisfaction of individual human desires at the top of its own internal moral hierarchy. This may be described as the ethics of economics, one that further provides a basic justification for modern technology as a means to increase efficiency in exploitation, production, and distribution, and has been subject to extended historicophilosophical assessment and some criticism (see, e.g., Polanyi 1944, Dumont 1977, Rhoads 1985, Achterhuis 1988, Nelson 2001).

The science of economics is divided into two main overlapping branches dealing with smaller scale and larger scale economic phenomena. The economic analysis of scarcity and the pursuit of productive efficiency in the sense of maximizing satisfaction (or utilities) among individuals at the level of consumers, firms, and markets is called microeconomics. The economic analysis of scarcity at the national level, usually in terms of policies that promote or hinder gross economic productivity, employment, investment, or inflation, is called macroeconomics. There is a greater consensus about the principles operative in and recommendations for behaviors in microeconomics than in macroeconomics.

A strong consensus at the level of microeconomics is exhibited around what are known as the first and second theorems of welfare economics. It is universally agreed that both theorems follow logically from the general equilibrium model—even while there are disagreements about the plausibility of the assumptions necessary for the theory to hold that make problematic any policy recommendations based on it. Again, see "Economics and Ethics."

The first theorem states that the general equilibrium in a competitive economy is Pareto efficient. A special kind of efficiency, Pareto efficiency (as formulated by the Italian engineer economist Vilfredo Pareto) is that situation in which it is not possible to make anyone better off without making someone else worse off. A competitive general equilibrium refers to the outcome in an ideal setting in which consumers are able, in a free and well-informed manner, to exchange goods and services in an open market with multiple independent producers. Of course, this ideal is not always the reality.

The second theorem states that any feasible allocation of welfare to economic actors can be achieved by the appropriate assignment of property rights to agents, followed by competitive production and exchange. What this means is that any desired Pareto-efficient outcome can be achieved simply by an appropriate initial distribution of property rights followed by free-market activity.

It is important to note that because of debates about the assumptions behind the model on which these theorems rely, they do not in themselves fully justify the market economy. The market economy based on private property upheld by the state simply seems to work better in achieving popularly approved welfare goals than alternative systems.

Insofar as economics involves both scientific theory about decision-making and techniques (or technologies) for decision-making, it has further implications for ethics. Indeed, those special economic analyses found in "Game Theory" and its generalization known as "Rational Choice Theory" have on occasion been presented as scientific assessments of some aspects of human behavior that also have normative force.

The less than strong consensus at the level of macroeconomics is reflected in extended debates about how science and technology contribute to national economic productivity, employment, investment, or inflation. These debates are reviewed in the entries on "Innovation," "Invention," "Political Economy," and "Science Policy." They are also related to a host of studies in the history and sociology of science, technology, and economic change that are relevant but not considered at length (see, e.g., Rosenberg 1976, 1982, 1994; Mokyr 1990, 2002; Rosenberg, Landau, and Mowery 1992; Mirowski and Sent 2002).

Still a third main branch of economic analysis concerns development. This field of economics and its special relations to science, technology, and ethics is considered in the entry on "Development Ethics."

Postmodern Economic Issues

Along with these three main branches of economics, there are a number of closely related specialized forms that qualify or extend the modern economic framework. Two of these have been given special entries: "Ecological Economics" and "Environmental Economics."

Environmental economics, which began to be recognized as a special field in the 1970s, seeks to adapt the principles of micro- or welfare economics to satisfying individual environmental desires for clean water and clean air by seeking to identify the best market mechanisms to promote pollution or emission reductions and waste management. To some extent it is often argued that this requires the social scientific management of markets.

Ecological economics, which emerged in the 1980s, especially contends that market mechanisms are insufficient to evaluate ecological phenomena. As a result, it seeks new ways to conceptualize, for instance, the carrying capacity of the environment and the economic value of natural goods and services.

Both environmental and ecological economics, because they require experts to adjust or correct markets to make them reflect social values, must deal with the problem formulated by social choice theory. Social choice theory concerns the question of whether societies—rather than individuals—can be said to have preferences, and if so, how these preferences relate to the preferences of the individual members of a society. The core result of social choice theory is an impossibility theorem, formulated by the economist Kenneth J. Arrow (1970), that challenges the notion that a society can rank its options in a coherent way. Arrow's theorem states that if everyone in a society has individual preferences that satisfy some basic principles of consistency, and applies these preferences to rank-order a set of options, unless everyone has the same preferences (or agrees to appoint a dictator) there will be no way to add up the individual preferences to achieve a social preference ranking that retains the consistency observed in individual preferences.

CARL MITCHAM
ROSS MCKITRICK

SEE ALSO *Capitalism; Development Ethics; Ecological Economics; Economics and Ethics; Environmental Economics; Game Theory; Innovation; Invention; Market Theory; Political Economy; Rational Choice Theory; Science Policy.*

BIBLIOGRAPHY

Achterhuis, Hans. (1988). *Het rijk van de schaarste: Van Thomas Hobbes tot Michel Foucault* [The reign of scarcity: From Thomas Hobbes to Michel Foucault]. Baarn, Netherlands: Ambo.

Arrow, Kenneth J. (1970). *Social Choice and Individual Values*, 2nd edition. New Haven, CT: Yale University Press.

Dumont, Louis. (1977). *From Mandeville to Marx: The Genesis and Triumph of Economic Ideology*. Chicago: University of Chicago Press.

Mirowski, Philip, and Esther-Mirjam Sent, eds. (2002). *Science Bought and Sold: Essays in the Economics of Science*. Chicago: University of Chicago Press. A collection of nineteen texts: one (by Charles Sanders Peirce) from the 1800s, three from the 1950s and 1960s, ten from the 1990s and 2000s, with five previously unpublished. Good introduction.

Mokyr, Joel. (1990). *The Lever of Riches: Technological Creativity and Economic Progress*. New York: Oxford University Press.

Mokyr, Joel. (2002). *The Gifts of Athena: Historical Origins of the Knowledge Economy*. Princeton, NJ: Princeton University Press.

Nelson, Robert H. (2001). *Economics as Religion: From Samuelson to Chicago and Beyond*. University Park: Pennsylvania State University Press.

Polanyi, Karl. (1944). *The Great Transformation*. New York: Rinehart.

Rhoads, Steven E. (1985). *The Economist's View of the World: Government, Markets, and Public Policy*. Cambridge, UK: Cambridge University Press. A widely regarded and often reprinted introduction by a political scientist.

Robbins, Lionel. (1932). *An Essay on the Nature and Significance of Economic Science*. London: Macmillan.

Rosenberg, Nathan. (1976). *Perspectives on Technology*. Cambridge, UK: Cambridge University Press.

Rosenberg, Nathan. (1982). *Inside the Black Box: Technology and Economics*. Cambridge, UK: Cambridge University Press.

Rosenberg, Nathan. (1994). *Exploring the Black Box: Technology, Economics, and History*. Cambridge, UK: Cambridge University Press.

Rosenberg, Nathan; Ralph Landau; and David C. Mowery, eds. (1992). *Technology and the Wealth of Nations*. Stanford, CA: Stanford University Press.

EDISON, THOMAS ALVA

Inventor and entrepreneur Thomas A. Edison (1847–1931) was born in Milan, Ohio, on February 11, and became the most prolific inventor in U.S. history, with a record 1,093 patents. Through his technological innovations and companies, "The Wizard of Menlo Park" (in New Jersey, where his laboratory was located) helped found the electric light and power, sound recording, and motion picture industries, and contributed substantially to the telecommunications, battery, and cement industries. He was also close friends with Henry Ford, the pioneer of mass production. Edison established the first industrial laboratories devoted to inventing new technologies and recast invention as part of a larger process of innovation that encompassed manufacturing and marketing. The philosopher Alfred North Whitehead famously credited him with the invention of a method of invention. Edison died in West Orange, New Jersey, on October 18.

Thomas Alva Edison, 1847-1931. The American inventor held hundreds of patents, most for electrical devices and electric light and power. Although the phonograph and incandescent lamp are best known, perhaps his greatest invention was organized research. *(© UPI/Corbis-Bettmann.)*

The Invention Process and Intellectual Property

After working as a telegraph operator in the mid-1860s, Edison began his inventive career by becoming a contract inventor in the telegraph industry. At a time when general incorporation laws were just beginning to reshape American business, these companies were learning how to deal with technological innovation. Concerns over conflict of interest were also just beginning to emerge, and Edison saw no conflict in working for companies in direct competition with each other.

Perhaps the best-known conflict of interest in Edison's early career arose over his most important telegraph invention—the quadruplex telegraph, which enabled four messages to be sent simultaneously over one wire. Edison worked on this invention under an informal arrangement with Western Union Telegraph. At the same time he was working under more formal contracts with officials of the Automatic Telegraph Company to develop a competing system that used machinery rather than human operators to send messages at high speeds. After successfully demonstrating his quadruplex in the fall of 1874 on Western Union lines, Edison sought payment from the company, but

Western Union did not act promptly on what he believed were relatively modest demands for payment. Facing the loss of his house and shop in Newark due to the general economic depression caused by the Panic of 1873, Edison felt free to sell his rights in the invention to railroad financier Jay Gould, who was in the process of creating a competing telegraph network by combining several small competing firms including Automatic Telegraph. Although Western Union had to sue to assert its rights to the invention, the company nonetheless agreed to retain Edison's services to continue work on multiple telegraph systems, but this time under a formal contract. Later Edison signed another agreement with Western Union that secured all his work related to landline telegraphy, including the new telephone technology.

Edison entered into this latter contract in early 1877 in an effort to secure support for his new Menlo park laboratory, the first devoted to the creation and commercialization of new technologies. Edison's *invention factory* played a key role in the creation not just of specific devices but of methodological research and development leading to market innovation. Indeed, in order to make the incandescent light bulb commercially viable, Edison created a system for the distribution of electricity and designed the manufacturing technology for producing lamps.

As the laboratory and its workforce grew, Edison depended more and more on the assistance of a large staff of experimenters and machinists who made important contributions to his inventive efforts. As a consequence, he was faced with finding ways to give appropriate credit and financial awards for their work. At the time employees entered the laboratory they were made to understand that they were working on Edison's ideas, and that their work on his inventions would be credited to him.

Nonetheless the issue of credit remained a tricky one. While Edison and his assistants perceived their role as working on his ideas, he gave general directions and relied on their abilities to work out important details. Edison thus generally made it a policy to take out the key patents, while permitting assistants to take out ancillary patents he considered to be primarily their contribution. At the time, U.S. patent law gave priority to an employer in disputes with employees and discouraged joint inventions unless a true partnership in the invention could be demonstrated. In lieu of joint patents or other credit for their inventive assistance, Edison gave his chief experimenters an interest in royalties and other profits. He also placed many of them in management positions in his companies, and some became partners. Edison continued these policies at the larger laboratory he opened in West Orange, New Jersey, in 1887.

The issue of credit was also a significant one for Edison's competitors, particularly because of the popular image of him as the primary inventor of several new technologies. Edison's reputation was partially a consequence of the fact that he had a much more sophisticated understanding of invention than his contemporaries. Edison saw invention as just the first stage of a larger process of innovation. Thus he took a leading role in marketing the inventions he developed through companies he established and that bore the Edison name. Because his name was associated with the technology he continued to make improvements to insure its reputation as well as his own. This kept him in the public eye as reporters wrote stories about his latest improvements.

Edison's public image was also a result of his skill at public relations. He had developed an understanding of the newspaper business while working as a press-wire telegraph operator and, after becoming famous for inventing the phonograph, he had established close relationships with several reporters in New York City who found Edison a ready source of news, opinion, and human interest. Thus even when other inventors made important technical contributions, the public credited Edison first.

While Edison's willingness to make announcements through the press aided his marketing efforts, it created problems for his scientific reputation. When Edison claimed that he had observed a new natural phenomenon and termed it *etheric force* in 1875, he made his first announcements through the newspapers and continued to press his claims through press interviews rather than through the scientific journals as did his opponents. Similarly after British inventor David Hughes's claim to the invention of the microphone appeared in the scientific journal *Nature,* Edison launched a public attack through the New York City newspapers rather than responding in the scientific press. In both cases, Edison's claims in the scientific community were weakened by his failure to adhere to the norms of scientific publication and debate.

While Edison saw himself as a member of the larger scientific community and presented papers before the American Association for the Advancement of Science (AAAS) and the National Academy of Sciences (NAS) in the 1870s and 1880s, he was foremost an inventor and more interested in attracting public interest in his work than advancing scientific knowledge. Nonetheless when his inventive work produced devices that were primarily useful for scientific research he was willing to forego royalties in their manufacture and make them available to the scientific community. This occurred with a heat measurer he called the tasimeter in 1878, when he gave some early light bulbs to scientific researchers in 1880, and with his work on X-ray technology in 1886.

Public Policy Issues

Because the public saw Edison as a leading figure of science and technology, his comments on important public issues could carry significant weight. In two instances his reputation proved crucial to the enactment of public policy.

In the first and more controversial instance, Edison was asked in 1888 for his expert opinion on the establishment of electrocution as a more humane form of execution than hanging. Although opposed to the death penalty, Edison agreed to support this position and also allowed Harold P. Brown, a self-taught electrician, to conduct experiments on animal electrocutions at his laboratory. These experiments in support of electrocution were undertaken in part due to Edison's firm belief in the dangers of high-voltage electricity, and thus his ethical opposition to its public use.

But it also stemmed from the increasing competition his low-voltage direct-current (DC) electrical system was receiving from the high-voltage alternating current (AC) system being marketed by George Westinghouse. The debate on electrocution thus became wrapped up in this commercial struggle. Edison's strong opposition to high-voltage and the demonstrations at his laboratory that showed high-voltage AC to be more dangerous than high-voltage DC led him to champion the electric chair and testify on behalf of the state in the appeals of the first death penalty case involving electrocution. Edison would later regret his role in the development of the electric chair but never gave up his opposition to high-voltage electricity.

Edison's other significant involvement in public policy came as the result of a 1915 *New York Times* interview in which he urged greater military preparedness and the need for a national research laboratory to develop new military technologies for defense. This led Secretary of the Navy Josephus Daniels to ask Edison to establish and head a new Naval Consulting Board. The Board was made up of leading inventors, engineers, and industrial research scientists. Edison would eventually lose the larger debate within the Board over the nature of the research laboratory. Based on the newer style of industrial research laboratories, the new Naval Laboratory, which was not established until after World War I and was headed by naval officers rather than civilians, focused on science-based research leading to the development of small-scale prototypes. It was not a works laboratory like Edison's, equipped with extensive machine shop facilities for turning prototypes into commercial technology.

The differences over the Naval Laboratory were also reflected in Edison's own contribution to research during World War I. Although Edison developed forty-two inventions that he believed could contribute to the war effort, the Navy adopted none. Instead the Navy officers responsible for introducing new technology turned to the efforts of those researchers whose approach included the mathematical rigor and theoretical basis that their university educations had taught them were the foundations of modern research.

The growing differences between Edison and more youthful researchers marked a shift in the nature of scientific and technical training. This shift became more evident by the end of Edison's life, when news accounts treated him as the last of the lone cut-and-try inventors rather than the creator of the first industrial research laboratory. A closer study of his life, however, reveals that in the course of reshaping the ways in which invention took place, including at his laboratories, Edison was faced with many of the same ethical issues encountered by twenty-first-century inventors and industrial researchers.

PAUL ISRAEL

SEE ALSO *Entrepreneurism; Invention; Technological Innovation.*

BIBLIOGRAPHY

Bazerman, Charles. (1999). *The Languages of Edison's Light*. Cambridge, MA: MIT.

Carlson, W. Bernard, and A. J. Millard. (1987). "Defining Risk within a Business Context: Thomas A. Edison, Elihu Thomson, and the AC-DC Controversy, 1885–1900." In *The Social and Cultural Construction of Risk*, ed. Branden B. Johnson and Vincent T. Covello. Boston: Reidel Publishing Co.

Carlson, W. Bernard, and Michael E. Gorman. (1990). "Understanding Invention as a Cognitive Process: The Case of Thomas Edison and Early Motion Pictures, 1888–1891." *Social Studies of Science* 20: 387–430.

Essig, Mark. (2003). *Edison and the Electric Chair: A Story of Light and Death*. New York: Walker and Company.

Hughes, Thomas P. (1983). *Networks of Power: Electrification in Western Society, 1880–1930*. Baltimore, MD: Johns Hopkins University Press.

Hughes, Thomas P. (1958). "Harold P. Brown and the Executioner's Current: An Incident in the AC-DC Controversy." *Business History Review* 32: 143–165.

Israel, Paul. (1998). *Edison: A Life of Invention.* New York: John Wiley and Sons.

Jonnes, Jill. (2003). *Empires of Light: Edison, Tesla, Westinghouse, and the Race to Electrify the World.* New York : Random House.

Millard, Andre. (1990). *Edison and the Business of Innovation.* Baltimore, MD: Johns Hopkins University Press.

Musser, Charles. (1991). *Before the Nickelodeon: Edwin S. Porter and the Edison Manufacturing Company.* Berkeley: University of California Press.

Pretzer, William S., ed. (1989). *Working at Inventing: Thomas A. Edison and the Menlo Park Experience.* Dearborn, MI: Henry Ford Museum and Greenfield Village.

EDUCATION

Any regular practice, for example, agriculture, craft production, navigation, or scholarship, requires learning opportunities for novice practitioners, which have often been provided in workplaces, or through informal instruction and self-directed study. This survey, however, will be limited to *formal* education, that is, to teaching and learning in institutions such as colleges and universities established exclusively for these purposes.

A broad historical account (to be elaborated below) of scientific and technical education in relation to ethics runs as follows.

Science and ethics initially were intimately related in ancient education, while technology was explicitly excluded. Medieval Christians were ambivalent about ancient pagan science, because they held an opposing notion of moral perfection. Greek science nonetheless retained a minor place in medieval education, though its intimate association with ethics was weakened insofar as morality was religiously based. When classical learning was recovered in Western Europe by the mid-thirteenth century, and the scholastics sought to render it consistent with church teachings, natural philosophy (science) and moral philosophy were added to the curriculum as standard, but distinct, university subjects.

Renaissance scholarship facilitated the scientific revolution of the sixteenth and seventeenth centuries. By the start of the eighteenth century, however, modern science had become divorced from teaching in the English universities, and had forged new institutional links with technology and commerce. Ethics, however, was revitalized as a university subject by the contributions of Renaissance humanists. Natural science was reestablished as a teaching field in the early-nineteenth century. Technology remained excluded from North American colleges, and moral philosophers attempted to harmonize the new science with the prevailing Protestant worldview and morality. New German universities, however, rejected all association with religious creeds and devoted themselves to the free study and teaching of science.

Engineering, agriculture, and other technical and professional fields became university degree subjects late in the nineteenth century in both England and the United States. Politics, economics, and sociology became separated from moral philosophy as positive sciences, and ethics attained autonomy from moral theology, becoming merely one academic discipline among others in the secular multiversity. The resulting civilization of science, technology, business enterprise, and the nation-state gained unprecedented control of nature and social life in the twentieth century.

The technoscientific civilization has nevertheless experienced a profound ethical crisis as a result of the atomic bomb, environmental pollution, resource depletion, nuclear accidents, and other *techno-shocks*. Many scholars and social leaders came to fear that technoscience had outstripped social capacities for its ethical control, and that it even threatened human survival. Some science, technology, and ethics professors, therefore, collaborated in forging closer relationships between their fields, in an attempt to bring ethical judgment to bear on further developments in science and technology.

From Greek *Paedeia* to Medieval Scholasticism

Systems of education in science and technology that have taken on worldwide influence have their root influences in classical school experiences. It is thus appropriate that the present survey should highlight this historical background.

SCIENCE AND ETHICS CONJOINED. Formal elementary education was established for free males in several Greek city-states by the fifth century B.C.E., taking place in the *didaskaleion*, the area set aside for teaching. After learning to read and write, older children learned classic literature and music. Youths attended public gymnasiums for physical and character training and military preparation. Beyond this level, education in the fifth century was not standardized. The gymnasiums, however, became sites for discussion groups and lectures given by sophists.

Science and ethics were esoteric subjects taught informally by masters to a few chosen disciples.

Science and ethics, however, were not distinct subjects. Pythagoras of Samos (ca. 580–500 B.C.E.), and Democritus of Abdera (460–370 B.C.E.), are important examples. Pythagoras of Samos studied arithmetic, astronomy, geometry and music at Miletus, and possibly also at Babylon and Egypt. Pythagorean ethics held that virtue was a harmony of the soul that mirrored the harmony of the spheres, and that mathematics is the pathway to moral perfection. In contrast Democritus conceived the natural world, including the soul, as a machine behaving in accordance with laws of matter, so that freedom of action is an illusion to be overcome by reflection on the determinism in nature. A state of tranquil acceptance of mechanistic reality is thus the ethical good.

By the fourth century B.C.E., more formal philosophical schools evolved from the informal learning at the gymnasiums, and Athens became the recognized center of learning. The school of Isocrates, based on the rhetorical teachings of the sophists, opened in 390 B.C.E.. In 387 B.C.E., Plato (428–347 B.C.E.) established a school with a program of study similar to that of Pythagoras. It came to be called the Academy because of its location near the Groves of Academus. Aristotle (384–322 B.C.E.) gave lectures after 335 B.C.E. at the gymnasium dedicated to Apollo Lyceios; his school became known as the Lyceum. Aristotle distinguished between theoretical and practical studies; science and ethics were taught as distinct subjects. Aristotle nonetheless agreed with Pythagoras and Plato that the highest good is contemplative knowledge, and thus he taught that the highest ethical life is not practical action in the polis, but theoretical contemplation.

Both Plato and Aristotle distinguished technical arts from those suitable for liberal education. In the Philebus (55e–56a) Plato argued that when the mathematics was abstracted from technical arts such as navigation and architecture, what remained was intellectually trivial. The educational program Plato laid out for the Guardians in Book 7 of the *Republic* (380 B.C.E.) was based on the four Pythagorean mathematical arts: arithmetic, geometry, astronomy, and harmonics. All of these he conceived entirely in abstract terms, with sensory observations and utilitarian applications removed. (*Real* astronomy, for example, had no concern for the sun, moon, or stars, but only with solids in revolution.) Aristotle considered technical arts degrading and slavish. (*Politics* Bk 3, 1277a5-a12, 1277b34-1278a14). As handcrafts workers engage in repetitive acts, they "are like certain lifeless things that act . . . without knowing what they do, as fire burns"(*Metaphysics* Bk 1, 981a13–b9).

The Athenian schools continued under new leaders (or *scholarchs*) after the death of the masters. While Aristotle's school devoted itself almost exclusively to natural science, the other schools continued to offer a program in which science and ethics were intertwined, but ethics soon became predominant. In 306 Epicurus (341–270 B.C.E.) established a school that followed the teachings of Democritus. Zeno of Citium in Cyprus (c. 335–263 B.C.E.), teaching at the painted column or stoa, taught a *stoic* ethic of rational preferences ordered according to nature, mastery of passions, and indifference to fate.

The theory of the liberal arts attained a definite form by the first century B.C.E. By that time the circle of learning, the *enkyklos paedeia,* had come to include logic, rhetoric, grammar (literature), and the four Pythagorean mathematical sciences. In the Roman Latin schools, however, the literary arts dominated. Mathematical subjects were recognized, but taught cursorily, if at all.

ROMAN AND MEDIEVAL SCHOOLING. The educated classes during both the Roman and medieval periods admired but exhibited a certain ambivalence regarding classical learning. Neoplatonic philosophers of the Roman period, for instance, preserved the Pythagorean and Platonic program—mathematical study for ethical perfection—but were more oriented toward education that would serve overt political ends, as with oratory. More than their pagan peers, perhaps, early Roman Christians admired Neoplatonism because of its unworldly and ascetic emphases. It made a deep impression on Augustine of Hippo (354–430 C.E.), and inspired the grand educational project of Boethius (480–525 C.E.).

Boethius, noting that prevailing Latin textbooks in grammar and rhetoric were adequate, sought to revitalize the *enkyklopaideia* by preparing Latin handbooks on logic and the four mathematical disciplines, for which he invented the name *the quadrivium*. Following the Neoplatonists, Boethius conceived these studies as pathways from the sensible world to supersensible reality as a means of ethical perfection. Boethius's manuals (on arithmetic, logic, and music) became standard school and university textbooks for almost 1,000 years.

The death of Boethius in 525 C.E. and the closing of the Platonic Academy of Athens, by the Eastern Emperor Justinian in 529 C.E., mark the end of Greek learning in the West. Barbarians gradually also destroyed the Latin schools, and eventually even Latin classics were unavailable in Western Europe. Greek classics were preserved at Byzantium and then entered the stream of Islamic learning. Latin classics were preserved in Ireland.

LATIN SCHOOLS REVIVED AND UNIVERSITIES BORN. Charlemagne, crowned Holy Roman Emperor in 800, sought to revive learning in order to provide educated clergy and administrators for his realm, and ordered his cathedrals to establish schools. An organized program of teaching, however, requires textbooks, and in logic and the sciences only those of Boethius, preserved in Ireland, were available. The Church retained a deep ambivalence about pagan learning, which contained a view of moral perfection at odds with its own as best expressed in Tertullian's famous question, "What has Athens to do with Jerusalem?"

Nonetheless the cathedral schools were, in theory, organized along classical lines: a grammar school for logic, rhetoric and grammar (for the first time called the *trivium*), followed by a higher school for the *quadrivium*. In practice, while the *trivium* provided useful training for clergy and administrators, the *quadrivium* was often neglected. Most schools could manage only practical arithmetic for calculation, geometry for architecture and surveying, and astronomy to calculate Easter. Science education improved in some cathedral schools in the eleventh century. At Reims Gerbert of Auillac (955–1003), acquainted with Arabic scholarship in Spain, refreshed the *quadrivium* by using Arabic numerals, the abacus for calculation, and the astrolobe for astronomical observation.

In 1079 Pope Gregory VII issued a papal decree ordering all cathedrals and monasteries to open schools for the training of clergy. As schooling expanded it became necessary to regulate teacher preparation and licensure. The church claimed a monopoly over teaching licenses (*licencia docendi*). Municipal chancellors offered these licenses only to those intending to teach in their districts.

Some municipalities, however, attracted students from many regions, and gained recognition as *studia generale*, whose degrees (licenses) were recognized throughout Europe. These *universities* were divided into lower schools for the seven liberal arts plus schools for law, theology, and medicine. Two models for the university emerged: one at Paris, Oxford, and Cambridge, where the arts course predominated; the other at Bologna and Salerno, where, contrary to the dictates of Plato and Aristotle, the arts course became merely a minor preliminary to technical education in the professions.

Science education in the arts course remained grossly inadequate. By papal decree, lectures on the *quadrivium* could be offered only on public holidays. By the last third of the twelfth century, however, the importation of classical texts from Muslim Spain reached its peak. Adelade of Bath had translated Euclid's *Elements*, and the Aristotelian corpus was made available in Latin translation.

SCHOLASTICISM: SCIENCE, ETHICS, AND RELIGION. In the thirteenth century the challenging task of assimilating the classical inheritance began. In geometry, for example, the study of Euclid prompted new discoveries in optics by Robert Grosseteste (c. 1170–1253) and his student Roger Bacon (c. 1220–1292). Grosseteste, chancellor of Oxford (1215–1221), made optical studies, wrote a commentary on Aristotle's *Posterior Analytics*, and championed empirical inquiry. Bacon, who said he had learned more from simple craftsmen than from famous professors, carried on Grosseteste's empirical studies of lenses as aides to natural vision.

Assimilation of Aristotle's writings in natural and moral philosophy was among the greatest challenges faced by the thirteenth century universities. Pope Innocent III banned the study of Aristotelian natural philosophy in 1210. A committee was formed in 1231 to expunge all heretical ideas from his texts so they might be suitable for teaching, and by 1255, Aristotle's works returned to the syllabus. Scholasticism, the project of rendering the classical inheritance compatible with church teachings, came to dominate university studies. Thomas Aquinas (1224–1274), the greatest of the scholastics, saw that with the recovery of ancient learning, the seven liberal arts had become inadequate as a pattern of study, and the arts course was expanded to include the *three philosophies*: metaphysics, natural philosophy (empirical science), and moral philosophy.

The scholastic method of education stressed formal definition and logical argument. The scarcity of books dictated its primary tools: lectures (where books were publicly read and interpreted), recitations (where students demonstrated their familiarity with the books), and public disputations (where students presented public arguments in syllogistic form). Scholastic natural philosophy thus remained confined to theory, logical argument, and thought experiment. Controlled observations and technical applications were rare. The old textbooks dominated the syllabus for centuries. Scholasticism, while useful as a method of organizing official knowledge and conveying it in a standard form as preparation for professional studies, failed to encourage systematic and creative scientific studies, and eventually became bogged down in fruitless verbal controversies.

Early Modernity: Science, Technology, Humanism, and the Reformation

By the fifteenth century medieval institutions no longer provided Europe with either social order or a rational world picture. Renaissance humanists, working outside the universities and in opposition to scholasticism, sought inspiration in the pagan classics for reshaping learning and civic life. They praised Aristotle's ethics, and placed moral philosophy at the center of their curriculum. Claiming that moral virtue grew from emulation of classical authors and orators, they tied ethics closely with rhetoric, history, literature, and classical languages in a complex that became the humanities.

The humanists, however, rejected Aristotelian logic as artificially formal. They promoted a practical, natural logic based on study of the arguments of the great orators, thereby incorporating logic within rhetoric. They also rejected Aristotle's qualitative natural philosophy in favor of Plato's quantitative approach, thus easing the path for Nicolaus Copernicus, Johannes Kepler, and Galileo Galilei. The latter's aphorism that *the book of nature is written in mathematical characters* might have been taken directly from Plato. Humanists made few direct contributions to scientific scholarship, as the recovery of pagan scientific classics had been completed, but their intellectual independence and daring established a new spirit of learning congenial to later modern scientific inquiry.

Martin Luther and John Calvin, the leaders of the Protestant Reformation, were themselves humanist scholars. Their encouragement of the close reading of scriptural texts stimulated close reading of the book of nature. Protestantism directly undermined scholasticism, as it eliminated the need to square classical authorities, including Aristotle, with Catholic Church teachings. The new Protestant universities of Northern Europe could start afresh, and thereby became leaders in incorporating modern science into their curricula.

THE SCIENTIFIC REVOLUTION AND ITS SOCIAL INSTITUTIONS. The fifteenth and sixteenth centuries were periods of rapid developments in commerce, navigation and ship construction, instrument making, mining, and mechanics. These new conditions, when conjoined with the mathematical knowledge brought to the Christian West from Byzantium and Muslim Spain, illuminated new pathways for the growth of scientific knowledge.

Until the seventeenth century Europe possessed no scientific societies or journals to stimulate or publish reports of new investigations. To develop an infrastructure for science required a vision, a site for meetings of scientists and technical experts, a critical mass of expert scientific workers, and an organization to stimulate and assess significant scientific achievements and make them widely known through its publications. The coordination of these factors in England led to the establishment of the Royal Society in 1660.

Francis Bacon (1561–1626) framed the vision. He maintained, against both classical authorities and the scholastics, that the only useful knowledge was based on empirical study of nature, and that a clear method for scientific work would provide human mastery over the natural world. Under such conditions, *knowledge is power*. His inductive method, though a technical failure, shaped an agenda for practically useful science that included close study of mechanical crafts.

Thomas Gresham (1519–1579), a wealthy London merchant, provided the site, by endowing a college for merchants and craftsmen that opened in 1598. Gresham College offered no degrees, but provided free public lecture courses in rhetoric, astronomy, geometry, music, divinity, medicine (physic), and law. The Gresham professors were selected from among the most eminent scholars of their time. The first Gresham Professor of Geometry, Henry Briggs, developed logarithmic tables and popularized their use. The college's central location in London provided the ideal meeting place for scientists and technicians. Briggs also made it the central clearing house for scientific and technical information.

Oxford provided the critical mass of scientific experts. When Briggs was appointed the first Savilian Professor of Geometry at Oxford in 1619, he strengthened ties between Gresham College and the university. In the 1640s a group of distinguished natural philosophers including John Wilkins (of Wadham College), Seth Ward (later the Savilian Professor of Astronomy), Robert Boyle, William Petty (later professor of anatomy), and Jonathan Goddard (of Merton College) frequently attended Christopher Wren's lectures at Gresham College and then met with coworkers, including navigators and instrument makers. Boyle called this group the *invisible college*.

In 1651 the Oxford Philosophical Society was formed and began publishing transactions. A similar organization failed at Cambridge because no scholars were willing to perform experiments. In 1660 members of the invisible college formed a national society, which was incorporated by royal charter as the Royal Society in 1662. It soon established its offices and meetings at Gresham College, and published its own transactions. Other nations established parallel societies. In France, Jean-Baptiste Colbert founded the Academie des Sciences in 1666, which was reorganized with royal approval in 1699. In Germany Frederick the Great founded the Academie der Wissenschafften in 1700, with Gottfried Wilhelm Leibniz as the first president. By the beginning of the eighteenth century the infrastructure for European science was in place.

SCIENCE EDUCATION. While English university scholars were central in the scientific revolution, science teaching retained its medieval character. The colleges at Oxford and Cambridge were at first mere residence halls, whose tutors were simply older men taking responsibility for the conduct and finances of younger students. By tradition recent graduates (regents masters) of the colleges were required to lecture. By the sixteenth century, however, the regents lecture system had broken down, and the universities recognized the need for a new organization of teaching, including appointment of permanent lecturers.

Lady Margaret, mother of Henry VII, endowed professorships of theology at both Oxford and Cambridge (1497–1502). Sir Robert Rede provided in his will for lectureships at Cambridge in philosophy, logic, and rhetoric. Henry VIII added royal patronage to this trend after conducting visits to the universities in 1535, following his break from the Roman church. Henry's reforms, reflecting the humanist spirit of the sixteenth century; replaced scholastic textbooks with humanist commentaries on Aristotle's natural and moral philosophy. Henry also endowed Regius professorships in classical Greek and Hebrew, as well as divinity, medicine, and civil law. A series of similar endowments and appointments include, for example, the Henry Lucas Professorship of Mathematics at Cambridge, which Isaac Newton held from 1669 to 1701.

These distinguished professorships had almost no impact on teaching, however, because the colleges, which were wealthier and more powerful than the universities, completely dominated teaching. Students were required to live in colleges, where tutors were assigned to lecture and conduct recitations on authorized texts. The tutors were generalists offering instruction on the *ordinary* subjects required for disputations and exams. Professors lectured only on *extraordinary* subjects outside the mandated curriculum. Since colleges prevented universities from examining students on extraordinary subjects for several centuries, few students attended the professorial lectures, and eventually few professors even bothered to deliver them. Not one of the three Regius professors of physic (medicine) at Cambridge from 1700 to 1817 gave a single lecture.

The situation was different in Germany. The first modern university opened at Halle in 1694. Gottingen rivaled Halle as a center of learning after its opening in 1736. The University of Berlin was established in 1800, under the direction of William von Humboldt. Berlin adopted the Platonic ideal, training leaders as philosophers. Professors combined original research with teaching, and students worked closely with professors on research projects. Students thus acquired the cultural and scientific heritage in the very process of working alongside those who knew it best. Berlin rejected attachments to religious creeds and schools of thought, accepting subservience only to science and learning. It thus added to the arts and professional universities of the middle ages a third model, the research university, which soon dominated Protestant Europe.

Science and Ethics in Eighteenth-and Nineteenth-Century American Colleges

The first colleges in the New World, Harvard (1636) and William and Mary (1693) based their statutes on those of the colleges of Cambridge and Oxford. As in England, while mathematics and science were given lip service, the seventeenth-century teachers lacked knowledge of current developments. In 1700 in North America the modern scientific subjects were still associated with navigation and mechanical arts, not with college education. The lack of constraint by an entrenched teaching elite, however, eased the way for their introduction into colleges.

ACADEMIC SCIENCE AND ETHICS IN THE EIGHTEENTH CENTURY. In the mid-eighteenth century Yale acquired some scientific apparatus, and introduced Newton's fluxions to the math curriculum. John Winthrop, the Hollis Professor of Mathematics and Natural Philosophy at Harvard (1738–1779), removed the last traces of Aristotle from the course in natural philosophy and introduced the new science of Galileo and Newton. When the American Philosophical Society for Promotion of Useful Knowledge was established in Philadelphia in 1769, with Benjamin Franklin serving as president, however, the founding members were amateur investigators rather than teachers. The society had

650 members by 1800, but only fifteen of 124 noted college teachers of the period ever became members.

Moral philosophy underwent a more profound revolution. John Locke's "Essay Concerning Human Understanding" (1690), with its consideration of the foundations of moral knowledge, was in the curriculum by 1720. By mid-century moral philosophy was central to both the college curriculum and public discourse, attracting the attention of such Enlightenment leaders as Franklin, Thomas Jefferson, and Benjamin Rush. The American Revolution further invigorated the Enlightenment spirit. William Paley's widely adopted textbook *Moral and Political Philosophy* (1785) presented Christian utilitarianism as a natural science based on empirical observations and first principles, which included the natural rights of man as expressed by Locke. Paley, in his *Natural Theology* (1802), based the existence of God, as the divine intelligence governing the universe, on the argument from design. A course on natural theology was added to the curriculum.

ACADEMIC SCIENCE AND ETHICS IN THE FIRST HALF OF THE NINETEENTH CENTURY. By 1820, as rapid advances took place in U.S. commerce and industry, leaders demanded that mathematics and science in the colleges be improved and made more practical. Mark Hopkins of Amherst called Francis Bacon's notion of knowledge as power the single most influential idea in the popular mind in the early-nineteenth-century. Science teaching, as a result, got a large boost between 1820 and 1850, though reformers had to contend with inadequate textbooks, untrained teachers, and lack of apparatus.

By 1836 adequate textbooks were available in algebra, geometry, trigonometry, analytical geometry, and calculus, and by 1840 calculus was a standard part of the liberal arts course. By 1850 natural philosophy had been reorganized as physics, chemistry, and natural history (biology and geology, formally subjects for amateur naturalists). Physics had been further divided into mechanics, hydrostatics, electricity and magnetism, and chromatics, and textbooks treating these topics in sufficient mathematical detail were widely available. By 1860 five clearly defined courses in natural science—astronomy, physics, chemistry, biology, and geology (including mineralogy)—were part of the liberal arts curriculum.

Prospective teachers began to study in the Protestant universities of Northern Europe. In 1802 President Timothy Dwight of Yale urged Benjamin Silliman (1779–1864), a distinguished graduate, to prepare himself for a professorship in chemistry by studying at the University of Edinburgh. He emerged in 1805 with current knowledge in theoretical and experimental chemistry, as well as practical knowledge of geology, mineralogy, and zoology. George Tinknor (1791–1871) was among the first Americans to prepare for a professorship at a German university; on his return from the University of Gottingen in 1817, he became a professor at Harvard and introduced German methods of study and research. Foreign preparation of college teachers remained the norm until U.S. research universities were established late in the nineteenth century.

The value of laboratory apparatus expanded twenty fold between 1820 and 1850. The introduction of the blackboard transformed mathematics teaching; professors were for the first time able to exhibit spontaneous thoughts and invite groups of students to the board, where the former could watch assigned problems worked out and probe methods of reasoning. Laboratories introduced similar changes in science teaching.

By 1850 the revolution in the liberal arts college was complete. The question of technology—mechanical, agricultural, and mercantile arts—now had to be faced due to popular demand for practical training. In 1828 a famous *Yale Report* maintained that mathematics and science belonged in the college, but not technology. Amherst issued an almost identical report. Despite public pressures, these sentiments prevailed among college leaders until the Civil War, although their marketing efforts emphasized the practical value of college education as early as 1850.

The college curriculum, however, had by then become seriously overcrowded due to the expansion of science and mathematics. Indeed demands for new scientific courses continued to proliferate. National surveys and requirements of the mineral industries created demands for separate mineralogy courses; developments in medical education led to demands for courses in organic chemistry and physiology. The colleges attempted to resolve these conflicts by introducing practical *partial* scientific courses outside the required curriculum, and diploma programs in *parallel* scientific schools such as the Lawrence School of Science at Harvard (1847) and the Sheffield School at Yale (1854). These efforts, though marketed as practical alternatives to the college course, failed because the programs lacked the prestige of a college education and provided no specific qualification for any position in the U.S. economy of that era.

Moral philosophers writing under the influence of New School Calvinism, a doctrine emphasizing that theology was completely compatible with human standards of reason and morality, did not resist the expansion of science. Instead they discarded the enlightenment empiricism of Locke and Paley, which they saw as undermining religion by making human reason self-sufficient. In its place they adopted the Scottish common sense philosophy of Thomas Reid and Dugald Stewart, which held that sense experience must always be actively assimilated by active powers instilled by God in the human mind, and that moral duties were presented immediately as intuitions.

The typical class in moral philosophy was taught as a capstone course by the college president, who deployed common sense principles as bases for conclusions on the ethical issues of the day. The *Elements of Moral Science* (1835) by Francis Wayland, president of Brown, was based on common sense realism, and became the most widely adopted textbook of its era. While the presidents did not even wish to dictate the results of science, they could strive to contain them within the consensus Protestant worldview and framework for moral action. This period in moral philosophy has thus been perceptively labeled as the era of *Protestant scholasticism*.

The Birth of the Multiversity

In the 1860s U.S. colleges faced three main criticisms: The curriculum was overcrowded with science and mathematics, which most students found daunting and unrelated to career plans, and threatened to marginalize the traditional humanities; the college was seen as elitist in neglecting technical and professional subjects; and due to the absence of research, colleges were failing to advance knowledge in the sciences and useful arts. The Massachusetts Institute of Technology's (MIT) founder and first president, William Barton Rogers, was among those who argued that practical studies and research would require a new kind of institution beyond the traditional network of liberal arts colleges.

Union College introduced a bachelor of science degree, parallel to its bachelor of arts degree, by 1828. Wayland, at Brown, proposed an elective system to alleviate the crowding of the prescribed curriculum as early as 1850. Charles Elliot made free election of courses central to his reform of Harvard after assuming the presidency in 1869, and other colleges soon followed Harvard's lead.

Technical and professional studies gained a foothold when Rensselaer Polytechnic Institute (RPI) opened in 1824 to provide engineering education. RPI was reorganized in 1849 and established the template for the engineering curriculum: humanities, physical science, mathematics, and hands-on shop training. The Morrill Land Grant Act of 1861 provided federal funding for colleges in the agricultural and mechanical arts. MIT, founded in 1861, was reorganized in 1865 under the provisions of the act, while Cornell, chartered in 1862, used funds from both the act and private sources for programs primarily in the agricultural and mechanical arts. Cornell soon became a model institution for maintaining harmony among its humanities, sciences, and technical-professional curricula.

The reorganization of industry into a national mass-production system created a vast demand for engineers, and universities reorganized engineering education to meet the need. In the early 1870s Victor Della Vos of the Moscow Imperial Technical School developed a new approach to practical training based on a careful sequencing of skills in shop-like classrooms. His method became widely adopted for practical elements of engineering education after John Runkle of MIT saw it exhibited at the Philadelphia Centennial Exposition in 1876. Engineering science, however, became increasingly dominant in the engineering curriculum. Universities soon added similar science-based degree programs in architecture, forestry, and veterinary medicine.

Because of the lack of opportunities for research training in the United States, many scholars before the 1870s traveled to Scotland or Germany for advanced degrees. Yale awarded the first Ph.D. in the United States in 1861, but graduate education was only institutionalized with the establishment of new research universities: Johns Hopkins (1876), Clark (1889), Stanford (1891), and the University of Chicago (1892).

At Oxford and Cambridge, from 1820 to 1850, the colleges felt the same pressures as their U.S. counterparts, and made modest accommodations. At Cambridge earning *distinction* in *both* classics and mathematics was dropped as a requirement for an honors degree in 1850. The moral science tripos and natural science tripos were introduced in 1851, providing students with two distinct areas of concentration. In the 1850s, and again in the 1880s, however, royal commissions were appointed to suggest education reforms to parliament. By 1890 the established colleges had lost their control over teaching. Instead the colleges provided lecturers for courses open to all university students, and cooperated in funding university-wide professorships. Early in the twentieth century the teaching staffs were reorganized, on an all-university basis, into branches corresponding to the main divisions of study. Civic university colleges opening in Leeds Manchester and Liverpool in the 1880s, like their Morrill Land

Grant Act counterparts, introduced technical and professional studies.

ETHICS IN THE LATE-NINETEENTH-CENTURY COLLEGE. Prior to the 1850s zoology, botany, and geology were offered primarily as bases for natural theology, by providing evidence of intelligent design in the universe. Charles Darwin (1809–1882) found natural theology, based on Paley's intricate demonstrations of the perfect adjustment of organisms and their environments, the most valuable course he attended at Cambridge. But like many others, he found it implausible that predesigned organisms would be dropped, ready-made, into preexisting niches. His theory of natural selection, as a mechanical explanation of organism-environment compatibility, helped to undermine the harmony between biological science and belief in divine intelligence.

Moral philosophy, or *moral science* as it was frequently called, was by 1900 becoming subdivided, as natural philosophy had been a half century earlier, into its component sciences: ethics, politics, sociology, and economics. Some college presidents continued to teach ethics as a senior course, though theological foundations were now downplayed in favor of exhortations to moral leadership in society. Gradually, however, ethics became merely one of the many specialist subjects students could elect to study.

By the turn of the twentieth century scientific rationality was the one core value of higher education. The Protestant worldview, with its religious constitution for moral action, had lost its intellectual and social authority. Free from all authoritative constraints, university-trained professionals began the march of progress through an allegedly 'value-free' technoscience that by the end of the century had transformed the way humans lived.

TECHNOSCIENTIFIC CIVILIZATION IN CRISIS As early as 1923, however, Henry Churchill King of Oberlin, one of the few clergyman-presidents still teaching moral philosophy, noted a "strange contradiction" between the arrogance of the new scientists with their acclaimed alliance with the forces of nature, and the pervasive sense that modern civilization is unleashing forces that are irresistible and inevitable. By the mid-twentieth century this contradiction was sharpened, as seductive new technologies pushed many areas of human activity beyond effective control. Medical technology gave us wonder drugs that cured age-old diseases, but drug resistant strains appeared and some diseases returned. Nuclear scientists created power plants that used *atoms for peace*, but nuclear power programs contributed to the proliferation of nuclear weapons. Humans conquered space, but created a race for space-based weapons. Computers dramatically increased human productivity, and also led to increased surveillance of all human activities.

Dramatic events—the atom bomb, DDT and asbestos, thalidomide babies, environmental pollution, napalm in Vietnam, the 1970s oil shocks, urban smog, electricity blackouts, Bhopal, the *Challenger* disaster, Three Mile Island and Chernobyl, Exxon-Valdez, global warming, the ozone hole, cloning, job outsourcing through network technologies, and child addictions to violent computer games—keep forcing this contradiction upon public consciousness. Science and technology can contribute to human life, but also create problems that challenge ethical guidelines and problem-solving capabilities.

The idea of continuous progress through science and technology is no more plausible in the early-twenty-first century than the idea of a fixed universe designed by divine intelligence was after Darwin. Scholars and public leaders are thus called upon to shape a new postmodern ethical vision for technological civilization.

Since the 1970s some science, technology, and ethics scholars have initiated collaborative efforts to forge a closer relationship among their fields. Applied ethical studies of agriculture, engineering, biomedical science, and computer technology have provided a knowledge base for mandated courses in professional ethics. Science and technology courses explicitly tied to social issues have been introduced in general education at universities and secondary schools to enable graduates to participate as democratic citizens in the ethical modulation of science and technology.

A significant problem is that contemporary moral philosophers, unlike those of Catholic or Protestant scholasticism, have neither a specific moral authority of their own, nor the backing of institutions with broad-based social authority. Their authority rests upon their positions in the multiversity, whose core value of unconstrained technoscientific rationality is precisely what is now in question.

At the start of the twenty-first century, therefore, significant questions remain about both the capacity of the human community to constrain scientific and technological developments within ethical bounds, and the role of institutions of formal education in fostering and maintaining that capacity.

LEONARD J. WAKS

SEE ALSO *Digital Libraries; Museums of Science and Technology; Robot Toys; Rousseau, Jean-Jacques.*

BIBLIOGRAPHY

Fiering, Norman. (1981). *Moral Philosophy at Seventeenth Century Harvard: A Discipline in Transition.* Chapel Hill: University of North Carolina Press. A detailed description of moral philosophy in the early colonial college, valuable in presenting the background for the development of moral philosophy as a modern discipline in the eighteenth century.

Frank, Thomas Edward. (1993). *Theology, Ethics and the Nineteenth-Century American College Ideal: Conserving a Rational World.* San Francisco: Mellen Research University Press. The essential study of moral philosophy in the nineteenth century liberal arts college curriculum, valuable for tracing the rise and fall of 'protestant scholasticism', the attempt to preserve the harmony of protestant Christian ethics and modern science.

Geiger, Roger. (1986). *To Advance Knowledge: The Growth of American Research Universities, 1900–1940.* New York: Oxford University Press.

Guralnick, Stanley M. (1975). *Science and the Ante-Bellum American College.* Philadelphia: The American Philosophical Society. An essential, highly detailed study of the evolution of science education in the American college in the period from 1820 to 1850, during which modern science gained a central place in the liberal arts curriculum.

Kimball, Bruce A. (1995). *Orators and Philosophers: A History of the Idea of Liberal Education,* 2nd edition. New York: College Entrance Examination Board. A useful history of the concept of liberal arts education, particularly useful in clarifying the shifting relationships between logic and rhetoric.

Kintzinger, Martin. (2000). "A Profession But Not a Career? Schoolmasters and the *Artes* in Late Medieval Europe." In *Universities and Schooling in Medieval Society,* ed. William Courtenay and Jürgen Miethke. Leiden, The Netherlands: Brill.

Leff, Gordon. (1992). "The Trivium and the Three Philosophies." In *A History of the University in Europe,* Vol. I: *Universities in the Middle Ages,* ed. Hilde De Ridder-Symoens. Cambridge, England: Cambridge University Press.

Lyons, Henry. (1968). *The Royal Society 1660–1940: A History of its Administration Under its Charters.* New York: Greenwood Press. Originally published in 1944.

Mallet, Charles Edward. (1968a). *A History of the University of Oxford* Vol II: The Sixteenth and Seventeenth Centuries. New York: Barnes and Noble. Originally published in 1924.

Mallet, Charles Edward. (1968b). *A History of the University of Oxford* Vol III: *Modern Oxford (1688–1887).* New York.: Barnes and Noble. Originally published in 1924.

Marenbon, John. (2003). *Boethius.* Oxford: Oxford University Press.

Mourelatos, Alexander. (1991). "Plato's Science: His View and Ours of His." In *Science and Philosophy in Ancient Greece,* ed. Alan Bowen. New York: Garland.

North, John. (1992). "The Quadrivium." In *A History of the University in Europe,* Vol. I: *Universities in the Middle Ages,* ed. Hilde De Ridder-Symoens. Cambridge, England: Cambridge University Press.

Porter, Roy. (1996). "The Scientific Revolution and the Universities." In *A History of the University in Europe,* Vol. II: *Universities in Early Modern Europe (1500–1800),* ed. Hilde De Ridder-Symoens. Cambridge, England: Cambridge University Press

Smith, Wilson. (1956). *Professors and Public Ethics: Studies of Northern Moral Philosophers before the Civil War.* Ithaca, NY: Cornell University Press.

Tuplin, Christopher, and Tracey Elizabeth Rihill, eds. (2002). *Science and Mathematics in Ancient Greek Culture.* Oxford: Oxford University Press.

Winstanley, Denys. (1935). *Unreformed Cambridge.* Cambridge, England: Cambridge University Press.

Winstanley, Denys. (1947). *Later Victorian Cambridge.* Cambridge, England: Cambridge University Press.

EFFICIENCY

In the fields of technological innovation, economic development, business management, and public policy planning, as well as in everyday life, efficiency is a pivotal criterion that guides the behavior of both individuals and institutions. The widespread utilization of this criterion, however, raises serious epistemological, methodological, and practical questions, along with ethical challenges. Although efficiency may seem to be a clear, morally neutral concept, difficulties arise in conjunction with its extremely abstract character, the vast array of interpretations involved in concrete applications, and the fact that its pursuit may crowd out or obscure other important values.

Origins and Abstractions

The term *efficiency* is derived from the Latin *efficere* ("to produce, effect, or make"). In his *Physics,* Aristotle sees *causa efficiens* as one of the four factors (along with formal, material, and final causation) that explain change. Traditionally, efficiency has been understood as the agency or power of something or someone to bring about results, to produce a desired effect. In this sense there was no clear distinction between *efficiency, effectiveness,* and *efficacy* until the second half of the nineteenth century, when the term was given a technical meaning in the field of engineering.

The contemporary technical concept of efficiency arose from analyses of engine performance, or what is known as thermodynamic efficiency. The performance of an engine was defined as a ratio of the useful work obtained to the energy (heat) used. At best, the maximal amount of energy obtained would be the same as the energy consumed in the process. The concept then was used in economic theory, disseminated through the work of an engineer turned social scientist, Vilfredo Pareto (1848–1923), and other influential economists and engineers (Mitcham 1994). Economists saw themselves as engineers who were managing the scarce resources devoted to promoting social welfare, just as engineers attempted to find economic solutions to technological problems. The concept of efficiency moved into the political and public domains during the twentieth century, becoming a universally applied value. In the twenty-first century it is widely accepted that to be effective—that is, to obtain the intended goals—is not enough. It is also necessary to be efficient, that is, to obtain the intended results without wasting resources.

There are several definitions of the concept in its widest scope. The most common usages define efficiency as a ratio of results to resources or, alternatively, of ends to means or outputs to inputs. An activity, process, design, or system is said to reach maximum efficiency if (1) a desired result (output) is obtained through the use of the minimal possible amount of resources (input), (2) the maximal amount of results from a given resource is obtained, or in general (3) a combination of results and resources is obtained in such a way that it is not possible to increase any of the results or reduce any of the resources without reducing some other result (or amount of a result) or increasing some other resource (or amount of a resource).

Multiple Meanings

In its various usages the concept of efficiency gives rise to multiple meanings when this abstract idea is given specific applications: technical efficiency, energy efficiency, economic efficiency, resource efficiency, productive efficiency, market efficiency, and ecological efficiency, among others. Imprecise use, lack of agreement among experts, different backgrounds of expertise and technical traditions, hidden assumptions, the mathematical and practical complexities involved in making measurements, and other factors often make it extremely difficult to know the extent to which these terms should be taken as mere delimitations of a more general concept or, rather, suggest different but related concepts. The situation becomes more complicated when one considers the wide array of uses of the concept in heterogeneous fields such as energy technology, agriculture, health care, business management, public administration, and academic or personal performance. As a consequence, there is a huge technical literature dealing with these problems. Philosophical analyses that do not take the definition of efficiency for granted are uncommon, although there are exceptions, such as the work of Mario Bunge (1989), Stanley Carpenter (1983), Miguel Angel Quintanilla (1989), and Henryk Skolimowski (1966).

Initially it seems easy to distinguish between purely technological or engineering and economic conceptualizations. The engineering solution to a problem is efficient when it uses the smallest amount of technological means independently of economic constraints. In real-life situations, however, technological means often must be measured in economic terms. For instance, although it is technically feasible to obtain gold from other elements, the cost of the procedure is so high compared with the value of the results that any attempt would be inefficient because of the excessive resources that must be used to achieve the objective.

Even in economics assessments generally are not equivalent. Narrowly productive points of view and the quest for personal profit repeatedly conflict with efficiency requirements in terms of social welfare. To harmonize legitimate aspirations with both personal gain and social benefit, economists, acting in effect as political assessors, resort to cost-benefit analyses that are supposed to identify a so-called Pareto optimum, which is defined as that situation in which it is not possible through any reallocation of resources to make any person better off without making someone else worse off without compensation.

Critics such as Amartya Sen (2002) have exposed the weaknesses in this conception and attempted to find more rigorous and fair alternatives. Because it does not take into account the problems associated with the fair distribution of public spending, the application of the Pareto optimum maintains unjust situations. Suppose there is a fixed public spending budget of $100 to be distributed between education and airport infrastructure. If the education budget is increased by $10 to make it easier for the poorest members of society to attend university on scholarship, that amount must be subtracted from the budget to improve airport infrastructure. Therefore, some benefit at the expense of others. The Pareto optimum no longer is reached because it would advise against any change in the assigned budgets. However, it would be difficult to defend denying scholarships to qualified students so that people who can afford a good education can reach their favorite vacation spots more easily.

Because efficiency is essentially context-dependent, many of the problems that arise in discussing it are caused by attempts to decide what counts as a resource or result and what is considered valuable, desirable, feasible, or even possible (Carpenter 1983, de Cózar 2000). Efficiency is not determined by preexisting conditions but is constructed by deciding which factors to consider in defining the problem and frequently by actively modifying the physical, economic, and legal environment in which an intervention is made to change the state of things. Geographical limits, the temporal vector, side effects, and other elements further frame the context of an intervention.

Aware of the practical problems raised by seeking the most efficient solution, or optimization, Herbert Simon (1982) proposed the concept of *satisficing:* the attempt to achieve a good, if not perfect, solution. A large telecommunications company may decide not to develop a radically new system of communication even though it is faster, more powerful, and easier to use if it has no clear estimation of the cost of gathering the information required to predict the success of the new technology in the market. This cost, together with the cost of research and development, can surpass the profits the innovation is projected to generate for the company. In other words, the company would be content with satisficing its behavior by making less ambitious improvements. Alternatively, a company might gamble on this major innovation if it were confident in its ability to influence, among other aspects of its social environment, public regulations and the perceived needs of the consumers.

Obscuring Other Values

Contextuality is a key issue in understanding the conflict between the modern technological project and the criticisms leveled at it by many philosophers of technology. The technological impulse is tied intimately to the design of increasingly more efficient machines, devices, tools, systems, and processes. In the course of this activity, which has contributed much to humanity in terms of safety, health, and welfare, the technological mind typically delimits problems in the narrowest possible way and then searches for basically quantitative solutions. Its success depends on this strategy, and much of the attraction of efficiency for experts and nonexperts alike lies in the perception that it always provides (as it really does in some cases) a mathematical, *automatic* comparison between alternatives that can be used to determine the best path to follow.

In this manner a descriptive concept becomes a prescriptive one. Arguments for efficiency appear to derive prescriptions from a dispassionate description of objects and situations, thus hiding the often conflicting values that lie behind decision making in real-world situations. For instance, Amory Lovins (1977) has argued in effect that proposals to build more efficient power plants ignore the possible desirability of reducing energy consumption by increasing the insulation of buildings.

It is important to remember that despite its familiarity, the concern for efficiency is relatively recent. The novelty of the current situation is that efficiency is being converted into an absolute criterion for decisions in many facets of life. As Jacques Ellul (1954) observed, if modern technological activity becomes indistinguishable from the pursuit of absolute efficiency, an ethics of nonpower is also conceivable. Such an ethics can, and indeed must, pose a limit to the *cult of efficiency* and its abuses. As Carl Mitcham suggests, there is a parallel between the well-known *naturalistic fallacy* and an *efficiency fallacy*. The philosopher David Hume (1711–1776) argued that *ought-statements* cannot be inferred from *is-statements*, and G. E. Moore (1873–1958) warned against equating goodness with some natural property. In regard to something that is said to be natural, with the implication that it is good, one may still reasonably ask, But is it good? Similarly, after one says that something is efficient, it makes sense to ask, But is it good? Twentieth-century history exhibits a long list of cases in which unethical goals were pursued with bloodcurdling efficiency. Therefore, one should define the goals one judges as good and only then, if appropriate, look for the means to achieve them efficiently.

JOSÉ MANUEL DE CÓZAR-ESCALANTE

SEE ALSO *Critical Social Theory; Economics and Ethics; Neutrality in Science and Technology; Pareto, Vilfredo; Taylor, Frederick W.; Work.*

BIBLIOGRAPHY

Bunge, Mario. (1989). *Treatise on Basic Philosophy*. Vol. 8. Dordrecht, Netherlands: Reidel. Bunge's extensive work contains one of the first attempts at dealing with efficiency as a key concept to consider in philosophy of technology but his approach remains too close to the neopositivistic paradigm.

Carpenter, Stanley R. (1983). "Alternative Technology and the Norm of Efficiency." *Research in Philosophy and Technology* 6: 65–76. A pioneer paper that contributes to the clarity and precision of discussions on technological practice that invoke efficiency, while at the same time adopting a critical stance on the abuse of this criterion.

De Cózar-Escalante, José Manuel. (2000). "Toward a Philosophical Analysis of Efficiency." *Research in Philosophy and Technology* 19: 87–100. This essay identifies two problems of the concept of efficiency (unicity and applicability) and argues for a critical reconsideration of efficiency in social life.

Ellul, Jacques. (1954). *La Technique, ou l'enjea du siècle*. Paris: A. Colin. Trans. by John Wilkinson as *The Technological Society* (1964). New York: Knopf. In this book Ellul defines technique as the totality of methods rationally arrived at and having absolute efficiency (for a given stage of development) in every field of human activity. One of the main aims of Ellul's work is to denounce the fixed end of technological design and activity, by which the multiplicity of means and ends are reduced to only one: the most efficient.

Mitcham, Carl. (1994). *Thinking through Technology: The Path between Engineering and Philosophy*. Chicago: University of Chicago Press. In his comprehensive revision of the most important analyses of the technological phenomenon, Mitcham includes useful information as well as insightful remarks about the meaning of efficiency in technological design and everyday life.

Quintanilla, Miguel Angel. (1989). *Tecnología: Un enfoque filosófico* [Technology: A philosophical approach]. Madrid: Fundesco. In a brief section of this book the author works out a formal definition of efficiency as a basis upon which to further distinguish other technological criteria.

Sen, Amartya. (2002). *Rationality and Freedom*. Cambridge, MA: Belknap Press. The reputed economist Amartya Sen is known, among other contributions to economic, social and ethical theory, for his sharp criticism of standard models of rational behaviour. Being reductionist and ill-conceived, those models tend to obscure crucial aspects of an individual's choice in real life situations.

Simon, Herbert A. (1982). *Models of Bounded Rationality*. Cambridge, MA: MIT Press. During his long career, Simon did impressive work to establish the strength and limits of rational design and management. One of his more interesting findings was the concept of bounded rationality: even if often is not realistic to search for the most efficient solution in absolute terms, a solution that is good enough can be achieved within the bounds set by the specific context in which the problem is stated.

Skolimowski, Henryk. (1966). "The Structure of Thinking in Technology." *Technology and Culture* 7(3): 371–383. Reprinted in *Philosophy and Technology: Readings in the Philosophical Problems of Technology* (1972), ed. Carl Mitcham and Robert Mackey. New York: Free Press. An early attempt at philosophically clarifying the concept of efficiency and its role as an ideal in engineering. However, Skolimowski's analysis has some weaknesses, especially because it does not clearly distinguish efficiency from effectiveness.

EINSTEIN, ALBERT

Albert Einstein (1879–1955) was born in Ulm, Germany, on March 14 into a middle-class assimilated German-Jewish family; by the time of his death on April 18 in Princeton, New Jersey, he was recognized as being equal in accomplishment to Isaac Newton, but one significantly more publicly involved in human affairs.

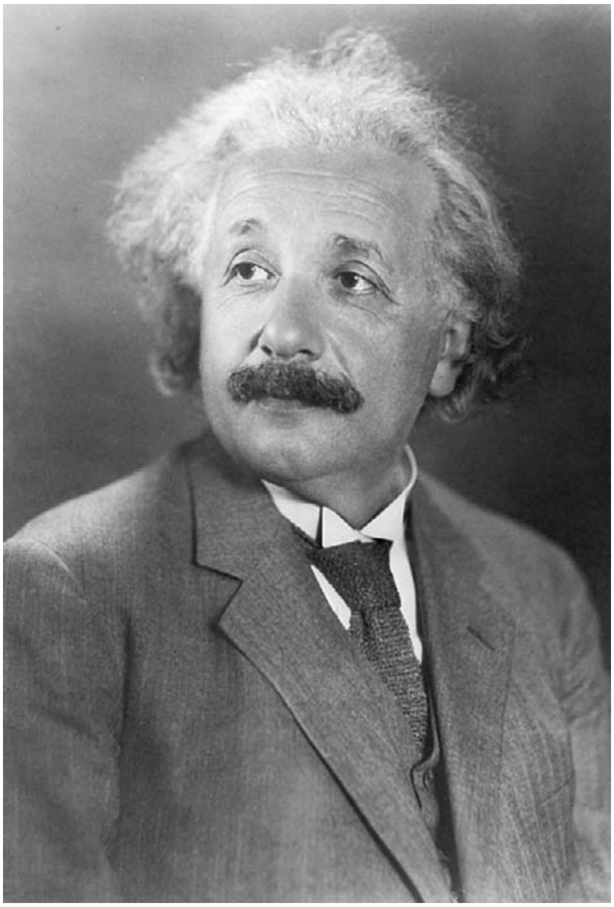
Life

Einstein showed precociousness in science and mathematics, with mixed accomplishment in other areas. He spent his early professional years in Switzerland working in the patent office. At age twenty-six—in the *miracle year* of 1905—he published several papers on special relativity, on the particle (photon) nature of light, resulting in the *complementary* idea that light was both a wave and a particle, and seminal papers in statistical physics. His general theory of relativity, first conceived in about 1907, achieved its final form in 1915. This theory was dramatically confirmed by its successful explanation of the hitherto mysterious precession of the perihelion of the planet Mercury, and with the observation during a solar eclipse of predicted bending of starlight by the Sun's gravitational field in 1919. It was especially this latter event that led to world fame.

Einstein's private life was not very dramatic; he was married twice and had two children. He emigrated to the United States at the time of Adolf Hitler's ascent in 1932, settling at the Institute for Advanced Studies at Princeton. He remained there for the rest of his life, continuing his physics research unabated, particularly his search for a *unified field theory*.

Achievements in Science

Einstein is best known for his theories of special and general relativity, although he also made enormous contributions to quantum mechanics, statistical mechanics, condensed matter physics, and cosmology. Through his contributions to the understanding of the nature of light and atomic structure, his revolutionary concepts of space and time, and his famous equation of $E = Mc^2$ (Energy equals mass times the speed of light squared) that shows the equivalence of mass and energy and led the way to the creation of controlled nuclear reactors and nuclear weapons, his impact on contemporary society and culture touches everyone.



Albert Einstein, 1879–1955. The German-born American physicist revolutionized the science of physics. He is best known for his theory of relativity. *(The Library of Congress.)*

Other less commonly appreciated impacts derive from early work on radiation theory, which led to the concept of stimulated light emission, the basis for the laser. In the 1990s his prediction, inspired by an earlier paper of Satyendra Nath Bose, of what is now known as Bose-Einstein Condensation, led to an entirely new field of physics that studies the macroscopic effects of quantum mechanics on extremely cold gaseous systems. The theory had been used earlier to help explain superconductivity and superfluidity.

Even this list of achievements does not adequately describe Einstein's involvement with the world of physics. Throughout his life he was in continual touch with numerous colleagues; he read voraciously and was fully involved with the developing conceptual framework of the new views of nature required by quantum physics and relativity. He was generous with his contemporaries, freely offering and taking suggestions from correspondents throughout the world, while eagerly conducting ongoing dialogues with the other great physicists then active, including Niels Bohr, Max Planck, Werner Heisenberg, Wolfgang Pauli, and Erwin Schrödinger. Although he was one of the original formulators of quantum mechanics he was never satisfied that it represented a complete theory, because it assumed the statistical nature of microscopic events, while he firmly believed in the Newtonian idea of causality in nature. Accordingly he always felt that quantum mechanics was incomplete, awaiting a deeper explanation for the statistical nature of the wave function in terms of a more causal theory. Einstein's often quoted statement, "God does not play dice," reflects this view. His *minority opinion* has resulted in an enormous literature on the interpretation of quantum theory, continuing with non-diminishing intensity into the twenty-first century.

Einstein's vision of a unified field theory that would unite all the known forces of nature into a single theoretical structure drove his research efforts during the last thirty years of his life. Although this incomparable challenge led to only limited success in his own hands, this holy grail of modern physics continues to inspire future generations of theoretical physicists.

Politics and Ethics

Einstein's overarching goal in physics was to formulate unifying principles for all phenomena in nature. This philosophy extended itself to other aspects of his life, including personal habits, and his deep involvement with issues such as world peace, human rights, and social justice. He was an implacable foe of militarism, even during his residence in Germany in World War I. He became the victim of intense anti-Semitism in Germany during the inter-war period, when his physics, especially relativity, was attacked as being *Jewish physics*. Although he espoused many liberal causes, he was never attracted to Communism and opposed Stalinist Soviet Russia as strongly as Nazi Germany. He was an unswerving advocate of international government and international control of armaments, including nuclear weapons. His advocacy of such positions often resulted in conflicts with authority, including the U.S. government. The Federal Bureau of Investigation (FBI) dossier on him consists of 1,427 pages. Although a non-practicing Jew, he was a strong supporter of the state of Israel, and was even proposed, at the time of Chaim Weizmann's death in 1952, to be its next President (although he swiftly turned down the invitation).

Additionally Einstein's name is indelibly connected with the atomic bomb, not only because of his famous formula for energy-mass equivalence but also because of the letter he signed in 1939, written by his friend Leo Szillard, alerting President Franklin Delano Roosevelt to the possibility that Germany might be working on the development of such a weapon. In his later years he regretted this action. Indeed, after Hiroshima and Nagasaki he argued that "everything has changed, save our modes of thinking" and that "the bomb [presents] a problem not to physics but of ethics." In 1955, in response to development of the hydrogen bomb, he co-signed with Bertrand Russell a public manifesto calling on all scientists to become involved in helping to reverse the nuclear arms race.

It is important to remember, however, that Einstein's concern for the social implications of science and technology always remained central to his core of beliefs. In 1931, for instance, in a talk at the California Institute of Technology, he told students that "concern for man himself and his fate must always form the field interest of all technical endeavors."

The literature on Einstein—his life, science, and beliefs—is overwhelming. There are more than 4 million Internet sites containing his name. As one noteworthy example, see the American Institute of Physics History site. At the end of the twentieth century *Time* magazine called him the *person of the century*. He remains the personification of the scientist. Einstein's combination of pure brilliance, high ideals, personal integrity, as well as human weaknesses yield the picture of a human being at the highest level of achievement.

BENJAMIN BEDERSON

SEE ALSO *Atomic Bomb; Energy; Pugwash Conferences.*

BIBLIOGRAPHY

Brian, Denis. (1996). *Einstein, A Life*. New York: John Wiley & Sons, Inc. Readable and anecdotal.

Einstein, Albert. (1931). *Address before the Student Body, the California Institute of Technology, February 16, 1931*. Original manuscript held at Pasadena, CA: Caltech Institute Archives. Quoted in many speeches and sources.

Einstein, Albert. (1954). *Ideas and Opinions,* ed. Carl Seelig. New York: Bonanza Books.

Einstein, Albert. (1987). *The Collected Papers of Albert Einstein,* ed. P Havas et al. 8 vols. Princeton, NJ: Princeton University Press. English translation.

Pais, Abraham. (1982). *Subtle Is the Lord: The Science and Life of Albert Einstein*. Oxford: Oxford University Press. The definitive scientific biography, highly recommended.

ELLUL, JACQUES

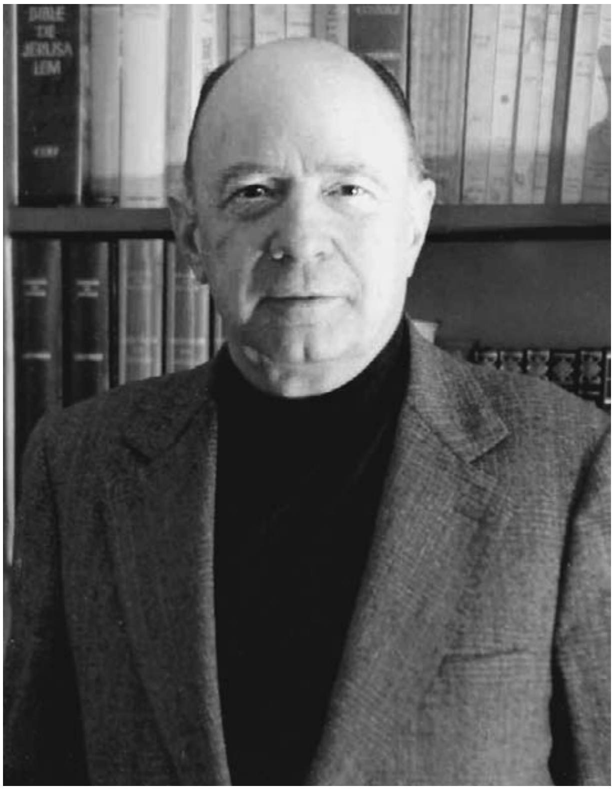
Jacques Ellul (1912–1994) was born in Bordeaux on January 6 and spent his academic career as Professor of the History and Sociology of Institutions at the University of Bordeaux Law Faculty and Professor in its Institute of Political Studies. His more than fifty books and hundreds of articles range across Christian theology, ethics, and biblical studies as well as sociological analysis and critique of mass media and communication, bureaucracy, and modern law and politics. He died in Bordeaux on May 19.

Technique: Ellul's Central Thesis

At the heart of his sociological works is his study of technology or, the term he preferred, Technique (*la technique*). Indeed Ellul initially became widely known in the English-speaking world for *The Technological Society* (1964). Its intellectual significance and originality derives in part from its argument being conceived twenty years before the original French edition (*La Technique* [1954]) when, after reading Karl Marx's *Capital,* Ellul (a law student in his early twenties) concluded that Technique, not capital, was central to modern civilization. This seminal idea was subsequently developed with Bernard Charbonneau in the French personalist movement of the 1930s.

Ellul was adamant that *la technique* "does not mean machines, technology, or this or that procedure for attaining an end" (Ellul 1964, p. xxv). He defined it as "the totality of methods rationally arrived at and having absolute efficiency (for a given stage of development) in every field of human activity" (Ellul 1964, p. xxv). Technique is, in other words, a universal category (Ellul compares it to *dog* rather than *spaniel*) embracing all the various self-consciously developed means found in art, politics, law, economics, and other spheres of human life. Central to these means is a quest for efficiency that is the defining characteristic of Ellul's account of Technique.

Two theses drive Ellul's analysis. First that "no social, human or spiritual fact is so important as the fact of technique in the modern world" (Ellul 1964, p. 3). Second that the contemporary "technical phenomenon . . . has almost nothing in common with the technical phenomenon of the past" (Ellul 1964, p. 78). Whereas previously Technique was limited and diverse, social changes in the eighteenth and nineteenth centuries led to its dominance and totally changed the relationship between Technique and society.



Jacques Ellul, 1912-1994. Ellul was a French thinker, sociologist, theologian, and Christian anarchist. He wrote several books against the "technological society," and some about Christianity and politics. *(© Patrick Chastenet.)*

In addition to its *rationality* and *artificiality*, Ellul proposes five more controversial characteristics of modern Technique. First there is *automatism* of technical choice because inefficient methods are eliminated and *the one best way* predominates. Second *self-augmentation* exists as technical developments automatically engender further innovations. Third Technique is characterized by *monism* as different techniques form an interconnected whole. This means that individual technologies must not be isolated and analyzed apart from an understanding of the wider technical phenomenon. Fourth there is a technical *universalism* that is both geographic (here Ellul offers an analysis that anticipates globalization) and qualitative (as every area of life is subordinated to technical efficiency). Fifth, and decisive for the novelty and hegemony of Technique, is its *autonomy*. This means Technique is no longer controlled by economics, politics, religion, or ethics; the common belief in Technique as a neutral means is false.

These five features are returned to in *The Technological System* (1980) where Ellul argues they characterize an elaborate technical system within society. The characteristic of *uncertainty*—seen in such factors as the ambivalence of technical progress and the unpredictability of its development—is then added in his *The Technological Bluff* (1990) that critiques contemporary discourse about Technique.

Technique in Society and Criticisms of the Analysis

Ellul's analysis leads him to conclude that whereas previous societies developed through the dialectical play of different social forces, it is now dominated by Technique. Most of *The Technological Society* is an account of the society that Technique is creating in relation to economics, politics, law, the state, and human affairs such as education, entertainment, sports, and more. Both there and in such works as *Propaganda* (1965) and *The Political Illusion* (1967) the prescience and power of Ellul's analysis remain striking at the beginning of the twenty-first century and explain why some describe him as a prophet. Having initially claimed Technique no longer belongs within human civilization but has established a technical civilization, Ellul later extended this, arguing that the social environment that had earlier replaced humanity's natural environment has in turn now been replaced by a technical *milieu:* Technique provides humans with what they need to live, is that which now threatens and endangers them, and is most immediate to them.

Most seriously, Ellul believed that Technique was incompatible with a truly human civilization. Technique focuses on quantitative improvements and facts rather than qualitative change based on values. It is a means of power—a central Ellul theme—and not subject to human values. Although it originally enhanced human freedom, building civilization by enabling people to overcome natural and social constraints and necessities, Technique has become human fate and a form of necessity. What used to be a means to freedom for humans has become a condition of slavery. In the terms of Ellul's theological writings, Technique is a contemporary idol that attracts human faith, hope, love, and devotion; a locus of the sacred in a supposedly secular society (Ellul 1975).

The criticism constantly made against Ellul is that he is a technophobe and a fatalist. Although the all-embracing nature of Technique in his work and his often caustic style of writing creates problems, Ellul's desire was "to arouse the reader to an awareness of technological necessity and what it means" and present "a call to the sleeper to awake" in order to challenge the destruction of human civilization. In later writings, Ellul sketched a new ethics of response to the dominance of Technique. This comprises the need for proper recognition of the other person (reflecting Ellul's personalism) and of nature (Ellul was an early environmentalist) and an ethics of voluntary limitation, rejecting the technical mindset that whatever can be done therefore should be done. The practice of such an *ethics of non-power* is very difficult in a world dominated by technological power and is a central part of Ellul's ethic for Christians that he suggests.

From the early 1930s, Ellul's aim was to help people understand and preserve a sense of criticism vis-à-vis technical civilization. More than half a century after it was written, his *Technological Society* remains an insightful, even if at times infuriating, analysis of modern Technique and its effects on contemporary society.

ANDREW J. GODDARD

SEE ALSO *Autonomous Technology; Efficiency; Freedom; French Perspectives.*

BIBLIOGRAPHY

Ellul, Jacques. (1964). *The Technological Society*. New York: Knopf. This is Ellul's classic text, written in the late 1940s, which was first published as *La technique ou l'enjeu du siecle* (Paris: Armand Colin, 1954).

Ellul, Jacques. (1975). *The New Demons*. New York: Seabury. Ellul's study of the new forms of the sacred in contemporary society.

Ellul, Jacques. (1980a). *The Technological System*. New York: Continuum. This, Ellul's second major study of technique, first appeared in 1977 as *Le systeme technicien* (Paris: Calmaan-Levy)

Ellul, Jacques. (1980b). "Nature, Technique and Artificiality." In *Research in Philosophy and Technology* 3: 263–283.

Ellul, Jacques. (1998). *Jacques Ellul on Religion, Technology and Politics: Conversations with Patrick Troude-Chastenet*. Atlanta, GA: Scholars Press. This important and wide-ranging collection of interviews with Ellul originally appeared as *Entretiens avec Jacques Ellul* (Paris: La Table Ronde, 1994).

Goddard, Andrew. (2002). *Living the Word, Resisting the World: The Life and Thought of Jacques Ellul*. Carlisle, UK: Paternoster Press.

EMBRYONIC STEM CELLS

In 1998 a team of researchers reported that they had isolated and removed stem cells from the inner cell mass of human embryos that had been donated by couples undergoing fertility treatment (Thomson et al. 1998). The embryos had divided for several days to reach the blastocyst stage of approximately 100 cells. At this stage embryos have a hollow sphere in the middle, an outer layer of cells committed to forming the placenta and other cell lines, and a mass of undifferentiated cells pushed to one side (inner cell mass). The cells in the inner mass have, for a short time, the capacity to develop into all cells in the human body, and are known as embryonic stem (ES) cells. The researchers' announcement that they had isolated ES cells in human embryos generated considerable interest because it suggested that the cells could be removed, cultured, and coaxed to differentiate for use in medical therapy. Among other things, it was thought that large supplies of specialized cells could be widely available and used to replace cells destroyed by Parkinson's disease, Alzheimer's disease, neural cord injuries, and other diseases and conditions. The announcement also generated controversy because the act of removing ES cells destroys the embryo. In the years since, research has been limited to pre-clinical studies. Numerous safety issues must be addressed before clinical trials ethically can be conducted.

Ethical Issues

Of the many ethical issue raised by ES cell research, four are described here. First what is the moral status of human embryos? Some individuals argue that embryos have the same moral status as persons, which means it would be purposefully unethical to destroy embryos for any reason. Others argue that embryos are potential human beings that do not share the same rights as children and adults. For them, the destruction of embryos may be warranted under certain circumstances.

Second, independent of the particular moral status of human embryos, will ES cell research contribute to a mindset that treats embryos as commodities? Some express concern that using embryos for medical purposes will turn embryos into merchandise and diminish the dignity of humans in the process. Others counter that strict rules overseeing ES cell research protect human dignity while respecting the interests of patients who need therapies

Third, are ES cells necessary for medical therapies? Proponents of ES cell research claim that ES cells are versatile and easy to work with, and that they raise significant hope for effective medical therapies. Opponents claim that adult stem cells, found in human tissues and not requiring the destruction of human embryos, also hold the potential for medical therapies and provide a viable alternative form of research.

Fourth, what impact does the source of the embryos have on the ethics of ES cell research? The embryos used by James Thomson and his colleagues were donated for research by couples who were patients at in vitro fertilization (IVF) programs and who no longer needed stored embryos for their conception efforts. Arguably these embryos were created for an ethical purpose (reproduction) but were not needed; therefore it would be appropriate to secure some good from them before their inevitable destruction. It has also been advocated that embryos may need to be created solely for ES cell removal in order to secure a sufficient number of healthy and genetically diverse embryos to meet research and therapeutic needs. Critics, however, contend that this would be less ethical than using donated embryos, because the embryos would be created with the intention of destroying them. Still another possible source of ES cells is from the creation of embryos through a cloning technique (somatic cell nuclear transfer), in which the intended patient's nucleus would be used to create an embryo for deriving genetically compatible ES cells. Creating cells specifically for a patient would presumably eliminate the need for anti-rejection drugs. Critics, however, argue that therapeutic cloning would tempt individuals to use the embryos for reproduction rather than therapy.

Policy issues

Policy issues for human ES cell research have revolved around whether governments should fund studies involving ES cells. The issue became volatile immediately after the announced isolation of human ES cells in 1998. In the United States, the U.S. Congress held hearings on the question, numerous interest groups lobbied both for and against funding, and policy advisory bodies convened to make recommendations (Bonnicksen 2002). For example, the National Bioethics Advisory Commission concluded it would be ethical to fund the removal and use of ES cells from donated embryos (National Bioethics Advisory Commission 1999). A working group convened by the National Institutes of Health (NIH), however, concluded it was appropriate to fund only the use of ES cells (National Institutes of Health 1999). The removal of cells (and hence destruction of the embryo) would have to be funded privately. Both groups agreed the government should not fund research creating embryos solely for ES cell removal.

Following intense lobbying by, among others, right-to-life groups opposed to federal funding and scientific associations and patient advocacy groups supporting funding, President George W. Bush announced a limited compromise position on August 9, 2001 (Vogel 2001). Under the new policy, the federal government would consider funding a narrow range of proposals in which (a) ES cells had been removed with private funds prior to the date and time of Bush's speech, and (b) the embryos were donated with informed consent by couples in IVF programs. At the time it was thought approximately sixty ES cell lines worldwide met these conditions. Within a couple of years, however, it became clear that fewer than fifteen cell lines were available for research.

Opponents argue that the government should not fund research that many people regard as immoral. Advocates argue that governmental funding is necessary for the potential of this research to succeed and for new therapies to become available to help persons with presently untreatable illnesses. Funding also has the benefit of opening the door to federal oversight of the research. Assuming ES cell research lives up to its potential, more studies will be conducted in the future and new cell lines will be needed to meet the standards required for clinical tests of medical therapies. If funding remains strictly limited, research will be conducted with private sector funding outside the public eye. Inasmuch as ES cell issues generate intense discourse, it is ironic that ES cell research will proceed without the public scrutiny that comes with significant federal funding.

Debates over the ethics of cell research are ongoing in nations worldwide. For example, in Europe differences among nations have precluded funding for ES cell research by the European Union (Vogel 2003). Research is proceeding in individual nations with accommodating governmental policy, such as the United Kingdom where, among other things, a UK stem cell bank has been set up with government backing (nibsc.ac.uk/divisions/dbi/stemcell.html).

ANDREA L. BONNICKSEN

SEE ALSO *Dignity; Fetal Research; Human Cloning; In Vitro Fertilization and Genetic Screening; Medical Ethics; Research Ethics.*

BIBLIOGRAPHY

Bonnicksen, Andrea L. (2002). *Crafting a Cloning Policy: From Dolly to Stem Cells*. Washington, DC: Georgetown University Press.

Jones, Howard W., Jr., and Jean Cohen. (2004). "IFFS Surveillance 04." *Fertility and Sterility* 81(Supp. 4): S1–S54.

National Bioethics Advisory Commission. (1999). *Ethical Issues in Human Stem Cell Research: Report and Recommen-*

dations of the National Bioethics Advisory Commission. Rockville, MD: National Bioethics Advisory Commission.

National Institutes of Health. (1999). "Draft National Institutes of Health Guidelines for Research Involving Human Pluripotent Stem Cells." *Federal Register* 64(231): 67576–67579.

Ruse, Michael, and Christopher A. Pynes, eds. (2003). *The Stem Cell Controversy: Debating the Issues*. Amherst, NY: Prometheus Books.

Thomson, James A.; Joseph Itskovitz-Eldor; Sander S Shapiro; et al. (1998). "Embryonic Stem Cell Lines Derived from Human Blastocysts." *Science* 282: 1145–1147.

Vogel, Gretchen. (2001). "Bush Squeezes Between the Lines on Stem Cells." *Science* 293: 1242–1245.

Vogel, Gretchen. (2003). "E.U. Stem Cell Debate Ends in a Draw." *Science* 302: 1872–1873.

EMERGENT INFECTIOUS DISEASES

Emergent infectious diseases (EIDs) are conditions caused by pathogenic microorganisms or parasites that have recently appeared or reappeared in human or animal populations. Typically, EID agents have begun to change the range of their infection, spread through new vectors or the movement of preexisting vectors, rely on shifts in patterns of host susceptibility, or have only recently been identified as the causes of existing diseases. This includes reemerging disease agents once thought to have been eradicated, but that have returned in resistant strains, or as a result of disintegrating public health infrastructure. Emergent diseases have tremendous impact on human health, and the health of pets and livestock. Furthermore, they pose a threat to biodiversity because many wild animal species are also at risk.

Science and Origins

An emerging infection can be caused by such viral agents as Ebola virus, HIV, or the SARS-associated corona-virus (SARS-CoV) identified as the cause of severe acute respiratory syndrome (SARS); bacteria such as methicillin-resistant *Staphylococcus aureus* (MRSA); or prions responsible for bovine spongiform encephalopathy (BSE, or "mad cow disease"), scrapie in sheep, chronic wasting disease in wild and domesticated deer and elk, and variant Creutzfeldt-Jakob disease (vCJD) in humans.

Emergence of an infectious agent is a two-step procedure: introduction into a new host species, followed by dissemination into a population. Varied origins include the evolution of a new virus or variant, bacteria, or prion; the introduction from another species (zoonoses); or dissemination from a smaller into a larger population. The latter two are usually the result of some environmental, social, or political disturbance bringing the naive host population into contact with the infectious agent.

Emergence can be illustrated through the case of Ebola virus, a virus of zoonotic origin. In 1995, a Swiss scientist died from Ebola while studying a chimpanzee population in the Côte d'Ivoire. In January of 1996, twenty-nine of thirty-seven confirmed cases of Ebola in a Gabon village were traced to contact with a dead chimpanzee.

Viruses and bacteria often mutate and adapt through the exchange of genetic material that can select for traits such as virulence, adaptability to different host organisms, and resistance to antiviral drugs or antibiotics. Viruses are ephemeral entities that undergo antigenic mutation, and adapt to new ranges of host, or vector.

A viral example that captures many of the characteristics of an EID is influenza caused by the influenza virus. Many influenza epidemics threatened public health throughout the twentieth century. A mutated influenza virus that originated in swine or avian hosts caused the 1918 Spanish flu pandemic, which killed more than twenty million people worldwide. It is thought that mixed variants of human and avian strains of influenza virus caused the 1957 Asian flu and the 1968 Hong Kong flu pandemics. In these cases, a preexisting swine or avian influenza virus either infected human beings directly and became adapted to the new hosts, or else previously-existing human variants of the influenza virus obtained genetic information from animal viruses. In some of these cases, the virulence of the newly adapted influenza virus was great enough to explode in the newly-acquired human host population, expanding throughout the global population.

Between 1998 and 1999, the previously unknown Nipah virus claimed 105 lives and resulted in the slaughter of 1.1 million hogs in Malaysia. Nipah virus exemplifies many of the characteristics of a newly emergent virus. It is carried by flying foxes (*Pteropus vampyrus*). The emergence of Nipah virus from the flying fox reservoir resulted from environmental changes in the infected hosts' environment. A drought allowed fires, set to clear land, to run out of control, destroying the flying foxes' habitat and food source. Many flying foxes set up new residence in orchards, often run in conjunction with swine husbandry operations. It has been

A crowd of people in Zaire watch health workers who have come to deal with an epidemic of the Ebola virus. Since its discovery in 1976, different strands of Ebola have caused epidemics with 50 to 90 percent mortality in several countries in Africa. *(© Patrick Robert/Corbis.)*

suggested the bats contaminated fruit that was then fed to the pigs, who then infected their caretakers. Changing environmental conditions and agricultural practices create conditions where the hosts of infectious diseases come into contact with new, potential hosts, with sometimes tragic consequences.

Of particular concern to public health is the emergence of infections by bacteria that have developed resistance traits to a variety of antibiotics. Antimicrobials are perceived as essential for combating both human and animal bacterial infections. In 1945, penicillin discoverer Alexander Fleming (1881–1955) warned of the danger of antibiotic resistance when bacteria in his lab developed resistance traits to penicillin through mutations and a process of natural selection. Resistance also develops through the transference of genes from resistant to non-resistant bacteria. An early case of the danger recumbent in the transference of genes for resistance is ampicillin-resistant *Haemophilus influenzae* and *Neisseria gonorrhoeae,* which appeared in the early to mid 1970s. Both diseases shared genetic material thought to have been transferred from one species of bacteria to another (Levy 2002).

It is now considered an item of scientific faith that the use of antimicrobials will favor the selection of resistant strains for most bacterial species. Some authors stipulate increasing resistance is the inevitable outcome of antimicrobial use in both human health and agricultural contexts (Levy 2002). Stuart Levy has coined the expression "the antibiotic paradox" to characterize the intertwined promises and threats of antimicrobial use.

Impacts

Antimicrobial resistant bacteria are increasingly ubiquitous, and their costs are immense and growing. One overview of the human health literature on resistance notes MRSA has been reported in community-based infections at rates from twenty to sixty-two percent of cases in the 1990s. This study reports widespread rising resistance to second and third generation cephalosporins in *Enterobacter* species, suggesting antimicrobial resistance has "become a fact of hospital life and is so common that it often goes unnoted until it is either extreme or epidemic" (Weinstein 1998, p. 215).

A 2001 Center for Disease Control and Prevention (CDC) publication notes "as we enter the 21st century, many important drug options for the treatment of common infections are becoming increasingly limited, expensive, and in some cases, nonexistent."

In a 1969 speech, the U.S. Surgeon General proclaimed that the frontiers of infectious diseases had been reached, remaining problems in the United States were marginal, and that it was the responsibility of the medical establishment to focus on chronic illness. Antibiotics were proclaimed miracle drugs (Levy 2002). They were understood to be an increasingly effective weapon in the armamentarium against bacterial infections and, with the promise of many new viral vaccines, it was believed the technology existed to eradicate disease worldwide.

With a growing awareness of the vastness of epizootic reservoirs of infectious agents, endemic changes in environment and agriculture, increasingly rapid global movement of animal and human populations, and growing problems with antibiotic resistance, this era of optimism is at an end.

Ethics and Policy Issues

One consequence of the emergent character of these diseases is the burden of uncertainty under which policy makers must function—far greater than the uncertainties faced by policy makers dealing with well understood risks such as cigarette smoking or automobile driving. The next EID may be innocuous, or it may be a deadly pandemic. This uncertainty makes it difficult to compare the risks of EIDs to other, more certain public health hazards. Indeed, one reason the media often covers EIDs more closely is because of this uncertainty.

Contemporary efforts to defend against EIDs follow the stages of prevention, detection, and response. Optimal allocation of resources among these stages is a question that has generated much controversy.

Conventional approaches to public health are incapable of preventing many of the factors that are presently increasing the rate of disease emergence. Public health institutions rarely have the resources or the mandates to put a halt to rapid environmental change or to changing patterns of agriculture, let alone to control the increased global movement of human and animal populations.

In the case of resistant bacteria, restrictions and judicious use guidelines on antibiotic use in human and animal health have been suggested as well as a curtailment of their use as growth promotants in the animal industries (Rollin 2001). Rising levels of resistance have fueled a debate over responsibility between representatives of the human and animal medical fields. For example, in 2004 the U.S. Food and Drug Administration was revising its drug approval and labeling procedure for antimicrobials to be used in animal agriculture, and a number of European countries have banned their use as growth promotants under the precautionary principle. The CDC and a variety of private initiatives are instituting educational programs encouraging patients and medical professionals to curtail their use of antibiotics. In the United States as of 2004, there was no legislation to further restrict doctors' prescriptions of antibiotics.

In the United States, responsibility for managing emerging infectious diseases is distributed widely. The CDC often takes the lead, but in instances of food-borne disease, the Food and Drug Administration (FDA) and the Department of Agriculture (USDA) are also involved. In the case of antimicrobial resistance, a U.S. federal government interagency task force initiated in 1999 involved more than eleven agencies and departments.

The implementation of vaccines as a means of prevention is hindered by the contemporary market in pharmaceuticals. Pharmaceutical companies tend to focus research and development monies on profitable repeatable treatments for chronic ailments. Vaccines and antibiotics—which will only be used once or a few times per individual over their lifetime—do not provide the same return on investment. Incentives, regulatory assistance, or an alternative drug research and development system is needed to address these gaps in the preventive armamentarium.

Around the turn of the twenty-first century, greater emphasis has been placed on understanding the role of industrial agri-food practices in the spread of infectious diseases. In the United States, rapid progress in the development of new techniques for managing industrial animal agriculture for food safety concerns have been hindered by the sometimes conflicting mandates of the principal governmental agencies involved in dealing with emerging diseases among food animals, including the CDC, the FDA, and the USDA.

Some policy suggestions have focused on early detection of aberrant syndromes through disease surveillance, on the anticipation of new host and virus interactions brought about by changing ecological and agricultural conditions, and on the control of new diseases through planned response. Similar surveillance tactics have been suggested to deal with antimicrobial-resistant bacteria.

There is limited but growing international coordination of emerging infectious disease surveillance and response. Most surveillance and response systems are national in scope. This includes the CDC, particularly

A health officer checks the temperature of an arriving passenger at Kuala Lumpur International Airport as part of a screening for Severe Acute Respiratory Syndrome (SARS). After the first outbreak occurred in China, the disease spread rapidly, reaching other countries via international travellers. *(© Reuters/Corbis.)*

the National Center for Infectious Diseases, which often responds to emerging disease emergencies outside the United States. Another CDC program, jointly run with the USDA, is the National Antimicrobial Resistance Monitoring System (NARMS).

At the international level, there are two institutions of note. The United Nations World Health Organization (UN-WHO) Communicable Disease Surveillance and Response is the principal international organization that identifies, verifies, and responds internationally to epidemics of infectious disease. This organization is overworked and underfunded. Animal diseases are monitored and managed by the Office Internationale des Epizooties (OIE), organized under the World Trade Organization (WTO) to maintain animal health and welfare worldwide. The OIE publishes trade standards on the presence of epizootic diseases, animal health, and food safety that govern the importation of animals and animal products between WTO member countries.

Responses to EIDs are administered by the above agencies and organizations and relevant agencies within a particular nationality's borders. Responses range from quarantine of humans and animals to radical eradication programs such as the slaughter of infected animals, vaccination programs, and mass-treatment with a variety of antiviral and antibiotic drugs.

The development of new antiviral and antibiotic medication suffers from the same market-induced problems as the development of new vaccines. Incentives or the creation of new, perhaps not-for-profit, institutions of drug research and development could alleviate the current dearth in treatment options. The National Institute of Health (NIH) supports research in drug development, but the costs of bringing these new drugs to market are still deemed prohibitive by many pharmaceutical companies.

Quarantines and mass animal slaughter wreak emotional, moral, social, and economic havoc. The

2003 SARS epidemic shut down international trade and travel and damaged the economic lives of cities as far apart as Toronto and Hong Kong. Foot and mouth disease and bovine spongiform encephalopathy (BSE) eradication programs in the United Kingdom resulted in massive animal slaughter, and in movement bans that eventually necessitated the welfare slaughter of even more animals as feed stocks were depleted. This devastated the British rural economy, and seriously affected British agricultural trade with Europe. Quarantines, animal slaughter, and animal movement bans are currently the most effective means of coping with an epidemic, but there is much research that needs to be done on how to lessen the impact of these techniques on the affected populations of humans and animals.

WESLEY DEAN
H. MORGAN SCOTT

SEE ALSO *Antibiotics; Health and Disease; HIV/AIDS; Medical Ethics.*

BIBLIOGRAPHY

Centers for Disease Control. (1995–). *Emerging Infectious Diseases*. Unless otherwise cited, all facts in this piece were taken from this flagship journal in the field.

Levy, Stuart. (2002). *The Antibiotic Paradox: How the Misuse of Antibiotics Destroys their Curative Powers*, 2nd edition. Cambridge, MA: Perseus Press.

Morse, Stephen, ed. (1993). *Emerging Viruses*. New York: Oxford University Press. Includes three articles of special note: Donald Henderson's "Surveillance Systems and Intergovernmental Cooperation," Morse's "Examining the Origins of Emergent Viruses," and Edwin Kilborne's "After word: A Personal Summary Presented as a Guide for Discussion."

Rollin, Bernie. (2001). "Ethics, Science and Antimicrobial Resistance." *Journal of Agricultural and Environmental Ethics* 14(1): 29–37.

Weinstein, Robert, and Mary Hayden. (1998). "Multiply Drug-Resistant Pathogens: Epidemiology and Control." In *Hospital Infections*, 4th edition, ed. John V. Bennett and Philip S. Brachman. Philadelphia, PA: Lippincott-Raven Publishers.

INTERNET RESOURCE

Center for Disease Control. (2001). *Preventing Emerging Infectious Diseases: Addressing the Problem of Antimicrobial Resistance, A Strategy for the 21st Century*. Available from http://www.cdc.gov.

EMOTION

The role of emotions in moral behavior has been debated by ethicists since ancient Greece. The scientific study of emotions is much more recent, yet the advances in twenty-first century understanding of the neural mechanisms that subserve emotions take on added meaning in the context of these ancient debates. New developments in *emotional technologies* add further nuances to these old questions. This entry provides a brief account of what emotions are, outlines the way emotions have been viewed in some major philosophical traditions, and discusses the ethical questions raised by some forms of technology.

What Are Emotions?

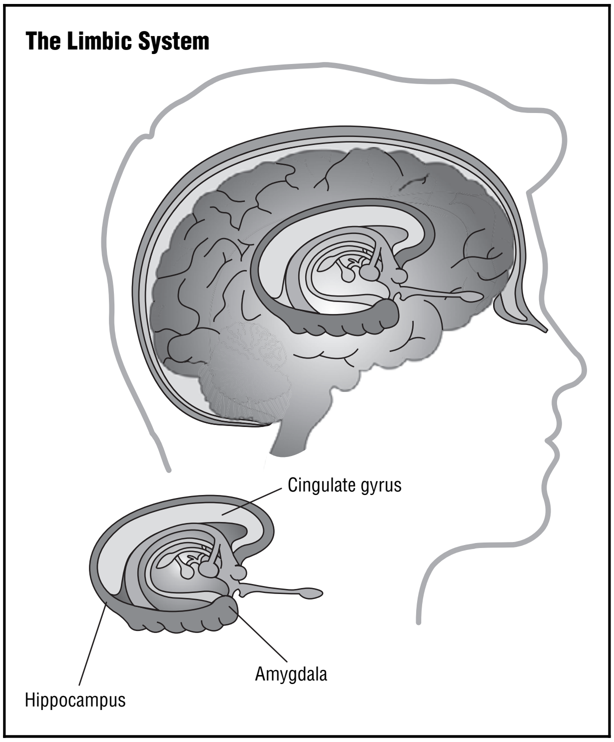
Emotions may be defined in a number of ways (Evans 2001). From a neurobiological perspective, emotions are defined in terms of the neural mechanisms that implement emotional processes in the brains of humans and other animals. In all mammals most emotional processes are mediated by a set of neural structures known collectively as the *limbic system*. The limbic system is an ill-defined term, but usually refers to a variety of subcortical structures, including the hippocampus, the cingulate gyrus, the anterior thalamus, and the amygdala (see Figure 1).

Neurobiological definitions of emotion can be regarded as parochial, because they exclude organisms that lack brains like those of humans from having emotions. A less chauvinistic alternative would be to define emotions in functional terms—that is, as dispositions to behave in certain ways. Fear, for example, disposes the organism to mobilize defensive and flight behaviors, and to focus attention on possible threats.

Functional definitions of emotion have been criticized on the grounds that they leave out feelings. Feelings—the conscious awareness of emotional states—have often been regarded as the central component of emotions, but some neuroscientists such as Antonio Damasio prefer to distinguish between emotions, which they regard as objectively measurable processes, and subjective feelings.

Emotions may be distinguished from other affective phenomena such as moods and personality traits by temporal duration. Many psychologists regard emotions as relatively rapid and brief processes, lasting no more than a minute or two, and class longer-lasting affective states

FIGURE 1



The human brain, with some of the limbic structures highlighted.

as moods, although this distinction is not universally accepted.

Emotions in Philosophy and Ethics

At the risk of over-simplification, it is useful to distinguish three main traditions in Western thought regarding the role of emotions in moral behavior. First many thinkers, such as Plato (c. 428–348 B.C.E. and Immanuel Kant (1724–1804), have regarded emotions principally as obstacles to good conduct. Plato compared the rational mind to a charioteer whose task was to keep his horses (his emotions) under a tight rein. Kant argued that good actions were only truly moral when performed purely out of concern for the moral law, and not motivated by any emotion.

A second tradition, exemplified by thinkers such as Aristotle (384–322) B.C.E. and economist Adam Smith (1723–1790), has regarded emotions as vital ingredients in generating moral behavior. Aristotelian ethics is based on the idea of virtue, which is a *golden mean* halfway between opposing vices. Because many vices are defined as deficits or excesses of particular emotions, Aristotelian virtues may be regarded as optimal midpoints between emotional extremes. This ancient approach to ethics finds many echoes in the modern concept of *emotional intelligence*, which also stresses the need for cultivating emotional self-regulation. Smith argued that certain social emotions such as sympathy, which he called *moral sentiments*, lay at the heart of all ethical conduct.

Finally, a third tradition takes issue with both of the preceding positions, arguing that all moral judgments are merely an expression of the speaker's emotions. According to this view, championed by philosopher David Hume (1711–1776), when someone says that a certain action is right or wrong, what is meant is that the speaker has a feeling of approval or disapproval toward the action. This is sometimes referred to as the *emotive theory of ethics*.

More recently the philosophy of emotions has begun to address other questions besides the role of emotions in moral behavior. Contemporary philosophers such as Paul Griffiths, for example, have argued that emotions are such a heterogenous bunch of phenomena that they cannot constitute a single natural kind. Others have attempted to clarify the complex relationship between emotions and rationality (de Sousa 1991).

Emotions and Technology

Since its very beginning, much human technology has been driven by the desire to exert greater control over the emotional states. Many human inventions, from cooking to music, may be viewed as *technologies of mood*, in the sense that they are designed primarily to induce certain emotions in the user. Modern developments such as psychotherapy and antidepressants, therefore, may increase the effectiveness of the ability to manipulate emotions by artificial means, but the ethical questions they raise are not new. The objections raised by critics such as Francis Fukuyama (2002) to the possibility of *cosmetic psychopharmacology*, in which people manipulate their emotional states at will by means of sophisticated new drugs, have many echoes in ongoing debates about authenticity. Such objections seem to some to smack of *psychopharmacological Calvinism*, the niggardly belief that happiness must be earned the hard way—that is, without the help of drugs (Kramer 1994). The inflammatory rhetoric that has so far characterized such debates needs to be eliminated if people are to have a mature and reasoned discussion about the benefits and dangers of developing more powerful technologies for influencing moods and emotions.

Other modern technologies raise ethical questions that had not previously been considered. The advent of neuroimaging techniques and other means of monitoring emotional processes that were previously thought to be irreducibly private and subjective raises new issues of neural privacy. How much of one's emotional life should others be able to assess by means of these technologies, and how reliable are they? These questions will become more urgent as new technologies such as *sensitive clothing* (garments with embedded sensors that monitor physiological changes) and brain-machine interfaces permit further intrusion into the emotional lives of others.

Another technology that raises new ethical questions concerning emotions is affective computing, a branch of artificial intelligence that attempts to build emotional machines (Picard 1997). One line of thinking in robotics argues that robots will need emotions if they are to be truly autonomous, and some commercially available entertainment robots already come programmed with a repertoire of basic emotions. It is arguable, of course, whether such mechanisms constitute genuine emotions or merely simulated emotions, but this distinction may be irrelevant because people tend to react to such robots as if they possessed genuine emotions. The ethical problems raised by such developments have been explored in great detail in science fiction, from Isaac Asimov's (1920–1992) short story "The Bicentennial Man" (1976) to Arthur C. Clarke's famous novel *2001: A Space Odyssey* (1968). While such fictional scenarios often postulate devices that are far in advance of available technology, the questions they raise are deep and sometimes disturbing. In Asimov's short story, for example, a robot redesigns his own circuitry so that he may experience the whole range of human emotions. Because some rights are often held to be contingent on having certain emotional capacities, a robot with human-like feelings might have to be accorded a moral status equivalent to that of a human. There are parallels here with the animal rights movement, which has placed great emphasis on the capacity of certain animals for pain and suffering in its attempts to provide them with greater legal protection.

More sinister scenarios envision emotional machines turning against their human creators, raising the question of whether efforts in affective computing should be curtailed. In Clarke's novel, for example, an onboard computer called HAL turns against the crew of the spaceship Discovery I, killing all but one of the astronauts. Asimov has suggested that such dangers might be avoided by programming machines to obey certain principles such as his *three laws of robotics*, stated in several of his stories and novels from 1950 onwards (including "The Bicentennial Man"), of which the first is that "a robot may not injure a human being or, through inaction, allow a human being to come to harm." Yet it is hard to see how such principles could be implemented in a computer program.

This list of issues raised by technologies of emotion is not exhaustive, but illustrates how a greater understanding of emotions impacts ethics. Science and technology have powerful emotional dimensions that are often ignored by those involved in developing them. Yet it is vital to think about these dimensions, because adverse emotional reactions to new technologies among the general public can have serious consequences. From the Luddites, eighteenth-century English artisans who destroyed machinery during the industrial revolution, to twenty-first century environmentalists who oppose the planting of genetically engineered crops, new technologies have often inspired deep feelings of mistrust. Those developing future technologies risk provoking similar reactions unless they engage the public at large in open and informed debate in which emotional dimensions are addressed as well as the scientific facts.

DYLAN EVANS

SEE ALSO *Artificial Intelligence; Emotional Intelligence; Evolutionary Ethics; Psychopharmacology; Neuroethics; Risk and Emotion; Robots and Robotics; Scientifc Ethics.*

BIBLIOGRAPHY

Asimov, Isaac. (1976). "The Bicentennial Man. In *The Bicentennial Man and Other Stories.* New York: Doubleday, 1976. In this story Asimov manages to explore many of the moral dilemmas of giving computers emotions more effectively than any non-fiction account.

Clarke, Arthur C. (1968). *2001: A Space Odyssey.* New York: ROC. A science-fiction classic, featuring HAL, the onboard computer.

Damasio, Antonio. (2003). *Looking for Spinoza: Joy, Sorrow and the Feeling Brain.* London: Heinemann. A prominent neuroscientist explores the distinction between emotions and feelings.

De Sousa, Ronald. (1991). *The Rationality of Emotion.* Cambridge, MA: MIT Press. A philosophical discussion of the role of emotions in rational behavior.

Evans, Dylan. (2001). *Emotion: The Science of Sentiment.* Oxford and New York: Oxford University Press. A good overall introduction to the science of emotion.

Fukuyama, Francis. (2002). *Our Posthuman Future: Consequences of the Biotechnology Revolution.* London: Profile Books. An emotional polemic against modern technology.

Griffiths, Paul E. (1997). *What Emotions Really Are: The Problem of Psychological Categories.* Chicago and London: University of Chicago Press. A philosophical discussion of the concept of emotion.

Kramer, Peter D. (1994). *Listening to Prozac*. London: Fourth Estate. A forceful advocate for the view that drugs can improve our emotional lives.

Picard, Rosalind W. (1997). *Affective Computing*. Cambridge, MA, and London: MIT Press. Discusses recent attempts to build emotional computers and robots.

EMOTIONAL INTELLIGENCE

Emotional Intelligence (EI) or Emotional Quotient (EQ) is a concept that challenges the assumption that the Intelligence Quotient (IQ) is the best predictor of professional success. Unlike IQ, which proposes to be a measurement of innate potential that is relatively stable, the proponents of EI maintain that it is a continuously developing ability, competency, or skill in which "the sky is the limit" (Segal 1997, p. 19). The same proponents claim that developing one's EQ is the key to succeeding in activities from academics, sales, customer service, and management to improving marriages, mental and physical health, lowering crime, and even an individual's spiritual relationship with God. Research on EI and attempts to apply it constitute extensions of science and technology into the ethical realm. In contrast the critics of EI argue that the concept is too all-encompassing, with EI measurements contributing little beyond existent constructs and its predictive claims largely unverified (Matthews et al. 2003).

The Scientific and Ethical Concept of EI

EI is conceptually related to Howard Gardner's (1985) theory of multiple intelligence, which criticizes the overemphasis on IQ and argues for the possibility of affective and social modes of intelligences. Peter Salovey and John Mayer (1990) first proposed the term *emotional intelligence* to describe a kind of ability to monitor, discriminate, and use the information of one's own and other's emotions to guide thinking and action. However it was Daniel Goleman's 1995 book *Emotional Intelligence* that popularized EI as a general capacity to motivate and persist at goals, to delay gratification, to regulate one's own emotions and those of others, to empathize, and to hope. In general the concept of EI is vague and there is no precision in attempts to clarify, define, or measure it. Some literature refers to EI as a type of sensitivity to emotions in self or others (Lam and Kirby 2002). Other literature understands it as an overarching term for any non-rational skill or ability, such as optimism, manners, empathy, or self-efficacy, that contributes to social and professional success beyond rational skills (Brown 2003).

The underlying scientific theory of EI relies on research, such as that by Antonio Damasio (1994), on the neuropsychology of emotions. This research has challenged the idea that emotions are irrelevant or an impediment to rational decision-making. Instead it suggests that the emotional circuitry of the brain (i.e., the amygdala, cingulate gyrus, hippocampus, and ventromedial prefrontal region) is interconnected with the higher cognitive areas (i.e., the neocortex) and indispensable for rational and social decision-making. Damasio's book *Descartes' Error* examined patients with damage to areas associated with emotional processing and found that they could successfully engage in rational abstract tests, such as those that measure IQ, but were unable to make even trivial social decisions. This research has also shown that, although innate emotional responses can function independently, the neocortical area of the brain works with emotions and can modulate emotional responses to environmental circumstances. This degree of plasticity of emotions supports the claim of EI as a life-long developing capacity.

Conceptually EI also has implications for ethical theory and related educational policies. EI can trace its ethical roots to Aristotle's analysis of emotions in the *Nicomachean Ethics*. Aristotle's ethical theory relies on the development of ethical dispositions or character traits in which both reason and emotion are habituated to deliberately choose the ethical action. Certain ethical theorists, for example Martha Nussbaum (2001), also reject ethical theories that understand ethics as purely a rational activity; instead, similar to Aristotle, Nussbaum stresses the importance of emotions as an integral aspect of ethical judgment and normative appraisals. In this view, ethical development does not depend on rational evaluation, but relies on learning how to check impulses and using USE emotional information to guide behavior. The practical implication of this ethical theory has been to implement educational curriculum and staff training that emphasizes the development of EI skills (Goleman 1995, Brown 2003).

Review of Research

EI literature spans many disciplines from the popular psychology self-help genre that has virtually no scientific evidence for its claims, to more scientific analysis in neuropsychology, clinical psychology, education, management, business, and behavioral economics. In addition many collaborators in the field of psychometrics have devoted attention to developing reliable and consistent standards in the attempt to measure and explain individual differences in EI.

Similar to ethical theory, certain avenues of research in the social sciences, such as behavioral economics, reject standard models of human decision-making, such as utility theory, that minimize or ignore the role of emotions in decision-making (Sanfey et al. 2003). This research focuses on the analysis of EI as a relationship between rational and emotional processes in decision-making. Adopting methods, such as functional magnetic resonance imaging (fMRI) from neuroscience into game theory, behavioral economics seeks to explain how and why individuals will often reject a purely rational decision when this decision is seen as unfair. In management research, Brown (2003) has also examined the role of emotions in enhanced service provision and profitability. In other disciplines, such as political science, George Marcus and colleagues (2000) have attempted to understand the role of emotion in political learning and decision-making.

The typical research analyzing EI as a type of aptitude focuses mainly on developing psychometric tests to measure EI for both scientific understanding and potential commercial applications (Matthews et al. 2002). One of the most popular measurement is the performance test, such as the Multifactor Emotional Intelligence Scale (MEIS) or the modified Mayer-Salovey-Caruso Emotional Intelligence Test (MSCEIT) developed and tested by David Caruso, John Mayer, and Peter Salovey, which measures the management and regulation of emotions by predetermined consensual, expert, or target scoring. The main difficulty with predetermined criteria is that, unlike IQ tests that have definite right or wrong evaluations, EI criteria are open to criticism of personal and cultural norms. Another type of measurement is a simple self-reporting questionnaire of competency, such as the Emotional Quotient Inventory (EQ-i) developed and tested by Bar-On and collaborators. Other tests used to measure EI include Goleman's Emotional Competency Inventory (ECI) and Nicola S. Schutte and collaborators' Schutte Self-Report Inventory (SSRI). Although self-reporting tests are less costly than performance tests, they are highly susceptible to response bias due to respondent's lack of awareness or even deliberate attempts to reflect expected social norms.

Assessment

Despite the popular and commercial appeal of EI as holding an indefinite possibility to improve an individual's personal and private life, there is little scientific evidence for such claims. Many of the popular claims of EI proponents offer little more than commonsense advice, such as proposing that children who are taught manners are more liked by their teachers (Shapiro 1997) or standard yoga meditation techniques for calming emotions (Segal 1997). Beyond such problems of popular accounts, the main difficulty of a scientific understanding of EI is the lack of a clear, concise concept. EI is often a catch-all term of any list of qualities or character traits that could explain why individuals with high IQs do not necessarily succeed professionally or why those with lower IQs often are more successful. But a simple negative categorizing of EI as any trait that is not measured by IQ does not provide for any clear scientific evaluation of EI or its popular claims. In addition, as Gerald Matthews NAME] and collaborators (2003) point out, many of the valuable aspects of EI, such as those reliably measured by the psychometric tests, have much in common with already established personality tests. The concept of EI is vague, imprecise, and in many cases redundant.

The most valuable aspect of EI is when it is conceptually understood not as a character trait such as optimism or self-efficacy, but as a concept reflecting the importance of emotion as a type of cognition that functions together with reason in social and ethical decision-making. This understanding of EI connects it with research in the neuroscience of emotion, which has focused on understanding how the brain receives and processes information. Unlike the popular version of EI that conceives it as an ability to use, manage or, control emotions, this version of EI rejects the notion of any simple mastery over emotions. Instead EI represents emotions as making a cognitive contribution essential to practical, non-abstract decision-making.

This conceptualization of EI has implications for possible research in various disciplines, from decision-making in the social sciences to ethical theory. The concept of EI suggests that because emotions are involved in social decision-making, understanding emotions is an essential aspect to understanding political, economic, and other social behavior. In addition EI understood as a necessary aspect of cognitive decision-making has practical ramifications for developing education and training policy that include more than simply teaching abstract, rational knowledge. However, before any useful practical application of EI-based programs, more clarification of the concept and measurement tests need to be developed to avoid the problems of unevaluated claims or measurement redundancy.

MARLENE K. SOKOLON

SEE ALSO *Aristotle and Aristotelianism; Emotion; IQ Debate; Risk and Emotion.*

BIBLIOGRAPHY

Aristotle. (1934). *The Nicomachean Ethics*, trans. Harris Rackham. Cambridge, MA: Harvard University Press.

Brown, Randall B. (2003). "Emotions and Behavior: Exercises in Informational Intelligence." *Journal of Management Education* 27(1): 122–134.

Damasio, Antonio R. (1994). *Descartes' Error*. New York: Harper Collins Publishers. A highly readable challenge to the assumption that emotions necessarily hinder social and ethical decision-making. Drawing on the experiences of patients who have had damage to emotional processing areas of the brain, this neuroscientific work provides scientific evidence that without emotional responses human beings are unable to assess ethical and social dilemmas.

Gardner, Howard. (1985). *Frames of Mind: The Theory of Multiple Intelligences*. New York: Basic Books.

Goleman, Daniel. (1995). *Emotional Intelligence*. New York: Bantam Books. The classic account of emotional intelligence as self-awareness and impulse control. A clear explanation of the brain and behavioral research underlying EI and limitations of IQ as a predictor of success. Less compelling is the commonsense guidance for encouraging the development of emotional awareness.

Lam, Laura Thi, and Susan L. Kirby. (2002). "Is Emotional Intelligence an Advantage? An Exploration of the Impact of Emotional and General Intelligence on Individual Performance." *Journal of Social Psychology* 142(1): 133–143.

Marcus, George, et al. (2000). *Affective Intelligence and Political Judgment*. Chicago: University of Chicago Press.

Matthews, Gerald, et al. (2002). *Emotional Intelligence: Science and Myth*. Cambridge, MA: MIT Press.

Nussbaum, Martha C. (2001). *The Upheavals of Thought: The Intelligence of Emotions*. New York: Cambridge University Press. An exhaustive account of the role of emotions in ethical decision-making, touching on such wide-ranging subjects as classical and modern moral philosophy, anthropology, child development, music, and religion. The conclusion of the lengthy volume is that emotions facilitate rather than impede human morality.

Salovey, Peter, and John Mayer. (1990). "Emotional Intelligence." *Imagination, Cognition, and Personality* 9: 185–211.

Sanfey, Alan G., et al. (2003). "The Neural Basis of Economic Decision-Making in the Ultimatum Game." *Science* 300: 1755–1758.

Segal, Jeanne. (1997). *Raising Your Emotional Intelligence*. New York: Henry Holt and Company.

Shapiro, Lawrence E. (1997). *How to Raise a Child with High EQ*. New York: Harper Collins.

ENERGY

Energy, from the Greek *energeia* or activity, denotes the capacity of acting or being active. Aristotle used the term to denote the activity of tending toward or enacting a goal, which differs from the modern understanding of energy as the capacity to do work. To a certain degree energy functions as the abstract equivalent of fire, one of the Aristotelian four elements. The modern concept of energy can engender either physical or psychological activity and be analyzed in one or more of three senses: scientific, technological, and ethical.

Science of Energy

In modern science, the term *energy* has become a precise technical concept with such distinctions as kinetic (energy related to the motion of a body) and potential (stored energy of position). Other important distinctions pertain to the different forms of energy, including thermal, mechanical, electrical, chemical, radiant, and nuclear.

The history of the modern science of energy reveals that developing a precise technical concept of energy is a convoluted process, one that raises controversial tensions between constructivist and realist interpretations of scientific knowledge (Crease 2004). To what extent did the phenomenon of energy precede the development of the concept itself? And to what extent do the cultural and technological contexts in which energy came to be represented actually shape that natural phenomenon in terms of intersubjective agreement? The modern concept of energy arose through both purely ahistorical theories and a changing social context, marked especially by the development of different energy technologies. This means that the contexts of discovery and justification cannot be isolated from one another, because energy cannot be justified without the use of historically given concepts (e.g., work and heat) and technologies (e.g., steam engines). Energy is at once real (i.e., not an artifact of language and culture) and constructed (i.e., inextricably embedded in human history).

The modern science of energy originated with the development of thermodynamics in the nineteenth century and efforts to understand the dynamics of steam engines and other mechanical devices. In 1842 Julius Robert von Mayer (1814–1878) calculated the caloric equivalent of mechanical work. This *Kraft* (force or power) was the precursor of energy as a scientific concept that denoted the quantitative equivalence between physiological heat and mechanical work. By the mid-nineteenth century, it was experimentally well established that such physical phenomena as electricity, heat, electromagnetism, and even light were interconvertible at determinate rates of exchange (Kuhn 1959). To German scientists in particular, the fixed rates of exchange governing the conversion of diverse phenomena suggested the existence of a single underlying substance. They postulated a metaphysical *Arbeitskraft* (workforce) behind physical manifestations.

In 1847 Hermann von Helmholtz (1821–1894) formulated the first law of thermodynamics by stating that *Arbeitskraft* can be neither created nor destroyed. So enshrined in the "law of energy conservation," energy denotes an unknowable substance manifest in the transformations of matter and measurable in units of work. Rudolf Clausius (1822–1888) formulated the second law of thermodynamics on the notion of entropy (a measure of disorder or the quality of energy) in 1850. The scientific concept of heat was reduced to the kinetic energy of theoretically postulated particles and divorced from the commonly experienced primal element of fire.

Work by Bernhard Riemann (1826–1866) and others further removed the concept of energy from common experiences, but Ernst Mach (1838–1916) argued that energy and other concepts in physics ought to be grounded in practical and experimental experience rather than theoretical abstractions. Albert Einstein (1879–1955) utilized Riemann's mathematically constructed curved "space-time" to formulate an "energy-momentum tensor" according to which mass and energy are interconvertible in the equation $E = mc^2$;, where c is the speed of light. This means that a small amount of matter (mass) is the equivalent of a large amount of energy, so that matter can be thought of in scientific terms as frozen energy.

Thus, E began as a principle of equivalence between the phenomena of physiological heat and mechanical work. First forged as a bridge between incommensurable domains, E slowly shed any reference to everyday experience. The scientific elaboration of an insensible E occurred through the interplay of mathematically formulated theories and controlled experiments set within evolving social and technological contexts.

Technologies of Energy

As an engineering concept, energy may be related to the primal element of fire, and insofar as fire has played a key role in civilizing human beings (as described in the myth of Prometheus), so energy development is described as central to human progress.

Although water mills and windmills have been in use for well over a thousand years, ancient and medieval technologies of energy were primarily animate (human and animal) in nature. Indeed many in the ancient Greek world viewed slavery as an indispensable means of providing the necessities of a civilized life. The domestication of draft animals roughly 10,000 years ago spurred the agricultural revolution. The transition from wood to coal, made first in England beginning in the sixteenth century, heralded vast social and technological changes. Coal powered the Industrial Revolution and its attendant energy technologies, especially the steam engine. Oil and natural gas were developed extensively in the nineteenth century, and nuclear energy for civilian and military purposes developed after World War II. These changes have led to the widespread use of modern energy technologies, including the heat engine, fossil fuel and nuclear-powered electricity generating plants, and dams, wind turbines, photovoltaic cells, and other forms of renewable energy generation.

The use of these technologies raises important distinctions among the terms *energy, power*, and *work* in their mechanical or technical senses. Energy (E) is the capacity for doing work. Work (W) is defined as the energy transferred to an object by a force as that object moves; it is the result of converting energy from one form to another. Power (P) is the rate at which work is done, that is, the rate at which energy is converted. So, $E = Pt$, and $P = dE/dt$, where t is time. In terms of electricity generation and consumption, the most common units for power (demand or capacity) are the watt (equal to one joule per second) and kilowatt, and the most common unit for energy (consumption) is the kilowatt-hour. For example, a 100 watt lightbulb left on for ten hours will use 1 kilowatt-hour of energy.

Power and energy are central to the classical definition of engineering, which the English architect and engineer Thomas Tredgold (1788–1829) formulated as "the art of directing the great sources of power in nature for the use and convenience of man." This highlights the fundamental human condition that in order to accomplish one's ends, energy must be exerted. The hardships endured have long fueled the utopian dream of infinite energy availability. Modern engineering has undoubtedly unlocked vast stores of energy for human use and convenience. But the quest for limitless energy has yielded dangers in the form of pollution and threats of nuclear war. This quest is apparent in the past hoax and future hope of cold fusion and the development of renewable energy technologies to replace nonrenewable forms.

Ethics and Politics of Energy

Engineer and physicist William Rankine (1820–1872) popularized *energy* as a technoscientific term in the mistaken belief that the Greek *energeia* meant work. In fact, in contradistinction to slave labor and craftwork, *energeia* originally indicated political and moral activity (Arendt 1958). But once the term was defined scientifically in the early 1800s as the power to do work, the lived meaning was relegated, against its own etymology, to secondary or metaphorical status. References to personal energy, psychic energy (e.g., Sigmund Freud's libido), spiritual energy (e.g., Hindu *prana,* Hebrew *rauch,* and Daoist *qi*), aesthetic energy, social or political energy, and more are all thought of as less rather than more concrete, and often interpreted in technological terms. Thus the meaning of the term was somewhat purged of its original ethical and political connotations.

But contemporary issues surrounding energy extraction and use have refocused attention on the fundamental connection between energy and ethics. Energy cannot be considered a neutral instrument, but rather an integral component of political and ethical ends. As the Industrial Revolution and countless other events in history demonstrate, the availability and use of different energy sources reciprocally interacts with social and technological developments. One major practical consequence of this derives from the heterogeneous global distribution of energy reserves (e.g., oil fields) and the unequal demands for energy consumption. Stores of energy and the resulting wealth generated by their extraction and sale can contribute to unequal wealth distribution, violence, war, corruption, and coercion both within and between nation-states.

Within this context, national energy policies inevitably manifest ethical values about distributive justice, health, and equity and raise geopolitical concerns about national security. The disproportionate energy consumption by developed countries causes transboundary environmental problems. Most controversially, the carbon dioxide produced from the combustion of fossil fuels contributes to rising sea levels, which negatively affect many developing countries that have not benefited from the goods and services provided by those fuels. Many of these countries cannot afford the adaptation measures necessary to mitigate their vulnerability, and the question becomes to what extent developed nations are responsible for helping the rest of the world cope with the consequences of their large energy appetites. Another political and ethical dilemma posed by proposals to shift away from fossil fuels is the status of nuclear energy. Do its attendant risks and benefits present an acceptable tradeoff as a transitional source of energy in the move from fossil fuels to renewables?

Questioning the dominant assumption that social progress depends on increases in per capita energy consumption raises deeper ethical issues about the good life. It is commonly believed that high civilization depends on high energy use, which explains the modern quest for new and greater reserves of energy. There is a correlation between quality of life, as measured by the Human Development Index, and per capita energy consumption, but this is not a linear relationship. Indeed the improvement in quality of life levels off when per capita electricity consumption equals 4,000 kilowatt-hours. Yet some countries have per capita consumptions over 20,000 kilowatt-hours. This relates to issues in development ethics (e.g., neocolonialism and cultural homogenization), because metrics of progress are often tied to energy consumption.

Although the rise of "energy slaves" (the use of mechanical or inanimate energy sources to replace animate forms) has brought enormous benefits (including the replacement of human slaves), it has also created risks and concerns about environmental sustainability. Furthermore it contributes to the questionable assumption that living well requires increasing dependence on these energy slaves. A. R. Ubbelohde (1955) characterized the modern ideal society as based on a large proportion of inanimate energy slaves as the "Tektopia." The Tektopia brings both new possibilities and new moral dilemmas resulting from such factors as increased luxury, changes in the administrative state, displacement of workers by machines, and difficulty in controlling, regulating, and distributing energy.

Ivan Illich (1974) also critiqued this image of the good life by noting that as the number of energy slaves increases, so rises not only inequity but also social control and personal stress, alienation, and meaninglessness. He challenged the energy crisis focus "on the scarcity of fodder for these [energy] slaves," preferring instead "to ask whether free men need them" (p. 4). He argued that energy policies (whether capitalist or socialist) focused on high energy consumption will lead to technocracies that degrade cultural variety and diminish human choice. For Illich, "only a ceiling on energy use can lead to social relations that are characterized by high levels of equity.... Participatory democracy postulates low-energy technology" (p. 5). Beyond a certain threshold, increased energy affluence can come only through greater concentration of control, and thus greater inequality.

Failure to differentiate the technoscientific concept of energy from its older political meaning can lead to dangerous ideologies that reduce the plural, lived energies of human interaction to manipulable technical constructs. People are reflected as mere human motors in the mirror of energy slaves (Rabinbach 1990). The technical notion of energy begins to blur distinctions between nature and machines, living organisms and persons, mechanical work and human action. Efficiency subverts more human goals. The resulting blindness to the distinction between the technoscientific and political versions of energy partially maimed moral judgments about the use of the atomic bomb. Consideration of ethical and political issues associated with energy thus becomes an opportunity to redistinguish what may have been improperly united: energy as a basic concept in science, as a resource, and as an ethical issue.

JEAN ROBERT
SAJAY SAMUEL

SEE ALSO *Automobiles; Einstein, Albert; Fire; Oil.*

BIBLIOGRAPHY

Arendt, Hannah. (1958). *The Human Condition*. Chicago: University of Chicago Press.

Crease, Robert P. (2004). "Energy in the History and Philosophy of Science." In *Encyclopedia of Energy*, ed. Cutler J. Cleveland. Amsterdam: Elsevier.

Illich, Ivan. (1974). *Energy and Equity*. New York: Harper and Row.

Kuhn, Thomas S. (1959). "Energy Conservation as an Example of Simultaneous Discovery." In *Critical Problems in the History of Science*, ed. Marshall Clagett. Madison: University of Wisconsin Press.

Rabinbach, Anson. (1990). *The Human Motor: Energy, Fatigue, and the Origins of Modernity*. New York: Basic.

Ubbelohde, A. R. (1955). *Man and Energy*. New York: George Braziller.

ENGINEERING DESIGN ETHICS

Engineering design ethics concerns issues that arise during the design of technological products, processes, systems, and services. This includes issues such as safety, sustainability, user autonomy, and privacy. Ethical concern with respect to technology has often focused on the user phase. Technologies, however, take their shape during the design phase. The engineering design process thus underlies many ethical issues in technology, even when the ethical challenge occurs in operation and use.

Engineering Design

Engineering design is the process by which certain goals or functions are translated into a blueprint for an artifact, process, system, or service that can fulfill these functions. The function of cutting bread, for example, can be translated into a knife. A car fulfills the function of transportation. Engineering design is different from other forms of design—such as fashion design or the design of policy—in that it results in artifacts and systems grounded in technical knowledge.

The character of the engineering design process has been much debated, but for present purposes it may be described as an iterative process divided into different phases. The following phrases are the simplest and most accepted (Pahl and Beitz 1996):

- Problem analysis and definition, including the formulation of design requirements and the planning for the design and development of the product, process, system, or service.
- Conceptual design, including the creation of alternative conceptual solutions to the design problem, and possible reformulation of the problem.
- Embodiment design, in which a choice is made between different conceptual solutions, and this solution is then worked out in structural terms.
- Detail design, leading to description that can function as a guide to the production process.

In each phase, engineering design is a systematic process in which use is made of technical and scientific knowledge. This process aims at developing a solution that best meets the design requirements. Nevertheless, the final design solution does not simply follow from the initially formulated function because design problems are usually ill-structured. Nigel Cross (1989) has argued that proposing solutions often helps clarify the design problem, so that any problem formulation turns out to be partly solution-dependent. It is impossible to make a complete or definite list of all possible alternative solutions to a problem. It is also extremely difficult to formulate any criterion or set of criteria with which alternatives can be ordered on a scale from "good" or "satisfactory" to "bad" or "unsatisfactory," even though any given feature of the design may be assessed in terms of some given criterion such as speed or efficiency.

Ethical Issues

Design choices influence how ethical issues are addressed in technology. Because such choices are differentially manifested in the different phases of the design process, ethical issues themselves take on distinctive forms in each case.

PROBLEM FORMULATION. Problem definition is of special importance because it establishes the framework and boundaries within which the design problem is solved. It can make quite a difference—including an ethical difference—from whose point of view a problem is formulated. The problem of designing an Internet search engine looks different from the perspective of a potential user concerned about privacy than from the perspective of a provider concerned about selling banner advertisements. The elderly or physically disabled will have different design requirements than the young or healthy.

An important ethical question in this phase concerns what design requirements to include in the problem definition. Usually design requirements will be based on the intended use of the artifact and on the desires of a client or user. In addition, legal requirements and technical codes and standards play a part. The latter may address, if only implicitly, ethical issues in relation to safety or environmental concerns. Nevertheless, some ethical concerns may not have been adequately translated into design requirements. Engineering codes of ethics, for example, require that engineers hold "paramount the safety, health and welfare of the public," an obligation that should be translated into design requirements.

The idea that morally relevant values should find their way into the design process has led to a number of new design approaches. An example is eco-design or sustainable design, aimed at developing sustainable products (Stitt 1999). Another example is value-sensitive design, an approach in information technology that accounts for values such as human well-being, human dignity, justice, welfare, and human rights throughout the design process (Friedman 1996).

Ethical issues may arise as well during the operationalization of design requirements. Take for example a design criterion such as minimizing global warming potential, which may arise from a moral concern about the greenhouse effect. The global warming potential of substances can be measured on different time scales potentially resulting in different rankings of these substances (Van de Poel 2001). The choice of different time scales is ethically relevant because it relates to the question of how far into the future the current generation's responsibility extends.

CONCEPTUAL DESIGN. Design is a creative process, especially during the conceptual phase. In this phase the designer or design team thinks out potential solutions to a design problem. Although creativity is not a moral virtue in itself, it is nevertheless important for good design, even ethically. Ethical concerns about a technology may on occasion be overcome or diminished by clever design.

One interesting example is the design of a storm surge barrier in the Eastern Scheldt estuary in the Netherlands (Van de Poel and Disco 1996). In the 1950s, the government decided to dam up the Eastern Scheldt for safety reasons after a huge storm had flooded the Netherlands in 1953, killing more than 1,800 people. In the 1970s, the construction plan led to protests because of the ecological value of the Eastern Scheldt estuary, which would be destroyed. Many felt that the ecological value of the estuary should be taken into account. Eventually, a group of engineering students devised a creative solution that would meet both safety and ecological concerns: a storm surge barrier that would be closed only in cases of storm floods. Eventually this solution was accepted as a creative, although more expensive, solution to the original design problem.

EMBODIMENT DESIGN. During embodiment design, one solution concept is selected and worked out. In this phase, important ethical questions pertain to the choice between different alternatives.

One issue is tradeoffs between various ethically relevant design requirements. While some design requirements may be formulated in such terms that they can be clearly met or not —for example, that an electric apparatus should be compatible with 220V—others may be formulated in terms of goals or values that can never be fully met. Safety is a good example. An absolutely safe car does not exist; cars can only be more or less safe. Such criteria as safety almost always conflict with other criteria such as cost, sustainability, and comfort. This raises a question about morally acceptable tradeoffs between these different design criteria. Is there a minimum level of safety each automobile should meet, or is it acceptable to design less safe cars if they are also cheaper?

Formal engineering methods—such as cost-benefit analysis and multiple criteria design analysis—exist to deal with design criteria tradeoffs. The question, however, is whether these methods result in morally acceptable tradeoffs. These methods often treat different design criteria and the moral values on which they are based as if they are commensurable, which may be problematic.

Alternative designs cannot only be compared in terms of the original design criteria, but also in terms of the risks they imply. In engineering, a host of methods exist to assess the risks of new technologies, and increasingly such methods also inform design choices. In general, one may prefer a design with minimal risks, but the acceptability of risks also depends on such issues as their distribution and the degree to which they are accepted voluntarily (Shrader-Frechette 1991). Free and informed consent can be an issue in engineering design, just as in the design of medical research experiments with human subjects.

Whereas an evaluation in terms of risks usually focuses on minimizing potential harm or justly distributing potential harm, other evaluations may focus on the possibility of doing good. An approach that may prove interesting in this respect focuses on the so-called "scripts" of technological artifacts. Authors such as Bruno Latour have used the notion of a script to describe the built-in use and moral presuppositions of an artifact (Latour 1992). The automatic or passive seat belt is a case in point. This artifact contains a script that forces the driver to use the seat belt before the car engine can be started, which raises an interesting ethical question. To what degree is it acceptable to limit user autonomy in order to achieve other moral goods such as safety? It is usually argued that a failure to use a seat belt will impose hardships and costs to others in the event of an accident.

DETAIL DESIGN. During detail design, a design solution is further developed, including the design of a production process. Examples of ethical issues addressed at this phase are related to the choice of materials: Different materials may have different environmental impacts or impose different health risks on workers and users. Choices with respect to maintainability, ability to be recycled, and the disposal of artifacts may have important impacts on the environment, health, or safety. The design of the production process may invoke ethical issues with respect to working conditions or whether or not to produce the design, or parts of it, in low-wage countries.

Design as a Social Process

Engineering design is usually not carried out by a single individual, but by design teams embedded in larger organizations. The design of an airplane includes hundreds of people working for several years. Organizing such design processes raises a number of ethical issues.

One is the allocation of responsibilities. What is the best way to allocate responsibility for safety in the design process? One option would be to make someone in particular responsible. A potential disadvantage of this solution is that others—whose design choices may be highly relevant—do not take safety into account. Another approach might be to make safety a common responsibility, with the danger that no one in particular feels responsible for safety and that safety does not get the concern it deserves.

A second issue is decision-making. During design, many morally relevant tradeoffs have to be made. Sometimes such decisions are made explicitly, but many times they occur implicitly and gradually, evolving from earlier decisions and commitments. Such patterned decision making may lead to negative results that never would have been chosen if the actors were not immersed in the problematic decision-making pattern (Vaughan 1996). This raises ethical issues about how to organize decision making in design because different arrangements for making decisions predispose different outcomes in ethical terms (Devon and van de Poel 2004).

A third issue is what actors to include. Engineering design usually affects many people with interests and moral values other than those of the designers. One way to do right to these interests and values is to give different groups, including users and other stakeholders, a role in the design and development process itself. Different approaches have been proposed to this issue, such as participatory design in information technology development (Schuler and Namioka 1993). Constructive technology assessment likewise aims to include stakeholders in the design and development process in order to improve social learning processes at both the technical and normative levels with respect to new technologies (Schot and Rip 1997).

As the heart of the process of technological development and future use, engineering design must likewise be at the core of ethical reflection on technology. Major ethical issues in engineering design include what requirements, values, and actors to include in the design process and how to trade off different requirements and values. Major issues also arise with respect to organizing the design process in such a way that moral responsibilities are adequately and fairly allocated.

IBO VAN DE POEL

SEE ALSO *Design Ethics; Engineering Ethics.*

BIBLIOGRAPHY

Cross, Nigel. (1989). *Engineering Design Methods*. Chichester, UK: Wiley. Discusses engineering design in general and the ill-structured nature of design problems.

Devon, Richard, and Ibo van de Poel. (2004). "Design Ethics: The Social Ethics Paradigm." *International Journal of Engineering Education.* 20(3): 461–469. Discusses ethical issues related to design as a social process.

Friedman, Batya. (1996). "Value-Sensitive Design." *Interactions* 3: 17–23. An introduction to the value-sensitive design approach in information technology.

Latour, Bruno. (1992). "Where Are the Missing Masses?" In *Shaping Technology/Building Society; Studies in Sociotechnical Change,* ed. Wiebe Bijker and John Law. Cambridge, MA: MIT Press. Introduces the notion of script or built-in morality in artifacts.

Pahl, G., and W. Beitz. (1996). *Engineering Design: A Systematic Approach*, 2nd edition, trans. K. Wallace, L. Blessing, and F. Bauert. London: Springer-Verlag. A general work on engineering design and the phases of the design process.

Schot, Johan, and Arie Rip. (1997). "The Past and Future of Constructive Technology Assessment." *Technological Forecasting and Social Change* 54: 251–268. An introduction to the approach of constructive technology assessment.

Schuler, Douglas, and Aki Namioka, eds. (1993). *Participatory Design: Principles and Practices.* Hillsdale, NJ: Lawrence Erlbaum.

Shrader-Frechette, Kristin S. (1991). *Risk and Rationality: Philosophical Foundations for Populist Reform.* Berkeley: University of California Press. Deals with ethical issues with respect to risk assessment and risk acceptance.

Stitt, Fred A., ed. (1999). *Ecological Design Handbook: Sustainable Strategies for Architecture, Landscape Architecture, Interior Design, and Planning.* New York: McGraw-Hill.

Van de Poel, Ibo. (2001). "Investigating Ethical Issues in Engineering Design." *Science and Engineering Ethics* 7: 429–446. Overview and illustration of main ethical issues in engineering design.

Van de Poel, Ibo, and Cornelis Disco. (1996). "Influencing Technology: Design Worlds and Their Legitimacy." In *The Role of Design in the Shaping of Technology,* ed. Jacques Perrin and Dominique Vinck. Luxembourg: Office for Official Publications of the European Communities. On social controversies about engineering designs. Contains the Eastern Scheldt example.

Vaughan, Diane. (1996). *The Challenger Launch Decision.* Chicago: The University of Chicago Press. Detailed description of design and research decisions eventually leading to the Challenger disaster.

ENGINEERING ETHICS

Overview
Europe

OVERVIEW

Engineering ethics is concerned with the ethical responsibilities of engineers, both as individual practitioners and organizational employees, and as members of a profession with obligations to the public. The issues in engineering ethics range from micro-level questions about the everyday practice of individual engineers to macro-level questions about the effects of technology on society (Herkert 2001). Because engineers are the primary creators of science-based technology, engineering ethics is one of the most important intersections between science, technology, and ethics.

Development of Engineering and Engineering Ethics

Compared to the clergy, law, and medicine, engineering is a relatively young profession, having acquired something like its present form in France in the eighteenth century. In the United States, the United States Military Academy at West Point graduated its first engineers in 1817. The first private engineering college in the United States was Rensselaer Polytechnic Institute, founded in 1823. By the mid-nineteenth century, the land grant colleges in the United States had programs in civil engineering. In 1850, the first year the United States census counted engineers, only one in 10,000 persons identified themselves as engineers (for 2,000 total). By 1900, however, the numbers were increasing dramatically and the fields of engineering multiplying because of new discoveries and inventions in electricity, power generation, chemical processing, automobile development, and flight. The emerging large corporations also required increasing numbers of engineers. At the end of the twentieth century, about one in one hundred Americans was an engineer (Davis 1998).

Codes of ethics appeared in England in the middle of the nineteenth century and in the United States early in the twentieth century. In 1912 the American Society of Mechanical Engineers (ASME) proposed to the American Society of Civil Engineers (ASCE) and the Institute of Electrical Engineers (IEE) that a code for all three societies be constructed. The attempt was unsuccessful due to differences in the disciplines and their different relationships to business. The societies agreed that a code of ethics was desirable, and each society wrote its own. Not surprisingly, the codes had many similarities (Layton 1986).

Early codes focused on such issues as limiting professional advertising, protecting small businesses and consulting firms from underbidding, and the primacy of the obligation of engineers to their clients and employers. After several decades of relative neglect of the codes, a major change occurred in 1974, when the Engineers' Council for Professional Development (ECPD) adopted a new code of ethics that held that the paramount obligation of engineers was to the health, welfare, and safety of the public. Virtually all engineering codes of the early twenty-first century identify this as the primary obligation of engineers, not the obligation to clients and employers.

The emergence of engineering ethics as an academic subject also began in the 1970s. From this period to the present, there has been a growing emphasis on including engineering ethics in some form in the engineering curriculum. The emergence and continuing growth of this new discipline is due to a number of factors. One is a series of high-profile disasters, such as the problems of the Ford Pinto and the crash of the DC-10 outside Orly Field in Paris in 1974. In the intervening years, such events as the *Challenger* and *Columbia* space shuttle disasters have reinforced the need for engineers to be both technically competent and ethically responsible.

In 1985, the Accreditation Board for Engineering and Technology (ABET, Inc.), which accredits engineering colleges, reached a decision to require engineering programs to provide students with "an understanding of the ethical characteristics of the engineering profession and practice," supplying still more impetus to the development of engineering ethics. The ABET 2000 requirements were even more specific with regard to the ethics dimension of engineering education, requiring engineering graduates to have not only an understanding of ethical and professional issues related to the practice of engineering, but also an understanding of the impact of engineering on larger social issues.

Finally, the increased emphasis on ethics in large business organizations, where most engineers work, has also reinforced the importance of engineering ethics. Ethics codes have proliferated in business organizations, as has the creation of "ethics officers" to interpret and implement the codes. In 1992 the Ethics Officers Association (EOA) was founded. The organization had almost 900 organizations as members at the beginning of its second decade. Business organizations may increasingly expect engineers to have some knowledge and sophistication in the area of ethics and professionalism.

In order to promote the development of the emerging field of engineering ethics and to develop material for classroom use, in the late 1970s both the National Endowment for the Humanities (NEH) and the National Science Foundation (NSF) sponsored a series of workshops to develop teaching materials and provide pedagogical advice for faculty who wanted to introduce engineering students to ethics. Led by Robert Baum and Vivian Weil, these workshops brought together engineering faculty and ethics teachers. One early fruit of these collaborations was the first edition of the textbook *Ethics in Engineering* (1996) by philosopher Mike Martin and engineer Roland Schinzinger, who came as a team to Baum's NEH workshop.

Because much of the impetus for the development of engineering ethics as an academic area came from the need for educational materials, some early publications focused on teaching. For example, Robert Baum's monograph, *Ethics and Engineering* (1983) included a statement of the goals of ethics education endorsed by a large group of educators across the curriculum who, sponsored by the Hastings Center, met over a three-year period to discuss the goals of ethics instruction in higher education. Adapted to each academic area, the five goals were:

1. to stimulate the moral imagination of students;
2. to help students recognize ethical issues;
3. to help students analyze key moral concepts and principles;
4. to stimulate a sense of moral responsibility; and
5. to help students deal constructively with moral ambiguity and disagreement.

Case studies have proven one of the most popular and effective ways of pursuing these goals. Since its early support of Vivian Weil's workshop, the NSF has consistently funded engineering ethics projects, particularly those designed to develop case studies for classroom use. In addition to Martin and Schinzinger, the first editions of a number of engineering ethics textbooks followed Baum's monograph. There was Unger (1994), Harris, Pritchard, and Rabins (2000), Whitbeck (1998), and Fleddermann (1999). Baum and Flores (1983), Schaub and Pavlovic (1983), Johnson (1991), and Vesilind and Gunn (1998) have published anthologies in engineering ethics, and Davis (1998) and Cook (2003) have published single-authored texts on aspects of engineering ethics.

Articles on engineering ethics began appearing frequently in engineering periodicals and philosophical journals such as *Business and Professional Ethics* and *Professional Ethics*. In 1995 *Science and Engineering Ethics*, a periodical that regularly publishes articles across a wide spectrum of issues in engineering ethics, began publication. With the support of NSF, Caroline Whitbeck initiated the Online Center for Ethics in Science and Engineering, which includes diverse resources for engineering ethics educators.

Although the emergence of engineering ethics as an academic area is especially evident in the United

States, serious interest is by no means confined to it. The editorial board of *Science and Engineering Ethics* is represented by Canada, the United Kingdom, Russia, Germany, Poland, Romania, Italy, Norway, France, Belgium, Sweden, and Japan, and it has had guest editors from the Netherlands. European educators have collaborated to produce a volume edited by Philippe Goujan and Bertrand Heriard Dubreuil (2001). The Martin and Schinzinger and Harris, Pritchard, and Rabins texts have been translated into Japanese. Shuzo Nakamura has also published an original textbook in Japanese, *Practical Engineering Ethics* (2003).

The rise of engineering ethics is not without its critics. Engineer Samuel Florman agrees that engineers should avoid being inaccurate, careless, or inattentive. For him, engineering ethics is about reliability; people count on engineers to do their work well and not make mistakes. However, cautions Florman, "We do not leave it to our soldiers to determine when we should have war or peace. Nor do we leave it to our judges to write our laws. Why, then, should we want our engineers to decide the uses to which we put our technology?" (Florman 1983, p. 332). Responses to Florman typically claim that engineers are in the best position to inform the public about the possible uses and likely consequences of technology, to alert employers and (if necessary) the public of defects and possible disasters associated with technology, to participate in the setting of engineering standards, and to help investigate problems, such as the *Challenger* and *Columbia* space shuttle disasters, or the collapse of the World Trade Towers in New York City on September 11, 2001. This does not necessarily mean that it should be left to engineers to decide all the uses for a technology. It only means that responsible decisions require information that engineers are in the best position to provide.

Topics in Engineering Ethics

Engineering experience as well as public responses to technological developments to which engineers contribute raise topics in engineering ethics. A review of key issues easily begins with the codes of ethics of professional engineering societies, which attempt to identify the major areas of ethical concern for engineers. Reflection on the nature and function of the codes themselves has itself produced considerable discussion. Some writers argue that the codes are coercive and should therefore be thought of as codes of conduct rather than codes of ethics (Ladd 1991, Luegenbiehl 1991). Others think of codes of ethics as guides and expressions of commitment that enable engineers, their clients, and the public to know what to expect rather than instruments of coercion (Davis 1998, Unger 1994). Even so, there are issues about the range of applicability of codes. Professional societies adopt engineering codes of ethics, but most engineers do not belong to professional societies. Do the standards, rules, principles, and ideals contained in the codes still apply to them?

A related issue is professional registration. Most U.S. engineers do not have the Professional Engineer (P.E.) license. This means that most engineers cannot cite the possibility of losing their P.E. registration as a way to resist pressures to engage in unethical conduct. There is considerable resistance in the engineering profession to making the P.E. license mandatory. Should the requirements for engineering registration be changed to make licensure more acceptable to most engineers? Short of P.E. registration, are there other ways of ensuring quality in engineering work and protecting engineers from undue pressure to be unethical?

As has already been noted, prior to the 1970s most engineering codes of ethics held that the first obligation of an engineer is loyalty to a client or employer. The codes said little about obligations to the public. By the turn of the twenty-first century, most codes gave pride of place to the so-called paramountcy clause, which requires engineers to hold paramount the safety, health, and welfare of the public. However, there has been surprisingly little discussion of what, specifically, this requires engineers to do. Most attention has focused on whether whistle-blowing is either morally required, or at least permissible, when violations of the paramountcy clause are observed (DeGeorge 1981, James 1995, Davis 1998).

The issue of whistle-blowing has been central to some classic cases in engineering ethics, such as the Bay Area Rapid Transit case (Anderson, Perucci, Schendel et al. 1980), the DC-10 case (Fielder and Birsch 1992) and, above all, the *Challenger case* (Boisjoly 1991, Vaughn 1996). Important as such cases are, however, they touch on only one aspect of engineers' responsibility for public safety, health, and welfare. Whistle-blowing typically occurs only when something bad is imminent or has already occurred. The codes have little, if anything, to say about engineers' attempting to anticipate and resolve problems before they get out of hand. This deficiency is also reflected in the engineering ethics literature, which tends to focus on wrongdoing and its prevention, rather than on steps that should be taken to promote public safety, health, and welfare.

Questions involving conflicts of interest produce dilemmas for engineers, especially those in private practice (Davis 1998). A conflict of interest in the professions is a situation in which some professional or personal interest threatens to interfere with professional judgment, rendering that judgment less trustworthy than it might otherwise be. One of the topics that often arises in discussions of conflicts of interest is accepting gifts and bribes. An offer of a bribe creates a conflict of interest, because it may corrupt professional judgment, even when rejected. While it may be easy to say that accepting bribes is unethical, offers of gifts and favors from vendors can produce more subtle dilemmas. Such offers are likely to pose the first ethical issues that engineers face in their professional careers. These issues lend themselves especially well to treatment by the method of casuistry. For example, a case where accepting a gift from a vendor would usually be considered permissible (such as accepting a cheap plastic pen) and a case where accepting a gift from a vendor would usually be considered impermissible (such as accepting a gift worth several thousand dollars) can be compared with a more difficult case. By determining whether the case in question is more analogous to the permissible or impermissible case, the engineer can decide on the moral status of the questionable case (Harris, Pritchard, and Rabins 2000). Of course, identifying legitimate and illegitimate cases will in part be guided by the particular culture in which one is working.

The issue of confidentiality arises most commonly for engineers in private practice (Armstrong 1994). Although engineers ordinarily owe strong obligations of confidentiality to clients, the primacy of the obligation to the safety, health, and welfare of the public can be overriding in some situations. Suppose an engineer is hired by a client to assess the structural soundness of a building and finds fundamental flaws that threaten the safety of the present occupants. The engineer may be obligated to violate engineer/client confidentiality in order to inform authorities or tenants of the danger. Again, the method of casuistry can be used effectively to deal with troublesome cases of confidentiality.

Computer ethics is a rapidly developing area of interest, raising a host of questions, such as the control of pornography and spam, privacy, intellectual property rights, the legitimacy of sending unsolicited and unwanted cookies, the proper uses of encryption, selling monitoring software to totalitarian states, the proper uses of Social Security numbers, national ID cards, identity theft, whether Internet sites for making bombs or holocaust denial should be allowed, the legitimacy of downloading music, and software piracy. Interesting conceptual issues can be raised about the status of such entities as computer programs. Are they more like books, where copyright would be the appropriate form of protection, or like inventions, where patents would be the more appropriate form of protection? (Johnson 2000, Johnson and Nissenbaum 1995).

Engineers have more effect on the environment than any other professional group; yet engineers are only gradually assuming environmental responsibilities. Provisions relating to engineers' responsibility for the environment appeared only in the codes of the Institute of Electrical and Electronics Engineers (IEEE), the American Society of Civil Engineers (ASCE), and the American Society of Mechanical Engineers (now ASME International). Vesilund and Gunn (1998) explore a number of religious and philosophical bases for engineers' directly embracing environmental concerns, and Gorman, Mehalik, and Werhane (2000) have published a wide range of case studies that pose environmental challenges for engineers. For those who support the notion that engineers have direct responsibility for the environmental effects of their work, the basis and extent of that responsibility is still under debate. A key question is whether accepting responsibility only in areas where there is a clear threat to the health or well-being of human beings is sufficient, or whether a concern for the environment for its own sake is needed.

Another area where engineering work directly affects the public is in the imposition of risk as a result of technology. Martin and Schinzinger have suggested that engineering work is a kind of social experimentation and, as such, imposes risks on those on whom the "experiment" is performed, namely the public. What is acceptable risk? Who should determine it? Answers to the first question strongly affect answers to the second. Scientists and engineers tend to take a somewhat consequentialist or utilitarian approach. Defining risk as the product of the probability and magnitude of harm, they find a risk acceptable if the potential benefits outweigh the potential harms. Because they believe the public is often irrational and ill-informed about risk, scientists and engineers may be inclined to say that the determination of acceptable risk should be left to them. Representatives of the public, however, tend to link acceptable risk to free and informed consent and the equitable distribution of risks and benefits. This position is more congruent with an approach that emphasizes respect for individual rights (Shrader-Frechette 1985, 1991).

Engineers increasingly have work assignments in host countries with different practices, traditions, and values from an engineer's home country, raising still other issues. What criteria are appropriate in determining when engineers should adopt the values and practices of the host country? For example, when, if ever, is it appropriate to make "grease payments" and to exchange rather substantial gifts with customers and potential customers, where this is commonly practiced? (Harris 2000).

Future Directions

As an academic discipline in an early phase of its evolution, engineering ethics can be expected to show further maturation in every area, but the following areas seem particularly in need of further cultivation and growth.

METHODOLOGY. As in many areas of practical ethics, methodology needs further development. In practical ethics there are at least three different methodologies, each with characteristic strengths and weaknesses. One is to turn to traditional philosophical theories, especially consequentialist or utilitarian and deontologist or person-respecting theories, a "top-down" approach. Traditional ethical theories serve several useful functions in engineering ethics. First, they help identify relevant moral considerations in a dilemma. For example, knowledge of moral theory is useful in identifying the different moral perspectives of scientists and engineers (who often take a consequentialist approach) and the lay public (who often take a deontological approach) with respect to risk, and in confirming that both perspectives have deep and legitimate moral roots.

Second, moral theories often allow one to construct and even predict the arguments that will be made for or against certain policies or courses of action. Suppose one is considering whether there should be strong or weak protections of intellectual property. Utilitarian arguments for strong protections point out that such protections give incentive for technical advancement by insuring that those who are responsible will reap the economic rewards. Utilitarian arguments against strong protections point out that severe restrictions can impede the advance of technology by restricting the flow of information. Arguments based on a respect for persons typically point out that respect for individual rights of the creators of new technology requires that their creations be protected from unauthorized use. These lines of thinking do in fact reflect the discussion in the courts and scholarly literature.

Third, moral theories are often useful in assessing whether an argument has been resolved satisfactorily. If arguments from the two perspectives agree, there is good reason to accept the conclusion. If they disagree, there is a clearer basis for identifying morally relevant differences and determining which arguments are the most persuasive. Despite these advantages, however, many writers and teachers find that theories are often not useful for analysis and resolution of many of the concrete dilemmas that engineers face. Furthermore, engineering students are often not sympathetic to grand theories.

In contrast, a "bottom-up" approach emphasizes the need for careful analysis of the particulars of a given situation and makes much less use of broad moral principles. One version of this approach is the ancient method of casuistry, which has also been revived in medical ethics (Jonsen and Toulmin 1988). As has already been pointed out, paradigms of acceptable (or unacceptable) action are first identified. Then the salient ethical features of the paradigms are compared with those of the case under consideration. The casuist must then determine whether the case in question more closely resembles the paradigm of acceptable behavior or the paradigm of unacceptable behavior. For this method to work effectively, appropriate paradigms of acceptable and unacceptable behavior must be identified and generally accepted by the profession. The critical question is whether this can be done without relying on just the sorts of principles those sympathetic to the top-down approach take as their starting point.

An approach that falls somewhere between the top-down and bottom-up approaches proceeds from what might be called "mid-level" moral rules and principles, such as: "keep your promises and agreements"; "don't cheat"; "don't harm others"; "be truthful"; and "minimize the influence of conflicts of interest." Engineering codes of ethics tend to operate at this level. Questions about the appropriate grounding of such mid-level rules and principles remain, however, as do questions about their application to particular circumstances. If, for example, one asserts that exceptions to the rules or principles are justified as long as a rational person would be willing to have others make the same exception, one must give reasons for taking this position. Do the reasons make reference to principles of a still broader nature, perhaps even general moral theories? Whether all three approaches are useful, or only one, or some other approach such as "virtue ethics," is still a matter of debate.

GOOD WORKS AND CHARACTER. Many of the cases that have driven research and teaching in engineering ethics have dealt with engineering disasters and the responsibilities of engineers to prevent them or respond to them adequately after they have occurred. Some writers, however, have begun to stress the importance of going beyond basic duties to protect the public from the disastrous effects of technology to the duty to promote the public good (Pritchard 1992, 1998). The General Electric (G.E.) engineers who in the 1930s worked together against odds and with relatively little managerial support to develop the sealed-beam headlight exemplified good works. Some writers have stressed the importance of character and personal ideals in motivating such good works (Pritchard 2001, Martin 2002). Physicians who are members of "Physicians Without Borders" and engineers in "Engineers Without Borders" exemplify this kind of activity, but there are many less dramatic examples, such as the G.E. engineers. Many believe that the place of good works and the motivations for them deserve more emphasis in teaching, in research, and in the engineering profession itself.

Taking on responsibilities that go beyond standard job requirements in order to improve public safety is not unusual for engineers. Beyond the efforts of individual engineers or small groups of engineers, professional societies can make important contributions. The rapid emergence of the boiler industry in the late nineteenth and early twentieth centuries provides an illustration of the constructive role engineers can play in the face of serious risks arising from technological development. Initially ill-understood and without a set of regulations to guide their safe construction and use, boilers frequently exploded, injuring and killing untold numbers of people. Through the efforts of the leadership and dedicated work of a large number of mechanical engineers in the ASME, guidelines and regulations for the construction and safe use of boilers were eventually put in place (Cross 1990).

SOCIAL POLICY ISSUES. Most cases in engineering ethics have focused on the decisions of individual engineers in the context of a particular situation, but the effect of technology on society is often more a function of larger social policy issues—what some have called "macro-issues" as opposed to "micro-issues" (Herkert 2001). The legal and medical professions often make policy statements in areas of their expertise. Engineers, perhaps because of the absence of a unified professional society that can represent the profession to the public, have been much less conspicuous in public debates related to technology. In the light of engineers' responsibility to hold paramount the safety, health, and welfare of the public, what are their responsibilities (if any) in this area?

Some believe that engineers should step forward to help the public reflect on what future technological development might hold in store—both positive and negative (Fouke 2000). These developments will have an impact on the quality of our environment, the availability and distribution of needed resources, the quality of life that is possible, and the ability to live in peace or conflict. Many of these questions have to do with the appropriate laws and governmental regulations.

Several such issues have already been suggested. Others include the relationship of bio- and related engineering to cloning and genetic engineering. Still others have to do with nanotechnology, national defense, and the use of cell phones. The proper decisions in these areas, as well as the extent to which engineers should have responsibility for making policy statements or informing the public, is a matter that deserves more consideration in the engineering profession and in engineering ethics.

Engineers must also be concerned with codes and laws that are important in protecting the public. The ASME has long been associated with the code governing boilers and pressure vessels. Some engineers have incurred considerable personal risk and liability by promoting requirements for trench boxes to protect workers in deep trenches. Engineers have been involved in promoting improvements in building codes that protect buildings from earthquake damage, damage due to subsoil shifting, and hurricane and wind damage. Yet the extent and nature of engineers' obligations in these areas has received scant attention in the literature of engineering ethics.

CONTEXT OF ENGINEERING DECISIONS. The context in which engineering decisions are made and the implications of this context for ethical analysis are insufficiently explored. Engineers commonly make recommendations and decisions about design and other issues in the context of incomplete knowledge and considerable uncertainty. Often their work is limited to only a part of the total project or product design, and managers, not engineers, sometimes make crucial decisions. Assessments of individual responsibility in such contexts and the proper criteria for making decisions under conditions of uncertainty have yet to be fully analyzed.

ENGINEERS, MANAGERS, AND RIGHTS IN THE WORKPLACE. The relationship of engineers to managers is an especially sensitive area. On the one hand, managers can overrule the decisions of engineers, even when professional issues are at stake. On the other, managers control the jobs of engineers, and many engineers aspire to management positions. Engineers do not want to jeopardize careers by unnecessarily offending managers. Some attention has been devoted to the question of when decisions are properly made by engineers and by managers, and to the professional rights of engineers in the workplace (Harris 2000, Martin 2000). The issues that arise between engineers and managers and how they should be dealt with have been insufficiently studied, however, and no engineering code of ethics has raised the question of the rights of engineers as professionals in the workplace. This is a topic that merits further study in academic engineering ethics and by professional engineering societies.

INTEGRATION WITH OTHER AREAS. Engineering ethics may need further integration with several other areas, such as the philosophy of technology, law, management theory, and the philosophy of engineering. Engineers, as well as teachers and writers in engineering ethics, need to be more aware of the nature of technology and its influence on society, the impact of law on ethical decisions, the relationship of engineering decisions to management decisions, and the important differences between the way engineers and scientists use scientific knowledge. This can help bring ethical analysis more closely in line with engineering practice. How this integration will affect the evaluation of professional decisions is not yet clear, but the need for this integration seems obvious (Mitcham 2003).

CHARLES E. HARRIS, JR.
MICHAEL S. PRITCHARD
MICHAEL J. RABINS

SEE ALSO *Architectural Ethics; Bay Area Rapid Transit Case; Bioengineering Ethics; Building Codes; Building Destruction and Collapse; Chinese Perspectives: Engineering Ethics; Codes of Ethics; Computer Ethics; Conflict of Interest; Consequentialism; DC-10 Case; Deontology; Design Ethics; Earth Systems Engineering and Management; Engineering Design Ethics; Engineering Method; Environmental Ethics; Ford Pinto Case; Institute of Electrical and Electronics Engineers; Preventive Engineering; Professional Engineering Organizations; Safety Engineering: Practices; Space Shuttle Challenger and Columbia Accidents; Whistleblowing.*

BIBLIOGRAPHY

Anderson, Robert M., et al. (1980). *Divided Loyalties: Whistle-Blowing at BART*. West Lafayette, IN: Purdue Research Foundation.

Armstrong, M. B. (1994). "Confidentiality: A Comparison Across the Professions of Medicine, Engineering, and Accounting." *Professional Ethics* 3(1): 71–88.

Baum, Robert J. (1983). *Ethics and Engineering Curricula*. Hastings-on-Hudson, NY: The Hastings Center.

Baum, Robert R., and Albert Flores, eds. (1978). *Ethical Problems in Engineering*. Troy, NY: Center for the Study of the Human Dimensions of Science and Technology.

Boisjoly, Roger. (1991). "The Challenger Disaster: Moral Responsibility and the Working Engineer." In *Ethical Issues in Engineering*, ed. Deborah Johnson. Englewood Cliffs, NJ: Prentice-Hall.

Cook, Robert Lynn. (2003). *Code of Silence: Ethics of Disasters*. Jefferson City, MO: Trojan Publishing.

Cross, Wilbur. (1990). *The Code: An Authorized History of the ASME Boiler and Pressure Vessel Code*. New York: American Society of Mechanical Engineers.

Davis, Michael. (1998). *Thinking Like an Engineer*. New York: Oxford University Press.

De George, Richard T. (1981). "Ethical Responsibilities of Engineers in Large Organizations: The Pinto Case." *Business and Professional Ethics Journal* 1(1): 1–14.

Fielder, John H., and Douglas Birsch, eds. (1992). *The DC-10*. New York: State University of New York Press.

Fleddermann, Charles B. (1999). *Engineering Ethics*. Upper Saddle River, NJ: Prentice Hall.

Florman, Samuel. (1983). "Commentary." In *The DC-10*, ed. John H. Fielder and Douglas Birsch. New York: State University of New York Press.

Fouke, Janie, ed. (2000). *Engineering Tomorrow: Today's Technology Experts Envision the Next Century*. New York: IEEE Press.

Gorman, Michael E.; Matthew M. Mehallik; and Patricia Werhane. (2000). *Ethical and Environmental Challenges to Engineering*. Englewood Cliffs, NJ: Prentice-Hall.

Harris, Charles E.; Michael S. Pritchard; and Michael J. Rabins. (2000). *Engineering Ethics: Concepts and Cases*. Belmont, CA: Wadsworth/Thompson Learning.

Herkert, Joseph R. (2001). "Future Directions in Engineering Ethics Research: Microethics, Macroethics and the Role of Professional Societies." *Science and Engineering Ethics*. VII(3): 403–414.

James, Gene G. (1995). "Whistle-blowing: Its Moral Justification." In *Business Ethics*, 3rd edition, ed. W. Michael Hoffman and Robert E. Frederick. New York: McGraw-Hill.

Johnson, Deborah G. (2000). *Computer Ethics*, 3rd edition. Englewood Cliffs, NJ: Prentice-Hall.

Johnson, Deborah G., ed. (1991). *Ethical Issues in Engineering*. Englewood Cliffs, NJ: Prentice-Hall.

Johnson, Deborah G., and Helen F. Nissenbaum, eds. (1995). *Computers, Ethics, and Social Values*. Englewood Cliffs, NJ: Prentice-Hall.

Jonsen, Albert R., and Stephen E. Toulmin. (1988). *The Abuse of Casuistry*. Berkeley: University of California Press.

Ladd, John. (1991). "The Quest for a Code of Professional Ethics: An Intellectual and Moral Confusion." In *Ethical Issues in Engineering*, ed. Deborah G. Johnson. Englewood Cliffs, NJ: Prentice-Hall.

Layton, Edwin T. (1986). *The Revolt of the Engineers*. Baltimore, MD: Johns Hopkins University Press.

Luegenbiehl, Heinz C. (1991). "Codes of Ethics and the Moral Education of Engineers." In *Ethical Issues in Engineering*, ed. Deborah G. Johnson. Englewood Cliffs, NJ: Prentice-Hall.

Martin, Mike W. (2000). *Meaningful Work*. New York: Oxford University Press.

Martin, Mike W. (2002). "Personal Meaning and Ethics in Engineering." *Science and Engineering Ethics* 8(4): 545–560.

Martin, Mike W., and Roland Schinzinger. (1996). *Ethics in Engineering*, 3rd edition. New York: McGraw-Hill.

Mitcham, Carl. (2003). "Co-Responsibility for Research Integrity." *Science and Engineering Ethics* 9(2): 273–290.

Mitcham, Carl, and R. Shannon Duball. (1998). *Engineer's Toolkit*. Upper Saddle River, NJ: Prentice-Hall.

Nakamura, Shuzo. (2003). *Practical Engineering Ethics*. Kyoto, Japan: Kagaku-Dojin Publishing.

Pritchard, Michael S. (1992). "Good Works." *Professional Ethics*. 1(1 and 2): 155–177.

Pritchard, Michael S. (1998). "Professional Responsibility: Focusing on the Exemplary." *Science and Engineering Ethics*. 4(2): 215–233.

Pritchard, Michael S. (2001). "Responsible Engineering: The Importance of Character and Imagination." *Science and Engineering Ethics* 7(3): 391–402.

Schaub, James H., and Karl Pavlovic, eds. (1983). *Engineering Professionalism and Ethics*. New York: John Wiley & Sons.

Schrader-Frechette, Kristen. (1985). *Science Policy, Ethics, and Economic Methodology*. Boston: Kluwer.

Schrader-Frechette, Kristen. (1991). *Risk and Rationality: Philosophical Foundations for Populist Reforms*. Berkeley: University of California Press.

Unger, Stephen H. (1994). *Controlling Technology*, 2nd edition. New York: Holt, Rinehart & Winston.

Vaughn, Diane. (1996). *The Challenger Launch Decision: Risky Technology, Culture, and Deviance at NASA*. Chicago: The University Of Chicago Press.

Vesilind, P. Aarne, and Alastair S. Gunn. (1998). *Engineering, Ethics, and the Environment*. New York: Cambridge University Press.

Whitbeck, Caroline. (1998). *Ethics in Engineering Practice and Research*. New York: Cambridge University Press.

INTERNET RESOURCE

Case Western University. Online Ethics Center for Engineering and Science. Available from http://www.onlineethics.org.

EUROPE

In most European countries engineering ethics is increasingly conceived as an interdisciplinary reflection at the crossroads of professional ethics, the human and social sciences, and the philosophy of technology (especially the ethics of technology). This is in marked contrast with the situation in the United States, where engineering ethics is a form of professional ethics.

Europe nevertheless includes countries with diverse cultural, juridical, professional, and educational traditions of engineering, something that has promoted efforts within the European Union to harmonize technical education, including its nontechnical requirements in the humanities, social sciences, and professional ethics. European integration has further required the development of professional guidelines for the mutual recognition of diplomas and titles. Thus any comparison between engineering ethics in Europe and in the United States cannot ignore a diversity of professional traditions. Engineering ethics in Europe requires a contextualist approach referencing the perceptions of the various engineers who formulate them.

Engineering Education: British versus Continental Models

Histories of engineering education frequently begin with France, ignoring that the first engineering schools in the world were the Moscow School for Military Engineers (established 1698) and the Apprenticeship School for Civil and Military Engineers (founded in Prague in 1707). As for Western Europe, from its commonly accepted origination with the Bureau des dessinateurs du roi (Bureau of the King's Draftsmen), established in France in 1744 (and the forerunner of l'École royale des ponts et chaussées, or Royal School of Bridges and Roads, founded in 1747), it is still a long way to engineering education as known in the twenty-first century, with its strong theoretical and practical content. The role of the bureau was primarily to provide a tutorial to guide new recruits in their first projects.

The creation of the Bureau des dessinateurs du roi was followed by l'École du génie de Mézières (School of Military Engineering, Mézières) in 1748 and l'École royale des mines (Royal School of Mines) in 1783. If these are among the oldest engineering schools in Western Europe, the one that has most influenced the engineering educational system is l'École polytechnique. The polytechnique was founded in 1794, one year after the dissolution of the French universities, and soon after the failure of the school at Mezières, from which it borrowed the idea of a formal curriculum, rather than imitating the ancien régime tutorship in place at l'École royale des ponts et chaussées. The polytechnique's formalized theoretical curriculum with its emphasis on mathematics became an influential model for engineering education throughout France and beyond. It also contributed to the establishment of a high scientific and technical education outside university.

Engineering in the United Kingdom adopted a different approach and only later established a structured education for engineers. Engineering degrees were not offered in the United Kingdom until 1838, when King's College, London, began to teach civil engineering. Indeed, Oxford and Cambridge Universities did not offer engineering degrees until the first decade of the twentieth century. Instead, British engineers were for a long time given occupational training exclusively in workshops; apprenticeship promotion is what truly integrated them into their peer group. For this same reason, Britain is the uncontested birthplace of industrial technology. These engineers were at the heart of the Industrial Revolution and played a major role in the development of both the steam engine and its uses.

It is also noteworthy that because of their habit of meeting in clubs in order to exchange ideas and proposals—and above all to capitalize on their experiences and projects—these British engineers prepared the ground for professional engineering organizations well before their Continental colleagues. It may also be significant that when engineering degrees did begin to be offered in the United Kingdom this was done not in independent institutions but in universities that already offered degrees in the liberal arts and sciences.

Professional Engineering Associations in Europe

With regard to France, historians of the engineering profession often cite the long existence of a particular organized group of engineers. Indeed, since 1676 there existed in France a Corps du génie (Engineering Corps) that was in fact a military organization. This particularly early institutionalization thus had little to do with those professional organizations that arose later in the majority of countries. The primary difference is that engineers of the Corps du génie were exclusively engineers of the state, that is, royal functionaries. Because of this state service the Corps du génie did not constitute a truly free organization of professionals, such as was established by "civil" engineers in Great Britain as an outgrowth of the previously mentioned informal clubs, notably the Society of Civil Engineers (founded 1771), later renamed "Smeatonians" after John Smeaton (1724–1792), one of its original members. Another of these societies, the Institution of Civil Engineers (ICE) was founded in 1818 by a small group of young engineers. In 1828, it obtained a royal charter and became a leader in the profession, with 80,000 members in the early twenty-first century.

From the middle of the nineteenth century, several European countries followed the British model, beginning with France (the Société des ingénieurs civils de France, founded in 1848), Germany (Verein Deutscher Ingenieure [Association of German Engineers], or VDI, 1856), and Spain (Asociación de ingenieros industriales [Association of Industrial Engineers], 1861). But while the prestigious British Institution of Civil Engineers was a club for practitioners, the French, German, and Spanish organizations were all created by a group of certified engineers coming from a single school in each country: the l'École centrale des arts et manufactures de Paris (Central School of Arts and Manufacturing in Paris), Berlin Gewerbeinstitut (Berlin Technical Institute), and the Escuela de ingenieros industriales de Madrid (School of Industrial Engineers in Madrid), respectively. Each association was only later open to qualified persons from other institutions or even to autodidacts (the self-taught).

By contrast, in the United Kingdom there still exist no institutions of higher education devoted exclusively to engineering such as those found on the Continent. The closest approximations are the British "polytechnics," founded in the mid-twentieth century, which include the education of technicians as well as engineers. Great Britain is also different from its neighbors in regard to another important point: It is the only European country in which the engineering associations were for a long time given a monopoly over designating who was an engineer and who was not. Since the 1920s this power has been limited to the power of the ICE to determine the legitimacy of the title "chartered engineer."

From Professional Organizations to Professional Ethics

This historical review shows that the early institutionalization of engineering education did not directly lead to the early establishment of professional engineering organizations. Instead, it was the autonomous organization of practitioners that promoted the initial affirmation of a collective identity and the formalization of a collective moral framework for professional conduct. It is not therefore by chance that the first code of professional ethics written by and for engineers was formulated in Great Britain.

Indeed, historians of the professions commonly consider the "professional code of conduct" adopted by the ICE in 1910 as the model for engineering ethics codes first in the United States and subsequently throughout the world. In 1911 the American Institute of Consulting

Engineers became the first U.S. association of engineers to adopt a code of ethics, a code composed of five articles strongly inspired by that of the British ICE, with seven supplementary articles.

On the Continent again, in 1604 in France, even prior to the creation of the Corps du génie in 1676, the prime minister of King Henry IV (1553–1610), who was also superintendent of fortifications, proclaimed a "Great Regulation" for all royal engineers. This set of directives and general rules was applied until the end of the seventeenth century, but had more the character of administrative law than of a code of professional ethics.

With regard to contemporary codes of professional ethics in Europe, their development is not the same in every country and they are much less important than in North America. Generally speaking, the presence of professional codes of ethics for engineers is stronger in those countries more influenced by Anglo-American cultural models, as is equally true throughout the rest of the world. Indeed, it is striking to note that when the Fédération européenne d'associations nationales d'ingénieurs (European Federation of National Engineering Associations, created in 1951) decided during the 1990s to formulate a code of ethics, it began by studying documents coming exclusively from anglophone countries (the United States, Canada, Australia, and New Zealand) rather than the few existing European codes, which were little known.

Among the little-known European codelike documents were three from Scandinavia and one from Germany. The Scandinavian documents were a "Code of Honor" from the Samlar Sveriges Ingenjörer (Swedish Association of Graduate Engineers), first adopted in 1929 and revised in 1988; a similar "Code of Honor" of the Tekniska Föreningen i Finland (Association of Swedish-Speaking Engineers in Finland) from 1966; and an "Ethical Code for Members of the Norwegian Civil Engineers Association" from 1970. In 1950 the VDI had adopted the "Engineer's Confession," which was more a quasi-religious statement than a professional code.

The European situation thus remains different from that of the United States, where the profusion of codes and of successive revisions within the different branches of the profession constituted a first fundamental phase of engineering ethics. This internalist phase ended during the 1970s, when ethical reflection began to take into account considerations external to the profession and thus challenged a hierarchy of values in which the public interest sometimes gave way to professional prestige. In Europe, however, the public interest has from the beginning been more pronounced, although in a different way than in countries that have had to deal with an ethos of individualism and competition influenced more strongly by American culture.

Engineering Ethics in Twenty-First-Century Europe

Contrary to the situation in the United States, contemporary European reflection on engineering ethics did not arise from a will to renew an existing and explicit reflection at the heart of the profession, and to open it to other actors such as scholars and academics. In the United States engineering ethics found new inspiration in the collaboration among engineering professionals, on one side, and philosophers, historians, and more recently social scientists, on the other. But in Europe engineering ethics was not heir to a prior internalist approach. Instead, its heritage was more that of a professional conscience intuitively sensitive to social responsibilities and to legal expectations for professional conduct associated with the Code Napoléon (the first modern legal code of France, promulgated by Napoléon Bonaparte in 1804).

Certainly, there existed at the end of the twentieth century, in some European countries, some more or less obsolete ethical codes. But there was no formalized ethical reflection, with one exception. In Germany, World War II led engineers to a painful crisis of conscience over the use of science and technology in the service of a monstrous program, and the postwar period saw a strong engagement of the VDI in reflection on the proper ends of technology and the moral responsibility of engineers. But even in Germany no formal code of ethics existed until 2001.

In France, a country with a long engineering tradition, the first ethics code dates back only to 1997, with a 2001 revision. But the two versions of this code, especially the first, are more French adaptations of the North American manner of formulating an ethical framework. A different dynamic, independent from that of the formulation of these initial codes, began in the 1990s to introduce ethical reflection into engineering education in courses (often under different names) dealing with the questions relevant to engineering ethics—courses on philosophy, on epistemology, and on the sociology of sciences and technologies, aroused by contemporary intellectual and social debates.

It is thus not surprising that the first European handbook on engineering ethics, *Technology and Ethics* (2001), which was the product of a team of thirty-seven researchers from ten different European countries, adopted an approach different from U.S. textbooks on the same topic. This volume, which provides one perspective on the state of ethical reflection in European engineering practice, distinguishes three levels of analysis. The first deals with the microsocial level and concerns ethical problems encountered by individual engineers (dilemmas and cases of conscience). The second focuses on the mesosocial level, where the technical systems and institutions are in competition. A third emphasizes the macrosocial level, and therefore technical development in general as a societal question.

Whereas textbooks from the United States are often centered on a code of professional ethics for the profession—that is, on the roles, responsibilities, decisions, and attitudes of engineers individually confronted by ethical dilemmas—*Technology and Ethics* situates this dimension within a more comprehensive framework. To some extent it makes engineering ethics more complex by situating it within the institutional and social context in which engineers participate with other actors (scientists, entrepreneurs, end users, and others) in the development of technologies. At the same time it strives to be more realistic and place less emphasis on individual moral heroism as the best response to ethical problems.

The contextualist approach taken here suggests two sets of questions. First, engineering ethics in Europe may be handicapped by the absence of strong and dynamic professional organizations. This weakness is partially compensated by the growing internationalization of technological universities and professional organizations such as the Institute of Electrical and Electronics Engineers (IEEE), the International Federation for Information Processing (IFIP), and others. But what is their influence with respect to the large, multinational corporations that employ the great majority of engineers? Is a collaboration possible with business ethics?

Second, the freshness of European ethical reflection has permitted it to adapt more rapidly to questions posed by those engineers who develop and maintain the new technological systems (within computer, nuclear, and biotechnological engineering). Engineers are indeed only one of several groups of agents who must articulate and address within their fields the new social and societal questions posed by the development of these techniques. On this point a collaboration with the Science, Technology, and Society (STS) studies movement is greatly desirable.

CHRISTELLE DIDIER
BERTRAND HÉRIARD DUBREUIL
TRANSLATED BY JAMES A. LYNCH

SEE ALSO *Tradeoffs.*

BIBLIOGRAPHY

Didier, Christelle. (1999). "Engineering Ethics in France: A Historical Perspective." *Technology in Society* 21(4): 471–486.

Goujon, Philippe, and Bertrand Hériard Dubreuil, eds. (2001). *Technology and Ethics: A European Quest for Responsible Engineering*. Leuven, Belgium: Peeters. The first textbook incorporating an interdisciplinary European perspective.

Grelon, André, ed. (1986). *Les ingénieurs de la crise: Titre et profession entre les deux guerres* [The engineers of crisis: Title and profession between the two wars]. Paris: Editions de l'École des hautes études en sciences sociales. A basic study of the engineering profession in France.

Ropohl, Günter. (1996). *Ethik und Technikbewertung* [Ethics and technical value]. Frankfurt am Main: Suhrkamp. The first engineering ethics textbook in Germany.

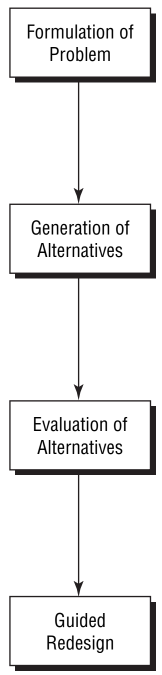
ENGINEERING METHOD

Since the early modern period natural science has been defined in terms of method. The two major approaches to scientific method are those of rationalist deduction and empirical experimentation, analyses of which are often traced back to René Descartes (1596–1650) and Francis Bacon (1561–1626), respectively. Both methods have been argued to have ethical components or to be applicable to ethics. Engineering has been much less described in terms of some distinctive method. In fact, it was only in the mid-twentieth century that discussions of engineering method came to the fore. Interpretations of engineering method are, however, more varied than with science, with less effort to draw connections to ethics, although on both counts the negligence is unwarranted. What follows is a modestly polemical assessment of engineering method that seeks to redress previous oversights by defining engineering method, comparing it with alternative definitions, and establishing the nexus between engineering method and engineering ethics.

The *engineering method* is "the use of heuristics to cause the best change in a poorly understood situation within the available resources" (Koen 2003, p. 28). Two words in this definition, *heuristic* and *best,* are used in an engineering sense. A *heuristic* is anything that provides a plausible aid or direction in the solution of a problem but is in the final analysis unjustified, incapable of justification, and fallible. Engineering heuristics include mathematical equations, graphs, and correlations as well as the appropriate attitudes for solving problems or minimizing risk in an engineering design. Such attitudes

FIGURE 1

Steps in the Guided Iteration Process



SOURCE: Adapted from Dixon and Poli (1995), p. xiv.

obviously have ethical dimensions. Suggestions to "allocate resources to the weak link," "complete a design by successive approximations," and "make small changes in the state-of-the-art," are also engineering heuristics. Engineers frequently use the synonyms *rule of craft, engineering judgment,* or *rule of thumb* to express these experience-based aids that, although helpful, are nonetheless fallible. In France, engineers use the near synonym *le pif* (the nose); in Germany, *faustregel* (the fist); in Japan, *menoko kanjo* (measuring with the eye), and in Russia, *na paltsakh* (by the fingers).

The engineer's word *best,* usually called the optimum, refers to the most desirable tradeoff of the design variables in a multi-variant space in which each criterion has been given its relative importance. This procedure differs from the ideal or best of Plato that is almost universally used in the Western tradition outside of engineering.

This definition of engineering method is consistent with the etymology of the word *engineer,* its formal definition in the dictionary, and common usage. According to one of England's most noted nineteenth-century engineers, Sir William Fairbairn, the term *engineer* comes from an old French word *s'ingenieur* meaning "anyone who sets his mental powers in action to discover or devise some means of succeeding in a difficult task." Contemporary dictionaries concur by authorizing the verb *to engineer* as "to contrive or plan usually with more or less subtle skill or craft" and by giving examples such as "to engineer a daring jailbreak." The word *engineer* is used daily in a similar fashion on radio, television, and in the newspaper.

The engineering term *state-of-the-art* (and its acronym, *sota*) refers to the collection of heuristics that were appropriate for a specific engineering project at a designated time. Thus, a state-of-the-art CD player will be one that is consistent with the set of heuristics that represented "best engineering practice" at the time it was made.

Derivative of the research in general problem solving (Polya 1945), the most frequent alternate definition of engineering used by engineers involves trying to establish a morphology or structure through which the design process is believed to pass (Dixon and Poli 1995, Pahl and Beitz 1995, Shigley and Mitchell 1983). This morphology is often presented in a flow diagram as in Figure 1. In addition to their multiplicity, engineering morphologies must fail as definitions of engineering because no one argues that the engineer can simply pass through the proposed steps; rather, engineers always back-track, iterate, and expand each step guided by heuristics.

Applied science is the most popular non-engineering definition of the engineering method. For the engineer, however, scientific knowledge has not always been available, and is not always available now, and even if available, it is not always appropriate for use. Some historians credit the Ionian natural philosophers of the sixth century B.C.E. as the founders of science, but undeniably homes, bridges, and pyramids existed before then. Precise scientific knowledge is still unavailable for many of the decisions made by the modern engineer. Although it cannot be said that engineering is applied science, engineers do use science extensively as a heuristic when appropriate.

The related claim that engineering is a branch of science called *design science* (Hubka and Eder 1996), similar to the social sciences, does not really advance a definition of engineering method. Although the much stronger view that engineering is a branch of science on a par with physics or chemistry is sometimes encountered (Suh 2001), this view implies that there are facts and axioms of design immutable and normed against an eternal truth, just as the facts of physics are said to be undeniably true. By contrast, most practicing engineers agree with the words of the noted engineer Theodore Von Kármán (1881–1963): "scientists explore what is and engineers create what has never been" (Krick 1969, p. 36).

Some, identifying the engineering method with trial and error (Petroski 1994), imply that engineers try random problem solutions and discard those that do not work. Contrary to this view, thousands of design decisions are made worldwide by engineers every day resulting in very few failures because the engineer usually modifies a previously assured sota in creating a new design.

While these alternate definitions are useful in expanding an understanding of engineering, they fail to be convincing as a comprehensive description of engineering method for the reasons specified, and because each can be subsumed into the definition given initially as simply additional engineering heuristics.

Because the engineering method applies to situations that contain uncertainty, some risk of failure is always present. The success or failure of an engineering design is, therefore, not a sufficient basis for judging whether an engineer has acted ethically. The *Rule of Judgment* in engineering is to evaluate an engineer against the sota that defines best engineering practice at the time the design was made (Koen 2003). This sota must contain all of the appropriate ethical, as well as technical, considerations.

When engineering is recognized as a pluralistic utilization of heuristics to bring about the best change in a limited resource situation that remains to be fully understood, then not only are ethical principles available as useful heuristics but the engineering method can itself become a reasonable description of ethical problem solving in general.

BILLY V. KOEN

SEE ALSO *Choice Behavior; Decision Theory; Engineering Design Ethics; Engineering Ethics; Rational Choice Theory.*

BIBLIOGRAPHY

Dixon, John, and Corrado Poli. (1995). *Engineering Design and Design for Manufacturing: A Structured Approach*. Conway, MA: Field Stone. Textbook for upper division engineering students.

Hubka, Vladimir, and W. Ernst Eder. (1996). *Design Science: Introduction to the Needs, Scope and Organization of Engineering Design Knowledge*. Berlin: Springer-Verlag. Extensive survey of the literature in engineering design.

Koen, Billy Vaughn. (2003). *Discussion of The Method: Conducting the Engineer's Approach to Problem Solving*. New York: Oxford University Press. This book is the basis of the analysis given here.

Krick, Edward V. (1969). *An Introduction to Engineering and Engineering Design*. New York: Wiley. One of the original descriptions of engineering design for beginning engineering students.

Petroski, Henry. (1994). *Design Paradigms: Case Histories of Error and Judgment in Engineering*. Cambridge, UK: Press Syndicate of The University of Cambridge. One of several popularizations of engineering method by this author.

Pahl, Gerhard, and Wolfgang Beitz. (1995). *Engineering Design: A Systematic Approach*. Berlin: Springer-Verlag. Definitive German morpholophy of engineering design.

Polya, George. (1945). *How to Solve It: A New Aspect of Mathematical Method*. Princeton, NJ: Princeton University Press. Classic book on general problem solving.

Shigley, Joseph, and Larry Mitchell. (1983). *Mechanical Engineering Design*, 4th edition. New York: McGraw-Hill. Classic textbook on engineering design for mechanical engineers.

Suh, Nam. (2001). *Axiomatic Design: Advances and Applications*. New York: Oxford University Press. Defines engineering in terms of axioms as is often done for science.

Taguchi, Genichi; Subir Chowdhury; and Shin Taguchi. (1999). *Robust Engineering*. New York: McGraw-Hill. The Taguchi method of engineering design is widely used in industry.

ENGINEERS FOR SOCIAL RESPONSIBILITY

The New Zealand engineering profession has a strong tradition of social responsibility, and many engineers have worked voluntarily on engineering projects in the Pacific Islands and in Southeast Asia. In keeping with this tradition, Engineers for Social Responsibility (ESR) was founded in 1983 and was the first such organization in the world. The driving force in its foundation was Gerald Coates, a Wellington-based electrical engineer. Its objectives are "to encourage and support social responsibility and a humane professional ethic in the uses of technology, to inform the engineering profession, general public and public policy makers about the impact of technology" (ESR). It is based in Auckland and has branches in Wellington and Christchurch, with a combined membership of around 200. Membership is open to all engineers and related professionals. Branches sponsor seminars and presentations that are open to the public.

ESR's focus has always been international: Initially it was concerned with nuclear and peace issues, and most of the papers at its first conference in Hastings in 1984 were on this topic. Its focus broadened after the end of the cold war to include a wide range of national and international issues, including an association with Water for Survival, an engineers' organization that provides technical advice and assistance for water supply and wastewater projects in poor countries.

ESR was initially criticized as a fringe organization, especially by the Institute of Professional Engineers New Zealand (IPENZ). But after a relatively short period, the temperate profile of ESR led to its general acceptance. Indeed, ESR has maintained a close association with IPENZ and become a model for similar organizations in other countries such as American Engineers for Social Responsibility (founded 1988) and Architects and Engineers for Social Responsibility in the United Kingdom (founded 1989, as a transformation of Engineers for Nuclear Disarmament, which began seven years earlier). ESR is also linked with the International Network of Engineers and Scientists for Global Responsibility (INES). Other related but not directly linked organizations include Computer Professionals for Social Responsibility and Physicians for Social Responsibility.

ALASTAIR GUNN

SEE ALSO *Engineering Ethics.*

BIBLIOGRAPHY

Coates, Gerald. (1983). "The Responsibility of Engineers." *New Zealand Engineering* 38(8): 23–24.

INTERNET RESOURCE

Engineers for Social Responsibility (ESR). Available from http://www.esr.org.nz/.

ENHANCEMENT

SEE *Therapy and Enhancement.*

ENLIGHTENMENT SOCIAL THEORY

Enlightenment social theory is important to science, technology, and ethics because it represents one of the first venues in which human activities were widely studied from a scientific perspective, and in which utilitarian and naturalistic ethical systems were offered to replace the religiously-based deontological, or duty-oriented, ethical systems which had dominated premodern society.

One of the most frequently stated goals of the Enlightenment of the eighteenth century was the creation of a science of human nature and society incorporating deterministic laws of behavior to match the spectacular successes of the physical sciences. David Hume (1711–1766), for example, announced his intention to become "the Newton of the Moral sciences." But eighteenth-century social theorists did not agree on which model from the physical sciences social theories should emulate.

Generally speaking, one can identify three classes of natural scientific models for the social sciences. The first stressed the approach of natural history and Hippocratic medicine, emphasizing the observation of phenomena in their situated complexity (empiricism). The second emulated the characteristics of rational mechanics, emphasizing the derivation of effects from a small number of well-defined a priori principles. The third attempted to apply the methods of the newly emerging experimental sciences, which insisted upon the isolation of salient variables whose relationships were established empirically, through their controlled manipulation. Within the social sciences, those who viewed themselves as introducing *experimental* approaches did emphasize the isolation of relevant variables; but their notion of experiment was generally different from that used in the natural sciences. Hume explained that difference very clearly:

> We must glean up our experiments in this science from a cautious observation of human life, and take them as they appear in the common course of the world, by men's behavior in company, in affairs, and in their pleasures. Where experiments of this kind are judiciously collected and compared [for example, from histories and travel accounts], we may hope to establish on them a science, which will not be inferior in certainty, and will be much superior in utility to any other of Human comprehension (1969, p. 46).

With few exceptions, those eighteenth-century scientists and philosophers who derived their approaches largely from natural history—such as Charles Louis de Secondat, Baron de la Brede et de Montesquieu (usually known simply as Montesquieu), Adam Ferguson, and Edmund Burke—usually focused on humans as habitual and emotional beings and ended up toward the conservative end of the political spectrum. Those who derived their approaches principally from the rational mechanics tradition—such as the physiocrat Jean Claude Helvétius, Mercier de la Rivière, Anne-Marie Condorcet, and the feminist Mary Wollstonecraft—focused on humans as rational beings and ended up at the radical end of the political and social spectrum. Those who saw themselves as synthesizing empirical and rational approaches—such as David Hartley, Adam Smith, and Etienne Condillac—tended to see humans as expressing both emotional and rational characteristics and ended up in the liberal portion of the political and social spectrum. Regardless of what model they adapted from the natural sciences, Enlightenment social theorists tended to reject deontological approaches to ethics in favor of consequentialist ones, though the utilitarian ethical theories of the radical and liberal thinkers were vastly different from those of the more thoroughly empirical conservatives.

In 1749 Montesquieu published his *Spirit of the Laws* in an attempt to explore how different legal systems developed. Though he was inclined to think that humans were pretty much identical everywhere, as the president of a local judicial body that often found itself in conflict with the central authority of the French crown, he was painfully aware of the immense variations in local customs and laws, and he took as his task the explanation of those variations. To classical republican arguments that laws had to be suited to the principles attached to the form of government of a people, Montesquieu added three kinds of arguments that were to have immense long-term significance.

First, he argued that the laws and customs of a country will depend upon the dominant mode of subsistence of that country, classifying modes of subsistence as hunting, herding, agricultural, and commercial. Hunting societies, for example, will have much less complex laws that herding societies because the complication of private ownership of animals is added in herding societies. Laws will be even more complex in agrarian societies in which heritable real property becomes important; and they will be even more complex in commercial societies in which it is critical to have legal means for enforcing a wide variety of contracts. Montesquieu felt that trade promoted mutual dependence and therefore increased tolerance for cultural differences among trading partners; so it promotes peace among nations. Within a given nation, however, Montesquieu argued that trade promoted competition and egotism rather than cooperation and altruism.

Second, Montesquieu argued for a kind of environmental determinism that made customs and laws suitable to one region quite unsuitable to others. For example, he argued that the high temperatures in the tropics made men lazy, justifying the practice of slavery so that work would get done. Similarly he thought that women aged more rapidly in tropical regions, justifying the practice of male plural marriage with women of different ages. Neither slavery nor plural marriage was, however, justifiable in temperate regions. This *situational* ethics that derived from Montesquieu's environmental determinism illustrates how attempts a social science could undermine deontological ethics.

Finally, Montesquieu was one of the first serious social theorists to articulate a principle that would become the hallmark of conservative political theory through the twentieth century. This principle is often called the principle of unintended consequences, and Montesquieu openly appropriated it from Bernard Mandeville's "Fable of the Bees" of 1705, though he gave it much greater currency. The particular example used by both Mandeville and Montesquieu was that of how the vanity of the wealthy produced the rise of fashion in clothing, which in turn provided jobs for textile workers. The vice of pride thus produced the unintended consequence of promoting commerce and industry. There was even a business in providing the baubles on which hierarchy could be seen to be based—beads, cosmetics, physical distinctions such as tattoos, and so forth.

In the long run, the principle of unintended consequences became the foundation for virtually all conservative claims that society cannot be successfully reformed by design: For every positive intended consequence there is likely to be a negative unintended one. It is better from this perspective to simply let society develop naturally. In the words of Adam Ferguson, one of Montequieu's most able admirers, "nations stumble upon establishments which are indeed the result of human action, but not the execution of any human design. . . . The establishments of men . . . were made without any sense of their general effect; and they bring human affairs to a state of complication which the greatest reach of capacity with which human nature was ever adorned, could not have projected" (Ferguson 1966, pp. 122, 182).

Taking his cue from Montesquieu, Ferguson attempted to write a "natural history of man" in *An Essay on the History of Civil Society* in 1767, but Ferguson made a number of new arguments that were widely adopted by subsequent social theorists. First, he temporalized Montesquieu's four modes of existence, creating a dynamic theory in which hunting, herding, agriculture, and commerce represented progressive stages in a temporal development that was repeated at different times in different places. Next, he emphasized the fact that people band together into societies not out of some rational expectation of meeting selfish needs, as Thomas Hobbes had proposed in the seventeenth century, but rather out of "a propensity to mix with the herd and, without reflection, to follow the crowd of his species" (Ferguson 1966, pp. 16–17). Finally, Ferguson argued that conflict, even to the extent of war, is often the vehicle for social advances: "Their wars . . . their mutual jealousies, and the establishments which they devise with a view to each other, constitute more than half the occupations of mankind, and furnish materials for their greatest and most improving exertions" (Ferguson 1966, p. 119).

Against the tradition of *philosophical history* initiated by Montesquieu and Ferguson, a second group of Enlightenment social theorists claimed that to argue for particular social arrangements from the simple fact of their historical existence was to grant the past far too much power over the future. Rivière, spokesman for a group of theorists known as *économistes* or physiocrats (persons who favored government according to the nature [physis] of things, rather than aristocrats who advocated government by an elite, or democrats who favored government by all) made their point particularly clearly in 1767:

> I do not cast my eye on any particular nation or sect. I seek to describe things as they must *essentially* be, without considering what they have been, or in what country they may have been. . . . By examining and reasoning we arrive at knowing the truth self-evidently, and with all the practical consequences which result from it. Examples which appear to contrast with these consequences prove nothing (Hutchinson 1988, p. 293).

Among the most important social theorists to adopt this rational mechanist model were Claude-Adrien Helvetius and his utilitarian followers, including Jeremy Bentham in Britain and Cesare Beccaria in Italy. According to this group, all social theory must begin from the fundamental insight that humans are motivated solely by a desire to be happy; so the goal of political and moral philosophy should be to create the greatest net pleasure for the greatest number in society. Because members of the utilitarian school generally assumed that the private happiness of one person was likely to diminish the happiness of others, they proposed to establish sanctions that would offer pleasurable rewards to those who acted for the general good and punish those who acted in opposition to it.

Among those who advocated a more experimental approach to social theory, the tradition initiated by Francis Hutcheson, David Hartley, and Adam Smith was undoubtedly most important in terms establishing a new foundation for ethics and morality. This group generally found strong evidence that humans acted not only out of self-interest, but also out of a social instinct or sense of sympathy. For most of these social theorists, there seemed to be a natural accommodation between the well-being of the individual and that of the group that was nicely articulated in Smith's image of the "invisible hand" that ordered economic activity for the general benefit if each actor worked to forward his own interests. This approach led to a *laissez faire* or naturalistic approach to moral and ethical behavior.

The heritage of Enlightenment social theory remains current in virtually all disagreements among different groups concerned with policies relating to science and technology. The principle of unintended consequences, as directly derived from Ferguson, for example, was still being appealed to by conservative social theorists such as Friederich A. von Hayek in the late nineteen-sixties (Hayek 1967). It later became the foundation for arguments by the often politically liberal or radical critics of rapid technological development. The consequentialist ethical tradition established among eighteenth-century utilitarians continues to inform policy makers at the beginning of the twenty-first century in the form of cost-benefit analyses so favored by advocates of development. And the *laissez faire* admonitions of the Smithian school continue to resonate in the market-driven analyses of public choice economic theorists.

RICHARD OLSON

SEE ALSO *Human Nature; Hume, David; Modernization; Shelley, Mary Wollstonecraft; Smith, Adam; Unintended Consequences.*

BIBLIOGRAPHY

Brandon, William. (1986). *New Worlds for Old: Reports from the New World and Their Effect on the Development of Social Thought in Europe, 1500–1800.* Athens: Ohio University Press. The title characterizes this excellent work beautifully. The discussions of how descriptions of indigenous American societies produced a change in traditional roman notions of "liberty," divorcing them from particular corporate status, are particularly interesting

Ferguson, Adam. (1966 [1767]). *An Essay on the History of Civil Society*, ed. Duncan Forbes. Edinburgh, Scotland: Edinburgh University Press. Important example of the empirical and "conservative" approach to society in the enlightenment.

Fox, Christopher; Roy Porter; and Robert Wokler, eds. (1995). *Inventing Human Science: Eighteenth Century Domains*. Berkeley and Los Angeles: University of California Press. Very good set of essays considering enlightenment discussions of topics that in the early 2000s would be identified with the social sciences.

Gay, Peter. (1966–1969). *The Enlightenment: An Interpretation*, 2 volumes. New York: Vintage Books. Still the most comprehensive introduction to the enlightenment. Contains a very extensive and valuable bibliographical essay.

Hayek, Friedrich A. (1967). "The Results of Human Action but Not of Human Design." In his *Studies in Philosophy, Politics, and Economics*. Chicago: Chicago University Press. Illustrates the explicit appropriation of Ferguson's ideas by a key twentieth century conservative theorist.

Hont, Istvan, and Michael Ignatieff, eds. (1983). *Wealth and Virtue: The Shaping of Political Economy in Eighteenth Century Scotland*. Cambridge, UK: Cambridge University Press. An outstanding collection of essays on Scottish social thought in the enlightenment.

Hume, David. (1969 [1739]). *A Treatise of Human Nature*, edited by Ernest C. Mossner. New York: Penguin. Hume's initial attempt to establish a science of humanity.

Hutchinson, Terence. (1988). *Before Adam Smith: The Emergence of Political Economy*. Oxford: Basil Blackwell. Excellent account of economic thought in the seventeenth and eighteenth centuries.

Kelley, Donald R. (1990). *Social Thought in the Western Legal Tradition. Explores the significance of eighteenth century legal education and legal reform for social theory*. Cambridge, MA: Harvard University Press.

Moravia, Sergio. (1980). "The Enlightenment and the Sciences of Man." *History of Science* 17: 247–248. A good short account of the importance of Locke's epistemology for Enlightenment social theorists.

Olson, Richard. (1990). "Historical Reflections on Feminist Critiques of Science: The Scientific Background to Modern Feminism." *History of Science* 28: 125– 147. Explores the use of arguments from eighteenth century associationist psychology to justify feminist arguments in the works of Condorcet and Mary Wollstonecraft

Olson, Richard. (1993). *The Emergence of the Social Sciences, 1642–1792*. New York: Twayne. Short argument that the key roots of most modern approaches to social scientific disciplines are to be found in the seventeenth and eighteenth centuries.

Reil, Peter. (1975). *The German Enlightenment and the Rise of Historicism*. Berkeley and Los Angeles: University of California Press. A good introduction to the centrality of organic and developmental models of social theory in the eighteenth and early nineteenth centuries.

Smith, Roger. (1997). *The Norton History of the Human Sciences*. New York: Norton. Outstanding and comprehensive account of the development of the social sciences with a strong section on the enlightenment.

ENQUETE COMMISSIONS

Enquete commissions are temporary groups established periodically by European parliaments in order to guide public discourse and decision making in complex areas. Commissions have focused on questions such as economic globalization, environmental sustainability, and the formation of new religious and ideological groups. Roughly half of the enquete commissions to date have addressed the use and regulation of emerging science and technology. In these cases, the commissions serve as forums for joint scientific and political consultation designed to inform decision makers, involve the public, and articulate recommendations and strategies for future action. Each commission is unique in terms of membership, topic, and mandate, so general evaluations of the enquete commission as an overarching system for improving democratic discourse and decision making are difficult to formulate. Although they have had mixed results and need improvement, enquete commissions are important innovations in the relationship between politics and science in democratic societies.

Background

Parliaments, as elected representative bodies, should play a key role in guiding public discourse about the proper development of society. There are doubts, however, about how well parliamentary bodies can fulfill this leadership position given the complex problems presented by the modern world. Decision makers are inundated with competing demands for investment in science, technology, and the military. They also deal with conflicting reports about economic, educational, environmental, and health care policies. In these areas, parliaments must rely upon the superior knowledge of experts and the bureaucratic structure of specialized departments and agencies. Yet mechanisms for delegating authority to specialists tend to alienate government officials from the very discourse they should guide and shape. Thus the legislative function of parliament becomes disengaged from the debate on essential issues of societal development.

Enquete commissions are designed to reengage the governmental body regarding these complex issues. They serve as independent agencies that support the parliament, thereby counterbalancing the institutional inertia toward bureaucratization and the delegation of decision making to experts who have no fiduciary or other responsibility to the public.

One of the most important roles of an enquete commission is to serve as a common institutional forum where scientific knowledge and political judgment meet. Several enquete commissions have been charged with the task of evaluating issues regarding the proper use and regulation of technologies and the proper conduct of scientific research. In these cases, especially, enquete commissions provide common ground for decision makers, the public, and experts. Cooperation between scientists and politicians is of particular importance when the knowledge of experts is contested or uncertain and when political party lines are ill-defined with regard to an issue. In many countries scientific advice issues from special institutions such as the Parliamentary Office of Science and Technology (POST) in the United Kingdom, the Parliamentary Office for Evaluation of Scientific and Technological Options (OPECST) in France, and the disbanded Office of Technology Assessment (OTA) in the United States, but these do not serve as institutions of joint scientific-political consultation.

Enquete commissions are partially modelled on various review commissions that are periodically appointed to investigate alleged failures by public officials or public institutions (for instance Royal Commissions in the United Kingdom and Congressional Committees in the United States). Enquete commissions, however, are usually established by parliamentary mandate in order to develop scenarios, strategies, and recommendations with respect to potential problems areas. Yet only a few parliaments—most notably France, Germany, Sweden, and Italy—have established rules for the membership and operations of such committees, and only these countries have significant experiences with the process of forming and evaluating enquete commissions.

German Experience

Because Germany has the most elaborate model with the broadest variety of applications, it is appropriate to include an in-depth discussion of German enquete commissions. Since 1969 the German parliament has, by standing order, permitted enquete commissions to be established by the approval of at least one quarter of its members for the purpose of providing information relevant to *extensive and important* issues. In practice a broader quorum distributed over the parties in power and opposition is necessary for any chance of successful work. The enabling legislation leaves open what qualifies problem areas as extensive and important.

Since the order was implemented, two to five commissions have been created in each electoral term. Roughly half have focused on topics in the fields of science, technology, and the environment. Some commissions that have been authorized by the German parliament include The Future of Atomic Energy Policy (1979–1982), New Information and Communication Technology (1981–1983), Prospects and Risks of Genetic Technology (1984–1986), Assessment and Evaluation of the Social Consequences of New Technology: Shaping the Conditions of Technological Development (1985–1990), Precautionary Protection of the Earth's Atmosphere (1987–1994), Protection of Human Beings and the Environment: Evaluation Criteria and Perspectives for Environmentally Acceptable Circular Flow Substances in Industrial Society (1992–1998), The Future of the Media in Economy and Society (1996–1998), Sustainable Energy Supply in the Modern Economy (2000–2002), and Law and Ethics of Modern Medicine (2000–2002; reinstated 2003).

These and other commissions have received a correspondingly wide set of mandates, but there are a few general purposes that underlie the task of all enquete commissions. These include:

- Establishing a political discourse with the intent of assuring, if not the preeminence, at least the influence of political and social concerns in shaping technological change.
- Searching for a consensus or well-founded dissent comprising knowledge, interests, values, and norms, and thereby preparing for compromise in the negotiation process.
- Elaborating long-term foundations for decisions and making concrete recommendations to parliamentary legislators.
- Enhancing public awareness of an issue by involving the media and by reporting to the public either as individual members or through official reports.

COMPOSITION AND STRUCTURE. Enquete commissions are unique institutions for the treatment of specific societal issues because of their consciously crafted representative mix of political parties and external experts. Each party nominates representative parliamentary members according to their relative political power (they are able to elect between four and fifteen members). Because all parties with parliamentary status participate, normative and ideological perspectives are represented in a manner that mirrors the larger legislative body. Each commission reflects the proportionality of power and perspective found in parliament. External experts are chosen either by an iterative process of nomination, rejection, and acceptance or they are simply appointed in a manner proportional to the power of each party. Representation on the science side is usually fairly well balanced because the selection of experts by the parties covers the spectrum of competing paradigms and can even include extreme opinions. Parliamentary and external members have the same voting rights.

The goal of every commission is to present a report, which serves as the basis for a general parliamentary discussion, before the end of the electoral term. As a rule, recommendations for legislative decisions are also expected. Usually additional experts without voting rights are also included and their opinions are commissioned. The commissions often organize public hearings and other public dialog. Initially governmental and department officials did not participate in the process at all. The main advantage of including parliamentary members with experts is to make commissions better equipped to structure and convey recommendations pertinent to the needs of decision makers. The corresponding disadvantage is a tendency to politicize scientific findings. Another impact of incorporating scientific experts and politicians in such tightly structured dialogue is the addition of more focused, problem-orientated discourse to traditional negotiations between majority and minority parties.

Each commission serves as a working group for intense research and reflection in a particular subject area. A research staff assists each commission by procuring and processing information. One member of the commission serves as the chair and is vitally important for ensuring the integrity and overall success of the commission. The privileged position of the chair is sometimes misused to serve individual or political ends.

ANALYSIS AND EVALUATION. The fairly long history of enquete commissions in Germany points to the importance of comprehensive and exhaustive dialogue at the intersection of politics and science. Though political maneuvering unavoidably comes into play when choosing members, setting an agenda, and negotiating reports, the underlying purpose is to hold open dialogues on problems and alternative solutions before party lines are settled and decisions reached. The goal is to transform solid party positions into negotiable interests. Scientific and political members agree to seek consensus and compromise, which can be further shaped by party leaders and wider government involvement. Nevertheless the commissions face constant pressure from both political and scientific interest groups, which often seek to use enquete commissions to achieve their own special interests rather than the common interest. Politicians often press particular agendas, whereas scientists repeatedly cloak their agendas in the guise of disinterested objectivity. Commissions require strong leadership if they are to bridge the differences among various stakeholders. When such leadership is present, the enquete commission is a successful model for crafting an improved and more democratic relationship between science, government, and the general public.

Whether and to what extent enquete commissions enrich and aid political culture is an open question. Case studies and empirical analyses of their mode of operation have generated serious criticisms. Party tactics repeatedly threaten the efforts of members to achieve mutual understanding and common perspectives. Often commissions are used as instruments of symbolic politics, giving the impression of governmental action that conceals an unwillingness to make real progress. For example, the commission on the future of media in economy and society was allegedly misused in this way. Its charge was to "pave Germany's way toward the information society," but one of its most distinguished members, Wolfgang Hoffmann-Riem, professor of law and judge at the constitutional court, commented in an essay that it was only "creeping along secret paths to non-decision." The chance was wasted to develop guidelines for new technologies (especially telecommunication and the associated changes of the occupational field), higher education, infrastructure, and the media.

By contrast the commission on genetic technology thoroughly influenced legislation on safety regulation at the work place, rules of liability, and restrictions on research with human embryos. The commission on technology assessment did not have direct impacts, but its work indirectly supported the foundation of the German Office of Technology Assessment in 1990, which offers recommendations about science and technology to parliament. The commission's report on the protection of the atmosphere was influential even at the international level. It played a decisive part in regulating and outlawing various ozone depleting chemicals within the European Union (EU) and assisted in the Montreal Protocol process.

Due to the variability in enquete commissions, it is not possible to make a general evaluation of their success in crafting consensus, aiding legislation, and guiding public discourse. Several criticisms, however, have suggested that the priorities of the enquete commission system need to be rethought in order to maximize its strengths. Critics argue that the indirect inputs into public discourse are more important functions of the commissions than direct impact on legislation. If the commissions are able to address and include important associations, not-for-profit organizations, nongovernmental organizations, the media, and influential individuals, then their procedures and reports can demonstrate parliament's ability to guide public discourse on important questions about the future development of society.

Scientists involved in enquete commissions often resent abandoning their position as (supposedly) neutral, outside analysts by engaging in the political system. Nonetheless most are able to maintain their reputations within the scientific community by crafting and supporting high quality, balanced reports. The politicians involved also have misgivings, especially concerning mandates for cooperation and consensus building with actionable recommendations. In addition engaging in long-term, complex issues usually does not offer the political payoff of involvement in more pressing, short-term issues. Usually, however, there is sufficient individual initiative among politicians to overcome these concerns.

No critics advocate abandoning the enquete commission model altogether. Some place deficiencies in the system on the early twenty-first century style of party politics and its focus on personalities and media resonance. More theoretically minded observers note a permanent overburdening of the commissions due to their hybrid structure. These critics argue that increasing the management skills and capacities of commission leaders is the only way in which improvements can be made. In the end, the continued existence of the commissions and the fact that both majority and opposition factions have initiated roughly the same number of them over ten election periods speaks for their value. Enquete commissions can be an important ingredient in the public culture of politics. They can increase understanding, elevate public discussion, and evaluate and respond to societal problems. They are especially useful in evaluating the risks and benefits presented by complex, emerging technologies.

Enquete commissions need to be used in conjunction with other procedures, such as lobbying, hearings, and stakeholder conferences, which often represent and consider interests in different ways. In spite of determined attempts to strike consensus or compromise and frame political programs, the complex and contested nature of many problems sometimes prohibits workable solutions. Yet even in these cases, enquete commissions can help improve and clarify public discourse, venture models for risk assessment, develop scenarios and options for the future, map the landscape of social values, and make tentative preparations for legislative action.

WOLFGANG KROHN

SEE ALSO *Bioethics Commitees and Commissions; Royal Commissions.*

BIBLIOGRAPHY

Altenhof, Ralf. (2002). *Die Enquete-Kommissionen des Deutschen Bundestages* [The enquete-commissions of the German parliament]. Wiesbaden, Germany: Westdeutscher Verlag.

Weaver, Kent, and Paul Stares, eds. (2001). *Guidance for Government: Comparing Alternative Sources of Public Policy Advice.* Tokyo and New York: Japan Center for International Exchange.

Vig, Norman, and Herbert Paschen, eds. (2000). *Parliaments and Technology: The Development of Technology Assessment in Europe.* Albany: State University of New York Press.

ENTERTAINMENT

Entertainment is a ubiquitous phenomenon that has been transformed extensively by science and technology. To some extent that transformation has ethical dimensions that merit more consideration than they usually receive.

The Historical Spectrum

There is evidence that human beings have found ways to amuse themselves since the beginning of history. Ancient Mesopotamians reserved six days a month for designated holidays, half of which were tied to religious lunar festivities. Hunting was a favorite pastime of Assyrian kings, as wall reliefs attest; that pastime was shared by Egyptian pharaohs, as is affirmed by the decorations on their tombs. Sports such as boxing and wrestling were practiced widely in the ancient world, sometimes between divine beings and men as in the struggle between Gilgamesh and Enkidu in the *Epic of Gilgamesh* and that between Jacob and an angel in the Hebrew Bible. Black-figure vases and amphorae indicate the Greeks' love for those two sports as well as the others featured in the ancient Olympic games and their imitators throughout the ancient Aegean world. A variety of board games from ancient times (e.g., serpent, dog-and-jackal, and senet from Egypt) challenge contemporary people to discern what the rules might have been, whereas games such as chess, go, and various others involving stone, bone, clay, or glass dice can be recognized by modern players in their earliest written, engraved, and stone forms from China, India, Mesoamerica, Africa, and the Near East. Children's model houses with miniature furniture and figures and model ships, wagons, chariots, and carts from sites across the ancient world indicate that toys are also of ancient origin.

People entertained one another on musical instruments, as many ancient literary and sacred texts attest, including ancient songs that survive in the form of the Psalms and the "Song of Miriam" in the Hebrew Bible, the *Iliad* and *Odyssey,* and hymns to Osiris and other ancient gods in addition to love songs and songs that express the challenges and triumphs of daily life. Singers, snake charmers, bear trainers, jesters, and acrobats—all the roles that later would be revived in vaudeville, traveling carnivals, and circuses—can be located among ancient peoples. String, wind, and percussion instruments, many trimmed with rare metals or precious stones, have been described in print and discovered in situ by archaeologists, allowing a better appreciation of the tonal systems and musical compositions that the ancients created as a source of creativity and for amusement. Ancient plays from the Greeks give voice to many modern concerns about life, meaning, and human affairs.

On an even wider scale one thinks of the grand public spectacles of ancient Babylon and ancient Rome, cities whose rulers spared no expense in putting on public entertainment for the masses, drawing on vast human, animal, and fiscal resources for events that could last for months and involve extensive human and animal carnage. Assurnasirpal II of Assyria, when inaugurating his palace at Calah, claims on a palace relief to have hosted a banquet for 47,074 people, who consumed, among other items, more than 1,000 cattle, 10,000 sheep, 15,000 lambs, 10,000 fish, 10,000 loaves of bread, and 100 containers of beer. Roman emperors staged banquets, games, and entertainments for the masses that sometimes bankrupted the state treasury.

Technological Presence

Pervasive in all these ancient forms of entertainment is the presence and necessity of technology. Natural materials have been reshaped to create implements and means by which human beings can amuse themselves, opening up vast areas for enjoyment beyond those afforded by nature. Technological innovations in chariot wheels and steering mechanisms, the raising and lowering of massive platforms through the use of advanced hydraulics, springs and hinges that could be opened and closed at a distance with precision and split-second timing, and many other inventions and improvements contributed to the crowd-pleasing spectacles of Greek and Roman theaters and the battles in the Colosseum in Rome between beast and beast, person and beast, and person and person.

Continuous innovation in designing and defining amusements of various kinds for particular classes of individuals and entire societies was accelerated with the advent of the printing press and then the Industrial Revolution as mass production of what had been luxury goods for the wealthy began to spread to other levels of society. Greater leisure time for a widening segment of the population created new opportunities for amusements to pass the time. Entertainment itself, however, always has manifested an ability to penetrate social barriers. Shakespeare's plays, for example, appealed not only to the masses but also to extremely wealthy and influential persons.

The modern era brought with it an array of new means of entertainment, including radio, television, video, computer games, virtual reality, film, e-mail, and chat rooms. However, even the older forms of entertainment underwent major changes as sports, for example, moved from the realm of mainly part-time amateur pursuits to a specialized, professional status (there were limited numbers of professional athletes in ancient times).

Within a generation, American football became a multi-billion-dollar television- and media-saturated semiglobal industry and football players became cultural heroes. Technological innovations transformed football from a game played by college students on dirt fields or cow pastures with no equipment to multi-million-dollar weekly gridiron contests in which each side employs advanced scouting technologies, sophisticated weight training and conditioning regimens, carefully managed nutrition programs, lightweight materials for protection, advanced telecommunications equipment to relay commands and insights, rapid-response medical treatments designed to keep players on the field as long as possible, complex ticketing systems, coordinated crowd control, prescheduled advertising breaks, and many other techniques and processes to induce fans to spend thousands of dollars to support their favorite teams.

Miniaturization and Combination

The latest miniaturization and communications technologies allow entertainment to be fully mobile. As they get increasingly smaller and more powerful in terms of resolution quality, camera phones have become the bane of many schools, fitness facilities, and other public venues where some people use them to take and transmit photographs of people in various stages of undress. Students have attempted to use them to film examination questions and send them to others, and similar problems arise with text messaging devices. At the same time users have employed them to film robberies, hit and run incidents, and other criminal acts that have led to court convictions that probably would not have been possible without the visual evidence they provide. Families and individuals have derived enjoyment from camera phone photographs they have taken of special moments and then downloaded into more permanent forms of storage for retrieval when desired. Cam-phone sites have joined the range of types of websites on the Internet, and it is estimated that 260 million camera phones were sold in 2004.

The pervasiveness of computers that are increasingly more powerful yet smaller with each new generation has spawned an enormous industry in designing sophisticated online games. A number of universities have established programs, and others are increasing the number of courses they offer in this area. The most advanced current form of these games are Massive Multiplayer Online Role-Playing Games (MMORPG) that involve thousands of players in a constantly evolving scenario that is affected directly by the self-selected roles and self-assigned personas of the players.

Blogs (web logs) and vlogs (video blogs) are a recent technological innovation in which individuals create self-published websites that feature video clips, running texts of observations or other materials, photographs, and sound to communicate their thoughts or express themselves. Originally pioneered in the late 1990s by sites such as Pop.com and Digital Entertainment Network, they initially failed to catch on but are having a resurgence though sites such as Undergroundfilm and Ourmedia. The more pervasive blogs, which often feature only text, are exerting a growing influence on mainstream media as bloggers democratize and decentralize journalism, news reporting, and information dissemination in entertaining forms.

Various forms of technology are being combined in new ways with the new media to create full-body experiences for people. In a way similar to the manner in which "surround sound" immersed a listener in a piece of music, people can experience a video in three dimensions while simultaneously feeling sensations on their skin and hearing things as if they were fully immersed in the environment they are seeing.

This ability to "experience the world" without really experiencing it raises important issues. Certainly there are training applications in which being able to experience an environment safely and learn how to react successfully within it could save lives in the future as pilots and others in high-risk situations can practice in a simulated world that looks, feels, smells, and tastes like the real thing. At the same time it is easy to imagine situations in which ethical issues should preclude exchanging the real thing for a simulated experience that mimics it exactly, for example, engaging in sexual experiences that one never could or would do in one's normal life.

Preliminary Assessment

The many forms of entertainment available today and the various means by which one can obtain and experience them can lead to a retreat from the world and oneself so pervasive that a person can focus only on the next thrill. Countries with a broad array of entertainment options suffer from what Gregg Easterbrook (2003) terms "the paradox of progress" because despite overwhelming numbers of possessions and experiences, real as well as vicarious, a sense of personal satisfaction and happiness elude people.

Some people have learned that certain forms of media can produce addictions as powerful as those caused by illicit drugs. This is the case in part because one never just uses technology; one also experiences it. This sensory, intellectual, and emotional interplay affects the user in both predictable and unpredictable ways. Reality shows on television have extended this impact more fully to the "actors" themselves as they create live, unscripted drama that others get to enjoy voyeuristically and register their pleasure or displeasure with a particular person on the show just as the emperor and the crowd determined the ultimate fate of ancient gladiators; the difference is that now the phone or mouse click rather than the thumb is the determining signal. Online chat rooms have led some people to alter the course of their lives; although some of the end results appear to be positive, they seem to be outweighed by media and professional counselors' stories of poor decisions and damaging consequences. Many people struggling with personal issues seek escape and relief in a fantasy world that makes them incapable of facing their problems.

Modern people's ancient ancestors would recognize most of the dilemmas that modern entertainment presents. They undoubtedly also would recognize that these ethical and moral challenges have multiplied over time and space.

DENNIS W. CHEEK

SEE ALSO *Movies; Music; Museums of Science and Technology; Popular Culture; Radio; Robot Toys; Science, Technology, and Society Studies; Special Effects; Sports; Television; Video Games; Violence.*

BIBLIOGRAPHY

Bender, Gretchen, and Timothy Druckrey, eds. (1994). *Culture on the Brink: Ideologies of Technology*. Seattle, WA: Bay Press. A set of essays on the meaning of technology that challenges notions of progress and determinism.

Bray, John. (2002). *Innovation and the Communications Revolution: From the Victorian Pioneers to Broadband Internet*. London: Institution of Electrical Engineers. A historical look at how global communications have developed and have affected the way people live.

Brende, Eric. (2004). *Better Off: Flipping the Switch on Technology*. New York: HarperCollins. A technology guru reveals his thoughts about the pervasive and unhealthy influence of technology on life in the twenty-first century.

Easterbrook, Gregg. (2003). *The Progress Paradox: How Life Gets Better While People Feel Worse*. New York: Random House. A hard look at one of the main dilemmas of modernity.

Hakken, David. (2003). *The Knowledge Landscapes of Cyberspace*. New York: Routledge. An anthropologist looks at the many aesthetic, ethical, and political questions posed by the uses and abuses of information technology.

McCarthy, John, and Peter Wright. (2004). *Technology as Experience*. Cambridge, MA: MIT Press. A thoughtful monograph that explores the emotional, intellectual, and sensual aspects of people's interactions with technology.

Pesce, Mark. (2000). *The Playful World: How Technology Is Transforming Our Imagination*. New York: Ballantine. A clever analysis of the way the use of distributed intelligence, engineered structures that interact with natural structures, and instantaneous access to information will transform culture and create a new Babel.

Peters, John Durham. (1999). *Speaking into the Air: A History of the Idea of Communication*. Chicago: University of Chicago Press. An evocative history of communication in Western thought, showing how it shapes and has been shaped by people.

Postman, Neil. (1986). *Amusing Ourselves to Death: Public Discourse in the Age of Show Business*. New York: Penguin. A well-known critique of contemporary life and culture.

Schultze, Quentin J. (2002). *Habits of the High-Tech Heart: Living Virtuously in the Information Age*. Grand Rapids, MI: Baker Book House. A Christian critique of contemporary high-tech culture in the United States.

Squier, Susan Merrill, ed. (2003). *Communities of the Air: Radio Century, Radio Culture*. Durham, NC: Duke University Press. A pioneering analysis of radio as both a material and a cultural production.

Sterne, Jonathan. (2003). *The Audible Past: Cultural Origins of Sound Reproduction*. Durham, NC: Duke University Press. A look at the technological and cultural precursors of telephony, phonography, and radio.

Stewart, David. (1999). *The PBS Companion: A History of Public Television*. New York: TV Books. A look at an American cultural icon that is frequently mentioned but infrequently watched.

ENTREPRENEURISM

"[An] entrepreneur is a person who habitually creates and innovates to build something of recognized value around perceived opportunities" (Kotelnikov Internet article). This "recognized value" should incorporate social and ethical concerns, as well as economic ones. There are moral dimensions to all forms of entrepreneurship.

Conceptual Distinctions

Entrepreneurs include both scientists seeking to advance research and engineers seeking new design opportunities. Entrepreneurship is not the same as invention. Alexander Graham Bell obtained a broad patent that included the transmission of speech, but he was not an entrepreneur—others took his patent and used it to create a corporate giant (Carlson 1994). Thomas Edison, in contrast, supervised invention, manufacturing, and marketing of a new electric lighting system (Hughes 1983); therefore, he is both inventor and entrepreneur. Classic theorists and economists also have developed and expressed their own opinions concerning entrepreneurship and its influence on economic development. In 1928, economist Joseph Schumpeter stated that the "essence of entrepreneurship lies in the perception and exploitation of new opportunities in the realm of business . . . it always has to do with bringing about a different use of national resources in that they are withdrawn from their traditional employ and subjected to new combinations" (Filion 1997, p. 3).

Entrepreneurs must promote their ideas relentlessly. They have, however, an obligation to be honest with themselves and others about their prospects.

Unethical Entrepreneurship

In the early twenty-first century, America watched companies such as Enron and WorldCom collapse. Enron was formed by the merger of Houston Natural Gas, a regional pipeline company, and InterNorth, a Nebraska-based pipeline owner, which was organized by Kenneth Lay in 1985. The beginnings of Enron's downfall can be traced to the late 1980s: When federal regulations allowed gas prices to fluctuate naturally, Enron saw this as an opportunity to add gas trading to its list of business endeavors. Then beginning in the mid-1990s, "Enron tried to duplicate its initial success at energy trading in new fields—coal, paper, plastics, metals and even Internet bandwidth. Many of these ventures went badly wrong, so executives turned to the tried-and-true method of big business—hide the problem and hope that everything gets better" (Maass 2002, pp. 6–7) Maass then notes that "Enron hid its mounting losses and skyrocketing debt, both in little-examined nooks and crannies of official statements and in off-the-record *partnerships* run by Enron executives. By hiding debt in the partnerships, Enron's official bottom line continued to look healthy—while executives raked in millions in fees for administering them" (Maass 2002, pp. 6–7). Enron lied to its own employees and shareholders, many of whom were left with virtually worthless stock. Joe Lieberman, Senator from Connecticut, commented that "Enron has become a grand metaphor for the real human problems that profit pressure can produce when it goes to gross extremes because it is unchecked by personal principles or business ethics" (Lieberman 2002). WorldCom, an entrepreneurial telecommunications company, masked losses by clever, but dishonest accounting schemes.

The environment in which new companies enter may be responsible for the ethics dilemmas companies encounter. Arthur Levitt, former SEC chairman, states "fierce competition in the marketplace is healthy, but we've seen that the corporate race to beat analyst projections can breed disdain for investors' interests and the law" (Lieberman Internet site). Jennifer Lawston also writes that "the entrepreneurial world—particularly the high-tech entrepreneurial world—is living through a time of high temptation. The devil on one shoulder tells you to make the numbers and set projections to make investors feel good, the angel on the other says to tell the story like it really is" (Lawston 2003 Internet article).

Entrepreneurship requires truth-telling—to investors and the public. The Enron and WordCom cases illustrate the consequences of lying. Entrepreneurs also need to be honest with themselves.

The history of dot-com company failures reveals the dangers of self-delusion. Peter Coy suggests thinking of "dot-com startups not as companies but as hypotheses—economic hypotheses about commercial methods that needed to be tested with real money in the real world. Nobody was forced to fund the experiments, but plenty of people who hoped to get rich quickly were happy to thrust money into the hands of entrepreneurs such as Walker, Jeff Bezos of Amazon, Tim Koogle of Yahoo!, and Candice Carpenter of iVillage, a Website for women" (Coy Internet article). The dot-coms suffered from confirmation bias (Gorman 1992)—they believed that because their stock was rising, their hypothesis was right, and the *old* economic laws did not apply to their situation.

Doing Well by Doing Good

Entrepreneurs are pioneers who open new territory. C.K. Prahalad and Allen Hammond (2002) have used a pyramid metaphor to describe the global market. Tier 1 consists of roughly 100 million people whose earnings are greater than $20,000 per year. Tier 2 consists of the poor in developed countries and Tier 3 consists of the rising middle class in the developing world, amounting to approximately 1.75 billion people whose earnings fall between $2,000 and $20,000 per year. Tier 4 includes the majority of the Earth's population, about 4 billion people earning less than $2,000 per year. As one goes down the pyramid, the proportions of people in each tier shift from the developed to the developing world.

In *Development As Freedom* Amartya Sen (1999) argues that "economic unfreedom, in the form of extreme poverty, can make a person helpless prey in the violation of other kinds of freedom" (p. 8). Sen believes the development of a competitive market system in poverty-stricken countries will, in time, improve the economic condition, which will in turn create numerous freedoms for their inhabitants.

The Tier 4 market therefore represents a new frontier that most established businesses shun—where an entrepreneur could make a profit while improving the quality of life. In 1969 Karsanbhai Patel, a factory chemist dissatisfied with his job and low income, decided to create and manufacture an affordable detergent for the Tier 4 market in India. Patel mixed a powder and began selling it to neighboring towns on his bicycle. Distributors eventually showed an interest in the product, and Patel's product spread nationwide.

Patel created a cottage industry that allowed individuals from Tier 4 markets to make money manufacturing and selling his product, but this cottage industry structure meant he did not have to pay his employees benefits. His efforts inspired Hindustan Lever Limited, the former leaders in market share, to enter this Tier 4 territory, thereby providing Tier 4 consumers with a choice between products.

Another example of an entrepreneur who wanted to benefit women around the world and also make a profit is Mary Ann Leeper. She bought the rights to a prototype female condom, but modified it, figured out how to manufacture it, and made it available on a global basis. Leeper created the Female Health Company, which "has focused its marketing efforts on establishing a presence in major world markets and building relationships with key world health agencies and programs. The female condom has been introduced in Japan, Africa, Latin America, the United Kingdom, the United States and Europe. ("The Female Health Company Biography: Mary Ann Leeper" Internet article). The female condom has been "hailed as a way of giving women increased power to protect themselves from sexually transmitted diseases" (Baille 2001).

Entrepreneurs have the ability to choose whether ethics will be a priority in their fledgling companies. Ben Cohen, a founder of Ben & Jerry's Ice Cream wrote in 1976 that "Business has a responsibility to give back to the community from which it draws its support" (Mead 2001). Cohen and Jerry Greenfield developed what they called a *values-led* company, which for them "meant a commitment to employees, the Vermont community, and social causes in general" (Mead 2001). In 1985 Cohen and Greenfield established the Ben & Jerry's Foundation to help disadvantaged groups, social change organizations, and environmentalists, donating 7.5 percent of the company's annual pre-tax profits. Ben & Jerry's became a subsidiary of Unilever, a multinational corporation that is also the parent company of HLL and is dedicated to measuring success via a triple bottom-line, in which environmental and social progress is just as important as financial gain (Gorman, Mehalik, and Werhane 2000).

Conclusions

For scientists and engineers, entrepreneurship represents an opportunity to discover and even create markets (Gorman and Mehalik 2002). Attention to social and ethical impacts will actually increase the likelihood that an innovation will be accepted.

The entrepreneur needs to:

- Be truthful with potential customers and investors.
- Consider whether a new technology is more likely to benefit or harm the global environment.
- Consider the impact of a new technology on the Tier 4 market. Will it increase the gap between rich and poor, or give the poor the opportunity to improve their situation?
- Measure progress using social and environmental metrics, as well as economic.

MICHAEL E. GORMAN
EMILY LYNN BRUMM

SEE ALSO *Business Ethics; Management: Models; Technological Innovation; Work.*

BIBLIOGRAPHY

Ahmad, Pia Sabharwal, et al. (2004). *Hindustan Lever Limited (HLL) and Project Sting: Case A*. Charlottesville: University of Virginia Darden School. This case-study, and others below, are available as Darden School publications; see www.darden.edu.

Carlson, W. Bernard. (1994). Entrepreneurship in the Early Development of the Telephone: How did William Orton and Gardiner Hubbard Conceptualize This New Technology? *Business and Economic History* 23(2): 161–192.

Gorman, Michael E. (1992). *Simulating Science: Heuristics, Mental Models and Technoscientific Thinking*. Bloomington: Indiana University Press. Describes when confirmation is and isn't a bias.

Gorman, Michael E., Matthew M. Mehalik. (2002). "Turning Good into Gold: A Comparative Study of Two Environmental Invention Networks." Science Technology and Human Values, 27(4): 499–529. This paper provides an STS framework for entrepreneurs in science and technology.

Gorman, Michael E., Matthew M. Mehalik, and Patricia Werhane. (2000). *Ethical and Environmental Challenges to Engineering*. Englewood Cliffs, NJ: Prentice-Hall. This book contains case-studies of engineers and businesses that encountered ethical dilemmas while they were conducting entrepreneurial activities.

Hughes, Thomas P. (1983). *Networks of Power: Electrification in Western Society: 1880–1930*. Baltimore: Johns Hopkins University Press.

Mead, Jenny, Robert J. Sack, and Patricia H. Werhane. (2001). "Ben & Jerry's Homemade, Inc. (A): Acquisition Suitors At The Door." Publication E-0225. Charlottesville: University of Virginia Darden School Foundation.

Prahalad, C.K., and Allen Hammond. (2002). "Serving the World's Poor, Profitably," *Harvard Business Review* 80(9): 48–57.

Sen, Amartya K. (1999). *Development as Freedom*. New York: Oxford University Press.

INTERNET RESOURCES

Baille, Andrea. "Women Offer to Participate in Female Condom Study." Canoe. Available from http://www.canoe.ca/Health0110/26_condom-cp.html.

Coy, Peter. "Rise & Fall." Cornell Magazine. Cornell University. Available from http://cornell-magazine.cornell.edu/Archive/2001mayjun/RiseFall.html.

"The Female Health Company Biography: Mary Ann Leeper." Availiable from http://www.femalehealth.com/PressReleasesAug99toCurrent/PressReleaseBiography7.19.2000.htm

Filion, Louis Jacques. (1997). "From Entrepreneurship to Entreprenology." Availiable from http://www.usasbe.org/knowledge/proceedings/1997/P207Filion.PDF.

Kotelnikov, Vadim. (2004). "The Entrepreneur: The Key Personality, Environmental and Action Factors. Available from http://www.1000ventures.com/business_guide/crosscuttings/entrepreneur_main.html.

Lawston, Jennifer. (2003). "Ethics and the Entrepreneur." *USA Today*. Available from http://www.usatoday.com/money/jobcenter/2003-01-03-entre-ethics_x.htm.

Lieberman, Joe (2002). "Business Ethics in the Post-Enron Era: What Government Can Do And What Business Must Do." 1 April 2002. Available from http://www.southerninstitute.org/Resources-GoodBusiness-Content(1).htm.

Maass, Alan, and Todd Chretien. (2002). "A Tale of Greed, Deceit, and Power Politics." Socialist Worker Online. Available from http://www.socialistworker.org/2002-1/390/390_06_EnronTaleOfGreed.shtml.

ENVIRONMENTAL ECONOMICS

As the entry on "Economics: Orientation" points out, welfare economics puts the "satisfaction of individual human desires at or near the top of its own internal moral hierarchy." Two economists observe, "The basic premises of welfare economics are that the purpose of economic activity is to increase the well-being of the individuals that make up the society, and that each individual is the best judge of how well off he or she is in a given situation" (Stokey and Zeckhauser 1978, p. 277).

Environmental economics builds on the theory of welfare economics (or microeconomics) and in particular the view—prepresented as an ethical theory—that the satisfaction of preferences taken as they come ranked by the individual's willingness to pay (WTP) to satisfy them is a good thing because (by definition) this constitutes welfare or utility. According to economist David Pearce (1998, p. 221), "Economic values are about what people want. Something has economic value—is a benefit—if it satisfies individual preferences." This approach uses maximum WTP to measure how well off the individual believes a given situation makes her or him. A representative text states, "Benefits are the sums of the maximum amounts that people would be willing to pay to gain outcomes that they view as desirable" (Boardman, Greenberg, Vining, et al. 1996).

Preference Satisfaction

The attempt to link preference satisfaction (and therefore WTP) with well-being or benefit, however, encounters four problems. First, one may link preference with welfare by assuming that individuals prefer what they believe will make them better off. Research has shown, on the contrary, that with respect to environmental and other policy judgments, people base their values and choices on moral principles, social norms, aesthetic judgments, altruistic feelings, and beliefs about the public good—not simply or even usually on their view of what benefits them. The basis of environmental values in moral principle, belief, or commitment rather than self-interest severs the link between preference and perceived benefit or welfare.

In recent decades, environmental economists have put a great deal of effort into developing methodologies for measuring the benefit associated with goods—sometimes called "non-use" or "existence" values—that people care about because of moral beliefs, aesthetic judgments, or religious commitments, rather than because of any benefit or welfare change they believe those goods offer them. According to economist Paul Milgrom (1993, p. 431), for existence value to be considered a kind of economic value, "it would be necessary for people's individual existence values to reflect only their own personal economic motives and not altruistic motives, or sense of duty, or moral obligation." The difference between what people believe benefits them (economic motives) and what they believe is right (moral obligation) divides economic value from existence or non-use value. The attempt to translate moral beliefs and political judgments into economic benefits—principled commitments into units of welfare and thus into data for economic analysis—may continue to occupy economists for decades to come, because many logical, conceptual, and theoretical conundrums remain.

Second, the statement that the satisfaction of preference promotes welfare states a tautology if economists define "welfare" or "well-being" in terms of the satisfaction of preference, as generally they do. Concepts such as "welfare," "utility," and well-being" are mere stand-ins or proxies for "preference-satisfaction" and so cannot justify it as a goal of public policy.

Additionally, if "well-being" or "welfare" refers to a substantive conception of the good, such as happiness, then it is simply false that the more one is able to satisfy one's preferences, the happier one becomes. That money (or income—a good surrogate for preference satisfaction) does not buy happiness may be the best-confirmed hypothesis of social science research. Thus, the thesis that preference satisfaction promotes welfare appears either to be trivially true (if "welfare" is defined as preference satisfaction) or empirically false (if "welfare" is defined as perceived happiness).

Third, if preferences are mental states, they cannot be observed. If they are inferred or "constructed" from behavior, they are also indeterminate, because there are many ways to interpret a person's actions as enacting a choice, depending on the opportunities or alternatives the observer assumes define the context. For example, the act of purchasing Girl Scout cookies could "reveal" a preference for eating cookies, supporting scouting, not turning away the neighbor's daughter, feeling good about doing the right thing, avoiding shame, or any of a thousand other possibilities. Choice appears to be no more observable than preference because its description presupposes one of many possible ways of framing the situation and determining the available options.

Fourth, few if any data indicate maximum WTP for any ordinary good. When one runs out of toothpaste, gets a flat tire, or has to buy the next gallon of milk or carton of eggs, one is unlikely to know or even have an idea about the *maximum* one is willing to pay for it. Instead, one checks the advertisements to find the *minimum* one has to pay for it. It is not clear how economists can estimate maximum WTP when all they can observe are competitive market prices. Competition drives price down to producer cost, not up to consumer benefit. For example, one might be willing to pay a fortune for a life-saving antibiotic, but competition by generics may make the price one actually pays negligible.

The difference between price and benefit is clear. People usually pay about the same prices for a given good no matter how much they differ in the amount they need or benefit from it. People who benefit more and thus come first to the market may even pay less, for example, for seats on an airplane than those who are less decided and make later purchases. Thus, maximum WTP, which may correlate with benefit, cannot be observed, while market prices, which can be observed, do not correlate with benefit.

Market Prices

Environmental economists also propose that the outcome of a perfectly competitive market—one in which property rights are well defined and people do not encounter extraordinary costs in arranging trades and enforcing contracts—defines the way environmental assets are most efficiently allocated. Market prices constantly adjust supply and demand—the availability of goods to the wants and needs of individuals. As the "Orientation" entry observes, a perfectly competitive market may be used to define the idea of economic efficiency—the condition in which individuals exhaust all the advantages of trade because any further exchange would harm and thus not gain the consent of some individual.

Economists often explain the regulation of pollution not in moral terms (trespass, assault, violation of rights or person and property) but in terms of the failure of markets to "price" goods correctly. Suppose for example a factory emits smoke that causes its neighbors to bear costs (such as damage to property and health) for which they are not compensated. The factory, while it may pay for the labor and materials it uses, "externalizes" the cost of its pollution. When only a few neighbors are affected, they could negotiate with the factory, either paying the owner to install pollution-control equipment (if the zoning gave the factory the right to emit smoke) or by accepting compensation. The factory owner and the neighbors would bargain to the same result; the initial distribution of property rights determines not the outcome but the direction in which compensation is paid. This is an example of the second theorem described in the "orientation" entry, according to which the initial distribution of goods and services does not really matter in determining the outcome of a perfectly functioning market.

Where many people are affected, as is usually the case, however, the costs of bargaining ("transaction costs") are large. Economists recommend that the government tax pollution in an amount that equals the cost it "externalizes," that is, imposes on society. The industry would then have an incentive to reduce its emissions until the next or incremental reduction costs more than paying the tax—the point where in theory the cost (to the industry) of reducing pollution becomes greater than the benefits (to the neighbors). Such a pollution tax would "internalize" into the prices the factory charges for its products the cost of the damage its pollution causes, so that society will have the optimal mix of those products and clean air and water.

Many economists point out, however, that the government, in order to set the appropriate taxes or limits, would have to pay the same or greater costs as market players to gather information about WTP for clean air or water and willingness to accept (WTA) compensation for pollution. Pollution taxes, to be efficient, "should vary with the geographical location, season of the year, direction of the wind, and even the day of the week . . ." (Ruff 1993, p. 30). The government would be "obliged to carry out factual investigations of mind-boggling complexity, followed by a series of regulatory measures that would be both hard to enforce and valid only for a particular, brief constellation of economic forces" (Kennedy 1981, p. 397). Thus, regulation is unnecessary when transaction costs are small (because people can make their own bargains) and unfeasible when they are great (because the government would have to pay them).

By arguing that emissions be optimized on economic grounds—rather than minimized on ethical grounds—economists reach an impasse. According to Ronald Coase, "the costs involved in governmental action make it desirable that the 'externality' should continue to exist and that no government intervention should be undertaken to eliminate it"(1960, p. 25–26).

Maximum WTP

Economists regard the ubiquitous and pervasive failure of markets to function perfectly as a reason that society, in order to achieve efficiency, should transfer the power to allocate resources to experts, presumably themselves, who can determine which allocations maximize benefits over costs. By replacing market exchange with expert opinion to achieve efficiency, however, society would sacrifice many non-allocatory advantages of the market system. For example, by making individuals responsible for decisions that affect them—rather than transferring authority to the government to act on their behalf—markets improve social stability. People have themselves, each other, or impersonal market forces to blame—not the bureaucracy—when purchasing decisions do not turn out well for them.

Economists have encountered logical and conceptual hurdles, moreover, in their efforts to develop scientific methods for valuing environmental assets and thus for second-guessing market outcomes. First, there is little evidence that economic experts are able to assemble information about WTP and WTA any better than market players when the costs of gathering that information are high. Second, economic estimates of benefits and costs when made by government agencies become objects of lobbying, litigation, and criticism. Experts can be hired on both sides of any dispute and then produce dueling cost-benefit analyses (Deck 1997). Third, when society transfers power to scientific managers, even if they are trained welfare economists, it courts all the problems of legitimacy that beset socialist societies, which likewise may rely on scientific managers to allocate resources.

Institutional Approaches

Pollution control law, from a moral point of view, regulates pollution as a kind of trespass or assault, on analogy with the common law of nuisance. Statutes such as the Clean Air Act and Clean Water Act, moreover, explicitly rule out a cost-benefit or efficiency test and pursue goals such as public safety and health instead (Cropper and Oates 1992). For this reason, the government often limits to "safe" levels the maximum amount of various pollutants industries and municipalities may emit into the water and air. To determine what levels are "safe enough" legislators and regulators have to consider the state of technology and make ethical and political judgments. To help society attain the mandated levels in the most cost-effective ways, economists have made an important contribution to environmental policy by urging government to create market-like arrangements and thus to generate price signals for allocating environmental goods for which markets do not exist.

For example, the Environmental Protection Agency, by creating pollution permits or allowances that firms can buy and sell under an aggregate total ("CAP"), gave industries incentives to lower emissions of lead, smog, and other pollutants to below permitted levels, because they could sell at least part of the difference to other companies that find emissions more expensive to reduce. Tradable rights in environmental assets (from emission allowances to rights to graze the public range) show that incentives matter; marketable permits can reduce pollution more effectively and at lower cost than "command and control" policies. In addition, market arrangements decentralize decisions by encouraging industries to make their own bargains to attain the overall "CAP" rather than to conform to one-size-fits-all regulation.

Environmental economics has enjoyed success in helping society construct market-like arrangements for achieving in the most cost-effective ways environmental goals, such as pollution-reduction, justified on moral, political, and legal grounds. Environmental economics as a discipline has been less successful in finding scientific methods to second-guess or replace markets in order to achieve goals it itself recommends, such as preference-satisfaction or efficiency, that are not plainly consistent with moral intuitions, legislation, or common law traditions.

MARK SAGOFF

SEE ALSO *Ecological Economics; Economics and Ethics; Environmental Ethics; Market Theory.*

BIBLIOGRAPHY

Anderson, Terry L., and Donald L. Leal. (1991). *Free Market Environmentalism*. San Francisco: Pacific Research Institute for Public Policy.

Boardman, Anthony; David H. Greenberg; Aidan R. Vining; and David L. Weimer. (1996). *Cost-Benefit Analysis: Concepts and Practice*. Upper Saddle River, NJ: Prentice Hall.

Coase, Robert H. (1960). "The Problem of Social Cost." *Journal of Law and Economics* 3(1): 1–44.

Cropper, Maureen L. and Wallace E. Oates (1992), "Environmental Economics: A Survey." *Journal of Economic Literature* 30: 675–740.

Daily, Gretchen C., ed. (1997). *Nature's Services: Societal Dependence on Natural Ecosystems*. Washington, DC: Island Press.

Deck, Leland. (1997). "Visibility at the Grand Canyon and the Navajo Generating Station." In *Economic Analysis at EPA: Assessing Regulatory Impact,* ed. Richard D. Morgenstern. Washington, DC: Resources for the Future.

Kennedy, Duncan. (1981). "Cost Benefit Analysis." *Stanford Law Review* 33: 387–421.

Milgrom, Paul. (1993). "Is Sympathy an Economic Value?" In *Philosophy, Economics, and the Contingent Valuation Method,* in Contingent Valuation: A Critical Assessment," ed. Jerry A. Hausman. Amsterdam: Elsevier North-Holland.

Pearce, David. 1998. *Economics and the Environment*. Cheltenham, UK: Edward Elgar.

Ruff, Larry. (1993). "The Economic Common Sense of Pollution." In *Economics of the Environment: Selected Readings*, 3rd edition, ed. Robert Dorfman and Nancy Dorfman. New York: Norton.

Stokey, Edith, and Richard Zeckhauser. (1978). *A Primer for Policy Analysis*. New York: W.W. Norton.

ENVIRONMENTAL ETHICS

Modern science and technology have brought about a unique, human-caused transformation of the Earth. Although humans have for thousands of years had measurable terrestrial impacts with fire, agriculture, and urbanization, since the Industrial Revolution the scope, scale, and speed of such impacts have exceeded all those in the past (Kates, Turner, and Clark 1990) and promise to become even more dramatic in the future. Humans have become what the Russian scientist V. I. Vernadsky in the 1920s called a *geological force,* in a sense even more strongly than he imagined it. Environmental ethics and, more generally, environmental philosophy comprise a variety of philosophical responses to the concerns raised by the magnitude of this transformation.

Basic Issues

Since the noxious clouds and pollution-clogged rivers of the Industrial Revolution, society has generally agreed that many modern technological activities, due to their potentially devastating impact on nature and people, are in need of regulation. Recognition of the fact that humans can foul their own nests is now widely accepted and often politically effective. Indeed concerns about the counterproductivity of scientifically and technologically enhanced human conduct in the early-twenty-first century extends to discussions of population increase, environmental costs borne by the poor and minorities, and responsibilities to future generations. But it is not clear that addressing such anthropocentric worries adequately encompasses all properly human interests. Beyond working to live within the environmental limits for the production of resources and absorption of wastes—which can be pursued both by moderating activities and transforming technologies—questions arise about whether nonhuman or extrahuman considerations have a role to play. What are the ethical responsibilities, the moral duties, of humans to nonhuman animals, plants, populations, species, biotic communities, ecosystems, and landforms? Should environmental outcomes for these, or at least some of these, not mean something in their own right quite apart from their mere resource value for human exploitation? Ought humans not to *respect* nature to some degree for what it is intrinsically? Much of the professional field of environmental ethics has been exercised with articulation and debate regarding the relative weight of human- and extrahuman-centered concerns.

Moreover early-twenty-first-century humans are often ambivalent about the place of nature in human life. Human beings of all times and places have needed and wanted freedom from many of the harsh conditions of the natural world, but earlier humans also celebrated the grace of nature in art, song, story, and ceremony. Modern technological efforts perfect the former and neglect the latter. Could it be that human flourishing is connected to nature flourishing? If so, over and above respect for nature, a *celebration* of things natural and the natural world in human lives and communities throughout the world is necessary. Although their numbers remain comparatively small, many people are stirred by passionate feelings about nature in communities that have long *turned their backs to the river*. While some critics argue the pathetic fallacy of such positions, the question of how much say nature and natural things will have over human life and the planet remains.

Any philosophical criticism of the anthropogenic transformation of the natural world must ultimately lead to an assessment of human culture. Perhaps humans have been at some level mistaken about the fundamental payoffs of environmental exploitation. In many instances, the technological control of nature that displaces its celebration leaves people numb, mindless, or out of shape. It seems necessary to coordinate a critique of technological damage with discovery of new ways for living with nature in order simultaneously to save the planet from environmental degradation and society from cultural impoverishment. The quality of the environment and of human life —questions of environmental and interhuman ethics (the good life)—may be inseparable.

The extensive transformation of the Earth deserves to be seen from the perspective of both the natural world and culture. This transformation could not have taken place without widespread agreement underlying the fundamental orientation of the modern technological project. There may be several ways of understanding this agreement, and there is debate among scholars on this issue (Borgmann 1984; Higgs, Light, and Strong 2000; Zimmerman et al. 2000). Despite differences, there is nevertheless a consensus that unless people unite concerns for nature and culture, environmental ethics will prove to be inconsequential. In other words, an effective environmental ethics and philosophy must include as well a philosophy of technological culture.

Historical Development

Historically environmental ethics is associated with a certain unease about the unbridled exploitation of nature that is typical of post-Industrial Revolution society. As Roderick Nash (2001), among others, points out, such uneasiness was first evidenced in post-Civil War United States concerns over the loss of both wilderness and natural resources—concerns that led to the creation of the first U.S. national park (1872) and then forest service (1905). After World War II, the creation of a second wave of environmental concern centered around the wilderness movement of the 1950s that led to the Wilderness Act (1964) and Rachel Carson's *Silent Spring* (1962), which argued that aggressive technology in the form of the extensive use of chemical pesticides, especially DDT, was killing millions of songbirds and could eventually have a much broader impact on plant, animal, and even human life. Nuclear weapons and energy production, technological disasters (such as the Santa Barbara oil spill of 1969), wasteful extraction and use of resources, the rise of consumerism, the population explosion, oil shortages (in 1973 and 1977), pollution, and a host of related environmental problems combined to establish in popular consciousness what can be called an environmental or ecological crisis about the health of the Earth as a whole. Existing conservation measures, with their many successes, were nevertheless judged too weak to respond to the new problems, leading to the enactment of the National Environmental Policy Act (NEPA 1969) and to the establishment of the first national Environmental Protection Agency (EPA) by President Richard Nixon in 1972. At the same time, some began to question whether enlightened self-interest was a sufficient basis for assessing the contemporary state of environmental affairs and argue that nature mattered in ways beyond its strictly human utilities and should be protected with an eye for more than human safety and health.

Among figures such as Ralph Waldo Emerson, Henry David Thoreau, John Muir, and Albert Schweitzer, wildlife biologist and ecologist Aldo Leopold advocated this position before environmental ethics became a popular movement. Early in his career as a professor of wildlife management, Leopold thought that nature could be reorganized for human ends (enhancing wildlife populations by eliminating wolves, for instance) if one took a long-range view and was scientifically informed. However in his mature work *A Sand County Almanac and Sketches Here and There* (1949), Leopold criticized reliance on the conservationist position, and argued that *the land,* what is now called an ecosystem, must be approached holistically and with love and respect, that is, with what he calls *the land ethic*. He said, "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise" (Leopold 2000, pp. 224–225). Leopold articulated the emerging new ethic concerning both living things as individuals and the natural system itself, including the *community concept* generated by the relatively new sciences of evolution and ecology. This was in contrast to earlier theories that invited human domination of nature, which Leopold believed were encouraged by the older hard sciences.

The groundwork for environmental ethics as such was laid in the 1970s. During the first half of that decade, four independent philosophical works launched the academic field. Arne Naess's "The Shallow and Deep, Long-range Ecology Movement: A Summary" (1973) called for a radical change in the human-nature relationship, and became a seminal work of the deep ecology movement. Richard Sylvan's (then Routley) "Is There a Need for a New, an Environmental, Ethic?" (1973) argued that modern ethical theories were inadequate for the full range of moral intuitions regarding nature. Peter Singer's "Animal Liberation" (1973) reanimated Jeremy Bentham's proposal for including sentient members of nonhuman species in the utilitarian calculus. And Holmes Rolston III's "Is There an Ecological Ethic?" (1975) distinguished between a *secondary sense* environmental ethic in which moral rules are derived from concerns for human health or related issues, and a *primary sense* environmental ethic, in which nonhuman sentient animals as well as all living things, ecosystems, and even landforms are respected because they are intrinsically valuable *apart* from any value to humans. For Rolston, the secondary ethic is anthropocentric and not truly environmental, whereas the primary is truly environmental and ecocentric. Subsequently Kenneth Goodpaster (1978) developed the fertile concept of *moral considerability* to discuss more generally who and what, if anything nonhuman, counts ethically. In 1979 Eugene C. Hargrove founded *Environmental Ethics*, the first journal in the field.

Mainstream environmental ethics matured over the next decade. Animal liberation and rights discussions flourished and became a separate field from, and often in conflict with, environmental ethics, because ecosystems sacrifice the welfare of individual animals. Within mainstream environmental ethics, ethical theories regarding individual *lives* of animals and plants, usually called biocentric or life-centered, began to be distinguished from holistic approaches that dealt with preserving entire ecosystems, called ecocentric or ecosystem-centered ethics. Leopold's earlier vision developed in different ways in the systematic works of J. Baird Callicot, deep ecologists, and others.

During the 1980s and 1990s, the field witnessed remarkable growth. Currently there are numerous journals, two professional organizations (the International Society for Environmental Ethics and the International Association for Environmental Philosophy), and an array of Internet sites devoted to it. Colleges and universities routinely teach courses in environmental ethics.

Environmental ethics theorists, in the early twenty-first century, believe they are taking a radically new direction because they are informed by scientific insight and philosophical prowess. Many aspire to produce universal claims about humans and the environment. They argue the urgent need for a new environmental ethic governing the duties of people toward nature, and reject the view of nature, which started with the rise of modern science, as value-neutral stuff that humans can manipulate as they please.

However recent developments in science complicate and challenge environmental ethics. Ecology has always accepted change, but modern ecology has moved away from early ecology's notion of stable, climax communities (usually pre-Columbian) reached by moving at a steady pace through successive stages. The notion that nature tends toward equilibrium conditions, a *balance of nature*, has become largely rejected in favor of the view that ecological processes are much more unruly and undirected. Catastrophic, episodic, and random events may be more responsible for the ecological condition than ordinary cycles. Ecological settings, once disturbed, do not automatically return to their predisturbance state. What were thought to be symbiotic relationships between members of an ecological community are often better understood as assemblages of individuals acting opportunistically. The assumed relationship between biodiversity and stability does not always hold up to scientific scrutiny. Added to these are complicating human and cultural influences such as the role of Native Americans in shaping ecosystems, the European introduction of horses, and global climate change. In light of these factors, environmental ethics theorists must again consider the acceptability of the control and maintenance of nature for human benefit. Those who have been inspired by ecology generally, and Leopold in particular, struggle to revise their theories. Most of these revisions turn on protecting dynamic processes rather than fixed-states and on considering the relative magnitude of anthropogenic transformation. Modern human-caused ecological changes differ dramatically from natural-caused changes in terms of rates (for instance, of extinction or of climate change), scope, and scale.

Beginning in the late 1980s and following a direction initiated by deep ecology, environmental ethics, with its focus on elaborating moral duties to nature, was felt by many to be too constrictive to address the questions of humankind's place in nature or nature's place in the technological setting. Nature seems to count in ways that were neither exclusively exploitive nor independent of humans. Others find that environmental ethics too often stops short of cultural critique. For instance, criticism of the modern transformation of the Earth from a predominantly technological and cultural standpoint is considered to be an inappropriate subject for the journal *Environmental Ethics*. Third, concern with a new environmental ethic in a primary sense was denounced for diverting attention from developing sophisticated and effective anthropocentric positions. Whereas environmental ethics is popularly understood as being synonymous with environmental philosophy, philosophers often conceive of environmental philosophy an alternative field, distinguished by its philosophical broader concern regarding the human and cultural relationship with nature (Zimmerman et al. 2000).

Scope and Central Issues of Environmental Ethics

Human beings are expected to act morally, but no such expectation exists for animals and plants; ethics is limited traditionally to the sphere of moral agents, those capable of reciprocity of rights and duties. No one in environmental ethics argues that anything in nature is a moral agent and morally responsible. If human beings can overcome the problem of extending moral duties beyond moral agents, other issues become central for environmental ethics including: (a) What duties should constrain human actions on the part of other beings who can suffer or are subjects of a life, that is, sentient animals? and (b) Should sentient animals be ranked, for example, primates first, followed by squirrels, trout, and shrimp, depending on the degree to which an animal can be pained or the complexity of their psychological makeup? Human duties toward different kinds of animals may be clarified with advances in neuroscience and animal psychology.

However ranking animals according to these hierarchies may simply be an imposition of anthropocentric norms, that is selecting paradigmatically human characteristics as a basis for rank. What duties do humans have toward those who are *alive*, usually defined as nonsentient animals and plants? Do all living things possess biological needs, even when there are no psychological interests? If some duties obtain, how should these take into consideration the natural order where life feeds on life and might makes right, for instance?

Other issues also merit consideration. Can *moral extensionism* by analogy apply beyond *individualistic accounts*, beyond selves, to other parts of the natural world? Do humans have duties to microbes and to mere things such as rocks, rivers, landforms, and places? A final crucial issue to be considered by environmental ethics is whether humans have duties to species and ecosystems that are not only not alive and do not suffer, but are not individual beings at all?

Many environmental ethicists believe that humankind can answer these questions only when the question of whether nature possesses intrinsic value is answered (Light and Rolston 2002). Normally intrinsic value is distinguished from *instrumental value*. Instrumental value is use-value, that is, something is valued merely for its utility as a means to some other end beyond itself. Exploiting nature for its instrumental value is seen as the root cause of the ecological crisis. If nature is value-neutral, then humans can dispose of it anthropocentrically as they please. The only alternative to instrumental value, it may seem, is a kind of hands-off, nonrelational respect for nature. If nature matters intrinsically, independently of humans, then its value may prescribe moral consideration.

For instance, all life forms seek to avoid death and injury and to grow, repair, and reproduce themselves by using elements (including other life forms) of the environment instrumentally. These elements have instrumental value for the life-form. On the other hand, in order to generate instrumental value these life-forms must be centers of purpose—growth, maintenance, and reproduction. They must have *sakes* or *intrinsic value* which they pursue. Because the organism's intrinsic value and the instrumental values derived from the organism's pursuit of its own well-being exist whether or not there are humans, such values are independent of humans. For example, grizzlies have a stake in the use of pesticides to control army cutworms in the Midwest because scientific studies show that migrated cutworm moths constitute a significant portion of their diet.

Yet, it is argued, this cannot be a complete account of intrinsic value because the individual may not be a *good kind*, for example, a nonnative species such as spotted-knapweed in North America. Should the life of such a species be respected and allowed to be a good of its kind, or should humans seek to eliminate it? Good kinds need to be weighed in relation to a natural ecosystem. Can a species that uses the forces of evolution to improve itself have intrinsic value, even though it has no *self*? Having wolves cull elk herds will help the species by assuring that elk maintain a *good* gene pool that is better adapted; however, no individual elk welcomes these wolves. Are any species more valuable than others? By genetic standards alone, there is more biodiversity among the microbes in some Yellowstone Park hotpots than the rest of the larger life-forms of the Greater Yellowstone ecosystem. Finally should the concept of intrinsic value be reserved for the *products* of the ecosystem and evolution and not the *processes* themselves, the source of these products?

Significant philosophical (and practical) problems as suggested occur here. How do humans adjust intrinsic values found in nature with people (Schmidtz and Willott 2002)? Second, can humans speak of intrinsic value apart from human minds? Environmental ethicists provide conflicting answers, ranging from conventional anthropocentric to nonanthropocentric *value subjectivist* versus *value objectivist* debates between Callicot and Rolston (Rolston 1993). Third, by focusing so much energy on the nonrelational, intrinsic value of the autonomy of natural things and of nature, environmental ethics tends to concentrate on nature disengaged from humans: particularly on wild nature and the independent natural order. Initial unease with the environment, however, is likely caused in part by the disruption of humanity's bonds of engagement with nature. Between the instrumental resource value of nature and the nonrelational intrinsic value of nature, between the misused and the unused, lies a third alternative: the well used and the well loved. Nature has *correlational value* for humans in the sense that nature's flourishing is bound up with human flourishing in a kind of *correlational coexistence* (Strong 1995, p. 70). Allowing consideration for nature to more strongly influence the design and maintenance of cities may make them more livable, enjoyable, and attractive.

Environmental Philosophy

Turning from environmental ethics to environmental philosophy, agreement about the limitations of conservation measures and analysis of nature solely in terms of its exploitive-value exists, but with an argument for broader reflection. Deep ecologists, for instance, call for metaphysical, epistemological, ethical, political, and cultural changes. What philosophers find most troubling—anthropocentrism, patriarchy, class struggle, placelessness, the technological project itself, and so on—colors the nature of the environmental philosophy.

Deep ecology has focused on anthropocentrism as the source of ecological problems. To overcome this, deep ecologists, such as Naess, advocate a new sense of self-realization (Fox 1995). Anthropocentric self-realization is atomistic, selfish behavior. From an ecological understanding of humankind as part of a larger whole, deep ecologists argue that human beings can reconceive of themselves as extending to that larger whole; reframed, human realization is tantamount to the realization of that larger whole, usually written as *Self-realization* in contrast to anthropocentric self-realization. From this perspective or reframing of human life, nature no longer seems like a resource to be used for a separate human good, but rather as its own good. Other ways of overcoming this anthropocentrism emphasize Naess's eight-point platform that includes a call for decreases in consumption. Yet to rail against consumerism and its destructiveness is not to understand its motivation and attraction. Without understanding those aspects (a topic for technology studies and ethics), can humans become genuinely liberated from it?

Stepping beyond strictly scientific accounts of ecosystems, humans historically and across cultures—for example, Greek, Chinese, and Incan temples—have understood profoundly, cared for, respected, revered, and celebrated the natural world. There is a good deal to learn from how some cultures prescribe the human relationship with nature, and for recent developments in environmental philosophy, such as bioregionalism, an understanding of cultures of place plays a central role their theories and practices (Abram 1996, Jamieson 2003, Snyder 2000). The intuitive and eclectic nature of deep ecology and bioregionalism, as well as their activist emphasis, has made these environmental philosophies especially popular.

Ecofeminism is another promising version of environmental philosophy. Common to different kinds of ecofeminism is the idea of, as Karen Warren puts it, the "twin domination of women and nature," and that both forms of domination ought to be overcome (Zimmerman et al. 2000, p. 325). Some ecofeminists distance themselves from other forms of environmental ethics by arguing that the latter are dominated by male voices and male-centrism, or androcentrism. Some ecofeminists, inspired by Carol Gilligan's work and postmodernism generally, criticize notions of abstraction and detachment, reason, and universality as pretentious and arrogant. They attempt to replace such concepts with an ethics of care, which is highly contextual, particular, and more focused on relationships than on formal rules and individuals (such as earlier philosophies that focused on animals and plants). For instance, ecofeminists have characterized the notion of Self-realization as a means of eradicating the differences between humans and the natural world rather than as an instrument that fosters recognition and acceptance of the differences of these *others*.

Val Plumwood in particular has shown that concerns about anthropocentrism can be addressed in the same ways concerns with androcentrism are dealt with by her, without giving up personal points of view, which she argues is impossible (Plumwood 1999). More specific analyses of anthropocentrism allow people to devise more alternatives to it. However arguments for an end to the domination of nature entirely are too general. One can criticize a limitless technological domination of nature without claiming that *all* human domination is unwarranted. Even though Warren rappels down a cliff as opposed to climbing and dominating it, she uses technological devices that lessen the risk involved and insure that the activity is performed safely. Whether humans use bicycles, public transportation, or SUVs to reach such cliffs, they use technology that dominates nature to some extent, albeit almost imperceptibly. What human beings must learn is to *carefully limit* technology and technological domination.

As with ecofeminist views of patriarchy, many social and political ecologists, inspired by socialist economic perspectives (and some inspired by the work Lewis Mumford), locate the source of human unease as social hierarchy, placing dominance of economic power at the root of social injustice and the ecological crisis. If social hierarchy does not end, humans cannot expect a substantive change in their relationship with nature.

Consideration of social issues opens environmental philosophy to social and philosophical theories of technology (and vice versa) in ways that remain largely undeveloped. The question concerns the earlier issue of how deeply human culture's fundamental orientation toward nature lies. Would a change of social hierarchy alone result in a sufficiently radical change of orientation or does society need to outgrow its current technological orientation, as is posited in the social theories of technology based on the work of Martin Heidegger and Jacques Ellul? Locating the center of gravity with technology, these theories of technology call for prescriptions that differ with other social theories. To use technology in a different way may call for a sea change for nature *and* material culture.

A related political issue is environmental justice. Some argue that it would take the resources of at least two more Earths to bring all people on this planet up to the standard of the developed nations. The environmental cost of the transformation of the Earth is borne disproportionately, both within and outside of the United States, by the poor, minorities, and women. Moreover the cost of environmental legislation often falls disproportionately on these groups, giving rise to a charge of elitism against environmentalists. Finally, those in developed countries who take modern conveniences for granted often callously disregard the genuine hardships suffered by those in developing countries where such technological relief is unavailable or inadequate. The challenge for environmental philosophy is to meet moral concerns for social justice and nature. What conditions are required to put a life of excellence within everyone's reach?

A Consequential Environmental Ethic?

What are the practical achievements of environmental ethics? While environmental ethics is not simply applied ethics (a body of traditional normative ethical theories is not being applied to specific ethical issues as is often the case in medical or business ethics), it is important to apply traditional theories of interhuman ethics to environmental problems in a secondary sense. Arguably the most valuable contributions to policy decisions have been made in terms of risk assessment and related issues (Shrader-Frechette 2002). Animal rights and liberation theories indirectly influence legislation such as the laboratory care and use of animals. Forest Service Employees for Environmental Ethics explicitly advances Leopold's land ethic in a quest for a new resource ethic; departments of natural resources, as they move toward ecosystem approaches of management, seem to be attentive to these discussions of Leopold and those philosophers influenced by him. More progressive hunting and fishing regulations sometimes mimic ecosystem processes by reducing the number of trophy animals harvested. Environmental philosophers have proven most effective publicly when they, like Rolston, listen and speak in intelligible ways to a broad spectrum of people including those in the fields of technical philosophy and science, activists, and ordinary people (Mitcham et al. 1999, Rolston 1993).

All major pieces of environmental legislation preceded the development of environmental ethics, and as yet there is no effective green party in the United States. In particular there is none inspired by philosophers. Environmental pragmatists criticize environmental ethics and environmental philosophy for missing opportunities to make significant contributions to policy because they are too impractical and dismissive of activism. In their view, environmental ethicists divert attention from actual environmental problems by being overly concerned with theoretical issues such as intrinsic value, whereas environmental philosophers do the same by concentrating on the impossible task of radical reform. Pragmatists urge philosophers to apply their unique abilities and resources to solving concrete environmental problems. Distinct problems, in their view, call for different approaches (ranging from the economic to the aesthetic); no single approach is the correct one. In fact, the same problem may require a solution that includes approaches from incompatible theoretical positions. Thus, as pluralists, they call for cooperation between environmental philosophers.

Although they would be wary of any absolutist tendencies, pragmatists also call for more cooperation between these philosophers and other kinds of, normally anthropocentric, reformist positions that have been developing simultaneously with the field. Some approaches are based on deeply held values, such as the difference between consumers and citizens, in conservative and liberal traditions in order to get people to change attitudes, behaviors, and polices toward nature. Others, such as environmental libertarianism, have developed free-market approaches to resolving environmental problems. This kind of thinking has been used to show that government subsidies to the forest service have been the impetus for much logging and road building that would not have otherwise occurred. More liberal economic approaches demonstrate that while the market is effective for resolving some environmental problems, it is limited with regard to ensuring environmental protection. Many of the market's shortcomings have to do with the limits of economic value, cost benefit analysis itself, or how ethically and scientifically sound solutions to environmental problems are ignored based on economic considerations (Sagoff 1984, Schmitz and Willott 2002). Alternatively green capitalism, in order to avoid ecological catastrophe, advocates government regulations and policies, such as "green taxes," that develop the economy in ecologically sustainable ways (Hawken, Lovins, and Lovins 1999, Thompson 1995).

Is an environmental ethic needed or is ecological prudence sufficient? Apart from meeting people's moral concerns with nature, many advocates argue that an environmental ethic is imperative in order to save the planet from catastrophe. Such pessimism invites detractors who contend that scientists and engineers are making progress with environmental problems and that some fears regarding the environment are unwarranted; moreover unfounded fear is cited as part of the problem (Baarschers 1996, Lomborg 2001, Simon 1995). Certainly informed debate, critical thinking, scientific literacy, and pragmatism are called for.

However even *if* some consensus were achieved and catastrophic outcomes could be ruled out safely, this debate is a diversion from a submerged but central environmental and ethical issue: Will a *saved planet* be worth living on? Those who would continue the technological project unimpeded except for refinements and adjustments are quite sanguine in their answer—often assuming that the indisputable early achievements of technology are analogous with later postmodern ones—whereas those concerned about survival are often covertly more concerned about the quality of human life. What level of environmental quality is correlatively important to the quality and excellence of human life? Where is nature's place in a technological setting? How *tamed* should nature be? Contemplating these questions requires the use of science, technology, ethics, and environmental ethics. These reflections will involve not only specialists, but also each and every person, in a public conversation that considers facts and fallacies, but ultimately ponders alternative visions of life. As Langdon Winner writes, "we can still ask, how are we living now as compared to how we want to live?" (Winner 1988, p. 163). Human beings need to reflect on whether to continue to seek prosperity and happiness entirely through affluence and goods provided by the technological project, or, alternatively, through a new engagement with, among other things that matter, the nonhuman world. In the former vision, the technological project is prudently modified to be environmentally sustainable and shared equally with all people, and nature is controlled as a mere resource and commodity. In the latter vision, nature plays a much greater role in a reformed technological setting.

Unreflective consensus threatens to subvert any substantive environmental ethic because most of the ethical claims of the natural world are overridden when they conflict with consumption as a way of life (Strong 1995). Quite often environmentalists and environmental academics want environmental protection and are attracted to affluence and full-scale technological development. Can both exist? Most people uneasily muddle ahead simply assuming they can. Humans need a vision that values the natural world and includes an understanding of why the planet is being transformed in the way that it is. Only then can people hope to attain some clarity with regard to the real environmental and social consequences of personal, collective, and material choices.

Environmental philosophers must remember the original environmental and cultural problems that caused them to reflect and measure their overall successes in terms of how far human culture has come in dispelling those concerns. In the early-twenty-first century, it is clear that the full autonomous, independent, and nonrelational character of nature has changed (McKibben 1989). Often in restoration work and matters concerning nature in urban settings, the questions are more clearly focused. Will nature be respected and celebrated as having dignity and a commanding presence, expressive of the larger natural and cultural world of particular places, and be correspondingly cared for in that way (will it have correlational rather than intrinsic value alone)? Or will nature be entirely demeaned as a mere resource for humans to control and modify for the convenience of consumption (Borgmann 1995; Higgs 2003)?

DAVID STRONG

SEE ALSO *Acid Mine Drainage; Biodiversity; Carson, Rachel; Dams; Deforestation and Desertification; Ecology; Engineering Ethics; Environmental Ethics; Environmentalism; Environmental Justice; Environmental Regulatory Agencies; Environmental Rights; Global Climate Change; Mining; National Parks; Nongovernmental Organizations; Oil; Pollution; Rain Forest; Scandinavian and Nordic Perspectives; Sierra Club; Thoreau, Henry David; United Nations Environmental Program; Waste; Water.*

BIBLIOGRAPHY

Abram, David. (1996). *The Spell of the Sensuous: Perception and Language in a More-Than-Human World.* New York: Pantheon Books.

Baarschers, William H. (1996). *Eco-Facts & Eco-Fiction: Understanding the Environmental Debate*. New York: Routledge.

Berry, Wendell. (1995). "The Obligation of Care." *Sierra* 80(5): 62–67, 101.

Borgmann, Albert. (1984). *Technology and the Character of Contemporary Life*. Chicago: University of Chicago Press.

Borgmann, Albert. (1995). "The Nature of Reality and the Reality of Nature." In *Reinventing Nature?: Responses to Postmodern Deconstructionism*, ed. Michael Soulé and Gary Lease. Washington, DC: Island Press.

Callicot, J. Baird. (1989). *In Defense of the Land Ethic*. Albany: State University of New York Press.

Carson, Rachel. (2002). *Silent Spring.* New York: Houghton Mifflin Mariner Books.

Fox, Warwick. (1995). *Toward a Transpersonal Ecology: The Context, Influence, Meaning, and Distinctiveness of the Deep Ecology Approach to Ecophilosophy*. Albany: State University of New York Press.

Goodpaster, Kenneth E. (1978). "On Being Morally Considerable." *Journal of Philosophy* 75(6): 308–325.

Hawken, Paul; Amory Lovins; and L. Hunter Lovins. (1999). *Natural Capitalism: Creating the Next Industrial Revolution*. Boston: Little, Brown.

Higgs, Eric. (2003). *Nature by Design: People, Natural Process, and Ecological Restoration*. Cambridge, MA: MIT Press.

Higgs, Eric; Andrew Light; and David Strong, eds. (2000). *Technology and the Good Life?* Chicago: University of Chicago Press.

Jamieson, Dale. (2003). *A Companion to Environmental Philosophy*. Oxford: Blackwell Publishers.

Kates, Robert W.; Billie Lee Turner; and William C. Clark. (1990). "The Great Transformation." In *The Earth As Transformed by Human Action,* eds. Billie Lee Turner, William C. Clark, Robert W. Kates, et al. Cambridge, UK: Cambridge University Press.

Leopold, Aldo. (2000 [1949]). *A Sand County Almanac and Sketches here and There*. Oxford: Oxford University Press.

Light, Andrew, and Eric Katz, eds. (1998). *Environmental Pragmatism*. London: Routledge Press.

Light, Andrew, and Holmes Rolston III, eds. (2002). *Environmental Ethics: An Anthology*. Oxford: Blackwell Publishers.

Lomborg, Bjørn. (2001). *The Skeptical Environmentalist: Measuring the Real State of the World*. Cambridge, UK: Cambridge University Press.

McKibben, Bill. (1989). *The End of Nature*. New York: Random House.

Mitcham, Carl; Marina Paola Banchetti-Robino; Don E. Marietta Jr.; and Lester Embree. (1999). *Research in Philosophy and Technology: Philosophies of the Environment and Technology*, Vol. 18. Stamford, CT: JAI Press.

Naess, Arne. (1973). "The Shallow and the Deep, Long-Range Ecology Movements." *Inquiry* 16: 95–100.

Nash, Roderick Frazier. (2001). *Wilderness and the American Mind,* 4th edition. New Haven, CT: Yale University Press.

Plumwood, Val. (1999). "Paths Beyond Human-Centeredness: Lessons from Liberation Struggles." In *An Invitation to Environmental Philosophy,* ed. Anthony Weston. New York: Oxford University Press.

Rolston III, Holmes. (1975). "Is There an Ecological Ethic?" *Ethics* 85: 93–109.

Rolston III, Holmes. (1993). *Conserving Natural Value*. New York: Columbia University Press.

Routley, Richard. (1973). "Is There a Need for a New, an Environmental Ethic?" *Proceedings of the XV World Congress of Philosophy* 1: 205–210. This author now publishes under the name Richard Sylvan.

Sagoff, Mark. (1984). *The Economy of the Earth*. Cambridge, UK: Cambridge University Press.

Schmitz, David, and Elizabeth Willott. (2002). *Environmental Ethics: What Really Matters, What Really Works*. Oxford: Oxford University Press.

Shrader-Frechette, Kristin. (2002). *Environmental Justice: Creating Equality, Reclaiming Democracy*. Oxford: Oxford University Press.

Simon, Julian L., ed. (1995). *The State of Humanity*. Cambridge, MA: Blackwell Publishers.

Singer, Peter. (1974). "All Animals Are Equal." *Philosophic Exchange* 1(5): 243–257.

Snyder, Gary. (2000). *The Gary Snyder Reader*. New York: Counterpoint Press.

Strong, David. (1995). *Crazy Mountains: Learning from Wilderness to Weigh Technology*. Albany: State University of New York Press.

Thompson, Paul S. (1995). *Spirit of the Soil: Agriculture and Environmental Ethics*. New York: Routledge.

Winner, Langdon. (1988). *The Whale and the Reactor: A Search for Limits in an Age of High Technology*. Chicago: The University of Chicago.

Zimmerman, Michael E.; J. Baird Callicot; George Sessions; et al., eds. (2000). *Environmental Philosophy: From Animal Rights to Radical Ecology*, 3rd edition. Upper Saddle River, NJ: Prentice-Hall.

ENVIRONMENTAL IMPACT ASSESSMENT

An environmental impact assessment (EIA) is a means for understanding the potential effects that a human action, especially a technological one, may have on the natural environment. It allows for the inclusion of environmental factors in making decisions by mandating a process for determining the range of environmental issues related to a particular action. The underlying assumption of an EIA is that all human activity has the potential to affect the environment to some degree, so that all major decisions should include environmental, as well as economic and political, factors. Understanding the potential environmental effects of an action helps policymakers choose which actions should proceed and which should not.

Many governments perform EIAs at the national, state, and local levels. Probably the best-known form of the EIA is the Environmental Impact Statement (EIS) of the United States government. The National Environmental Policy Act of 1969 (NEPA) mandates an EIS to accompany every major federal action or nonfederal action with significant federal involvement. NEPA tries to ensure that U.S. federal agencies give environmental factors the same consideration as other factors in decision making.

Most EIAs follow a process similar to the one mandated for the EIS. The first step is the preparation of an environmental assessment (EA) to determine whether the environmental impact of the action requires a complete EIS. The actual EIS begins by identifying issues and soliciting comments on the scope of the action, alternatives, and various impacts that the EIS should address. Then the lead agency collects and assimilates all the environmental information required for the EIS. In the United States, the Council on Environmental Quality (CEQ) regulations outline the recommended format for the EIS. The EIS must include public involvement throughout the process. All mitigation measures to address identified harms must be included in the EIS.

The primary problem of environmental impact assessments is that once the environmental factors have been analyzed there is little to force the actors to actually use the information in decision making. When the EIA is complete, the action can go forward regardless of any negative environmental consequences. In the case of the EIS, NEPA provides no enforcement provisions, though various court decisions have developed some such mechanisms. Decision makers are informed of potential environmental problems and can include environmental issues in making their decisions, but nothing requires them to nor is there any penalty for ignoring the environmental impact.

This is not to say that identifying environmental issues has no effect on the process. The fact that the information exists means it plays a role. Decision makers must elect to include or exclude it from their project. If they choose to ignore the information, others have a right to bring pressure on them. The identification of potential problems has sometimes motivated public criticism of planned actions and led to their rethinking. The existence of the information creates a better situation than not having the information at all.

FRANZ ALLEN FOLTZ

SEE ALSO *Environmental Regulation; Pollution; Waste; Water.*

BIBLIOGRAPHY

Sullivan, Thomas F. P. (2003). *Environmental Law Handbook*, 17th edition. Rockville, MD: Government Institutes.

INTERNET RESOURCE

Council on Environmental Quality. Available from http://www.whitehouse.gov/ceq/.

ENVIRONMENTALISM

Environmentalism is a broad term used to describe the ideology of social and political movements that emerged in the 1960s around concerns about pollution, population growth, the preservation of wilderness, endangered species, and other threatened non-renewable resources such as energy and mineral deposits. As such it is a vivid nexus for science, technology, and ethics interactions. Since the 1970s, environmentalism has proved to be one of the most powerful and successful of contemporary ideologies, although this very success has generated so many strains of environmentalist ideas as to threaten the meaningfulness of the term itself.

Intellectual Roots

Although modern environmentalism can be traced to multiple intellectual roots, in the United States there are three primary influences. The first are the U.S. romantic and transcendentalist movements, which found moral and artistic inspiration in the natural world. The greatest representative of these ideas is the nineteenth-century writer Henry David Thoreau (1817–1862), whose *Walden* (1854) uses the natural world as a philosophical vantage point from which to evaluate and criticize U.S. society and politics. From this tradition, which was developed by John Muir (1838–1914) and others, environmentalism gains a focus on the value of preserving wilderness and non-human species.

A second major intellectual source for environmentalism is the U.S. conservation tradition. The most important founders of this tradition are Theodore Roosevelt and his close adviser and the first head of the U.S. Forest Service, Gifford Pinchot (1865–1946). These and like minded progressive reformers from the early-twentieth century led a movement to regulate and conserve natural resources and preserve some spectacular wilderness areas as national parks. The overall concern of the conservation movement was to maintain a sustainable supply of natural resources for a growing economy, which was believed to be essential for the health of a democratic society. From this tradition, environmentalism has inherited concerns about sustainability, the impact of the economy on the natural world, and human equity and justice issues concerning the distribution of environmental benefits and risks.

A third intellectual source for environmentalism is found within the scientific community of the 1950s and 1960s, when scientists became alarmed by the worldwide impact of nuclear weapons use and testing, chemical pollution of the environment by modern economic activity, and the stress on the environment caused by the sharp growth in human population during the twentieth century. The three greatest representatives of this tradition are biologists who wrote highly popular and influential books that caused broad-based alarm about environmental problems, Rachel Carson (*Silent Spring* [1962]), Paul Ehrlich (*The Population Bomb* [1969]), and Barry Commoner (*The Closing Circle* [1971]). Inspired by such works, environmentalism has gained a focus on public health problems that grow from modern productive processes and military technology.

Although these three traditions are responses to different types of problems and have generated different sets of concerns, environmentalism weaves them loosely together. Environmentalist thinkers and organizations stress different strains of environmentalism, but concerns as disparate as wilderness preservation, reducing environmental pollution and addressing the health problems it causes, and evaluating and protesting the injustice of unequal environmental impacts of various public policies and economic activities on disadvantaged subgroups in U.S. society (such as the poor, or people of color), are all recognized as part of the environmentalist agenda.

Two key facts about environmentalism must be stressed. First it is simply one of the most remarkably successful of all contemporary social and political ideologies. What was a marginal set of concerns and views during the 1960s has become part of the social and political mainstream. Public opinion polls consistently demonstrate wide-ranging public support for environmentalist values and policies, even if the saliency of environmentalist concern is somewhat less than that found for other issues such as the economy. Not surprisingly, candidates from across the political spectrum have found it necessary to profess environmental values, even if there is reason at times to doubt their sincerity. The corporate world has discovered that it is increasingly good business to market products and services as *green, natural, organic,* or environmentally responsible. Academic disciplines, from law to ethics to the natural sciences to engineering to economics and beyond, have been influenced by environmentalist concerns and have developed sub-disciplines focusing on environmental issues. Vast rivers of private financial donations flow into the coffers of a variety of environmental organizations found on the local, national, and international levels. In short, in the course of a single generation, environmentalism has grown to be one of the most visible and important ideologies in contemporary life. Rarely has an ideology enjoyed this level of achievement in such a short period of time.

The second key fact to note is that this very success, coupled with the diverse intellectual roots that nourish it, has made the intellectual content of environmentalism ambiguous, perhaps even incoherent if one is looking to find a unified ideology.

Three Types of Environmentalism

In light of this ambiguity, it is helpful to divide the universe of environmentalist views into three broad categories. First *liberal* environmentalists think of environmental problems in the political and social context of conventional liberal ideals and social policy. Drawing primarily, but not only, on the conservation tradition, liberal environmentalists have been successful in promoting extensive environmental regulation of industry and other polluting activities. The environmental justice movement, as well as increased interest in applying the philosophical tools of pragmatic philosophy to the study of environmental ethics, are also fundamentally liberal developments in environmentalism; the first demands respect for liberal equity in the distribution of environmental risk, and the second draws on the liberal tradition of U.S. philosophical pragmatism in order to evaluate the ethical implications of particular human behaviors in relation to the natural world. Much of the growing field of environmental economics may also be included in the category of liberal environmentalism, because it applies conventional liberal economic principles and tools to the study of environmental policy. What liberal environmentalists share is a perspective that views environmental problems within the context of recognized liberal philosophical, political, and social values.

Radical environmentalism can be thought of as an array of environmentalist ideas that challenge the philosophical and political underpinnings of liberal democratic society. The greatest unifying theme among radical environmentalists is the insistence that the anthropocentrism of liberalism, the assumption that human beings are the source and measure of all value, be rejected in favor of a moral perspective more inclusive of values intrinsic to the non-human world, a view that is sometimes called biocentrism or ecocentrism. The claim is that conventional moral perspectives are incapable of appropriately appreciating non-human things, and therefore there is a need to discover fundamentally new ways of thinking about the natural world and its relationship to people. Beyond these claims, radical environmentalists quickly part company, pursuing a multitude of philosophical paths. Eco-feminists, for example, suggest that women have natural connections with and insights into nature that men are less likely to experience, and that are lost or suppressed within a patriarchal society; fighting patriarchy is therefore related to not only freeing women from men, but to the reconnection of human beings with nature more generally. Rather than emphasizing gender, deep ecologists promote what they understand to be more primal, unified understandings of the proper relationship of humans to the natural world than they find in modern social and political theory and practice. Social ecology, a form of eco-anarchism, claims that humans could naturally live in just, non-hierarchical social organizations, and that environmental problems grow out of and reflect the oppression of humans by humans in unjust, hierarchical societies. Some would include eco-socialists among radical environmentalists, because they promote a political vision contrary to contemporary liberal democracy. Not all radical environmentalists, however, believe the socialist political program is sufficiently biocentric to be truly radical or environmentalist.

As an illustration of the huge growth in the ideological power of environmentalism, the late-twentieth and early-twenty-first centuries began to see the emergence of new forms of *conservative* environmentalism. While it is true that there have always been conservation groups that have historically appealed primarily to hunters and other groups not conventionally thought to be liberal or radical, these have been on the margins of environmentalism. Historically, conservatives have more often than not been hostile to environmentalism, on the grounds that it threatened to over expand the government's regulatory powers (in the case of liberal environmentalism) or, even worse, that it attacked the moral foundations of conventional society (in the case of radical environmentalism). There is a new and growing *free market environmentalism*, however, that is attacking the liberal environmental regulatory programs, and defending private property rights and conventional capitalist economic organization as the best way to promote environmental health and resource conservation. There is also some growth of a less militantly free market conservative sympathy for environmentalism that emphasizes the continuity of community traditions and religious piety toward what is understood to be a created universe.

Conclusion

Beyond the U.S. context, environmentalism has become a powerful force throughout the world, both within other countries and in the international order. The diversity of environmentalist views explodes within this broader context, from the demands of indigenous peoples to control local ecosystems in the face of pressure by international markets and corporations, to the growth of Green political parties (most importantly and successfully in Germany), to the attempt to design international policies for contending with world-wide environmental issues such as global climate change, to attempts to address wildly inequitable resource allocation between the rich and poor, the developed and developing, nations. In different contexts, and with different aims and intentions, environmental politics has become a factor in local, national, and international politics, and as such contexts have proliferated, so too has the breadth of environmentalist ideology expanded almost beyond measure and clear focus.

Given this array of environmentalist views and projects, it is clear that the very notion of environmentalism is being stretched to include incompatible ideas. The single unifying theme, to the degree that it can be found, is simply the attention paid to the human relation to the natural world and the promotion of ideas and policies intended to protect the health and fecundity of nature.

In light of the diversity of environmentalist views, it is difficult to clearly assess the implications of this ideology for modern science, technology, and ethics. It is clear, for example, that there have been elements of misanthropy and hostility toward science and technology in some strains of radical environmentalism, a kind of primitivism that views modern society in all its facets as a plague on the natural world to be resisted, even turned back, as much as possible. It is also true, however, that this is a marginal set of attitudes even within the radical environmentalist camp. Radical environmentalism does indeed insist on an ethical reorientation toward non-human things, but this by no means always reflects misanthropic views. On the contrary, the claim more often includes a presumption that humans will find their lives more meaningful if they learn to live harmoniously with nature, that radical environmentalism is a positive good for both people and nature. Likewise, even while much radical environmentalism distrusts science and technology, it often draws heavily on the science of ecology to inform its own analysis of problems, and often promotes what it considers to be environmentally friendly technologies.

Liberal and conservative environmentalisms usually appeal to conventional ethical categories (for example, the weighing of public goods against individual rights), and tend to work within the conventions of mainstream science and technology to promote their ends. The debates they engage are more often about the proper balancing of environmental goods against other important values, than about the need for such a balance in the first place. Liberal environmentalism also tends to be committed to using modern science to closely evaluate the overall environmental impact of existing technologies, and to producing the most environmentally benign technologies currently feasible.

Although it is difficult to generalize about environmentalism, given the great diversity of ideas and concerns found within the movement, the very power and popularity of environmentalist ideas reflects a growing sensitivity to and concern about the natural world. While environmentalists often worry about different issues, from wilderness preservation to public health to social justice, and often see the world in different ways, from radical biocentrists to conservative free market advocates to almost an infinity of variations in between, environmentalism reflects a rich diversity of attempts to think seriously about the appropriate relationship between people and the rest of nature. It is clear, from the popularity of environmentalist ideas, that there is a broad and growing sense of the importance of this overall project.

BOB PEPPERMAN TAYLOR

SEE ALSO *Air; Carson, Rachel; Conservation and Preservation; Deforestation and Desertification; Earth; Environmental Ethics; Fuller, R. Buckminster; Rain Forest; Sierra Club; Sustainability and Sustainable Development; Thoreau, Henry David; United Nations Environmental Program; Water*.

BIBLIOGRAPHY

Anderson, Terry Lee, and Donald R. Leal. (2001). *Free Market Environmentalism Today*. New York: Palgrave. A good representative of the free market environmentalism literature.

Bliese, John. (2001). *The Greening of Conservative America*. Boulder, CO: Westview Press. An example of a conservative environmentalism that is distrustful of a simple faith in the free market.

Bookchin, Murray. (1982). *The Ecology of Freedom: The Emergence and Dissolution of Hierarchy*. Palo Alto, CA: Chesire Books. A classic social ecology text.

Dobson, Andrew. (1998). *Justice and the Environment*. Oxford and New York: Oxford University Press.

Guha, Ramachandra. (2000). *Environmentalism: A Global History*. New York: Oxford University Press.

Luke, Timothy. (1999). Urbana: University of Illinois Press. *Capitalism, Democracy and Ecology*. Luke weds environmentalism to a leftist populism.

Merchant, Carolyn. (1996). *Earthcare: Women and the Environment*. New York: Routledge. A historian's view of the relationship between women and the environment.

Norton, Bryan. (1991). *Toward Unity Among Environmentalists*. New York: Oxford University Press. Among the most sophisticated works in the pragmatic school of environmental ethics.

Sagoff, Mark. (1988). *The Economy of the Earth: Philosophy, Law and the Environment*. New York: Cambridge University Press. The best liberal critique of the use of cost benefit analysis as the primary tool of environmental policymaking.

Sessions, George, ed. (1995). *Deep Ecology for the Twenty-first Century*. Boston: Shambhala. A standard deep ecology text.

Taylor, Bob Pepperman. (1992). *Our Limits Transgressed: Environmental Political Thought in America*. Lawrence:

University Press of Kansas. A survey and discussion of some of the primary strains of environmental thought in the United States.

ENVIRONMENTAL JUSTICE

Environmental justice encompasses distributive and political justice to address the interlocking relationship between environmental issues and social justice. Environmental justice can include a myriad of struggles experienced by local communities whose concerns include protecting the environments where people live, work, play, and pray. A central focus is on the environmental burdens of modern industrial society including, but not limited to, issues of toxic waste, pollution, workplace hazards, and unequal environmental protection. Another focal point involves the equal political representation of diverse groups in environmental values and decision-making processes. Environmental justice has served to effectively criticize the inequitable distribution of environmental benefits and harms that can be associated with many technological developments, often employing science to identify and assess these benefits and harms.

Historical Emergence

Because many of these issues are tied to specific grassroots organizations and networks, environmental justice fundamentally pertains to a larger social phenomenon referred to as the environmental justice movement (EJM). The EJM emerged in the 1980s when people of color formed grassroots responses to the location of environmental burdens, particularly toxic waste facilities and point production pollution sources. Luke W. Cole and Sheila R. Foster (2001) identify six intersecting social movements as the undercurrents of the EJM: the civil rights movements, labor movements, Native American movements, the anti-toxic movement, movements in academic scholarship, and the mainstream environmental movement. Although not included in their six undercurrents, the women's movement must be considered a seventh tributary, because it serves as a historical linchpin to the sciences currently used in environmental justice cases and because 70 to 80 percent of grassroots leaders in the EJM are working-class women, many of them women of color.

As early as the work of Jane Addams (1860–1935) and Alice Hamilton (1869–1970), when Hull-House pushed bacteriology and the new sciences of toxicology and epidemiology into connections between health, environment, and politics, women have been critical to the scientific knowledge of the neighborhood. As a result, new methods of data collection and analysis were created by these early environmental reformists to improve the industrial living conditions of the modern city. The attention given to women's health issues and environmental dangers from industrialization carries a direct thread between Hull-House and the contemporary EJM. Contemporary science and policy agendas, like those found in the U.S. Superfund Act (the Comprehensive Environmental Response, Compensation, and Liability Act of 1980), were spawned by the activism of women such as Lois Gibbs in Love Canal, New York. Thus the early advances in toxicology and epidemiology were partly due to environmental justice struggles led by women, and from that time policies to address environmental justice have had their origins in the activism of these community leaders.

Other important precursors that relate to Cole and Foster's six movements are identifiable as early as the 1960s when Martin Luther King Jr. and other civil rights leaders observed that people of color suffer higher pollution and more denigrated environments. By the end of the 1970s a series of studies had again drawn the historical inference that different human environments are directly related to social stratification. In a chapter of their seminal book addressing environmental justice, *Race and the Incidence of Environmental Hazards*, Paul Mohai and Bunyan Bryant compare studies dating from 1971 to 1992 that assess the correlation of toxics, including air pollution, hazardous waste, solid waste, and pesticide poisoning, with the impact on people of low income and racial minorities (Mohai and Bryant 1992). Two critical findings from this comparative study are worth highlighting. First, the study clearly proves that government agencies observed the relationship between social stratification and environmental burdens as early as 1971. Second, the comparisons provide empirical evidence that in the United States the distribution of environmental burdens has a strong correlation to race and socioeconomic class.

In addition to the Mohai and Bryant comparative study, the federal government in 1978 released a brochure called *Our Common Concern* that described the disproportionate impact of pollution on people of color. The struggle of César Chávez and the United Farm Workers to protect the health, environment, and rights of farmworkers was a vital precursor to the environmental justice movement. Studies of rural Appalachian living conditions were revealing the connection between poverty and environmental burdens, providing further evidence of trends of environmental injustice. Environmental justice also pervaded the struggles of Native Americans dealing with issues stretching from land rights to the hazardous industries of uranium mining, coal mining, and nuclear waste depository.

Addressing shared interests in environmental justice, the City Care Conference, held in Detroit in 1979, was jointly sponsored by the National Urban League and the Sierra Club. The intended purpose of this conference was to bring the civil rights movement and the environmental movement together for a dialogue to reconceptualize the very meanings of the terms *environment* and *environmental issues*. By the late 1980s and early 1990s, *environmental justice* became a newly established term used by scholars and policymakers. "Environmental justice" was first used in book and article titles by 1990, and the first environmental justice college course was offered in 1995. The latter came a year after President Bill Clinton signed Executive Order 12898, titled "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," which introduced environmental justice as a federal mandate by White House fiat.

Founding Events

Although the EJM in the United States is not bound by a single event, many scholars and activists regard the 1982 protests in Warren County, North Carolina, as a historical launching point. These protests marked the first major civil rights–style response to an environmental issue. It involved nonviolent civil disobedience blocking trucks hauling PCB-laced soil from entering a newly placed toxic landfill, leading to over 500 arrests and drawing national media attention. The Afton site in Warren County prompted many questions about the direct correlation between African-American communities and hazardous waste sites. It incited District of Columbia Delegate Walter E. Fauntroy, who was himself arrested in the protest, to initiate the 1983 U.S. General Accounting Office study of hazardous waste landfill siting, which found a strong correlation between sitings of hazardous-waste landfills and race and socioeconomic status.

Fauntroy's study spawned later comprehensive studies, including the United Church of Christ's Commission for Racial Justice's frequently cited *Toxic Wastes and Race in the United States* (1987), a national study not only confirming the disparate environmental burdens suffered by minorities and lower socioeconomic groups nationwide, but also centrally locating race in the disparity: "Race proved to be the most significant among variables tested in association with the location of commercial hazardous waste facilities" (p. xiii). At the presentation of *Toxic Wastes and Race* to the National Press Club in 1987, Benjamin Chavis, then director of the United Church of Christ, described the phenomenon as: "racial discrimination in environmental policy making and the enforcement of regulations and laws, the deliberate targeting of people of color communities for toxic waste facilities, the official sanctioning of the life-threatening presence of poisons and pollutants in our communities, and the history of excluding people of color from leadership in the environmental movement" (U.S. House 1993, p. 4).

Environmental Racism

Numerous studies concerning what came to be called environmental racism followed. In 1992 Marianne Lavelle and Marcia Coyle published their seven-year study of the U.S. Environmental Protection Agency in the *National Law Journal,* which revealed that polluters were fined more in white communities, responses were slower in people of color communities, and scientific solutions differed between the communities. The same science that would be used to determine the toxicity of a facility to a community was used differently between white communities and minority communities. Likewise, the same science that would determine the technological and economic responses, such as the technology of soil washing or soil removal or the shutting down of the polluting facility itself, would be compared to the economic assessment of community relocation because the implications of dangerous conditions involve costly relocations that make the project too expensive. Lavelle and Coyle revealed that different technological solutions would be used when the same scientific data described the health threats to the community. The different responses follow the trend that white communities receive more expensive and updated technological solutions and also receive higher compensation for health and property damage, and that polluters pay greater fines for damages to white communities than to minority communities even though scientifically, with regard to the pollution, the circumstances do not warrant these dramatic differences.

Further sociological and legal studies responded to the environmental racism charges by addressing fundamental methodological questions: Did the community or the environmental burden arrive first? Are there other categories to consider, such as age? How should a community be defined? Vicki Been (1994) argues that market forces drive the location of toxic facilities and the choice of many workers to come to a highly industrial sector. Admitting of racism in many social institutions, Been's study challenges the main measuring units used by earlier studies and raises important temporal questions about the relationship between minorities and environmental burdens. Other studies that altered the measuring unit of what constitutes a community found less disparity in the distribution of environmental burdens with regard to race than was initially claimed by the earlier studies defending the environmental racism charge. Numerous studies responded to this debate, thus generating a community of scientists, scholars, and activists to help deepen the ethical questions and broaden the scope of environmental sciences. What are the proper characteristics for determining the community that will host the environmental burden? What procedures will be used? Which scientific perspectives would best measure the risk of danger? How will race and socioeconomic background be considered in these risk assessments?

Discriminatory Environmentalism

The ethical considerations of these questions pertain to the discrimination undermining distributive justice and fair compensation for health or property loss. While environmental racism is indicative of actions considered illegal under federal laws such as the Civil Rights Act of 1964 and the Fourteenth Amendment to the Constitution, environmental discrimination on the basis of socioeconomic factors is not specifically illegal. Ethically, however, fundamental principles of distributive justice are violated. Peter S. Wenz has studied the environmental racism debate as a form of double effect in which race may be incidental to the socioeconomic target (Wenz 2001). Even if the market forces argument is true, he argues, distributing the environmental burdens onto the poor violates the principle of commensurable benefits and burdens, which stipulates that unless there are morally justifiable reasons, persons receiving the benefits of modern industrial technology should also receive the commensurate burdens. Those who receive an abundance of consumer goods should therefore be the targets of hazardous waste facilities and polluting industries, whereas those who receive noticeably fewer benefits, the poor residents, should be relieved of this incommensurable burden. Compensatory justice would follow the same moral foundation for redistributing benefits for incommensurable burdens.

Environmental justice also pertains to the principles of equality that require respect for the basic rights of all individuals. The most pronounced right in environmental justice is the right to a safe environment, which has assignable duty holders in the public (government) and private (corporate) sectors. In addition, the principle of self-determination, which honors the autonomy of individuals and their moral capacities to direct the activities that impact them the most, is of vital importance in the participatory justice dimension of environmental justice. The principle of self-determination entails that citizens ought to participate in the process of siting hazardous waste, as well as the procedures for determining fair compensation. Direct political participation, however, is not available for many residents in the burden-affected neighborhoods. The environmental decision-making is typically made prior to the time when community members are able to voice their opinions in the public review-and-comment meetings that are standard political mechanisms in the siting process.

The lack of representation in the mainstream environmental movement or the vital decision-making sectors can be referred to as discriminatory environmentalism. In discriminatory environmentalism, representation and participation in mainstream environmental groups, participation in environmental policymaking, representation in federal, state, and local environmental agencies, and decision-making power over the location of environmental burdens and benefits are either intentionally or unintentionally exclusionary. Underrepresentation in the mainstream environmental movement is also a fundamental contention of injustice against political recognition and participatory justice. In an effort to establish a genuine voice that would better represent the environmental concerns of people of color in the United States, alternative environmental caucuses were created. Often highlighted is the First National People of Color Environmental Leadership Summit, held in Washington, DC, in 1991, which symbolizes two important foundations of the environmental justice movement. The summit represents the lack of political representation of people of color in the greater environmental movement, and it generated seventeen "Principles of Environmental Justice."

Discriminatory environmentalism also identifies the ways in which mainstream environmental ethics has considerably overlooked the poorest and most disenfranchised peoples of the world in its efforts to securely ground moral obligations to nonhuman nature. In particular, the biocentric and ecocentric approaches of land ethic philosophy and "deep ecology" received criticisms for discriminatory environmentalism. The Indian ecologist Ramachandra Guha (1989) argues that the broad-sweeping universalist claims of deep ecologists would cause further distribution of resources for biological protection and environmental improvement away from poor nations to the wealthy nations. Various expressions of misanthropy emerged from deep ecology, which served to undermine environmental struggles of the poor and failed to distinguish between those who hold institutional control over our resource use and those who are subjected to the worse side effects of resource depletion and consumption. By making all human responsible for ecological impacts, deep ecologists overlooked not only the dramatic distinctions between the rich and the poor, but also who has consumed and controlled the use of the natural resources.

Originators of the deep ecology philosophy fundamentally distinguished this non-anthropocentric ethic from "shallow forms" of environmentalism that reflected anthropocentric ethics directed at pollution, work place hazards, and public health. This distinction between anthropocentric (shallow) and non-anthropocentric (deep) environmental ethics overlooked the populations of people struggling with the intersection between shallow and deep ecology. An irony of the split between non-anthropocentric environmental ethics and anthropocentric environmental ethics—a split that is often used to characterize the EJM as a shallow environmentalism—is that while the Principles of Environmental Justice reflect a challenge to the discriminatory environmentalism of mainstream environmentalism in the 1990s, it also shares fundamental values that clearly echo deep ecological sentiments. The first principles states, "Environmental justice affirms the sacredness of Mother Earth, ecological unity and the interdependence of all species, and the right to be free from ecological destruction" (Lee 1992). Although the mainstream environmental movement maintains an affluent, white membership, many of the mainstream environmental groups, such as Greenpeace, Ancient Forest Rescue, and the Sierra Club, have addressed discriminatory environmentalism by fusing environmental justice dimensions to their respective environmental agendas.

Greater pollution, cumulative climatic impacts, and mass consumption of resources have tremendous environmental consequences for the poorest and marginalized populations in the world. Many technological advances have been introduced around the world as strategies for economic development; the introduction of technologies, however, does not necessarily entail the introduction of environmental safety. In 1969 Union Carbide Corporation expanded its global production of pesticides, specifically methyl isocyanate, to Bhopal in central India. A technological disaster occurred in 1984 when a chain reaction of pressure, leaking hydrogen cyanide, and other lethal chemicals exploded and enveloped 40 square kilometers with a poisonous cloud. Failure to maintain safety systems and poor community communication led to the deaths of more than 2,000 residents and over 200,000 further injuries in the region (Applegate, Laitos, and Campbell-Mohn 2000). This tragedy, the worst chemical disaster in world history, is linked directly with global environmental justice in terms of transnational corporate responsibility, distribution of the most dangerous products and conditions to the least well-off, and the violation of public participation in the environmental issues that most affect the local residents. According to S. Ravi Rajan (2001), the Bhopal disaster should be considered "technological violence" because design engineers and executives at Union Carbide decided against a common corporate practice of keeping methyl isocyanate storage tanks underground. The high storage capacity and aboveground tanks at Bhopal aggravated the potential dangers to the environment and local residents, and the failure to install common safety features, when greater safety was warranted under the design conditions, made the corporation accountable for the massive technological disaster. Sophisticated modern technology involved in chemical manufacturing and petrochemical production, and even systems such as those found in military and space programs, involve numerous technological and scientific uncertainties. Basic safety precautions do not address this range of possibilities, and the level of disaster that can follow accidents makes risk assessment a statistical gamble for the local residents.

The magnitude of technological disasters such as that in Bhopal, the global reach of transnational corporations, and the existence of a select group of powerful global scientists and policymakers has given global environmental justice a dramatic scope. Issues pertaining to indigenous land rights and compensation for damages from technological expansion fall directly under the study of environmental justice. New technologies such as genetically modified foods and the ability to acquire and patent the traditional environmental knowledge of indigenous people have emerged as environmental justice concerns. Compensation and donor policies between the global North and South, as well as the environmental and economic consequences of global trade agreements, spark the distributive and participatory justice dimensions of the EJM. Transcontinental pollution and environmental impacts to the global commons find their ethical implications in the EJM. And across the globe there are localized environmental justice movements, such as Japan's Soshisha movement to address victims of Minamata disease, a debilitating neurological disorder caused by the dumping of mercury oxide into the public water supply, or Nigeria's Movement for the Survival of the Ogoni People (MOSOP), struggling against military aggression in a region of petrochemical corporate neglect. All this provides evidence of the expansive scope of global environmental justice, which Lois Gibbs has declared to be the fastest-growing, largest social movement in the world.

Basic Issues

The environmental justice movement has generated a host of ethical questions regarding environmental benefits and technological advances: To what extent is industrial technology implicated in the underlying struggle for the fair distribution of environmental burdens? What is the appropriate relationship between scientific analysis and environmental policies? What technological solutions are available and to whom? How can environmental burdens and benefits be fairly distributed to Earth's populations? What kinds of risks and social conditions constitute an unfair distribution of environmental burdens?

The movement has also produced ethical questions concerning the fair representation and inclusion in the decision-making and social dynamics surrounding environmental hazards: Do marginalized groups receive their proper voice in the process that is likely to affect them the most? How are racial dynamics related to environmental decision-making and environmental harms? What role does gender play? Is it morally acceptable to environmentally discriminate against communities, such as working-class and poor neighborhoods, if it is legal? To what extent are all interests represented in the process? Is the process appropriate for understanding the social and scientific relationships, and the community perception of risk compared to the scientifically acceptable range of risk?

Environmental justice has given scholars and activists the tools to address the environmental conditions of social justice. A vocabulary and conceptual framework now exists to discuss the relationship between environmental values and institutional racism. The political underpinnings of dominant environmental movements are now more easily exposed by the lens of environmental justice. False distinctions between social problems and environmental problems, which caused the splintering of movements such as the civil rights movement and the environmental movement, are now confronted by environmental groups, civil rights groups, and the numerous grassroots groups that have formed to address environmental injustices in their communities. The movement has broadened the possible interpretations of justice itself by combining distributive justice with political justice and economic justice with cultural justice, under a new rubric of environmental empowerment for the least-well-off populations around the world. Indeed, the dimensions of nature and environment are being revised and transformed by the closer scrutiny that the environmental justice perspective entails. The contention that environmental justice brings new rigor to anthropocentric environmental ethics is an underestimation of the potential critique forged by environmental justice.

ROBERT MELCHIOR FIGUEROA

SEE ALSO *Environmental Ethics; Justice; Pollution; Race; Sierra Club; United Nations Environmental Program.*

BIBLIOGRAPHY

Applegate, John S.; Jan G. Laitos; and Celia Campbell-Mohn. (2000). *The Regulation of Toxic Substances and Hazardous Wastes*. New York: Foundation Press.

Been, Vicki. (1994). "Locally Undesirable Land Uses in Minority Neighborhoods: Disproportionate Siting or Market Dynamics?" *Yale Law Journal* 103(6): 1383–1422.

Cole, Luke W., and Sheila R. Foster. (2001). *From the Ground Up: Environmental Racism and the Rise of the Environmental Justice Movement*. New York: New York University Press.

Ferris, Deeohn, and David Hahn-Baker. (1995). "Environmentalist and Environmental Justice Policy." In *Environmental Justice: Issues, Policies, and Solutions*, ed. B. Bryant. Washington, DC: Island Press.

Gottlieb, Robert. (1993). *Forcing the Spring: The Transformation of the American Environmental Movement*. Washington, DC: Island Press. A revolutionary environmental history revealing various origins of the environmental justice movement and its early parallel path with the mainstream environmental movement.

Guha, Ramachandra. (1989). "Radical American Environmentalism and Wilderness Preservation: A Third World Critique." *Environmental Ethics* 11(1): 71–83.

Lavelle, Marianne, and Marcia Coyle. (1992). "Unequal Protections: The Racial Divide in Environmental Law." *National Law Journal* 15(3): S2.

Lee, Charles, ed. (1992). *Proceedings: The First National People of Color Environmental Leadership Summit*. New York: United Church of Christ, Commission for Racial Justice. A crucial moment in the environmental justice movement, and a defining document of the breadth and depth of the movement.

Mohai, Paul, and Bunyan Bryant. (1992). "Environmental Racism: Reviewing the Evidence." In *Race and the Incidence of Environmental Hazards*, ed. Bunyan Bryant and Paul Mohai. Boulder, CO: Westview Press. A seminal study of race and the disparate distribution of hazardous waste.

Rajan, S. Ravi. (2001). "Toward a Metaphysic of Environmental Violence: The Case of the Bhopal Gas Disaster." In *Violent Environments*, ed. Nancy Lee Peluso and Michael Watts. Ithaca, NY: Cornell University Press.

Schlosberg, David. (1999). *Environmental Justice and the New Pluralism: The Challenge of Difference for Environmentalism*. Oxford: Oxford University Press.

Shrader-Frechette, Kristin. (2002). *Environmental Justice: Creating Equality, Reclaiming Democracy*. Oxford: Oxford University Press.

United Church of Christ. Commission for Racial Justice. (1987). *Toxic Wastes and Race in the United States: A National Report on the Racial and Socio-economic Characteristics of Communities with Hazardous Waste Sites*. New York: Author. First national study of the correlation between race and class and the distribution of hazardous waste sites. Concluding that race plays the stronger role, this study sets off the environmental racism debate.

U.S. General Accounting Office. (1983). *Siting of Hazardous Waste Landfills and Their Correlation with Racial and Economic Status of Surrounding Communities*. Washington, DC: Author.

U.S. House. (1993). Committee on the Judiciary. Subcommittee on Civil and Constitutional Rights. *Environmental Justice: Hearings before the Subcommittee on Civil and Constitutional Rights of the Committee on the Judiciary*. 103rd Cong., 1st sess. A testimony of the environmental racism debate which influenced a number of federal and state agencies.

Wenz, Peter S. (1988). *Environmental Justice*. Albany: State University of New York Press. The first book titled "environmental justice."

Wenz, Peter S. (2001). "Just Garbage." In *Faces of Environmental Racism: Confronting Issues of Global Justice*, 2nd edition, ed. Laura Westra and Bill E. Lawson. Lanham, MD: Rowman and Littlefield.

ENVIRONMENTAL PROTECTION AGENCY

SEE *Environmental Regulation*.

ENVIRONMENTAL REGULATION

The regulation of human interactions with the environment has taken shape in various political institutions, policies, and market mechanisms that have evolved over time according to changes in social, cultural, and technological conditions. Forms of environmental regulation differ among nations and continue to emerge on the international level as industrialization and globalization create transboundary issues.

From the liberal or socialist perspective, in which the state is understood as a legitimate extension of the community, environmental regulation is regarded as a state activity representing effective public administration. But the conservative or libertarian perspective, in which the state should intervene as little as possible in the lives of its citizens, holds that market mechanisms or private agencies can provide environmental benefits more effectively. The complexity of environmental regulatory efforts also arises from questions about the proper role of scientific knowledge and various mechanisms for handling scientific uncertainty. Environmental regulation is a complex interdisciplinary effort involving ethical principles, political interests, scientific knowledge, and technological capacities. This broad scope of considerations ensures that several worldviews, with their attendant values and recommendations, will interact in regulatory efforts.

Environmental Regulation in the United States

The history of U.S. environmental and natural resource regulation can be categorized into three phases. The first phase, lasting roughly from 1780 to 1880, saw the evolution of legislation that promoted the settlement of the West and the extraction and use of its natural resources (Nelson 1995). Defining laws of this period are the General Land Ordinances of 1785 and 1787, the Homestead Act of 1862, the Mineral Lands Act of 1866, and the Timber Culture Act of 1873.

The success of western expansion spurred a second phase of environmental regulations. Generally termed the conservation movement, this period lasted from roughly the 1880s to the early 1960s. Policies of this period shifted the government's role from simply disposing of public lands to managing them. This management was informed by a philosophy of *wise use*, which held that resources should be managed for the greatest good, for the greatest number, for the longest time. This philosophy was enacted by a rising scientific elite, including Gifford Pinchot (1865–1946) and John Wesley Powell (1834–1902), who argued that the scientific management of natural resources must guide economic development in order to accomplish sustained yield and maximum efficiency. This placed the conservationists in conflict with John Muir (1838–1914) and other preservationists, who sought to maintain environments in their natural state (Caulfield 1989). The second phase witnessed the creation of the national park and national forest systems (for example, Yellowstone National Park in 1872; and the Organic Act [Forest Management Act] in 1897). The 1964 Wilderness Act, which sought to preserve pristine wilderness "untrammeled by man, where man himself is a visitor who does not remain," represents the culmination of this era.

The third phase marks the beginning of modern environmentalism, and received its greatest impetus from consciousness-raising works such as Rachel Carson's *Silent Spring* (1962) and Stewart Udall's (b. 1920) *Quiet Crisis* (1963). These books along with social changes wrought by modernizing technologies, industrialization, and urbanization triggered increased awareness of environmental problems and focused environmental policies on the regulation of air and water pollution, toxic chemicals, solid waste, and other impacts of the growing industries fueled by advances in science and technology. A later concern developed over global issues such as biodiversity and climate change. The modern environmental movement initiated an expanded role for the federal government in environmental regulation, which is especially evident in the major pieces of legislation passed in the 1970s: the National Environmental Policy Act in 1969; the creation of the Environmental Protection Agency (EPA) in 1970; Clean Air Act amendments in 1970 and 1977; the Clean Water Act in 1972 and amended in 1977; the Endangered Species Act in 1973; and the Toxic Substances Control Act in 1976.

By the end of the 1970s, federal and state governments had greatly expanded their environmental roles from public lands management to public health, industrial health and safety, agricultural development, and urban planning. The EPA took charge of a number of federal environmental responsibilities. Although independent of other federal agencies, the EPA is still a part of the executive branch and reports to the president. It operates within a context of other major federal agencies, including those housed under the Department of the Interior (DOI) (such as Fish and Wildlife Service, National Park Service, Bureau of Land Management, and Bureau of Reclamation) as well as the Department of Agriculture and the National Marine Fisheries Service. An enormous amount of regulatory activity continued to occur at the regional, state, and local levels. Governmental entities at every level have their own environmental regulations, constrained by the fact that they cannot defeat the purpose of federal regulations.

The 1980s, during the Ronald Reagan and George H. W. Bush presidencies, witnessed some weakening of environmental regulations, as an extension of more general deregulation policies that argued the inefficiencies of bureaucratic or command-and-control mechanisms as well as the need to perform cost-benefit analyses on regulatory activities. These changes were matched by the creation and strengthening of many nongovernmental organizations (NGOs) and other environmental activist and lobbying groups.

The Bill Clinton era (1992–2000) witnessed a modest revival of federal regulatory efforts. The George W. Bush presidency once again sought the de-federalization of environmental regulation as well as the more active extraction of energy resources on federal lands.

Other Nations and International Efforts

Other countries institutionalized environmental regulation by creating ministries of the environment (for example, Great Britain), or placed environmental responsibilities in existing ministries (such as West Germany). Eventually most European countries established environmental ministries, even though other ministries (such as agriculture, energy, or urban planning) continued to manage some environmental regulatory activities. Austria, France, Germany, Ireland, Italy, Sweden, and the United Kingdom eventually created more or less independent environmental regulatory agencies. At the European Union (EU) level, the European Environment Agency (EEA) is charged with generating and disseminating environmental information.

In Latin America, the process of introducing environmental regulation followed the European model. Until the 1990s, in many Central and South American countries there existed various national environmental commissions charged with coordinating different environmental protection activities. The 1992 Rio Conference (United Nations Conference on Environment and Development Earth Summit) provided an important impulse for administrative reforms in Latin America related to environmental protection and led to the creation of ministries of the environment throughout the Spanish- and Portuguese-speaking countries of the Americas.

As globalization continues, an increasing number of environmental problems present transboundary issues. Global climate change, invasive species and biodiversity, water use, and air and water pollution are just some of the problems that raise environmental regulation into the realm of international law and policy. The United

Nations has played a leading role in two of the more prominent instances of international collaboration around environmental issues. First, the UN Environment Programme established the international legal framework known as the Vienna Convention on the Protection of the Ozone Layer in 1985. This led to the Montreal Protocol on Substances that Deplete the Ozone Layer in 1987, which required industrialized countries to reduce their consumption of chemicals that harm the ozone layer. Second the United Nations Framework Convention on Climate Change (Framework) established in 1992 provides a forum for governments to gather and exchange information and adapt to the effects of climate change. An international meeting in Kyoto, Japan, held under the Framework, produced a document (the 1997 Kyoto Protocol) that established binding limitations on greenhouse gas emissions by developed nations. Russia's ratification of the protocol in 2004 fulfilled the participation requirements for developed nations, thus allowing the treaty to become effective.

However such international agreements generally just set basic guidelines that require domestic legislation. This is usually difficult to achieve, and in the case of the Kyoto protocol, monitoring compliance is complex and there is no international enforcement authority. Furthermore international negotiations usually involve several governmental bodies, such as agencies, ministries or departments. For example, the State Department (not the EPA) controls U.S. involvement in international climate negotiations. The proliferation of bureaucratic agencies can create political gridlock.

Types of Environmental Regulation

Environmental regulation is plagued by two intrinsic challenges. First, because many environmental regulations involve the protection of public (common) goods, they often conflict with individual rights (especially property rights). Second, environmental problems often occur over long time periods and wide physical areas, whereas most individuals involved in regulatory processes have short-range, narrow interests, especially concerning economic growth. For both reasons, traditional environmental regulations usually entailed the implementation of strict controls on the otherwise unrestrained expression of personal and economic interests in the free market. As John Baden and Richard Stroup point out:

> The dawn of the environmental movement coincided with an increased skepticism of private property rights and the market. Many citizen activists blamed self-interest and the institutions that permit its expression for our environmental and natural resource crises. From there it was a short step to the conclusion that management by professional public "servants," or bureaucrats, would significantly ameliorate the problems identified in the celebrations accompanying Earth Day 1970. (Baden and Stroup 1981, p. v)

What followed during the 1970s was a command-and-control approach to environmental regulation, wherein the government set strict legal limits and enforced sanctions against violators.

Although this top-down and sometimes heavy-handed approach resulted in important successes, it also revealed a crucial element of regulatory practices: There are governmental failures just as there are market failures. Several reasons for governmental failures exist. Bureaucrats, like all people, are self-interested, and when governmental structures are not designed to link authority with responsibility for program outcomes, "decision makers have few incentives to consider the full social costs of their actions" (Baden and Stroup 1981, p. v). Furthermore decision makers have only a limited capacity to comprehend complex social and environmental interactions, which can limit their ability to make wise regulatory decisions.

One response has been to improve the structure of government, but another reaction has been to improve the structure of markets by implementing what Terry Anderson and Donald Leal term *Free Market Environmentalism* (1991). The underlying philosophy of this regulatory approach is that markets and environmental concerns can be made compatible by internalizing costs and establishing the proper incentives. This perspective also challenges the common assumption that environmental degradation is inherently linked to economic growth. It should also be noted that the relationship between environmental regulations and job loss or economic downturns is controversial, and no such correlation may exist (Goodstein 1999).

Anderson and Leal claim that the approach of free market environmentalism is founded on a core assumption of human nature: Humans are self-interested. They write, "Instead of intentions, good resource stewardship depends on how well social institutions harness self-interest through individual incentives" (Anderson and Leal 1991, p. 4). Examples of utilizing market mechanisms for environmental regulations include green taxes, marketable emissions permits (for example, cap-and-trade systems), and the elimination of harmful government subsidies.

Command-and-control and free market regulatory strategies are not incompatible and can often be used in conjunction to achieve desired environmental outcomes. Free market mechanisms obviously also have social dimensions insofar as they influence levels of public service, consumer rights, minority interests, and more. Social regulations likewise have economic implications in that they provide a framework within which economic activities can take place. Public or private institutions may advocate for both types of regulation. At the public level, environmental agencies such as the EPA are often subject to enormous political pressures that can complicate their mission and even compromise their integrity (Landy, Roberts, and Thomas 1994).

Many environmental regulations involve statutes, which often include a citizen suit provision or other appeals procedures that allow citizens to challenge an agency's action (or inaction) when it appears to be out of compliance with the law. In the United States, suit can also be filed under the Administrative Procedures Act, which is another mechanism for holding federal employees and agencies accountable for properly exercising their authority. Many environmental statutes specify the basis on which decisions must be made. In the United States, public input at the scoping stage is usually mandatory, and notice and comment periods through the Federal Register are always required. Some statutes require protection of the environment, while others focus primarily on human health. Some mandate cost-benefit analysis, while others call for decisions based on the best available science alone, with no consideration given to economic cost.

Science and Environmental Regulation

For all environmental problems, a certain amount of scientific understanding of natural systems and their interaction with human social systems is a necessary component of any regulatory action. This partially explains the preeminent importance of scientific advice in the crafting of environmental regulation or *science for policy*. The role of scientific expert knowledge is independent of the type of administrative process. Establishing an independent agency raises further questions of democratic legitimacy and accountability. This is true especially in relation to the problems of scientific advisers turning into policy makers and policy makers delaying action while continuing to fund more scientific research (Jasanoff 1990).

In theory, the process of environmental regulation depends on two factors: the definition (by democratically legitimized institutions) of the public goods to be protected, including the degree and costs of protection; and the scientific knowledge necessary to determine how an action may impact those public goods. But it is erroneous to assume that these two factors alone define the regulatory framework. Also, in this view, moral and political considerations play a role only during the definition of regulatory aims; and the justification for adopting certain regulations is based solely on expert knowledge. However, as regulatory practice demonstrates, this position has to be complemented by other considerations, because the facts and values components of environmental regulations are engaged in an iterative dialectic.

The different regulatory approaches created to safeguard public health and the environment from the effects of a large number of technological applications have stimulated new kinds of scientific activity, among them environmental impact and risk assessment. The scientific evaluation of risks and impacts has spawned various types of cost-benefit and risk-cost-benefit analyses (National Research Council 1996). These management tools permit a limited comparison of the environmental and economical effects of various alternative technologies and production processes, as well as different regulatory approaches. They can also be used to analyze risk-tradeoffs, where the regulation itself may lead to the emergence of other risks and negative impacts.

The Role of Science

Such predictive models are often limited by lack of data and the impossibility of modeling complex, higher-order interactions. For example, identifying the environmental impacts and risks presented by a chemical substance is made difficult by long term, cumulative interactions (sometimes called the *cocktail effect*) that cannot be mimicked in a laboratory setting. In some cases, the environmental degradation may be patent but establishing the pertinent causal relations may nevertheless be extremely difficult. In the case of global climate change, this type of persistent uncertainty has tended to sidetrack political discussion and hamper the process of producing alternatives for decision makers and stakeholders. So, even though scientific understanding is indispensable, it is not the only ingredient in formulating and implementing sound environmental regulations. There are very few instances where science provides enough clarification to clear away politically charged, open-ended environmental problems. This has led some policy analysts such as Daniel Sarewitz (2004) to suggest that the values bases of disputes must be fully articulated and adjudicated before science can play an effective role in resolving environmental problems.

Scientific investigation is certainly crucial to crafting wise regulations, but also presents several challenges (Cranor 1993). First is the issue of burden of proof. Generating all the necessary scientific information can be a time and resource intensive task. This can delay any decision, which in turn means that a harmful activity continues unregulated. In such case, putting the burden of proof on those who try to demonstrate that an environmental impact indeed exists tends to favor the environmentally harmful activity instead of the protection of the environment. This situation has led those social groups most concerned about environmental protection to demand, at least for certain technologies, the inversion of the burden of proof (that is, the need for demonstrating the absence of important environmental impacts).

A related problem concerns the standards of proof, which determine if a technological activity is harmful for the environment or human health. A number of factors can make environmental risk and impact analysis a very complex activity. If standards are rigorous, regulatory action may be excessively delayed. The debate on global warming and its relation to the emission of greenhouse gases provides a good example. In many cases it may be more effective for the protection of the environment to synthesize all available information from different sources and make decisions based on cumulative weight instead of trying to identify and quantify with precision any single environmental impact or risk. This highlights the fact that the choice of a standard of proof is as much a political and ethical dilemma as a scientific question (Shrader-Frechette 1994).

A third problem is the indeterminacy that is inherent in any environmental impact or risk assessment (Wynne 1992). Indeterminacy can only be reduced through methodological choices (for instance, about different available mathematical models that establish the relationship between the presence of a substance and environmental effects). Any choice that affects the scientific methodology leads either to an increase of false positives (reaching the conclusion that the activity is harmful for the environment even though it is not) or of false negatives (reaching the conclusion that the activity is not harmful even though it is). In other words, any methodological choice has important regulatory consequences. This leads inevitably to the conclusion that scientists must take into account the consequences of the methodologies they choose, while society and decision makers must be aware of the uncertainties inherent in scientific knowledge about impacts and risks (Funtowicz and Ravetz 1992).

Since the 1990s, an important field in the debates on environmental regulation has focused on the so-called precautionary principle, proposed by some environmentalists as a means to face those problems posed by scientific uncertainties regarding environmental impacts (Raffensperger and Tickner 1999). A number of agreements and international treaties have adopted this principle. However, so far no commonly accepted definition exists. One of the more popular definitions is the one to be found in the 1992 Rio Declaration on Environment and Development: "Where there are threats of serious irreversible damage, lacks of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." Besides the discussion about its definition, there also exists a debate about when to invoke the precautionary principle, about its general meaning as well as its scope.

A Typology of Worldviews

John Dryzek and James Lester (1989) have created a typology of environmental worldviews that serves as one way of organizing the variety of problem definitions and prescriptions for regulatory policies and institutions. Six worldviews are distinguished according to their particular blend of two different dimensions: the locus of value (individuals, anthropocentric communities, or biocentric communities) and the locus of solutions (centralized or decentralized). Each worldview thus supports different policy recommendations.

The first three worldviews all agree that solutions must be centralized. First are the *Hobbesians and structural reformers*, who believe in modern liberal individualism, but argue that it must be checked by a certain degree of political centralization. This is still the dominant worldview, and most of its adherents are moderates, convinced that "more laws to regulate polluters, more funds for enforcement, and minor structural reforms" will suffice (Dryzek and Lester 1989, p. 318). Second are the *guardians*, who still value centralization, but argue that an elite group of scientific and technical experts should monopolize power. Examples include Alvin Weinberg's proposal to create a *permanent priesthood* of nuclear technologists to oversee energy systems and William Ophul's *class of ecological mandarins*. The third group of centralizers is the *reform ecologists*, who argue that ecological values must be represented in the highest echelons of government. Reform ecologists (for example, Eugene Odum, Paul Ehrlich, and Lester

Brown) are usually less concerned with the structure of political and economic institutions than with their scientifically defended ecocentric values.

The other three worldviews find the locus of solutions in decentralization. First are the *free market conservatives,* who, like Anderson and Leal, believe that government intervention in environmental problems has gone too far and self-regulating market systems can work much better. Second are the *social ecologists*, who base their decentralized vision not on the market but rather on the ideal of a cooperative community. Murray Bookchin represents the main stem of this worldview, but it also applies to ecofeminists and other groups that call for classless, stateless, and decentralized societies far removed from capitalism. Finally the *deep ecologists* take little interest in human communities (like the reform ecologists) and stress the importance of the realization of the self within the greater *Self* of the biotic community. Although it can verge on misanthropic antipolitics, deep ecology is also represented by such luminaries as Henry David Thoreau and Aldo Leopold and other insightful theorists such as Arne Naess, Bill Devall, and George Sessions.

Although not without its gaps and ambiguities, Dryzek and Lester's typology can be used as a heuristic to organize the complex and contested nature of environmental regulations. It captures the various roles that science can play (for instance, informing modest reforms or monopolizing entire discourses) according to the dominant worldview in the particular topic. It distinguishes between various forms of centralized and decentralized regulations. The typology also hints at the alternative futures that can occur as worldviews rise and fall from social and political dominance, thus leading to different regulatory mechanisms and philosophies. Finally it highlights the constructed nature of reality as participants bring different worldviews to the political agenda, which in turn opens up the dialogue over which values ought to be represented and which regulatory mechanisms can best deliver the valued outcomes.

JOSÉ LUIS LUJÁN
ADAM BRIGGLE

SEE ALSO *Environmental Ethics; National Parks; Pollution; Regulation; Science, Technology, and Law; United Nations Environmental Program; Waste.*

BIBLIOGRAPHY

Anderson, Terry, and Donald Leal. (1991). *Free Market Environmentalism*. San Francisco: Westview Press. The first comprehensive treatment of the idea that free markets can achieve environmental goals.

Anderson, Terry, and Donald Leal. (1997). *Enviro-Capitalists: Doing Good While Doing Well.* Lanham, MD: Rowman & Littlefield. An updated version of the central idea that free markets and environmentalism are not fundamentally antagonistic.

Baden, John, and Richard Stroup. (1981). *Bureaucracy vs. Environment: The Environmental Costs of Bureaucratic Governance*. Ann Arbor: University of Michigan Press. Outlines the failures of bureaucratic solutions to environmental problems and offers suggestions for reforms based on aligning incentives with valued outcomes.

Brunner, Ron; Toddi A. Steelman; Lindy Coe-Juell; et al. (2005). *Adaptive Governance: Integrating Natural Resource Science, Decision Making and Policy*. New York: Columbia University Press. Focuses on community-based initiatives to overcome the gridlock that can ensue from scientific management.

Caulfield, Henry. (1989). "The Conservation and Environmental Movements: An Historical Analysis." In *Environmental Politics and Policy: Theories and Evidence,* ed. James Lester. London: Duke University Press. Utilizes elite theory to explain the evolution of political movements and provides a historical analysis of these two movements.

Carson, Rachel. (1962). *Silent Spring*. Boston: Houghton Mifflin.

Cranor, Carl. (1993). *Regulating Toxic Substances: A Philosophy of Science and the Law*. New York: Oxford University Press. A detailed analysis of the political dimension of the epistemological characteristics of scientific research on impacts and risks. Its main focus is U.S. regulatory agencies.

Davis, Charles, and James Lester. (1989). "Federalism and Environmental Policy." In *Environmental Politics and Policy: Theories and Evidence,* ed. James Lester. London: Duke University Press. Contends that a state's ability to implement environmental programs depends on its institutional capacity and its degree of dependence on federal grants.

Dryzek, John, and James Lester. (1989). "Alternative Views of the Environmental Problematic." In *Environmental Politics and Policy: Theories and Evidence*, ed. James Lester. London: Duke University Press. Creates a typology of world views based on locus of value and locus of solutions.

Funtowicz, Silvio O., and Jerome R. Ravetz. (1992). "Three Types of Risk Assessment and the Emergence of Post-Normal Science." In *Social Theories of Risk,* ed. Sheldon Krimsky and Dominic Golding. West Port, CT: Praeger. In order to manage the uncertainty inherent in environmental risk assessment, especially in the case of global environmental risks, the authors propose the introduction of a methodologically diverse science, the so-called post-normal science, based on an extended peer community.

Goodstein, Eban. (1999). *The Trade-Off Myth: Fact and Fiction about Jobs and the Environment*. Washington, DC: Island Press. Argues that there is no jobs-environment trade-off.

Jasanoff, Sheila. (1990). *The Fifth Branch: Science Advisers as Policymakers*. Cambridge, MA: Harvard University Press.

An analysis of the policy role of science advisers in the United States, especially in the case of agencies such as the EPA or the Food and Drug Administration (FDA).

Landy, Marc; Marc Roberts; and Stephen Thomas. (1994). *The Environmental Protection Agency: Asking the Wrong Questions: From Nixon to Clinton*. Oxford: Oxford University Press.

Lash, Scott; Bronislaw Szerszynski; and Brian Wynne. (1996). *Risk, Environment & Modernity: Towards a New Ecology*. London: Sage Publications. Includes several articles of European scholars on the concept of risk society.

National Research Council. (1996). *Understanding Risk: Informing Decisions in a Democratic Society*. Washington, DC: National Academy Press. An analysis of the characterization of risk that defends a very broad definition of this concept.

Nelson, Robert. (1995). *Public Lands and Private Rights: The Failures of Scientific Management*. Lanham, MD: Rowman & Littlefield. Provides historical context for U.S. public land management debates. The first chapter examines the unexpected consequences of early public land laws.

Raffensperger, Carolyn, and Joel Tickner, eds. (1999). *Protecting Public Health & the Environment: Implementing the Precautionary Principle*. Washington, DC: Island Press. Includes a number of analyses of different aspects of the precautionary principle.

Sarewitz, Daniel. (2004). "How Science Makes Environmental Controversies Worse." *Environmental Science and Policy* 7(5): 385–403. Explains why environmental problems tend to become *scientized,* and offers some recommendations for improved decision making.

Shrader-Frechette, Kristin. (1994). *Ethics of Scientific Research*. Lanham, MD: Rowman & Littlefield. A study of ethical science-related problems, with special attention to the analysis of scientific knowledge in the area of environmental regulation.

Tesh, Sylvia Noble. (2000). *Uncertain Hazards: Environmental Activists and Scientific Proof*. Ithaca, NY: Cornell University Press. Shows the ways in which pressure exerted by activist groups leads to changes in scientific research on impacts and risks.

Udall, Stewart. (1963). *Quiet Crisis*. New York: Holt, Rinehart, and Winston.

Wynne, Brian. (1992). "Uncertainty and Environmental Learning: Reconceiving Science and Policy in the Preventive Paradigm." In *Global Environmental Change* 2(2): 111–127. An analysis of the indeterminacy in environmental risk assessment, as well as its consequences for environmental policy.

ENVIRONMENTAL RIGHTS

Often referred to as part of the *third generation* of human rights, the concept of environmental rights is unclear in meaning and content. Environmental rights are elusive because there is no universal definition, and they are controversial because they hybridize the ecocentric perspectives of environmentalists and the anthropocentric perspectives dominant among human rights activists (Apple 2004). No binding international agreement has had environmental rights as its primary focus because such rights fail to fit neatly into either of these two groups. This fact combined with the scarcity of binding international legal instruments has prevented environmental rights from becoming international law. Nonetheless progress on defining and enforcing environmental rights continues on the international, regional, and national levels.

Background

Throughout the late-1950s and early-1960s serious environmental disasters occurred in various regions of the world: oil spills at sea (for example, the tanker *Torrey Canyon* in the English Channel in 1967), the release of toxic substances from chemical industries (such as mercury in Minamata Bay, Japan, in 1968), and nuclear disasters (for instance, the nuclear center Kytchym, in the former Soviet Union, in 1957). Such accidents, repeated over the years, demonstrated the dangers of incorporating technology into human activity without including some regulation. People also became increasingly aware of risks to human health and the environment due to high-tech industrial and agricultural activities. Emblematic of this concern was Rachel Carson's *Silent Spring* (1962), which argued the presence and persistence of toxic substances in living organisms as a consequence of the massive use of pesticides.

Legal measures to control unhealthy and dangerous activities and to protect the environment from the abuses of human intervention followed. In 1970, on the date of the first Earth Day celebration, the U.S. government enacted the National Environmental Policy Act, which submitted major development projects to environmental review. Since then laws concerning the environment have multiplied around the world.

Many in the ecological and human rights movements argued that these legal measures were insufficient to guarantee a healthy environment for present and future generations. Some proposed the proclaiming a new human right: the right to a healthy environment. This right does not fit within the category of civil and political or *first generation* rights, nor of economic, social, and cultural or *second generation* rights. For this reason environmental rights (along with others, such as rights to development) are sometimes described as *third generation* rights. Just as the first generation aspired to guarantee individual liberties, and the second equality, the third aims to guarantee solidarity across national boundaries and between present and future generations. Third generation human rights are conceived as collective rather than individual, and they tend to challenge the sovereignty of the modern nation-state.

Formulations at Different Political Levels

The appearance and development of the right to a healthy environment is traceable on three levels: global, through three world conferences on the environment organized by the United Nations; regional, through some agreements on the subject of human rights; and national, through the inclusion of environmental rights in the constitutions of some countries. (Rachel Carson had in fact proposed consideration of an amendment to the U.S. Constitution guaranteeing the right to a clean environment.)

GLOBAL. During the First World Conference on Human Development (Stockholm 1972), the Declaration of the Human Environment was approved, proclaiming the right to a clean environment for the first time at the international level: “Man has the fundamental right to freedom, equality, and adequate conditions of life, in an environment of a quality that permits a life of dignity and well-being, and he bears a solemn responsibility to protect and improve the environment for the present and future generations” (principle 1). This was followed ten years later by the U.N. World Charter for Nature (1982), which proclaimed that, in recognition of the fact that humankind is part of nature, “Nature shall be respected and its essential processes shall not be impaired” (principle 1).

Twenty years after the Stockholm meeting the World Conference on the Environment and Development, known as the Earth Summit, took place in Rio de Janeiro. One of the documents approved at this conference was the Declaration of Rio, which affirmed: “The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations” (principle 3). The declaration accepted the idea of sustainable development, a concept that had been defined by the World Commission on the Environment and Development in *Our Common Future* (1987) as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” The 2002 Johannesburg Summit unfortunately had neither the level of state participation nor world impact of the two prior conferences.

REGIONAL. Environmental rights are mentioned more explicitly at the regional level. In 1981 the African Charter on Human and People’s Rights was approved in Banjul, Gambia, West Africa. The charter states: “All peoples shall have the right to a general satisfactory environment favorable to their development” (article 24). Similarly the additional protocol to the American Convention on Human Rights in the area of economic, social, and cultural rights, the Protocol of San Salvador (1988), affirms in article 11 that (1) Everyone shall have the right to live in a healthy environment and to have access to basic public services; and (2) The States’ Parties shall promote the protection, preservation, and improvement of the environment.

In Europe the 1950 European Convention on Human Rights did not include environmental rights. Nevertheless the European Tribunal on Human Rights has included demands for the protection of the environment in some of the articles from the European Convention on Human Rights, such as the right to private and family life (article 8) and the right to information (article 11).

Also in Europe another important advance came in the form of the Aarhus Convention on Access to Information, Public Participation in Decision-making, and Access to Justice in Environmental Matters. Negotiated by the UN Economic Commission for Europe (UNECE), it was adopted in 1998 and implemented on October 30, 2001. Its first article expresses the object of the convention: “In order to contribute to the protection of the right of every person of present and future generations to live in an environment adequate to his or her health and well-being, each Party shall guarantee the rights of access to information, public participation in decision-making, and access to justice in environmental matters in accordance with the provisions of the Convention.”

NATIONAL. At the national level are many constitutions passed in the seventies and eighties that include a mention of human rights to a sound environment. But those references do not specify jurisdictional guarantees, so some authors deny that they are real rights and consider them only as guidelines for the public powers.

Characteristics of Environmental Rights

There is no consensus on how to define environmental rights. First, it is difficult to define the environment: Is it physical, social, cultural, or all of these? Does it pertain only to nature or also to urban spaces, workplaces, and homes? Second, there is debate as to whether the holders of these rights are individuals, contemporary human communities, future generations, or even ecosystems. Third, there is no agreement about whether environmental rights can be exercised before a juridical organ or simply constitute a mandate to public powers that they develop policies to protect the environment. Finally, doubts arise as to whether environmental rights can also involve duties, as has been proclaimed in some constitutions.

Environmental rights present a challenge to the concept of human rights as they are formulated in the early-twenty-first century. Seriously considering the grant of these rights questions the modern world model that promotes unlimited growth for the rich and permits unjust environmental burdens on the poor, both within countries as well as among different nations. The concept may even be interpreted as challenging the assumed hierarchy of humans over nature that underlies so much economic and social activity.

Environmental rights have a double dimension: juridical and political. The strictly juridical can be narrowed down to a set of powers that individuals or communities can exercise: the right to participate in the making of development policies, the right to information on environmental matters, the right to access tribunals in order to make demands in matters related to the environment, and the right to environmental education. In the United States a number of parties have sued multinational corporations for environmental rights abuses under a federal statute, the Alien Tort Claims Act (ATCA). While the ATCA has been used successfully to prosecute first generation human rights abuses (torture, for example), it has not provided a legitimate basis for environmental rights claims. Environmental wrongs resulting in human harm are not interpreted as violations of international law in the early-twenty-first century (Apple 2004). The applicability of ATCA to non-state actors such as corporations also remains unclear.

The political dimension of environmental rights has both a national and international manifestation. At the national level it involves assuring that political leaders take action to protect and promote the environment. At the international level it extends to the set of endeavors that states undertake in order to achieve sustainable and shared development for the entire world. Environmental rights not only aspire to preserve nature, but also to achieve the conditions necessary for a more just and healthy life for all persons and all peoples on Earth.

Such broad ambitions, however, contribute to the ambiguity of the concept and hinder attempts to realize these goals in particular contexts. Jorge Daniel Taillant (2004) argues that it is unclear whether the term environmental rights refers to human rights with respect to the environment, the human obligation to respect nature for its own sake, or something else. He contends that a conceptual framework based on development and more traditional forms of human rights, rather than environmental rights, can bring better practical results.

Assessment

Any assessment of environmental rights in relation to science, technology, and ethics must recognize the tenuous status of even first and second generation human rights. The Universal Declaration of Human Rights itself is simply a declaration that establishes a common standard, urging individuals and organizations to strive to promote respect for human rights and freedoms. However there do exist many environmental treaties that have well-defined, binding clauses, such as the Law of the Sea Treaty. The extent to which such environmental treaties influence the governance of science and technology is a subject deserving of further examination and development.

VICENTE BELLVER CAPELLA
TRANSLATED BY JAMES A. LYNCH

SEE ALSO *Environmental Ethics; Environmental Justice; Environmental Regulation; Human Rights.*

BIBLIOGRAPHY

Bellver Capella, Vicente. (1994). *Ecología: de las razones a los derechos* [Ecology: From reasons to rights]. Granada: Comares. Analyzes the relevance of ecophilosophies in the configuration of the human right to the environment.

Jordano Fraga, Jesús. (1994). *La protección del derecho al medio ambiente* [The protection of the right to the environment]. Barcelona: Bosch.

Kiss, Alexandre, and Shelton, Dinah. (2003). *International Environmental Law.* Ardsley, NY: Transnational Publisher.

Loperena Rota, Demetrio. (1994). *El derecho al medio ambiente adecuado* [The right to a sound environment]. Madrid: Civitas. The author maintains that the human right to a sound environment is not only a principle to inform the political activity but a right in the strict sense of the term.

INTERNET RESOURCES

Apple, Betsy. (2004). "Commentary on the 'Enforceability of Environmental Rights.'" Carnegie Council on Ethics and International Affairs. Available from http://www.carnegiecouncil.org/viewMedia.php/prmTemplateID/8/prmID/4464.

Taillant, Jorge Daniel. (2004). "A Nascent Agenda for the Americas." Carnegie Council on Ethics and International Affairs. Available from http://www.carnegiecouncil.org/viewMedia.php/prmTemplateID/8/prmID/4461.

EPIDEMIOLOGY

Epidemiology is the study of the frequency, distribution, and determinants of disease in humans. Its aim is the prevention or effective control of disease. The term originated in the study of epidemics, rapidly spreading diseases that affect large numbers of a population (from the Greek *epi* meaning upon and *demos* meaning people). Epidemiology touches on ethics in two key areas: The need for competent and honest use of its information, and questions of responsibility raised by the global picture it presents of the health of humanity.

Speculation about the nature and causes of disease dates back to antiquity. The formal history of epidemiology, like that of statistics, begins with the systematic official recording of births and deaths in the seventeenth century, proceeding to the quantitative investigation of diseases with the emergence of scientific medicine in the nineteenth. Based on the theory of probability, statistical inference reached maturity in the early-twentieth century and gradually spread into a wide range of disciplines. Its application to medical research gave rise to biostatistics and contemporary epidemiology.

There is no clear division between the two fields. Epidemiology focuses more on public health issues and the need for valid population-based information, but it uses the theory and methods of biostatistics. Its practitioners tend to be individuals with primary interest and training in medicine or a related science, whereas biostatisticians come from mathematics. They work together as members of the medical research team, in the dynamic context of scientific advances and the latest information technology.

Modern Epidemiology

The mathematical approach to medicine, with the methodical tabulation of patient information on diseases and treatment outcomes, was introduced in the 1830s by the French physician Pierre C. A. Louis (1787–1872). As a notable result of his researches in Paris hospitals, his Numerical Method revealed the uselessness of bloodletting. Inspired by Louis, his British student William Farr (1807–1883) became the central figure in the development of vital statistics in England and the use of statistics to address public health concerns. Farr worked with John Snow (1813–1858), the physician who investigated the cholera epidemic sweeping through London in 1854. Snow's finding that the *cholera poison* was transmitted in contaminated water from the Broad Street pump was a milestone event in epidemiology and public health. Farr also provided guidance in statistics for Florence Nightingale (1820–1910) to support her work in hospital reform.

The existence of microbes was discovered in the late-seventeenth century by the Dutch lens grinder Antonie van Leeuwenhoek (1632–1723), who saw "animalcules, more than a million for each drop of water" through his microscope (Porter 1998, p. 225). The role of germs as causes of disease was established by Louis Pasteur (1822–1895), French chemist and founder of microbiology. Pasteur invented methods to isolate and culture bacteria, and to destroy them in perishable products by a heat treatment now called *pasteurization*. He found that inoculation by a weakened culture provided *immunity*, protection against the disease. This explained the earlier discovery of the English physician Edward Jenner (1749–1823) that vaccination with the milder cowpox protected against smallpox. (Vaccination comes from the Latin *vacca* meaning cow.) The German physician Robert Koch (1843–1910), founder of bacteriology, further developed techniques of isolating and culturing bacteria. He identified the germ causing anthrax in 1876, tuberculosis in 1882, and cholera in 1883. He contributed to the study of other major diseases, including plague, dysentery, typhoid fever, leprosy, and malaria.

Extensive public health measures of hygiene and immunization, along with the introduction of the sulfonamide drugs in the late 1930s and antibiotics in the 1940s, brought most infectious diseases under control. Attention turned to chronic diseases, by then the leading causes of morbidity and mortality—multicausal diseases with a long latency period and natural course. Two historic discoveries of the mid-twentieth century were tobacco use as a cause of lung cancer, and risk factors for heart disease. From the study of infectious and chronic diseases epidemiology has evolved into a multidimensional approach, defined by disease, exposure, and methods, with focus on new developments in medical science. Its many specialties include cancer, cardiovascular, and aging epidemiology, environmental, nutritional, and occupational epidemiology, clinical and pharmaco-epidemiology, and molecular and genetic epidemiology. With the sequencing of the human genome,

TABLES 1–3

Table 1: Some Basic Terms of Epidemiology

Measures of Morbidity and Mortality

- PREVALENCE (Burden of disease): Number of existing cases of a disease at a given point in time divided by the total population.
- INCIDENCE (Cumulative incidence, risk): Number of new cases of a disease during a given time period divided by the total population at risk.
- INCIDENCE RATE (Incidence density): Number of new cases of a disease during a given time period divided by the total person-time of observation.
- PERSON-TIME (usually person-years): Total disease-free time of all persons in the study, allowing for different starting dates and lengths of time observed.
- CRUDE DEATH RATE: Number of deaths during a given time period divided by the total population.
- STANDARDIZED DEATH RATE: Crude death rate adjusted to control for age or other characteristic to allow valid comparisons using a standard population.

Example of Age-Adjusted Death Rates (2000 US Standard Population)

	Alaska	Florida	United States
Crude death rate/1,000 population (in 2000):	4.6	10.3	8.9
Percent of population over age 65 (in 2000):	5.7	17.6	12.4
Age-adjusted death rate/100,000 population (avg. for 1996–2000):			
Breast cancer	25.2	25.6	27.7
Prostate cancer	24.2	28.4	32.9

Prevalence, incidence, and death rates are expressed in units of a base (proportion mulitplied by base), usually per 1,000 or 100,000 population.

SOURCE: Courtesy of Valerie Miké. Data in example from U.S. Census Bureau website and American Cancer Society (2004).

Table 2: Case-Control Study of Lung Cancer and Smoking

Smokers		Lung Cancer	Controls	Odds Ratio (ad/bc)
Males:	**Yes**	647 (a)	622 (b)	14.0
	No	2 (c)	27 (d)	P<.00001
	Total	649	649	
Females:	**Yes**	41 (a)	28 (b)	2.5
	No	19 (c)	32 (d)	P<.05
	Total	60	60	

Historic study showing the association between cigarette smoking and lung cancer. No association would correspond to an odds ration of 1. P-values obtained by chi-square test for 2x2 tables.

SOURCE: Data from Doll and Hill (1950).

Table 3: Cohort Study of Risk Factors for Coronary Heart Disease: Systolic Blood Pressure

Systolic BP (mmHg)	Age 35–64 Men	Age 35–64 Women	Age 65–94 Men	Age 65–94 Women
<120	7	3	11	10
120–139	11	4	19	13
140–159	16	7	27	16
160–179	23	9	34	15
>180	22	15	49	31
Total Events	516	305	244	269

Average annual incidence per 1,000 persons of coronary heart disease, by systolic blood pressure. Example of relative risk (RR): For men (35-64), systolic BP>180 relative to <120 mmHg, RR=22/7=3.1. No association would correspond to RR=1. Results of 30-year follow-up in historic Framingham Heart Study of risk factors for cardiovascular disease.

SOURCE: Adapted from Stokes et al. (1989).

genetics is assuming increasing importance across all lines of inquiry. In its principles of studying human populations, epidemiology is related to psychology, sociology, and anthropology, all of which employ statistical inference.

Basic Concepts and Methods

Epidemiology may be *descriptive* or *analytic*. Descriptive epidemiology reports the general characteristics of a disease in a population. Its methods include *case reports*, *correlational studies* (to describe any association between potential risk factors and disease in a given database) and *cross-sectional surveys* (to determine prevalence of a disease and potential risk factors at a given point in time). Analytic epidemiology uses *observational* and *experimental* studies. The latter are *clinical trials* to test the effectiveness of interventions to treat or prevent a disease. But experimentation on humans is not ethically feasible for studying causes of disease. Observational research designs are thus the primary tools of epidemiology, the main types being *case-control* and *cohort* studies. After definition of some basic terms, these are discussed further below.

TABLE 4

Interpreting a Statistical Association

Possible Reasons for an Observed Statistical Association

1. CHANCE: This is precisely the meaning of P-value, the probability that the observed outcome is due to chance.
2. BIAS: Systematic errors that distort the results, such as selection bias, recall bias, and observation bias.
3. CONFOUNDING: There is an extraneous, confounding variable (perhaps as yet unknown) that is related to the risk factor being studied and is an independent risk factor for the disease.
4. CAUSE-AND-EFFECT: The risk factor in the observed association is a cause of the disease.

SOURCE: Courtesy of Valerie Miké.

Careful study is required to assess potential biases and confounding variables. General guidelines for establishing causality are provided by Hill's Criteria (Table 6).

MEASURES OF MORBIDITY AND MORTALITY. Some basic concepts of epidemiology are listed in Table 1. It is important to distinguish between the *prevalence* of a disease and its *incidence*. Prevalence signifies the amount of disease present at a point in time, such as the proportion of people with adult-onset diabetes in the United States on January 1, 2005. Incidence refers to new cases diagnosed during a given period of time, such as the proportion of U.S. adults diagnosed with diabetes in 2005. The denominator of *incidence rate* is *person-time*, a useful concept that allows for inclusion of subjects with different starting dates and lengths of time observed in a study. Causes of a disease can be investigated by observing incidence in a well-defined group of subjects without the disease, and patterns of disease incidence can be compared over time or populations.

Mortality is measured in terms of *crude death rate*, the actual proportion observed, or the *standardized death rate*, which involves adjustment for some characteristic. The example shows *age-adjusted* cancer death rates for the states of Alaska and Florida. Alaska has a much lower crude death rate than Florida, but its population is much younger. Both breast and prostate cancer are associated with older age, but after age-adjustment the two states are seen to have similar death rates for these two sites, both lower than the national average. The adjusted figures are meaningless in themselves, but provide for valid comparison of rates across groups and time. U.S. cancer death rates have been adjusted using the 2000 U.S. age distribution to make them comparable back to 1930 and ahead to the future.

OBSERVATIONAL RESEARCH DESIGNS: CASE-CONTROL AND COHORT STUDIES. A case-control study is *retrospective:* It identifies a group of people with the disease (cases) and selects a group as similar as possible to the cases but without the disease (controls). The aim is to determine the proportion of each group who were exposed to the risk factor of interest and compare them. Table 2 shows results of the case-control study of lung cancer and smoking reported in 1950 by Sir Richard Doll (b. 1912) and Sir Austin Bradford Hill (1897–1991), British pioneers of epidemiology and biostatistics. They identified 649 men and sixty women with lung cancer in twenty London hospitals and matched them with controls of the same age and sex but without lung cancer. The information they collected on all participants included their smoking history. The observed association, measured by the so-called *odds ratio* (the odds of smoking in cases over the odds of smoking in controls), was clearly statistically significant.

A cohort study is usually *prospective*. (It may be *historical*, if based on recorded past information.) It identifies a large group (cohort) of individuals who do not have the disease but for whom complete information is available concerning the risk factor(s) of interest; the cohort is then observed for the occurrence of the disease. A noted cohort design was the Framingham Heart Study, initiated by the U.S. Public Health Service in 1948 to identify risk factors for heart disease. Over 5,000 adult residents of Framingham, Massachusetts, men and women with negative test results for cardiovascular disease, agreed to join the study and undergo repeat testing at two-year intervals. The age and test measures at the start of each two-year period were used to classify subjects. Results of a thirty-year follow-up evaluation (part of a multivariate analysis including other risk factors and cardiovascular outcomes) are shown in Table 3, demonstrating a strong association between systolic blood pressure and incidence of coronary heart disease. Other suitable groups for cohort studies are members of professional groups, like doctors and nurses.

There are advantages and disadvantages pertaining to each research design, and the choice depends on the circumstances of the scientific question of interest. Any observed association then requires careful interpretation.

Association or Causation?

Possible reasons for an observed statistical association are listed in Table 4. *Chance* is simply the meaning of

TABLE 5

Koch's Postulates for Establishing the Causes of Infectious Diseases, with Molecular Update

Koch's Postulates	Molecular Koch's Postulates*
1. The microorganism should be found in all cases of the disease in question, and its distribution in the body should be in accordance with the lesions observed.	1. The phenotype or property under investigation should be significantly associated with pathogenic strains of a species and not with nonpathogenic strains.
2. The microorganism should be grown in pure culture in vitro (or outside the body of the host) for several generations.	2. Specific inactivation of the gene or genes associated with the suspected virulence trait should lead to a measurable decrease in pathogenicity or virulence.
3. When such a pure culture is inoculated into susceptible animal species, the typical disease must result.	3. Reversion or replacement of the mutated gene with the wild type gene should lead to restoration of pathogenicity or virulence.
4. The microorganism must again be isolated from the lesions of such experimentally produced disease.	

*In addition, guidelines for establishing microbial disease causation in terms of the prevalence of the nucleic acid sequence of a putative pathogen in relation to disease status are given in the third column of the table from which this is taken.

SOURCE: Brooks et al. (2001), p. 134.

Proposed in 1884 by Robert Koch for bacteria, the original wording has been modified to include other microbes. Further versions use molecular biology as a tool to associate microbial agents with disease. Table is adapted from a leading textbook of medical microbiology.

the P-value, the probability that the association is due to chance. *Bias* refers to systematic errors that do not cancel out with larger sample size, but distort the results in one direction. For example, in a case-control study patients with the disease may be more likely to recall exposure to the risk factor than the controls, leading to *recall bias*. Bias is a serious problem in observational studies and needs to be assessed in the particular context of each research design. *Confounding* is the effect of an extraneous variable that is associated with the risk factor, but is also an independent risk factor for the disease. For example, an association between birth rank and Down's syndrome, the genetic disorder Trisomy 21 (an extra copy of chromosome 21) does not imply causality; the confounding variable is maternal age, which is associated with birth rank and is a known risk factor for the disease. There may also be confounding variables as yet unknown, but their potential effects must always be considered.

The establishment of causation is a long-debated problem in the philosophy of science. In the practical field of medicine, where life-and-death decisions must be made every day, there are guidelines to help assess the role of agents in the etiology of disease. When microbes were being identified as causes of devastating diseases in the late-nineteenth century, Robert Koch formulated postulates to prove that a particular microbe causes a given disease. Anticipated by his teacher Jacob Henle (1809–1885), these are also called Henle-Koch Postulates. They are shown in Table 5, along with current updates using molecular biology. The original version claims only necessary causation, not sufficient; the microorganism needs a *susceptible* host. Even more general, the molecular guidelines are expressed in terms of statistical association. But they are the organizing principle in contemporary studies of microbial etiology, crucial for the identification of newly emerging pathogens that may pose serious threats to public health.

Guidelines for establishing causality in observational studies are listed in Table 6. Formulated by Sir Austin Bradford Hill, they are based on criteria employed in the 1964 U.S. Surgeon General's Report to show that smoking causes lung cancer. Applied in a wider context, they are to be used primarily as an aid to exploration. In general there is no necessary or sufficient condition to establish causality from an observed association. Such conclusions result from a consensus of the scientific community.

Epidemiology and Ethics

The complex, probing methods of epidemiology yield tentative, partial, often conflicting results, replete with qualifications. Taken out of context by interest groups or the media, they can mislead and have harmful consequences. Their correct use requires professional competence and integrity. But beyond these issues of immediate concern, epidemiology plays a larger role. With its adjusted measures allowing comparison of health patterns over space and time, it provides a quantitative aerial video of the globe. Some of the images it presents are troubling.

TABLE 6

Hill's Criteria for Establishing Causality in Observational Studies

Aspects of Association to Consider

1. STRENGTH: Stronger associations more likely to be causal.
2. CONSISTENCY: Association is observed repeatedly in different populations under different circumstances.
3. SPECIFICITY: Disease outcome is specific to or characteristic of exposure.
4. TEMPORALITY: Exposure precedes disease.
5. BIOLOGIC GRADIENT: Monotone dose-response relationship (increase in exposure corresponds to increase in disease).
6. PLAUSIBILITY: Causal hypothesis is biologically plausible.
7. COHERENCE: Causal interpretation does not conflict with what is known about the natural history and biology of the disease.
8. EXPERIMENTAL EVIDENCE: Removal of putative cause in an intervention or prevention program results in reduction of disease incidence and mortality.
9. ANALOGY: Drug or chemical structurally similar to a known harmful agent may induce similar harmful effects.

SOURCE: Hill (1965).

Formulated in 1965 by Sir Austin Bradford Hill, these are very general, tentative guidelines, with numerous exceptions and reservations. Aside from temporality, which may be considered part of the definition of causation, there is no necessary or sufficient criterion for establishing the causality of an observed association.

There are now more obese than undernourished people living on earth, and their number is increasing rapidly in developing nations. According to a 2000 estimate of the World Health Organization (WHO), there are 220 million adults with Body Mass Index (BMI) <17, classified as undernourished, and over 300 million with BMI > 30, defined as obese. (BMI is weight in kilograms divided by height squared in meters.) This global epidemic of obesity, called *globesity*, brings with it the related conditions of diabetes, hypertension, and heart disease, and the problem is equally serious for children.

The harmful effects of tobacco have been known for half a century, and while the prevalence of smoking has been slowly declining in most industrialized nations, it has been rising steadily in the developing world. It is estimated that the number of smoking-related premature deaths worldwide, 5 million in 2000, will rise to 10 million per year by 2030, with 70 percent occurring in developing countries. Tobacco use will kill more people than the combined mortality due to malaria, pneumonia, tuberculosis, and diarrhea.

In the area of infectious diseases, after decades of exuberant optimism reality set in with the appearance of acquired immune deficiency syndrome (AIDS) in the 1980s. Homo sapiens lives in a sea of microbes and will never have total control. Vigilance for the emergence of disease-causing strains must be the aim, to detect outbreaks, identify pathogens and their mode of transmission, and seek control and prevention. Knowing the cause may not eliminate the disease, even when possible in principle, if (as with smoking) it hinges on human behavior. AIDS, for example, is preventable. Ongoing threats include new diseases from mutation or isolated animal reservoirs (Ebola, West Nile, severe acute respiratory syndrome [SARS]), resurgence of older strains, drug-resistance, targeted release through bioterrorism, and rapid spread through global travel.

At a WHO conference held in Geneva in November 2004, experts issued an urgent appeal for greater international cooperation, and called on governments to make pandemic preparedness part of their national security planning. Of particular concern was the new bird influenza strain A(H5N1), which could mutate and cause a pandemic on the scale of the influenza epidemic of 1918 that killed more than 20 million people. It is estimated that a new pandemic virus could spread around the world in less than six months, infecting 30 percent of the population and killing about 1 percent of those infected. The drug industry would have to prepare billions of doses of the influenza vaccine within weeks of an outbreak to halt its course. There are questions of what could possibly be feasible technologically, the huge investment needed, and the driving force to motivate the effort when it cannot be a matter of fiscal gain.

In March 2005 the British medical journal *Lancet* published four articles reporting on the appalling state of global infant health care. Four million babies die each year in the first month of life, nearly all in low- and middle-income nations. The highest numbers occur in south-central Asian countries, while the highest rates are generally in Sub-Saharan Africa. It is estimated that three-quarters of these deaths could be prevented with low-lost interventions. A similar number of babies are stillborn and 500,000 mothers die from pregnancy-related causes each year. The moral implications of this public health tragedy are overwhelming.

The problems humanity faces at the start of the twenty-first century are inseparable from dominant worldviews and the interplay of powerful economic and political forces. Epidemiology provides health-related information as a guide to action. Its proper use is an essential component of the *Ethics of Evidence*, proposed for dealing with the uncertainties of medicine in the framework of contemporary culture (Miké 1999, 2003).

The *Ethics of Evidence* calls for integrating the best evidence of all relevant fields to promote human well-being, anchored in an inescapable moral dimension. Looking to the future, it urges all to be aware, to be informed, and to be responsible.

VALERIE MIKÉ

SEE ALSO *Biostatistics; Health and Disease.*

BIBLIOGRAPHY

Altman, Lawrence K. (2004). "Experts Urge Greater Effort on Vaccine for Bird Flu." *New York Times*, November 13, p. A3.

American Cancer Society. (2004). *Cancer Facts and Figures 2004*. Atlanta, GA: Author. Includes report on worldwide effects of tobacco use.

Brooks, George F.; Janet S. Butel; and Stephen A. Morse. (2001). *Jawetz, Melnick, & Adelberg's Medical Microbiology*, 22nd edition. New York: McGraw-Hill.

Doll, Richard., and Austin Bradford Hill. (1950). "Smoking and Carcinoma of the Lung: Preliminary Report." *British Medical Journal* 2: 739–748.

Gail, Mitchell H., and Jacques Benichou, eds. (2000). *Encyclopedia of Epidemiologic Methods*. New York: John Wiley & Sons.

Hill, Austin Bradford. (1965). "The Environment and Disease: Association or Causation?" *Proceedings of the Royal Society of Medicine* 58: 295–300.

Hennekens, Charles H., and Julie F. Buring. (1987). *Epidemiology in Medicine*. Boston: Little, Brown.

Lawn, Joy E.; Simon Cousens; and Jelka Zupan. (2005). "Neonatal Survival 1: 4 Million Neonatal Deaths: When? Where? Why?" *Lancet* 365: 891–900. First report in the four-part series.

Lilienfeld, David E.; Paul D. Stolley; and Abraham M. Lilienfeld. (1994). *Foundations of Epidemiology*, 3rd edition. New York: Oxford University Press.

Miké, Valerie. (1999). "Outcomes Research and the Quality of Health Care: The Beacon of an Ethics of Evidence." *Evaluation & the Health Professions* 22: 3–32. Commentary by Edmund D. Pellegrino, "The Ethical Use of Evidence in Biomedicine," is included in this issue.

Miké, Valerie. (2003). "Evidence and the Future of Medicine." *Evaluation & the Health Professions* 26: 127–152.

Porter, Roy. (1998). *The Greatest Benefit to Mankind: A Medical History of Humanity*. New York: W. W. Norton.

Rothman, Kenneth J., and Sander Greenland. (2000). "Hill's Criteria for Causality." In *Encyclopedia of Epidemiologic Methods*, eds. Mitchell H. Gail, and Jacques Benichou. New York: John Wiley & Sons.

Stokes, Joseph III; William B. Kannel; Philip A. Wolf; et al. (1989). "Blood Pressure as a Risk Factor for Cardiovascular Disease: The Framingham Study—30 Years of Follow-up." *Hypertension* 13(Supplement I): 113–118.

INTERNET RESOURCE

Controlling the Global Obesity Epidemic. World Health Organization (WHO). Updated September 2003. Available from http://www.who.int/nut/obs.htm. From the organization's Nutrition pages.

EQUALITY

Equality is a key concept in both ethics and politics, one that influences personal and public self-understandings, and provides guidelines for relations between individuals and for state action. Insofar as scientific knowledge and technological change can either diminish or increase inequalities, and scientific research influences the understanding of what it means to be human, issues of equality exercise important ethical influences on the uses of science and technology. The ideal of equality also presents a special challenge within science and engineering, insofar as peers are supposed to be treated as equals at the same time that expertise makes claims to special influence.

Background

It is an empirical given that human beings are in many respects unequal. They are of different shapes, sizes, and sex; different genetic endowments; and different abilities. From the earliest age, some children manifest gregariousness, others pugnacity, some pleasant dispositions, others dullness and apathy. Take almost any characteristic—health, longevity, strength, athletic prowess, sense of humor, ear for music, intelligence, social sensitivity, ability to deliberate or do abstract thinking, sense of responsibility, self-discipline, or hormonal endowment (for example, levels of testosterone and endorphins)—and there are major differences among humans. Yet it is one of the basic tenets of almost all contemporary moral and political theories that humans are in some fundamental respect equal, and that this truth should be reflected in economic, social, and political structures.

Historically this was not always the case. In Plato's *Republic* Socrates argues for equal opportunity for women and men among the guardians, but some of his interlocutors contest the possibility of this ideal. Aristotle rejects it outright, holding to strong differences between males and females, free men and slaves. "It is manifest that there are classes of people of whom some are freeman and others slaves by nature, for these slavery is an institution both expedient and just" (*Politics* 1.5.1255). Indeed, for many Greeks, Romans, and premodern cultures, the primary challenge was not to treat equals as equal, but to avoid treating unequals as equals.

In the Jewish, Christian, and Islamic traditions all humans are seen as possessing equal worth because they are created in a common relation to God. In Hinduism and Buddhism people have unequal worth based on their karmic status, that is, depending on how well they have carried out their *dharma* (duty), but they have equal opportunity to progress to higher modes of existence and eventually to attain nirvana.

With the Enlightenment equality became a political ideal. In the words of the U.S. Declaration of Independence (1776): "We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable Rights, that among these are Life, Liberty and the pursuit of Happiness.—That to secure these rights, Governments are instituted among Men, deriving their just powers from the consent of the governed." The first article of the French Declaration of the Rights of Man and of the Citizen (1789) likewise stipulates: "Men are born and remain free and equal in rights. Social distinctions may be founded only upon the general good." As has been often noted, however, there is a tension between the ideals of liberty and equality. Inequality is not only produced by inheritance and traditional social orders; it is also produced anew by liberty, as people freely distinguish themselves from each other. Thus one is forced to inquire more precisely what kind of equality ought to be protected.

In relation to what should be "equalized" and the arguments that ground various egalitarian claims, one discovers both limited consensus and a plethora of competing ideas with regard to citizenship, law, opportunity, welfare, resources, opportunity, and capabilities. For instance, there is a measured consensus in support for equality in the areas of civil liberties, political participation, and opportunity. In the twentieth century, however, levels of social and welfare equality as a base for the exercise of individual liberty became contentious in the extreme. Moreover, together with debates between egalitarians about which version of egalitarianism is correct, there exists an even more fundamental argument between egalitarians and nonegalitarians, who question the moral significance of equality.

Conceptual Analysis

The first step in addressing such debates is to analyze more carefully the concept of equality. To begin, it is important to note that equality is sometimes interpreted as equity or fairness, but the two concepts are distinct. Whether or not and in what ways treating people as equals is equitable or fair is subject to argument.

Equality involves a triadic relationship. A is equal to B with respect to some property P. Except with abstract ideas, such as numbers, there is no such thing as equality per se. Two objects are always different in some respect—even two Ping-Pong balls are made up of different pieces of plastic and exist in different places. Two things A and B, if they are equal, are also equal with respect to something. Two trees are of equal height, two baseball players have equal batting averages, two workers have produced the same amount of widgets in the same time frame, and so forth. So descriptive equality always must answer the question, "Equal in what respect?"

When equality has a normative dimension, the relationship is quadratic: If A and B are equal with respect to the normative (or merit-ascribing) property P, then A and B deserve equal amounts of dessert D. Two persons A and B who are equal with respect to the law deserve equal treatment by the law. Two scientists or engineers who are equally competent professionals and performing equal services deserve equal compensation. Determining equality with respect to P in such cases is, of course, difficult.

Normative egalitarian theories fall into two types: *formal* and *substantive*. A formal theory states a formula or policy but includes no specific content. A substantive theory identifies a criterion or metric by which egalitarian policies are to be assessed.

Aristotle's notion that "injustice arises when equals are treated unequally and also when unequals are treated equally" (*Nicomachean Ethics* 5.3.23–24) is the most common statement of a formal normative theory. If two things are equal in some respect, then if one of them is treated one way based on that respect, it is wrong to treat the other differently based on that same respect. When applied to distributive justice, the formula of formal equality stipulates giving equals equal shares and unequals unequal shares based on some criterion left unspecified. Formal equality is simply the principle of consistency, and Aristotle, who articulated it, was substantively what in the early twenty-first century would be called an inegalitarian, because he defended class, racial, and sexual inequalities.

Substantive normative theories of equality either identify a criterion in the formula for equality in relation to which people should be treated equally or simply assume that all people should receive equal shares of some good(s). But because people are unequal in many respects, the first question concerns which respects are morally indefensible. One of the major controversies of the modern period has been the degree to which class, wealth, race, and sexual differences are legitimately recognized as bases for inequalities in various treatments.

A second question concerns whether the state should do anything to delimit inequality or promote equality. Socialists and liberals, for instance, tend to be interventionists, calling for government action to redistribute goods when a moral case can be made for mitigating the effects of inequality. Conservatives and libertarians tend to limit the governmental role, leaving such matters to individual or voluntary action.

Debating Substantive Equality

Returning to the first question, a few idealists, such as the radicals of the French Revolution, have called for the abolition of virtually all distinctions between persons. Graccus Babeuf's "Manifesto of the Equals" (1796) suggested even the elimination of the arts, because they reveal the difference between a Rembrandt or Michelangelo and everyone else. Sports and academic grades would have to be abolished for the same reason.

Most egalitarians nevertheless agree that not all inequalities are morally repugnant. Candidates for those sorts of inequalities that are morally wrong and thus subject to correction include primary goods, resources, economic benefits, power, prestige, class, welfare, satisfaction of desire, satisfaction of interest, need, and opportunity. Some egalitarians emphasize great differences in wealth as the most morally repugnant item and propose various redistribution policies such as the regressive income tax. Other egalitarians emphasize political power as the item to be equalized.

Certainly there is no doubt that the ideal of equality has inspired millions to protest undemocratic forms of government, monarchies, oligarchies, despotisms, and even republicanism. The sense that each individual is of equal worth has been the basis for rights claims from the English Civil War (1642–1648) to women's suffrage (granted in the United Kingdom, 1918; United States, 1920) and the civil rights movements in the United States (1960s) and South Africa (1980s). Who is not moved by the appeal of Colonel Thomas Rainsborough of Oliver Cromwell's Parliamentary Army, petitioning in 1647 for political equality?

> I think that the poorest he that is in England hath a life to live, as the greatest he; and therefore truly, sir, I think it's clear, that every man that is to live under a government ought first by his own consent to put himself under that government; and I do think that the poorest man in England is not at all bound in a strict sense to that government that he hath not had a voice to put himself under. (Putney debates, October 29, 1647)

But the ideal of equality has dangers too. The French aristocrat Alexis de Tocqueville, in his visit to the United States in the 1830s, was amazed at Americans' passion for and preoccupation with equality. He saw in it both the promise of the future and a great danger. Its promise lay in the prospect of full citizenship, political participation, and economic equality. Its danger lay in the tendency to mediocrity and the envy of those who stood out from the crowd.

Contemporary egalitarians most commonly divide on whether *resources* or *welfare* is the primary good to be equally distributed. Resource egalitarians, such as John Rawls, Ronald Dworkin, and Eric Rakowski, hold that in societies of abundance human beings are entitled to minimally equal shares of the resources or opportunities. Welfare egalitarians, such as Kai Nielsen, R. M. Hare, and Richard Norman, go further and maintain that in such societies people should receive equal welfare, interpreted in terms of fulfillment, outcomes, or preference satisfaction.

The strongest pro-equality consensus concerns equality of opportunity, of which there are two versions. The first is weak equal opportunity (sometimes called "formal equal opportunity"), which holds that offices should be open to talent. This was classically set forth by Plato and in postrevolutionary France by Napoleon Bonaparte, who chose officers not by class but by ability (''*la carriere ouverte aux talents*'' [the tools to him that can handle them]) It is meritocratic equal opportunity, but does not address the advantages people have because of natural or family resources, thus leaving the matter of initial starting points untouched.

The second is strong equal opportunity (sometimes called "substantive equal opportunity"), which holds that individuals ought to have equal life chances to fulfill themselves or reach the same heights. It calls for compensation for those who had less fortune early in life to bring them to the level of those who had advantages. This kind of equal opportunity would support affirmative action programs and other compensatory policies. At the extreme, such equal opportunity would have to result in groups succeeding in obtaining coveted positions in proportion to their makeup in the population. Insofar as equal opportunity would be equivalent to equal outcomes, it might be called "superstrong equal opportunity."

Justifying Equality

One important theoretical issue in the debate over equality concerns whether or not equality of whatever substance is an intrinsic or an instrumental good. Thomas Nagel (1979), for instance, after making the distinction, affirms its intrinsic value for providing an independent reason to favor economic equality as a good in its own right.

Even more strongly, Christopher Jencks, in *Inequality: A Reassessment of the Effect of Family and Schooling in America* (1972), a report on U.S. education, maintains that "for ... a thoroughgoing egalitarian, inequality that derives from biology ought to be as *repulsive* as inequality that derives from early socialization" (p. 73). And Richard Watson (1977) argues that equality of resources is such a transcendent value, at least for many purposes, that if equal distribution of food were to result in no one getting enough to eat, this annihilation of the human race should nevertheless be chosen rather than an unequal distribution.

By contrast, it can be argued that equality is not a value in itself but only in relation to its potential effects. Utilitarians commonly argue that total happiness in a society is best maximized by means of equality. And although economists often argue that certain kinds of equality are in the interest of market efficiency, they also criticize efforts to achieve strong equality as themselves being too costly for the marginal utility they may introduce.

Science, Technology, and Equality

As science and technology have become increasingly important goods, inequalities in distribution within and between nations have become public issues. Indeed, scientific exchanges and communications technology, by making people more aware of disparities, intensify the discussion. Under appropriate circumstances, the same scientific and technological activities can also serve as means for the more effective promotion of equality. Ethical and political issues arise in relation to considerations of the extent to which this may be appropriate or feasible.

During the latter third of the twentieth century, as extensions of the civil rights and women's movements, equality within science and engineering became topics of intense debate. What was the cause of the underrepresentation of minorities and women in such sciences as physics or in engineering as a whole? To what extent was this the result of natural differences in interest or ability, or of inequality in access and opportunity?

During this same period scientific research, while not rejecting numerous well-recognized differences between individuals, tended to challenge if not minimize their importance. For instance, genetics points to minimal differences not only between races but also between the sexes, and even between human beings and some higher animals. What significance, if any, does this have for the egalitarian versus libertarian debate? On the one hand, it might well be argued that egalitarianism is so well established at the genetic level that nothing more need be done. On the other, it could also be argued that basic genetic equality is grounds for a more vigorous promotion of social equality.

Finally, increasing possibilities for the technological manipulation of human physiology open doors to radically new forms of the promotion of equality. Should science be used to alter individual genetic endowments through genetic modification? Even before such powers become generally available, it is already known that when parents have the power to choose the sex of their children, there exist strong tendencies in some cultures to choose males over females, thus creating a new kind of radical sexual equality. Moreover, the use of plastic surgery, performance-enhancing drugs, and eventually genetic engineering may be able to undermine inequalities among the gifted and the nongifted in many areas of physical appearance, athletic ability, and perhaps mental achievement. In such cases there may be dangers not only in the top-down or government-sponsored promotion of equality but even in the bottom-up initiatives of individuals practicing personal liberties. The decentralization of scientific and technological powers may alter the theory and practice of equality in unexpected ways.

Finally, ideals of equality pose challenges for relations between democratic practice and scientific or technical expertise. To what extent are scientists and engineers properly to be given special influence in decisions regarding such issues as the control of nuclear weapons, environmental pollution, or global climate change? Is technocracy an antiegalitarian danger in an economy that is dependent on scientific and engineering expertise? Such questions constitute important dimensions of any general reflection on science, technology, and ethics.

LOUIS P. POJMAN

SEE ALSO *Justice*.

BIBLIOGRAPHY

Abernethy, George L., ed. (1959). *The Idea of Equality*. Richmond, VA: John Knox Press.

Arneson, Richard. (1989). "Equality and Equal Opportunity for Welfare." *Philosophical Studies* 56(1): 77–93.

Clayton, Matthew, and Andrew Williams, eds. (2002). *The Ideal of Equality*. New York: Palgrave Macmillan.

Cohen, Gerald A. (1989). "On the Currency of Egalitarian Justice." *Ethics* 99(4): 906–944.

Dworkin, Ronald. (2000). *Sovereign Virtue: The Theory and Practice of Equality*. Cambridge, MA: Harvard University Press.

Jencks, Christopher. (1972). *Inequality: A Reassessment of the Effect of Family and Schooling in America*. New York: Basic.

Nagel, Thomas. (1979). "Equality." In *Mortal Questions*. New York: Cambridge University Press.

O'Neill, Onora. (1977). "How Do We Know When Opportunities Are Equal?" In *Feminism and Philosophy*, ed. Mary Vetterling-Braggin, Frederick A. Elliston, and Jane English. Totowa, NJ: Rowman and Littlefield.

Pojman, Louis P., and Robert Westmoreland, eds. (1996). *Equality: Selected Readings*. New York: Oxford University Press.

Rae, Douglas; Douglas Yates; Jennifer Hochschild; et al. (1981). *Equalities*. Cambridge, MA: Harvard University Press.

Rakowski, Eric. (1991). *Equal Justice*. Oxford: Clarendon Press.

Roemer, John E. (1998). *Equality of Opportunity*. Cambridge, MA: Harvard University Press.

Sen, Amartya. (1992). *Inequality Reexamined*. New York: Russell Sage Foundation; Cambridge, MA: Harvard University Press.

Temkin, Larry S. (1993). *Inequality*. New York: Oxford University Press.

Walzer, Michael. (1983). *Spheres of Justice: A Defense of Pluralism and Equality*. New York: Basic.

Watson, Richard. (1977). "World Hunger and Equality." In *World Hunger and Moral Obligation*, ed. William Aiken and Hugh LaFollette. Englewood Cliffs, NJ: Prentice-Hall.

Westen, Peter. (1990). *Speaking of Equality*. Princeton, NJ: Princeton University Press.

ERGONOMICS

Ergonomics (used by many interchangeably with such terms as human factors, human engineering, engineering psychology, and the like) can be thought of as the field in which the social and biological sciences are applied to various problems related to the use of products, equipment, or facilities by humans in the performance of specific tasks or procedures in a variety of natural and artificial environments. Ergonomics attempts to evaluate and design the things people use, in order to better match their capabilities, limitations, needs, or physical dimensions (Sanders and McCormick 1993). General elements of the ergonomics field may include the study of humans as (technology-based) system components, design of human-machine interfaces, and consideration of the health, safety, and well-being of humans within a system. Specific areas of study may examine human sensory processes and information processing or anthropometric data to allow professionals in this field to design more effective displays or controls for an engineered system.

Examples

There are many examples of the kinds of successes that the ergonomics field has achieved over the years. As the military is one of the primary users of ergonomic advances, the evolution of military equipment serves as an excellent example of how ergonomics has changed the way things are. The development of the infantry helmet from a shallow "steel pot" to a protective device fabricated from advanced materials formed into a highly functional shape demonstrates the efficacy of ergonomic design.

Ergonomic advances are, by no means, limited to the military. The changes over the years in consumer products such as snow shovels, electric razors; or even more recently, cellular telephones establish the role of human factors in people's everyday lives.

Background

The term *ergonomics* is a combination of the Greek *ergon*, work, and *nomos*, law. The term was created in 1857 by the Polish scientist Wojciech Jastrzebowski (1799–1882) as a name for the scientific study of work. More than a century earlier, however, the Italian physician Bernardino Ramazinni (1633–1714) had initiated the study of work-related illness in the second edition of his *De Morbis Artificum* (1713). And it was not until a century later, in 1952, that the name was given official status in the formation of the British Ergonomic Society.

In the United States, the development of the principles of scientific management by Frederick W. Taylor (1865–1915) and his followers Frank Gilbreth (1868–1924) and Lillian Gilbreth (1878–1972) initiated similar research. It was out of this tradition that the Human Factors Society was founded in 1957. What began as research on work in the civilian sector became during the 1950s and thereafter heavily associated with the military, especially the Air Force Research Laboratory Human Effectiveness Directorate.

Ethical Issues

Given that one of the objectives of this field is to adapt technological systems to the needs, capabilities, and limitations of human beings, there is an inherent ethical dimension in ergonomics. Certainly the members of this profession must consider their ethical responsibilities. For example, practitioners should not function outside their areas of competence. They should have the proper education, professional training, and work experience. They should avoid and must disclose any actual or perceived conflicts of interest (Human Factors and Ergonomics Society 1989). While these principles seem obvious, they may prove to be problematic for those in the ergonomics field.

Because there is limited formal training in ergonomics and many practitioners come from other disciplines (for example, experimental psychology, industrial engineering), care must be taken so that individuals engaged in ergonomics truly understand their own professional "capabilities and limitations." This is especially true because ergonomics is such a broad and diverse field. For example, someone who works primarily in the area of visual perception may be qualified to work in the allied area of visual cognition, but not be qualified to perform work in the area of bioacoustic protection (that is, mitigating the effects of harmful noise).

Experts in many professions provide forensic testimony that goes beyond the mere recounting of facts. These experts are retained primarily to offer opinions regarding certain elements of a case. This is no different in the ergonomics field. The conduct of ergonomic experts in these types of proceedings should be governed by their professional ethics. The principles they should follow in these matters cover subjects such as the objectivity of their testimony; respect of the integrity of other witnesses; discretion regarding the disclosure of details about the case with outside parties; or discernment if making any public statements regarding the matter, as imprudence here may influence the judicial proceedings or be harmful to the litigant's interests (Human Factors and Ergonomics Society 1989).

As with many fields where the recruitment and use of experimental subjects is a key component in the performance of much of the work (such as in sociology and medicine), the treatment of subjects is of paramount importance and lapses in this area could lead to serious ethical criticisms. Approval of the work and the qualifications of the professionals involved by an institutional review board (IRB) is an important concern. Further, complete disclosure regarding the general nature of the work that the subjects will be involved in and specific risks they may be exposed to are requisite elements of any methodology involving humans.

Examining ethical issues entirely within the realm of ergonomics, Yili Liu (2003) considers several questions. Can ergonomically-based approaches be used to address ethical issues in general? This could also be thought of as whether a better understanding of humans from a psycho-physical standpoint can contribute to a greater understanding of ethical issues. An example of this might be whether providing avionics to fighter pilots that extend their ability to identify a friendly or enemy aircraft is helpful when considering the morality of war. Can ergonomics make human-machine systems more ethical? This might seem obvious given the objectives of the field; however, is an improvement in an individual assembly line process that reduces a worker's exposure to hazardous conditions (for example, the mechanization of a manual chemical dipping process to treat a material), but also speeds up the assembly line, which may cause increased levels of stress for all of the workers, really "ethical"?

Such questions point toward moral responsibilities for those working in product planning, design, or evaluation—with "product" including systems, processes, and more. Most professionals engaged in ergonomics work for paid compensation. Most of the products they plan, design, or evaluate are used by others. There would seem to be a compelling moral responsibility on the part of those employed in these practices to inform employers or clients if they know of an inherent danger or serious hazard associated with the use of a certain product. However, if the ergonomicist knows that use of the product would be inconvenient, inefficient, or difficult, and the cost to correct or change the product so that any problems could be ameliorated might be sizeable, what then is the proper course of action? Does the designer give allegiance to the client or the consumer? If one thinks of the ultimate user as the controlling factor here, how would one's opinion change if the inconvenience were characterized as slight and the cost as monumental? Specifics of a case often make it difficult to reach a final decision.

The advent of ergonomics in the twentieth century brought about great improvements in the design of technological systems from the standpoint of the user or the person in the system. Ergonomics has contributed to the improved safety and usability of technology. Given that this specialized field of knowledge holds the keys to understanding the soft boundary between humans and technology, it must be applied within a moral and ethical framework that, in many respects, is still evolving.

MARTIN T. PIETRUCHA

SEE ALSO *Taylor, Frederick W.*

BIBLIOGRAPHY

Liu, Yili. (2003). "The Aesthetic and the Ethic Dimensions of Human Factors and Design." *Ergonomics* 46(13/14): 1293–1305.

Sanders, Mark S., and Ernest J. McCormick. (1993). *Human Factors in Engineering and Design*. New York: McGraw-Hill.

INTERNET RESOURCE

Human Factors and Ergonomics Society. (1989, amended 1998). "Human Factors and Ergonomics Society Code of Ethics." Available from http://www.hfes.org/About/Code.html.

ETHICAL PLURALISM

Pluralism is a term used to describe a number of positions from different fields. This entry will confine itself to a discussion of ethical—as opposed to political, social, or metaphysical—pluralism.

Basic Definition and History

Ethical pluralism (also referred to as value pluralism) is a theory about the nature of the values or goods that human beings pursue, and the pursuit of which make up the substance of their moral lives. Most simply ethical pluralism holds that the values or goods legitimately pursued by human beings are plural, incompatible, and incommensurable. That is, there are many genuine human values, which cannot all be reduced to, or described in terms of, a single overriding value or system of values. This is because certain human values, by their very nature, come into conflict with other, equally valid, human values. Individual liberty, for instance, can conflict with equality, public order, or technological efficiency; impartial justice with compassion and mercy; scientific truth with public utility; and so on.

Sometimes compromises between values can be achieved, or solutions to value conflicts found; at other times, one is forced to choose between values. Such a choice may entail the sacrifice of a genuinely important, attractive, binding value or good, and so a moral loss. Finally, pluralism holds that values are incommensurable in that they cannot be ranked: There is no single most important or ultimate value, nor can values be ranked in a stable or universal hierarchy, nor is there a single principle or source of truth—such as utility, or a rational principle of moral duty, or natural law or the will of God—that can serve as a sure guide in making choices or compromises between values. Whether there can be any comparison between values of a less general and more practical sort is an issue that divides exponents of pluralism.

The first self-avowed pluralist was the U.S. philosopher and psychologist William James (1842–1910), who applied pluralism to the theory of knowledge and metaphysics. An early, forceful application of pluralism to ethics was made in 1918 by the German sociologist, historian, and philosopher Max Weber (1864–1920). The first full exposition of ethical pluralism under that name and in the form in which it is now known was given by the U.S. philosopher Sterling P. Lamprecht (1890–1973) in 1920. The thinker who did the most to develop and popularize ethical pluralism was the British historian, philosopher, and political theorist Isaiah Berlin (1909–1997), and it is from his work that most contemporary discussions of pluralism take their bearings.

Contemporary Problems and Debates

The theory of pluralism expounded by Berlin contained a number of ambiguities and possible weaknesses, and these have been the basis for recent debates among the proponents and opponents of pluralism. One of the most persistent debates concerns the meaning of the claim that values are *incommensurable*. Berlin used the term to suggest that there is no single standard by which all values can be ranked, or that can be used to determine which value should be chosen in a particular case; and that no eternal scale or hierarchy of values exists—liberty is not inherently more valuable than equality, or spontaneity than dependability, or beauty than practicality. But Berlin also suggested that human beings can, at least sometimes, compare the relative importance and desirability of different courses of action or different values in particular circumstances; and that sometimes, at least, this comparison will lead to the conclusion that one value or course of action is more valid or desirable than another.

Other theorists have given a more radical account of incommensurability, holding that different values are wholly *incomparable*—they cannot be compared, or rationally chosen among, in any circumstance or way. This could lead to the conclusion that choices among values must be arbitrary, because, values being incomparable, there is no way to give a reason for regarding one value as inherently more important or better than another in any circumstance.

Many critics of pluralism maintain that it is no different from *relativism*—a claim that is difficult to evaluate in part because such critics rarely define exactly what they mean by relativism. Berlin insisted that pluralism is different from relativism by defining relativism in terms of a denial of common human understanding and common rules and values. Relativism, in Berlin's definition, holds that a Homeric Greek's admiration of ferocity, pride and physical prowess as moral attributes, for example, is as difficult for a person living in the early-twenty-first century to understand or share, as it is for one person who strongly dislikes peaches to understand another person's enjoyment of peaches. A person in the early 2000s may not admire Homeric heroism. Tastes simply differ; and values are ultimately a matter of taste. Berlin's pluralism holds, on the contrary, that one can understand the attractiveness and value of the Homeric ethic, even if one ultimately rejects that ethic in favor of other values, which are of greater importance to that particular individual.

One problem with this argument is that it rests on a distinctive and tailor-made definition of relativism that not everyone would accept. Another more common definition of relativism is the view that there simply is no inherently right or good course of action or true answer. On this definition, too, pluralism is opposed to relativism, because it holds that there are such things as inherently right or good courses of action and true values and answers; but right and goodness and truth are not singular. This is why pluralism insists that there are genuinely tragic moral dilemmas and conflicts, while relativism cannot allow that such dilemmas are genuinely tragic—they may be frustrating for individuals who feel pulled in different directions, but those individuals need not feel so conflicted.

Relativism can also be defined as holding that certain things are valuable or good solely in relation to their context. This, too, is opposed to pluralism, in at least two ways. First it can be taken to mean that, relative to a particular context, there is a correct value or way of being, which is not appropriate to a different context; pluralism holds that there are a variety of values that remain valid regardless of context, and that in many cases there will not be a single value which is obviously best or most important in a given context. Thus the relativist might say that social cohesion is of greater importance than individual freedom in, say, a traditionalist, pre-industrial society, while the opposite is the case in a modern, *advanced* society; while the pluralist would hold that both values are important to both sorts of society, and that people in both societies will be drawn to, and torn between, and have to choose or find a balance between both values.

Finally relativism can be interpreted as denying the existence of a universally valid, binding, and morally limiting core or horizon of human values; yet, Berlin—and other writers after him—have insisted on the existence of such a core or horizon as part of pluralism.

The most lively debate among political theorists about pluralism is the connection between pluralism and political liberalism. While Berlin attempted to link pluralism with liberalism, arguing for liberalism on pluralist grounds, the British political theorist John Gray (b. 1948) has argued that pluralism actually undermines the authority of liberalism. Liberalism is a theory of government that privileges, and seeks to promote, certain values—primarily individual liberty—against and above other, non-liberal values. Gray asserts that if one take ethical pluralism seriously, one cannot assert the superiority, or impose on others, a single form of life, political system, or culture, because these embody and promote certain values to the detriment or exclusion of others.

While liberalism is certainly a valid choice for certain societies that, given their historical development and present situation, are more oriented toward the values that are central to liberalism, other forms of social and political organization have their own validity, and people in liberal societies must respect the claims and rights of societies that pursue other, non-liberal values. Other political theorists have tried to show that, while pluralism may not entail allegiance to liberalism, liberalism is a preferable political system to others because it better recognizes a genuine plurality of values, and allows for and protects greater freedom and variety of individual choice in pursuing these values.

The Relevance to Science, Technology, and Ethics

Pluralism presents a radical and important challenge to most traditional ethical doctrines, such as Kantianism and Utilitarianism, as well as an alternative to relativism, while also offering a distinctive and versatile perspective on moral experience.

One of the few major exponents of pluralism to address the ethics of the use of science and technology is Gray. Earlier pluralists have generally shared an anthropocentric perspective, treating pluralism as a theory concerned with human values. Gray, however, has expanded pluralism beyond the human sphere, arguing that anthropocentrism—and thus humanism—are misguided. The world should be viewed as a whole—a *biosphere*—with human beings counting as but one species among many. Human-centric conceptions of humanity's place and stature are akin to monism in their denial of the incommensurability and conflict between human and non-human goods. Moral philosophers and ethicists should cease to always put human beings first, and should denounce humanity's arrogant subordination and abuse of nature—Gray has remarked that *homo sapiens* should be re-christened *homo rapiens*—in favor of a moral outlook that takes into account the whole of the earth. Few other pluralists have followed Gray's lead.

Much work remains to be done in applying pluralism to the ethical consideration of science and technology. A pluralistic ethics would suggest that people be aware of the varied and sometimes conflicting values that science and technology seek to serve. A pluralist perspective would recognize the inherent value of scientific research as conducive to the acquisition of knowledge—a genuine value in itself—as well as the value of applied science and technology in increasing human happiness, physical well being, and power. But it would also recognize the costs of the scientific quest, and of the employment of technology. It is a further reminder that, in using science and technology in the pursuit of other values, human beings are faced with choices between the competing values that science and technology may serve.

In doing so pluralism does not provide answers, but rather affirms the validity, difficulty, and intractability of the problems. A pluralist will, for example, recognize that both sides in the debate over the use of animals for medical experiments appeal to genuine values, and that a victory for either side would mean a serious moral sacrifice. A pluralist might also see the conflict between economic growth and environmental safety as embodying a genuine conflict of values—between the well being provided by jobs, economic expansion, and greater human control over nature, and thus comfort, versus the health of the environment, the existence of other species, and, ultimately, human health as well. A pluralist will advocate deciding between contending parties advocating conflicting values on a case-by-case basis, and will be wary of the use of monistic ethical theories (such as utilitarianism) to derive authoritative answers to such conflicts.

Pluralism thus provides ethicists, scientists, political activists, and policy makers with no certain answers to their moral problems, or sanction for their agendas. But it may inspire an increased awareness of, and respect for, the importance of such problems, promoting a greater moral seriousness and honesty in confronting the conflicts of values and possible moral sacrifices and losses that are involved in the pursuit and use of scientific knowledge and technology, and fostering a spirit of greater deliberation, humility, and respect for the priorities and perspectives of others.

JOSHUA L. CHERNISS

SEE ALSO *Berlin, Isaiah; Values and Valuing; Weber, Max.*

BIBLIOGRAPHY

Berlin, Isaiah. (1997). *The Proper Study of Mankind: An Anthology of Essays*, eds. Henry Hardy and Roger Hausheer. London: Chatto and Windus. A collection of Berlin's major essays, including his lengthiest expositions of pluralism.

Crowder, George. (2002). *Liberalism and Value Pluralism*. London and New York: Continuum. An argument for the compatibility of pluralism with a liberal political theory.

Galston, William. (2002). *Liberal Pluralism: The Implications of Value Pluralism for Political Theory and Practice*. Cambridge, UK: Cambridge University Press. An attempt to bring the insights of pluralism to bear on questions of political theory and public policy; argues that pluralism can support and improve liberalism, rather than undermining it.

Gray, John. (1996). *Isaiah Berlin*. Princeton, NJ: Princeton University Press. An exposition of Berlin's thought that offers a fuller, more systematic, and possibly more radical account of pluralism than Berlin himself did.

Gray, John. (2002). *Straw Dogs: Thoughts on Humans and Other Animals*. London: Granta Books.

Hampshire, Stuart. (1983). *Morality and Conflict*. Oxford: Blackwell. A set of terse and withering reflections by a major exponent of pluralism, condemning humanity's use of science and technology to master nature.

Kekes, John. (1993). *The Morality of Pluralism*. Princeton, NJ: Princeton University Press.

Lamprecht, Sterling P. (1920). "The Need for a Pluralistic Emphasis in Ethics." *Journal of Philosophy, Psychology and Scientific Methods* 17: 561–572. The first explicit articulation of what has become familiar as the theory of ethical pluralism.

Lukes, Steven. (1998). "Berlin's Dilemma." *Times Literary Supplement* March 27, 8–10. Discusses the problem of whether pluralism is distinguishable from relativism.

Walzer, Michael. (1983). *Spheres of Justice: A Defence of Pluralism and Equality*. New York: Basic Books. Develops a pluralistic theory of distributive justice, thus applying pluralism to questions of government policy.

Weber, Max. (1946 [1918]). "Politics as a Vocation." In *From Max Weber: Essays in Sociology*, trans. and eds. Hans H. Gerth and C. Wright Mills. New York: Oxford University Press.

Weber, Max. (1946 [1918]). "Science as a Vocation." In *From Max Weber: Essays in Sociology*, trans. and eds. H. H. Gerth and C. Wright Mills. New York: Oxford University Press.

INTERNET RESOURCE

Hardy, Henry. "Writings about pluralism before/independently of Isaiah Berlin." The Isaiah Berlin Virtual Library. Available from http://berlin.wolf.ox.ac.uk//lists/pluralism/onpluralism.htm.

ETHICS AND PUBLIC POLICY CENTER

SEE *Public Policy Centers.*

ETHICS ASSESSMENT RUBRICS

The introduction of new engineering accreditation criteria that includes "an understanding of professional and ethical responsibility" has firmly established the teaching of ethics as an important component of undergraduate education (Engineering Accreditation commission 2003, Herket 2002) yet, in establishing this outcome criterion, the commission also required its assessment. This is a particularly challenging proposition because ethics education is concerned not only with learning content but equally important, with developing problem solving skills. Further, such problems, or dilemmas, are rarely clear-cut and consequently do not have a definitive resolution, making traditional forms of assessment of limited value. One promising approach to this challenge is the development and use of scoring rubrics, a process that has been used for a broad range of subjects when a judgment of quality is required (Brookhart 1999). As opposed to checklists, a rubric is a descriptive scoring scheme that guides the analysis of a student's work on performance assessments. These formally defined guidelines consist of pre-established criteria in narrative format, typically arranged in ordered categories specifying the qualities or processes that must be exhibited for a particular evaluative rating (Mertler 2001, Moskal 2000). A valid rubric would allow educators to assess their students learning to date, and identify areas of weakness for further instruction.

There are two types of scoring rubrics: holistic and analytic. A holistic rubric scores the process or product as a whole, without separately judging each component (Mertler 2001). In contrast, an analytic rubric allows for the separate evaluations of multiple factors with each criterion scored on a different descriptive scale (Brookhart 1999). When it is not possible to separate the evaluation into independent factors—that is, when overlap between criteria exists—then a holistic rubric with the criteria considered on a single descriptive scale may be preferable (Moskal 2000).

Further, rubrics are intended to provide a general assessment rather than a fine-grained appraisal (such as in a 1–100 grading scale). For example, a rubric might include levels from one ("shows little or no understanding of key concept") to five ("shows full understanding of key concept; completes task with no errors"). Among the advantages of using rubrics are: (1) assessment can be more objective and consistent; (2) the amount of time faculty spend evaluating student work is reduced; (3) valuable feedback is provided to both students and faculty; and (4) they are relatively easy to use and explain (Georgia Educational Technology Training Center 2004).

Generally, rubrics are best developed starting from a desired exemplar learning outcome and working backward to less ideal outcomes, preferably using actual student work to define the rubric's various levels. The scoring system should be objective, consistent, and relatively simple, with a few criteria sets and performance levels; three to five evaluative criteria seem to be appropriate (Popham 1997).

Extensively used in K–12 education assessment, higher education areas such as composition and art, and, increasingly, engineering education (Moskal, Knecht, and Pavelich 2001), rubrics have yet to be widely adopted for assessing ethics tasks. An example is Holt et al. (1998) who developed an analytical rubric for assessing ethics in a business school setting, identifying five categories:

(1) Relevance: Analysis establishes and maintains focus on ethical considerations without digressing or confusing with external constraints;

(2) Complexity: Takes into account different possible approaches in arriving at a decision or judgment;

TABLE 1

Analysis Component of Scoring Rubric for Assessing Students' Abilities to Resolve Ethical Dilemmas

Level 1	Level 2	Level 3	Level 4	Level 5
• No analysis provided. • Defaults to a superior or authority without further elaboration. • Takes a definitive and unambiguous position without justification. • Any analysis appears to have been done without reference (explicit or implicit) to guidelines, rules or authority.	• Authoritative rule driven without justification. Position may be less definitive (e.g., "should do" vs. "must do"). • Minimal effort at analysis and justification. • Relevant rules ignored. • May miss or misinterpret key point or position. • If ethical theory is cited, it is used incorrectly.	• Applies rules or standards with justification, notes possible consequences or conflicts. • Correctly recognizes applicability of ethical concept(s). • Recognizes that contexts of concepts must be specified. • Coherent approach.	• Applies rule or standard considering potential consequences or conflicts. • Uses an established ethical construct appropriately. Considers aspects of competence and responsibility of key actors. • May cite analogous cases. • Incomplete specification of contexts of concepts.	• Correctly applies ethical constructs. • May offer more than one alternative resolution. • Cites analogous cases with appropriate rationale. • Thorough evaluation of competence and responsibility of key actors. • Considers elements of risk for each alternative. • Explores context of concepts.

SOURCE: Courtesy of Larry J. Shuman, Barbara M. Olds, and Mary Besterfield-Sacre.

Shown is the Analysis Component (one of five components) of the rubric. Note that the rubric gives the rater criteria to classify the student's response into one of five levels with five being the highest. The rater should choose the criteria set that most closely matches the student's response.

(3) Fairness: Considers most plausible arguments for different approaches;

(4) Argumentation: Presents a well-reasoned argument for a clearly-identified conclusion, including constructive arguments in support of decision and critical evaluation of alternatives;

(5) Depth: Shows an appreciation of the grounds or key moral principles that bear on the case.

These categories were rated from 1 for "non-proficient" to 6 for "excellent" according to each level's criteria.

Although not developed specifically for assessing ethical problem solving, the widely used Holistic Critical Thinking Scoring Rubric (HCTSR) with its four criteria could be adapted for a holistic assessment of students' ethical problem solving ability (Facione and Facione 1994). One recent effort along these lines has resulted in the development and validation of a rubric designed to measure engineering students' ability to respond to ethical dilemmas using case scenarios, for example, a case based on the first use of an artificial heart (Sindelar, Shuman, Besterfield-Sacre, et al. 2003). To a certain extent, the rubric follows the case analysis process of Charles E. Harris, Michael S. Pritchard, and Michael J. Rabins (1999). It consists of five components each with five levels (See Table 1):

(1) Recognition of Dilemma (relevance): Levels range from not seeing a problem to clearly identifying and framing the key dilemmas.

(2) Information (argumentation): At the lowest level, pertinent facts are ignored and/or misinformation used. At the high end, assumptions are made and justified; information from student's own experiences may be used.

(3) Analysis (complexity and depth): At the lowest level no analysis is performed. Ideally, thorough analysis includes citations of analogous cases with consideration of risk elements with respect to each alternative.

(4) Perspective (fairness): The lowest level is a lack thereof; that is, a wandering focus. The ideal is a global view of the situation, considering multiple perspectives.

(5) Resolution (argumentation): At the base level only rules are cited, possibly out of context. The ideal considers potential risk and/or public safety, and proposes a creative middle ground among competing alternatives.

Using such a rubric holds out the promise of being able to assess the learning of ethics reasoning skills in a more objective manner than has previously been the case. Indeed, there is the possibility that, given new developments in technology and learning, such rubrics could be programmed into computer-based learning modules that would be comparable to some of those developed for the self-guided teaching and learning of technical subjects.

LARRY J. SHUMAN
BARBARA M. OLDS
MARY BESTERFIELD-SACRE

BIBLIOGRAPHY

Brookhart, Susan M. (1999). *The Art and Science of Classroom Assessment: The Missing Part of Pedagogy*. Washington, DC: George Washington University, Graduate School of Education and Human Development.

Harris, Charles E., Jr.; Michael S. Pritchard; and Michael J. Rabins. (2000). *Engineering Ethics: Concepts and Cases*, 2nd ed. Belmont, CA: Wadsworth.

Herkert, Joseph R. (2000). "Continuing And Emerging Issues In Engineering Ethics Education," *The Bridge* 32(2): 8–13.

Holt, Dennis; Kenneth Heischmidt; H. Hammer Hill, et al. (1998). "When Philosophy And Business Professors Talk: Assessment Of Ethical Reasoning In A Cross-Disciplinary Business Ethics Course," *Teaching Business Ethics* 1(3): 253–268.

Moskal, Barbara M.; Robert D. Knecht; and Michael J. Pavelich. (2001). "The Design Report Rubric: Assessing the Impact of Program Design on the Learning Process." *Journal for the Art of Teaching: Assessment of Learning* 8(1): 18–33.

Popham, W. James. (1997). "What's Wrong—and What's Right—with Rubrics." *Educational Leadership* 55(2): 72–75.

INTERNET RESOURCES

Engineering Accreditation Commission. (2003). *Criteria for Accrediting Engineering*. Baltimore, MD: Accreditation Board for Engineering and Technology (ABET). Available from http://www.abet.org/criteria.html.

Facione, P.A., and N.C. Facione. (1994). "Holistic Critical Thinking Scoring Rubric." Available from http://www.insightassessment.com/HCTSR.html.

Georgia Educational Technology Training Center. (2004). "Assessment Rubrics." Available from http://edtech.kennesaw.edu.

Mertler, Craig A. (2001). "Designing Scoring Rubrics for Your Classroom." *Practical Assessment, Research & Evaluation* 7(25). Available from http://PAREonline.net.

Moskal, Barbara M. (2000). "Scoring Rubrics: What, When, and How?" *Practical Assessment, Research & Evaluation* 7(3). Available from http://PAREonline.net.

Sindelar, Mark; Larry J. Shuman; Mary Besterfield-Sacre; et al. (2003). "Assessing Engineering Students' Abilities to Resolve Ethical Dilemmas." *Proceedings, Frontiers in Education Conference*. Available from http://fie.engrng.pitt.edu/fie2003/index.htm.

ETHICS OF CARE

The ethics of care is a distinctive approach to moral theory that emphasizes the importance of responsibility, concern, and relationship over consequences (utilitarianism) or rules (deontologism). The concept of care is inherent to professions that care for individuals and this approach to ethics has therefore been a central part of professional ethical issues in both nursing and medical ethics, but in fact has much broader applications in relation to science and technology. "Due care" has for example, been a part of statements in engineering and has been used to include such typically technical activities as the maintenance and repair of an engineered system.

Origins and Development

As a moral theory the ethics of care originated during the 1970s and 1980s in association with challenges to the standard moral theories of utilitarianism and deontologism, primarily by women philosophers. The original work was Carol Gilligan's, conducted in the early 1970s and articulated in *In a Different Voice* (1982). Gilligan argued in response to the psychology of moral development formulated by Lawrence Kohlberg (1927–1987). Kohlberg himself built on the ideas of Jean Piaget (1896–1980), who did preliminary work on moral development as one facet of cognitive growth.

In his research Kohlberg posed moral dilemmas to males of various ages and compared the kinds of reasoning with which they responded. The dilemmas tended to be shorn of details about the people involved. The responses moved from self-centered thinking, emphasizing the importance of physical pleasure through thinking under the influence of peer pressure, to a moral orientation toward justice and abstract appeals to universal rights (Kohlberg 1984). Gilligan, on the basis of alternative research with both men and women, discovered a contrasting tendency, predominantly but not exclusively among women, to interpret "the moral problem as a problem of care and responsibility in relationships rather than as one of rights and rules" (p. 73). "While an ethics of justice proceeds from the premise of equality—that everyone should be treated the same—an ethic of care rests on the premise of nonviolence—that no one should be hurt" (p. 174).

Like Kohlberg, however, Gilligan sees an ethics of care emerging in three phases. In the early phase individuals care more for themselves than for others. In a middle phase care comes to emphasize concern for others over care for oneself. Finally, in its mature form the ethics of care seeks a balance between care for oneself and care for others. What nevertheless remains primary in each case is personal relationships: of others to oneself, of oneself to others, or mutually between oneself and others.

This new ethics of care was developed further by Nel Noddings (1984) in relation to education, and given a more philosophical formulation by Annette C. Baier (1985). According to Baier, Gilligan exemplifies a strong school of women philosophers that includes Iris Murdoch (1919–1999) and G. E. M. Anscombe (1919–2001), out of which have developed moral theories that stress living relationships over abstract notions of justice illustrated, for example, by the work of Immanuel Kant (1724–1804). Indeed, three decades prior to Gilligan, Anscombe had already suggested the need for a philosophical psychology as the gateway to any moral philosophy that might be adequate to issues arising in relation to science and technology.

Baier herself criticizes the rationalist individualism that rests content with establishing a minimalist set of traffic rules for social interaction as inadequate on a multitude of counts. Historically, it has failed to oppose injustices to women, the poor, and racial and religious minorities. While most human relations are between unequals, it has focused almost exclusively on relations between alleged equals. Despite the fact that many morally significant relations are not freely chosen, it has emphasized freedom of choice and rational autonomy. And although emotions are often as important as reasons, it has persistently stressed the rational control of behavior. At the same time Baier is careful to emphasize how an ethics of care complements rather than discards an ethics of justice. A good moral theory "must accommodate both the insights men have more easily than women, and those women have more easily than men" (Baier 1985, p. 56).

Applications in Biomedicine

From her empirical studies of people faced with difficult moral decisions, Gilligan identified a distinct approach—one of care, responsibility, concern, and connection, based on personal relations. This care orientation forms the basis of the ethics of care, "grounded in responsiveness to others, that dictates providing care, preventing harm and maintaining relationships" (Larrabee 1993, p. 5). It was natural that such an approach to ethics would be applied in the field of medicine, especially in nursing, where caregiving is already a defining characteristic. It is often argued that care is distorted by the dominance of scientific and technological practices in the practice of medicine.

In this regard one can note, for instance, how care has come to play an increasingly prominent role in such an influential text as Tom L. Beauchamp and James F. Childress's *Principles of Biomedical Ethics*. From its first edition (1979), this representative of the "Georgetown School" of bioethics emphasized a deontological "system of moral principles and rules" that highlighted four principles: autonomy (of the patient), nonmaleficence, beneficience, and justice. In neither the first nor the second edition (1983) did the ethics of care play a role. In the third edition (1989) and subsequent editions care has nevertheless been acknowledged especially in conjunction with an account of criticisms of principlism.

> Although [principled] impartiality is a moral virtue in some contexts, it is a moral vice in others. [Principlism] ... overlooks this two-sidedness when it simply aligns good and mature moral judgment with moral distance. The care perspective is especially meaningful for roles such as parent, friend, physician, and nurse, in which contextual response, attentiveness to subtle clues, and the deepening of special relationships are likely to be more momentous morally than impartial treatment. (Beauchamp and Childress 2001, p. 372)

The authors go on to note the centrality of two themes in the ethics of care—mutual interdependence and emotional responsiveness. For the ethics of care, "many human relationships involve persons who are vulnerable, dependent, ill, and frail [and] the desirable moral response is attached attentiveness to needs, not detached respect for rights" (p. 373). The ethics of care further corrects a "cognitivist bias [in principlism] by giving the emotions a moral role" (p. 373) and encouraging attention to aspects of moral behavior that might otherwise be ignored.

In the field of nursing, in which care exercises an even more defining role than in other medical professions, the ethics of care has been accorded even more significance. Helga Kuhse's *Caring: Nurses, Women, and Ethics* (1997) provides a good overview in this area.

Criticisms

Beauchamp and Childress also summarize key criticisms of the ethics of care in the biomedical context. First, the ethics of care is incompletely developed as a theory. Second, one can easily imagine situations in which relatives or medical professionals are called on to override emotional responses and to abide by principles. Third, the ethics of care can be distorted by cultural expectations. Indeed, some feminist critics have argued that care is easily distorted by contemporary interests, as in cases in which the terminally ill request to be allowed to die because they do not want to continue to be a burden to those around them. Finally, still others have challenged the empirical basis for some of conclusions advanced by Gilligan and others, and questioned popular associations between the ethics of care and female experience.

More constructively, it is unnecessary to maintain an essentialist connection between the ethics of care and female experience. In fact, Gilligan herself argues that the connection may be only historical. It may just be that those who are marginalized in a rule-governed scientific and technological culture have a natural tendency to emphasize alternatives. But this possibility reinforces rather than diminishes the need to attend to the claims in ethics of care. In a culture that values competition and efficiency the ethics of care also promotes such activities as conflict resolution and dispute mediation when dealing with ethical and other conflicts.

Application to Technology and Engineering

The most salient definition and framework of care to apply to the contexts of science and technology is that of Joan C. Tronto and her colleague Berenice Fisher. Tronto and Fisher suggest that caring be viewed as "a species activity that includes everything that we do to maintain, continue and repair our world so that we can live in it as well as possible. That world includes our bodies, our selves, and our environment, all of which we seek to interweave in a complex, life-sustaining web" (Tronto 1993, p. 103).

The ethics of technology and of science needs to be a system ethics to be followed by a system of actors, doers, and stakeholders. It needs to work in the context of the science and technology enterprises, which are distinct. The justice and rights perspective gives an abstract, universalizable goal as Kohlberg, and indeed Kant before him, intended, but the praxis of science and technology calls for a guide for action in terms denoting action. This is what the ethics of care provides. Care in this sense is larger than care implied by familial and close community relationships. Care, too, is universalizable, but not abstract.

The Fisher-Tronto definition provides the actions—maintain, continue, and repair—that care demands, words closely associated with engineering, the action element of technology. This definition of care also recognizes that human existence is intricately woven into the web of the natural environment and that the ethics of care must apply to nature as well as to humans and their communities. In this perspective, care is well positioned as an ethics for a sustainable world, a prime challenge to today's technology. In her analysis of care, Tronto recalls David Hume's understanding of justice, an artificial passion, as a necessary complement to the natural passion of benevolence, which alone may not be sufficient as a moral basis in a human society. These ideas also hark back to Aristotle who sees practical deliberation as the means of achieving the ethical good and praxis as the end of ethics.

Marina Pantazidou and Indira Nair (1999), who have examined care particularly in the context of engineering, identify care as a value-guided practice, not a system of values. Care emerges in response to a need. Meeting human needs is indeed the ideal for technology. Tronto has provided a framework for practicing care that is particularly suited for application to technology and indeed to science. Tronto identifies four phases of care that parallel closely stages identified with the process of engineering design.

(1) Attentiveness, or "caring about," is the phase of recognizing the correct need and realizing care is necessary. This is parallel to the need identification stage in design.

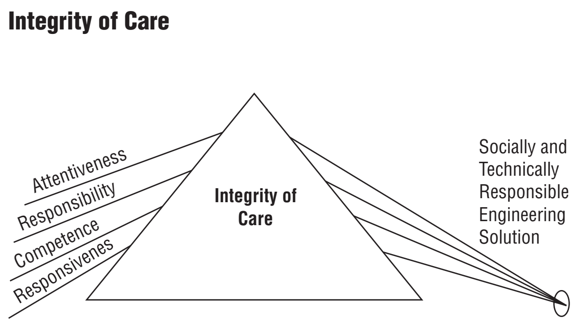
(2) Responsibility, or "taking care of," is the phase that involves "assuming responsibility for the identified need and determining how to respond to it" (Tronto 1993, p. 106). This is parallel to the conceptualization phase of design.

(3) Competence, or "caregiving," is the phase in which the need is met with the expertise needed. This is parallel to the actual design and production.

(4) Responsiveness, or "care receiving," is the phase in which "the object of care will respond to the care it receives" (Tronto 1993, p. 107). This is parallel to the acceptance (or rejection) of the designed product.

Total care requires an attuned caregiver, who through commitment, learning, and experience has an understanding of the process as well as the competence and skills and watches the response of the one cared for. Tronto introduces a fifth component to complete the process. She calls this the Integrity of Care, requiring

FIGURE 1



SOURCE: Pantazidou and Nair (1999).

"Engineering with care" depicted as a prism that integrates the four elements of care into the resulting engineering product. For a sharp focus, the proportion of attentiveness, responsibility, competence, and assessment (responsiveness), represented by the rays and angles of incidence, has to be accurate. Engineering with less than accurate angles will result in a smeared focus in this prism analogy (Pantazidou and Nair 1999).

"that the four moral elements of care be integrated into an appropriate whole."

Figure 1 is the representation of this process by Pantazidou and Nair with the Integrity of Care as a prism that focuses the four care components to a socially and technically responsible technological product. Carrying the prism analogy forward, a technology that has no room for any error will require extremely fine tuning of the four angles of the phases of care to yield a sharp focus. One may argue that in general an ethics of care applied to a technology will say that such a technology poses high risk and may be best avoided. Where such precision is not required, there may be more tolerance of how the phases come together. In some cases, a single focused solution may not be possible or it might not be critical. Then, a range of perhaps suboptimal solutions—a smeared focus—may be sufficient or even necessary for pragmatic reasons.

Figure 2 shows how the ethics of care and the description of the engineering design process compare.

Care in Science

Science in general is not as easily mapped into such a scheme unless it is science done expressly for the purpose of answering a technology-derived question or problem. In this case, Figure 1 applies directly, because the science is done in response to a need.

In the case of science in general, the ethics of care can provide some ethical tests attuned to each phase.

(1) Attentiveness: Is the science being done in response to a perceived need? Or, are needs being scientifically assessed so that a given technology is likely to be the best response? As human needs are perceived, are scientific resources being directed toward those?

(2) Responsibility: What is the science that determines if a technological process or product is the answer to the need? Does new scientific knowledge direct action toward the appropriate human need?

(3) Competence: This is perhaps the one phase toward the accomplishment of which the current scientific ethic is almost solely directed.

(4) Responsiveness: The science of the consequence of a technology is a requisite. This would include predictive science. Hans Jonas (1984) has suggested that one imperative of human technological power is that "knowledge (science) must be commensurate with the causal scale of our action . . . that predictive knowledge falls behind the technical knowledge that nourishes our power to act, itself assumes ethical importance" (p. 8).

This last corollary is perhaps the most important result that the ethics of care can yield in the case of science—that science to reduce the uncertainty of human technological actions take on importance in the scientific enterprise.

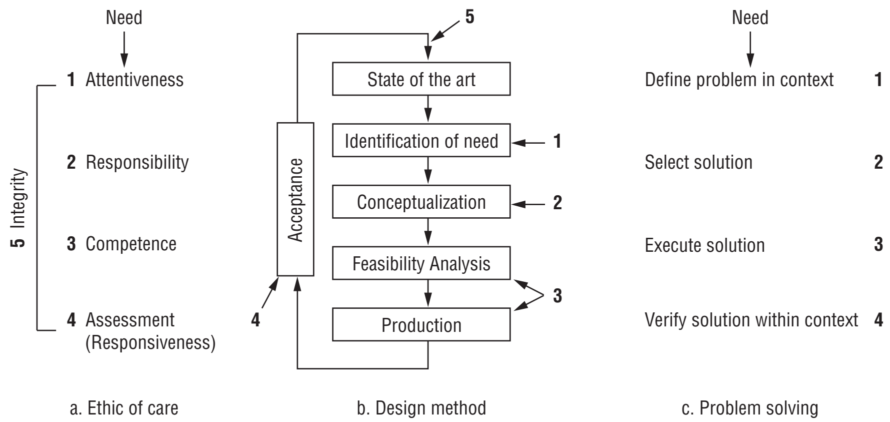
Care in Engineering

"Reasonable standard of care" has been common parlance in product specifications separate from the consideration of any ethical standard. Product liability issues assess whether "due care" was taken. Thus care has become an inherent notion in technological products spurred over time by legal demands. A working definition of the standard of care for engineering, set by legal precedent, has been proposed by Joshua B. Kardon (2002) as "That level or quality of service ordinarily provided by other normally competent practitioners of good standing in that field . . . under the same circumstances." While proposed as an ethic for the engineer to follow, this standard does not fully address all the elements of the ethics of care.

Moreover, challenged by the requirements of sustainability, technological planning has begun to consider system characteristics such as environmental impacts of a product life cycle in the design of a product or a process. With technology intertwining with everyday lives in

FIGURE 2

Analogies Between the Ethic of Care, the Design Method, and the Problem-Solving Method



SOURCE: Pantazidou and Nair (1999).

Analogies between the ethic of care, the design method and the problem solving method. (a) The five components of the ethic of care; (b) Mapping between steps of the design process (after Dieter [24]) and components of the ethic of care.

intricate ways, interface design of all sorts of technology has become important. Industrial ecology, green design, green chemistry, and humane design are some of the trends that illustrate the ethics of care at work (Graedel and Allenby 2003; Collins Internet article).

A systematic application of the ethics of care to science and technology is yet to be done and may indeed benefit practice. Such an analysis and a synthesis of standards of the practice of science and technology with the ethics of care may yield a framework that is realistic enough for the handling of the complexity of technological and scientific progress. The ethics of care may aid in this by responding to Jonas's condition of the sustainability of humanity as a technological imperative, Manfred Stanley's call for placing human dignity on par with species survival (1978), and Anthony Weston's observation that tough ethical problems be treated as problematic situations and not as puzzles (1992).

INDIRA NAIR

SEE ALSO *Anscombe, G. E. M.; Bioethics.*

BIBLIOGRAPHY

Anscombe, G. E. M. (1958). "Modern Moral Philosophy." *Philosophy* 33: 1–19. Calls for an adequate philosophy of psychology before attempting moral philosophy.

Baier, Annette C. (1985). "What Do Women Want in a Moral Theory?" *Nous* 19(1): 53–63. Reprinted in the author's *Moral Prejudices: Essays on Ethics* (Cambridge, MA: Harvard University Press, 1994).

Beauchamp, Tom L., and James F. Childress. (2001). *Principles of Biomedical Ethics,* 5th edition. New York: Oxford University Press. First edition, 1979; 2nd edition, 1983; 3rd edition, 1989; 4th edition, 1994. Standard text in the field of biomedical ethics.

Dieter, George E. (1991). *Engineering Design: A Materials and Processing Approach,* 2nd edition. Boston: McGraw-Hill. Standard text in engineering design.

Flanagan, Owen. (1991). *Varieties of Moral Personality*. Cambridge, MA: Harvard University Press. An exploration of the relationship between psychology and ethics, arguing for constructing ethical theory and theory of moral development from an understanding of cognitive psychology.

Gilligan, Carol. (1982). *In a Different Voice: Psychological Theory and Women's Development*. Cambridge, MA: Harvard University Press. A classic work that set forth the care perspective in moral reasoning.

Gilligan, Carol; Janie Victoria Ward; and Jill McLean Taylor, eds. (1988). *Mapping the Moral Domain*. Cambridge, MA: Harvard University Graduate School of Education. Collection of essays discussing research and research strategies for exploring care and justice perspectives in diverse populations.

Graedel, Thomas E., and Braden R. Allenby. (2003). *Industrial Ecology,* 2nd edition. Upper Saddle River, NJ: Prentice Hall. First textbook covering the emerging field of industrial ecology.

Jonas, Hans. (1984). *The Imperative of Responsibility: In Search of an Ethics for the Technological Age*. Chicago: University of Chicago Press. Jonas, a pioneer of bioethics, explores constraints that technology should follow in order to be able to preserve life on the planet.

Kohlberg, Lawrence. (1971). "From Is to Ought." In *Cognitive Development and Epistemology,* ed. Theodore Mischel. New York: Academic Press.

Kohlberg, Lawrence. (1981). *Essays on Moral Development,* Vol. 1: *The Philosophy of Moral Development*. San Francisco: Harper and Row.

Kohlberg, Lawrence. (1984). *Essays on Moral Development,* Vol. 2: *The Psychology of Moral Development*. San Francisco: Harper and Row. Standard works on moral psychology by pioneer Lawrence Kohlberg.

Kuhse, Helga. (1997). *Caring: Nurses, Women, and Ethics*. Malden, MA: Blackwell.

Larrabee, Mary Jeanne, ed. (1993). *An Ethic of Care*. New York: Routledge. Collection of essays concerned with the ethics of care over a decade following Gilligan's first work.

Noddings, Nel. (1984). *Caring: A Feminine Approach to Ethics and Moral Education*. Berkeley and Los Angeles: University of California Press. 2nd edition, 2003. Applies the care ethic to education.

Pantazidou, Marina, and Indira Nair. (1999). "Ethic of Care: Guiding Principles for Engineering Teaching and Practice." *Journal of Engineering Education* 88(2): 205–212. First paper on applying care ethics to engineering.

Stanley, Manfred. (1978). *The Technological Conscience*. New York: Free Press. A sociologist's call for an ethic of technology that values human dignity above species survival.

Tronto, Joan C. (1993). *Moral Boundaries: A Political Argument for an Ethic of Care*. New York: Routledge. Presents care as a central and sustaining activity of human life; examines the moral boundaries set by the politics of power in devaluing care professions.

Weston, Anthony. (1992). *Toward Better Problems: New Perspectives on Abortion, Animal Rights, the Environment, and Justice*. Philadelphia: Temple University Press. An application of the philosophy of pragmatism acknowledging the context and the multiplicity of values in ethical problems.

INTERNET RESOURCES

Collins, Terrence. "Ethics." Institute for Green Oxidation Chemistry, Carnegie Mellon University. Available from http://www.chem.cmu.edu/groups/collins/ethics/. Discusses the responsibility of chemists to promote sustainability.

Kardon, Joshua B. (2002). "The Structural Engineer's Standard of Care." Online Ethics Center for Engineering and Science, Case Western Reserve University. Available from http://onlineethics.org/cases/kardon.html. Points out the role care plays in the practice of engineering.

ETHICS: OVERVIEW

From the perspective of science, technology, and ethics, ethics itself—that is, critical reflection on human conduct—may be viewed as a science, as a technology, and as providing multidimensional independent perspectives on science and technology. The encyclopedia as a whole constitutes manifold illustrations for each of these possibilities. It is nevertheless appropriate to provide in a separate entry some orientation within the manifold.

Ethics as Theory and Practice

In the works of Plato (c. 428–347 B.C.E.), dialogues rather than treatises, ethics is interwoven with logical analysis and theories of knowledge, reality, and political affairs so as to resist clearly distinguishing these different branches of philosophy. What came to be called ethics nevertheless clearly serves as first or primary philosophy. In Socrates's autobiography (*Phaedo* 96a ff.) it is not the foundations of nature but the ideas of beauty, goodness, and greatness that act as the basis of philosophical inquiry. The search for a full account of ethical experience calls forth an appreciation of different levels of being and different forms of knowing appropriate to each—although the highest reality is once again ethical, the good, which is beyond being (*Republic* 509a–b).

According to Aristotle (384–322 B.C.E.), however, philosophy originates when discourse about the gods is replaced with discourse about nature (compare, e.g., *Metaphysics* 1.3.983b29 and 1.8.988b27). It is the study of natures, as distinguishing functional features of the world, that both constitutes natural science and provides insight into the *telos* or end of an entity. For Aristotle the various branches of philosophy themselves become more clearly distinguished, and ethics functions as the systematic examination of *ethos,* as constituted by the customs or behaviors of human beings. More than any other type of entity, humans have a nature that is open to and even requires further determinations. At the individual level these supplemental determinations are called character; at the social level, political regimes. Their very multiplicity calls for systematic (that is, in the classical sense, scientific) analysis and assessment.

Such analysis and assessment takes place on three levels. In the first instance it is descriptive of how human beings in fact behave. As Aristotle again notes, human actions by nature aim at some end, and the end pursued can be of three basic types, defining in turn the lives of physical pleasure, of public honor, and of intellectual investigation.

In the second instance, ethics compares and contrasts these ends and seeks to identify which is superior and for what reasons. For Aristotle the life of reason is superior because it is that which humans by nature do only or best, and is itself the most autonomous way of life. Humans share with other animals the pursuit of pleasure; the pursuit of honor is dependent on recognition by others and the historical contingency of having been born into a good regime.

Finally, in the third instance the ethical life itself becomes a striving simply for knowledge of human behavior. It seeks conceptual clarification regarding different forms of perfection (virtue) and imperfection (vice), synthetic appreciation of the relations between human nature and other forms of nature, and ultimately a transcendence of the subordinate dimensions of human experience. Ethics in this final form becomes science in the most general sense, concerned not with the part (humans) but the whole (cosmos).

Yet as Aristotle also notes, humans undertake ethical inquiry not simply to know about the good but also to become good (*Nicomachean Ethics* 2.2). Ethics is not just a science but a practice, a technique for self- and social improvement. Insofar as this is the case, ethics provides guidelines for development of character and counsel for political organization and rule. Ethics leads to politics, meaning not just political action but political philosophy (*Nicomachean Ethics* 10.9).

Roman philosophers, continuing the Greek tradition, likewise examined the *mores* (Latin for *ethoi*, the plural of *ethos*) of peoples, in what came to be called moral theory. Thus ethics is to ethos as moral theory is to morals. *Ethics* and *moral theory* are but two terms for the same thing: systematic reflections on human conduct that seeks to understand more clearly and deeply the good for humans.

During the Middle Ages these articulations of ethics or moral theory (science) and ethical or moral practice (technique) were enclosed within the framework of revelation. For instance, according to the argument of Augustine (354–430 C.E.) in *On True Religion*, revelation takes the truths of philosophy, known only by the few, and makes them publicly available to the many. By so doing religion makes the practical realization of the good more effective than was previously possible, at both personal and political levels.

According to Thomas Aquinas (c. 1225–1274), the supernatural perspective allows Christians to provide more accurate descriptions, more sure assessments, and more perfect insight into the ultimate nature of reality and the human good than was possible for pagans. What for Aristotle could be no more than the counsels of practical wisdom became for Thomas natural laws of human conduct, laws that gear down the cosmic order and are manifest in human reason as a "natural inclination to [their] proper act and end" (*Summa theologiae* I–II, ques. 91, art. 2). The self-evident first principle of ethics that "good is to be done and promoted and evil is to be avoided" is given content by the natural inclinations to preserve life, to raise a family, and to live in an intelligence-based community (*Summa theologiae* I–II, ques. 94, art. 3).

The traditional forms of ethics as science and as technique acted to restrain the independent pursuit of science and technics. As entries on "Plato," "Aristotle," "Augustine," and "Thomas Aquinas" further suggest, these traditions provide continuing resources for the critical assessment of modern science and technology. Indeed, the contentious character of these often alternative assessments may be one of their most beneficial aspects, in that they call for reconsidering the assumptions that now animate scientific and technological activity.

Ethics as Science and Technology

In the modern period a basic transformation occurs in the understanding of ethics, one related to a transformation in science and technology. The scientific understanding of nature came to focus no longer on the natures of different kinds of entities, but on laws that transcend all particulars and kinds. The knowledge thus promoted the merger of technics into technology, the systematic power to control or reorder matter and energy. Technological knowledge became the basis for a technological activity that produced artifacts in greater regularities and quantities than ever before possible.

In like manner, the science of ethics sought to elucidate rules for human action. Divides emerged in the details of different ethical systems, but the major approaches nevertheless all pursued ethical decision-making processes that could be practiced with competence and regularity on a scale to cope with the new powers first of industrialization and then of globalization. The modern period thus witnessed the development of ethics as a science with a unique intensity and scope.

From their origins science and technology were supported with fundamentally ethical arguments—by Francis Bacon (1561–1626), René Descartes (1596–1650), and others—for a new vision of human beings as deserving to control the natural world and dominate it. The Enlightenment and the Industrial Revolution flourished in conjunction with the progressive articulation of ideas about how humans might, through science and technology, remake both the physical and social worlds. Romanticism served as a critical response to the difficulties, threats, and complications inherent in such a reshaping of human experience, but in ways that were ultimately incorporated into the emerging cultural transformation. (Encyclopedia entries on "Bacon, Francis," "Descartes, René," and the "Industrial Revolution," among others, explore such issues in more detail.)

The systematic development of the modern science of ethics itself emerged in two major traditions. One was the consequentialist utilitarian tradition as elaborated by Jeremy Bentham (1748–1832), John Stuart Mill (1806–1873), and their followers. The other was a deontological or duty-focused tradition with roots in the thought of Jean-Jacques Rousseau (1712–1778) but most closely associated with the work of Immanuel Kant (1724–1804). For consequentialists, rules for ethical decision-making are best determined by end uses or the effects of actions; for deontologists rules are grounded in the intentional properties of the actions themselves. Leading twentieth-century representatives of these two traditions include Peter Singer (b. 1946) and John Rawls (1921–2002), respectively. Both traditions are efforts to deal with the moral challenge created by the loss of nature as a normative reality within and without human beings. (Encyclopedia entries on the traditions of "Consequentialism" and "Deontology" are complemented by separate entries on such thinkers as "Rousseau, Jean-Jacques," "Kant, Immanuel," and "Rawls, John.")

Prior to the modern period, natural entities were understood as possessed of functional tendencies toward internal and external harmonies. When they function well and thereby achieve their *teloi*, plural of *telos* or ends, acorns grow up into oak trees, human beings speak and converse with one another in communities. Furthermore, both oak trees and humans fit in with larger natural orders. Because these harmonies are what constitutes being itself, they are also good, which is simply the way that reality manifests itself to, draws forth, and perfects the appetite. Although the first name of the good may be that which is one's own, a second and superior name is form or being, the different instances of which themselves come in an ascending order. For the Platonic and Aristotelian traditions, ethics as practice was thus constituted by the teleological perfection of human nature, realizing ever-higher states of functional potential. Such a view has obvious affinities with religious traditions as diverse as Hinduism, Buddhism, and Christianity. But insofar as nature comes to be seen as composed not of entities with natures to be realized, but as constructions able to be used one way or another and modified at will, fundamental questions arise about the foundations of the good as an end to be pursued as well as the rightness of any means to be employed in such pursuit.

The fundamental problem for modern ethics is not just what the good is, but its basis. In simplified terms, for the consequentialist tradition the good is what human beings need or want, and there are no limits on actions as means other than what might be at odds with perceived wants; for the deontological tradition right means are those whose intentions may be consistently pursued or universalized, with no limits on the goods that might flow from them.

Efforts to make consequentialist and deontological systems truly scientific have been pursued both formally and substantively. In the first half of the twentieth century a pursuit of formal rigor led to the development of metaethics. Eschewing any normative goals, metaethics simply aspires to clarify the structure of ethical language and reasoning. In its radical form metaethics has tended to reduce the meaning of ethical statements to forms of emotional approval; in more moderate forms it has simply disclosed the complexities of ethical judgments, sometimes pointing up and seeking to rectify inconsistencies. In the second half of the twentieth century the inadequacies of metaethical analysis for the substantive issues faced in the creation and use of science and technology brought about development of applied ethics. The term is somewhat anomalous, because all traditional ethics applied to real life. Applied ethics is applied only in contrast to metaethical formalist aspirations.

Across the twentieth century efforts to make ethics scientific in more substantive ways developed in two tracks. One was to try to base ethics on evolutionary theory. This approach commonly takes those behaviors that are descriptively given moral value (such as altruism) and shows how and why such approval could have been the outgrowth of the processes of evolutionary selection.

Another effort to make ethics substantively scientific has been to elucidate the rationality of ethical behavior through the mathematics of game and decision theory. In the same spirit as game and decision theory, parallel efforts to supply practical wisdom with the strengths of quantitative methods have given rise to operations research and risk–cost–benefit analysis. Much more than evolutionary theory, such efforts have produced ethical techniques for dealing with the complexities of the advanced scientific and technological world, especially in relation to public policy analysis.

Continuing efforts to model ethics on the authority of modern science and the powers of technology, including the computer modeling of artificial ethics, have proved selectively suggestive and insightful. Despite significant achievements, however, neither scientific nor technological ethics has proved able to capture the richness of ethical reflection that is spread across the diversity of ethical traditions, ancient and modern.

Ethical Perspectives on Science and Technology

A different approach to the ethics of science and technology eschews making ethics into a science or a technology but to consider science and especially technology as new fields requiring ethical analysis and reflection. Here there has been a divide between those who seek to bring ethics to bear on science and technology as a whole, and those who choose to limit their ethical reflection to specific sciences or technologies.

With regard to the holistic approach, the work of Hans Jonas (1903–1993) may be taken as representative. For Jonas the powers of modern technology, which are more extensive across space and time, on the macro- and the microscale, than all previous human abilities, require a new ethics of responsibility. In his words, "Modern technology has introduced actions of such novel scale, objects, and consequences that the framework of former ethics can no longer contain them" (Jonas 1984, p. 6). In response Jonas formulated the new imperative of responsibility as: "Act so that the effects of your action are compatible with the permanence of genuine human life" (p. 11). (For more detail, see the entry on "Jonas, Hans.")

With regard to approach that focuses on specific technologies, this is well represented by the various fields of applied ethics such as agricultural ethics, bioethics, business ethics, computer ethics, engineering ethics, environmental ethics, and more (each of which is given its own entry). Further specificity can be found in many of the case studies included in the encyclopedia, from "Abortion" to "Zoos."

In both holistic and particularist approaches, however, there are at least two common themes. One is whether on balance science and technology—or some particular science or particular technology—should be encouraged or in any way restrained. Another is whether existing ethical traditions are adequate to deal with the ethical challenges of science and technology, or whether instead wholly new ethical concepts and frameworks need to be developed.

Finally, even when the adequacy of existing traditions is assumed or defended, there are a number of distinctive concepts and principles that tend to recur in the ethical examinations of science and technology—or particular fields therein. Examples include the principles of respect for human autonomy and the exercise of responsibility and public participation, along with the concepts of safety and risk, the environment, and expertise. Each of these, along with a number of closely related terms, are thus also accorded encyclopedic entries.

The Limitations of Ethics

Any overview of ethics, especially one that highlights the way ethics attempts to deal with the dangers and challenges of science and technology, should not fail to mention the danger of ethics itself. These dangers come in three forms: economic, personal, and philosophical.

First, the economic danger in bringing ethics to bear on science and technology will limit scientific and technological progress, which in turn will limit economic development.

Second, there is what may be called the personal temptation to false righteousness. Turning a technical problem into an ethical one can make it more difficult to discuss, because the discussants now address it in terms of emotionally loaded senses of right and wrong or good and bad rather than the less loaded senses of more or less efficient or effective. Because of such emotional investments, social and political discussions can become intractable when ethical principles are invoked and people become unwilling to compromise. When the NIMBY ("not in my backyard") syndrome is justified not simply on the basis of practical concerns but by appeal to fundamental rights or other principles, it can become almost impossible to find common ground solutions. The opposition between fundamentalist religious beliefs about abortion and zealous commitments to women's rights provide another example of the problems that can be created by assessing science or technology in ethical terms.

Third, philosophers from Karl Marx to Michel Foucault have argued that morality is often simply a disguised form of self-interest. A modern tradition of the philosophical criticism of ethics has highlighted numerous ways that morality has been used to justify human oppression and exploitation, from racism to gender discrimination. Ethics can be simply another name for lack of self-knowledge, a kind of false consciousness.

Finally, another philosophical issue with ethics is that to define a problem as one of ethics can obscure not only its scientific and technical aspects but also its epistemological, metaphysical, aesthetic, and even theological dimensions. As philosopher Robert Frodeman

(2003) has argued with regard to an extended examination of problems in the geosciences, environmental ethics is not enough. The issues of environmental ethics are often as much aesthetic and ontological as they are ethical. The category of the ethics must not be allowed to obscure other equally significant categories of reflection that are called forth by efforts to understand and assess science and technology.

CARL MITCHAM

SEE ALSO *Consequentialism; Cosmology; Deontology; Humanization and Dehumanization; Nature; Virtue Ethics.*

BIBLIOGRAPHY

Chadwick, Ruth, ed. (2001). *The Concise Encyclopedia of the Ethics of New Technologies*. San Diego, CA: Academic Press. Thirty-seven articles on various technologies (biotechnology, genetic engineering, nuclear power) and related issues (brain death, intrinsic and instrumental value, precautionary principle) selected from the *Encyclopedia of Applied Ethics* (1998).

Frodeman, Robert. (2003). *Geo-Logic: Breaking Ground between Philosophy and the Earth Sciences*. Albany: State University of New York Press.

Jonas, Hans. (1984). *The Imperative of Responsibility: In Search of an Ethics for the Technological Age*, trans. Hans Jonas and David Herr. Chicago: University of Chicago Press. Combines two German books published first in 1979 and 1981.

Kaplan, David M., ed. (2004). *Readings in the Philosophy of Technology*. Lanham, MD: Rowman and Littlefield. Includes substantial sections on ethics and politics.

Keulartz, Jozef, Michiel Korthals, Maartje Schermer, and Tsjalling Swierstra, eds. (2002). *Pragmatist Ethics for a Technological Culture*. Dordrecht: Kluwer Academic. A collaborative argument for pragmatism as the best ethical tradition for dealing with science and technology.

Mitcham, Carl, and Robert Mackey, eds. (1983). *Philosophy and Technology: Readings in the Philosophical Problems of Technology*. New York: Free Press. The "Ethical-Political Critiques" section includes a number of classic texts; other articles in this early collection are also relevant.

Scharff, Robert C., and Val Dusek, eds. (2003). *Philosophy of Technology: The Technological Condition*. Malden, MA: Blackwell. Part V, "Technology and Human Ends," includes thirteen relevant contributions.

Scott, Charles E. (1990). *The Question of Ethics: Nietzsche, Foucault, Heidegger*. Bloomington: Indiana University Press. A critical and sympathetic examination of the modern tradition of the ethical questioning of ethical thought.

Tavani, Herman T. (2003). *Ethics and Technology: Ethical Issues in an Age of Information and Communication Technology*. Hoboken, NJ: Wiley.

Winner, Langdon. (1986). *The Whale and the Reactor: A Search for Limits in an Age of High Technology*. Chicago: University of Chicago Press.

INTERNET RESOURCE

"The Online Ethics Center for Engineering and Science." Case Western Reserve University. Available from http://onlineethics.org.

ETHOLOGY

Ethology is the biological study of animal behavior. It derives from the Greek root *ethos*, which, in normal English usage, refers to the manner of living, or customary behavior, of a social entity. One may therefore speak of the ethos of a particular sports club, small town, or professional organization, for example. By the same token, ethologists are concerned with the ethos of animals: their way of behaving.

Ethology traces its history to the early decades of the twentieth century, especially the work of the Austrian physician Konrad Lorenz (1903–1989), Dutch biologist Niko Tinbergen (1907–1988), and German entomologist Karl von Frisch (1886–1982); in recognition of their achievements, these three shared the Nobel Prize in physiology or medicine in 1973. The characteristics of ethology as a scientific discipline can be appreciated by comparing it to one of its well-known counterparts, comparative psychology.

Whereas comparative psychology is primarily concerned with understanding human behavior, such that animal research is conducted with an eye to better understanding *Homo sapiens*, ethology focuses specifically on the behavior of animals for its own sake. Similarly, comparative psychologists study a small range of animal species—particularly laboratory rats, macaque monkeys, and pigeons—as easily manipulated substitutes for human beings. By contrast, ethologists study the diversity of animal species, especially invertebrates, fish, and birds. Because of their underlying concern with understanding human behavior, researchers in comparative psychology are especially interested in examining the various concomitants of learning (which have a notable impact on human beings). Ethologists pay considerable attention to behavior that is loosely described as "instinctual," which tends to be more prevalent in the species with simpler nervous systems that are typically the subject of ethological research. Ethologists also emphasize the study of animal behavior in its natural context; that is to say, under field conditions where the organisms normally live and to which they are adapted by natural selection. By contrast, comparative psychologists typically conduct their research in a laboratory setting within which they can carefully control for extraneous factors while focusing on the role of various aspects of experience.

Some Aspects of Classical Ethology

Ethology, as the study of how organisms conduct their lives, long has been especially concerned with compiling careful, detailed descriptions of actual behavior patterns, known as *ethograms*. These detailed records (including verbal descriptions, photographs, and sonograms of vocal communications, for example) are not generally considered ends in themselves, but are fundamental to a rounded, ethological understanding of any species: Ethologists emphasize that they must first know what the animals in question do before they can pose meaningful questions.

According to Niko Tinbergen, those questions are especially concerned with the following:

(a) How does the behavior in question influence the survival and success of the animal? In modern evolutionary terms, what is its adaptive significance; or, how does it contribute to the inclusive fitness of the individual and the genes responsible, recognizing that inclusive fitness involves not only personal, Darwinian reproductive success but also the effect of each behavior on the fitness of other genetic relatives.

(b) What actually makes the behavior occur at any given moment? This might include the role of hormones, brain mechanisms, prior learning, and so forth.

(c) How does the behavior in question develop as the individual grows and matures? What is its developmental trajectory, or *ontogeny*?

(d) How has the behavior evolved during the course of the species' evolutionary history? In short, what is its *phylogeny*?

It is worth noting that of these, question *a* has become the special province of *sociobiology*, a research discipline closely allied to ethology and that emphasizes matters of adaptive significance and evolutionary—often called *ultimate*—causation. By contrast, question *b* is associated in the public mind with research into animal behavior more generally; it is often called *proximate* causation. Ideally, a complete understanding of animal behavior will involve both ultimate and proximate considerations, as well as attention to matters of ontogeny and phylogeny.

Through their research, early ethologists developed a number of concepts now considered part of "classical ethology." These include, but are not limited to, the following. *Fixed action patterns* are the fundamental building blocks of behavior, consisting of simple, relatively unvarying movements that are more or less independent of prior experience. Once initiated, fixed action patterns generally continue to completion even if the initiating stimulus is no longer present; this emphasizes the unthinking nature of these acts, which are the products of natural selection rather than complex cognition or daily experience. Fixed action patterns, in turn, are evoked by *releasers*, features of the environment or other animals to which the receiving animal is delicately attuned. The situation is analogous to a lock-and-key mechanism: a lock is carefully adjusted (in the case of animal behavior, by natural selection rather than by a locksmith) to the specific characteristics of a key. In ethological terminology, the lock is an *innate releasing mechanism*, a characteristic of the receiving animal—usually but not necessarily located in the animal's central nervous system—that responds to the traits of the releaser. Continuing the analogy, when the key fits the lock, a door opens; this is equivalent to the fixed action pattern. And, just as a door moves along a fixed, predetermined pathway, so do the behavior patterns with which ethologists have traditionally been most concerned.

Although it may appear that this schema is only capable of generating simple behaviors (a simple releaser evokes a comparably simple fixed action pattern), ethologists demonstrated that these connections can be "chained," such that fixed action patterns by one individual, for example, can serve as a releaser for another, whose fixed action pattern, in turn, serves as a releaser for another fixed action pattern in the first; and so on. In the process, complex sequences of courtship, parental care, or communication can be constructed.

In the courtship behavior of the three-spined stickleback fish—a species that has been intensively studied by ethologists—males develop a bright red abdomen in response to the warming water and increased day length of spring; females react to this releaser by their own fixed action pattern, a "head-up" display which in turn reveals their abdomens, swollen with eggs; the male, in turn, responds by his own fixed action pattern, a "zigzag dance," which involves swimming rapidly toward a nest made of algae that he would have previously constructed and then swimming quickly toward the female; the female responds by following the male; the male lays on his side in a characteristic posture "showing" the nest entrance to the female; she enters; he rhythmically prods the base of her tail with his snout, whereupon she deposits her eggs; she swims away; he enters the nest, fertilizes the eggs, and continues to care for them until they hatch. Throughout this complex sequence, each situation or behavior by one animal serves as a releaser for a fixed action pattern by the other, and so on in turn.

Ethologists also developed descriptive models for the control of behavior. Two notable models are the hydraulic model of Lorenz and Tinbergen's hierarchical schema. Lorenz proposed that a kind of motivational pressure—which he labeled *action specific energy*—builds up within the central nervous system of an individual. This energy is dissipated when the appropriate fixed action pattern is performed. In some cases, if the behavior in question is blocked, the motivational energy spills over into another channel, generating a seemingly irrelevant behavior, known as a *displacement activity*. For example, shorebirds known as avocets, when engaged in a dispute at a territorial boundary, may tuck their heads into their wing feathers, in a posture indistinguishable from that normally assumed during sleep.

Lorenz's scheme is also consistent with vacuum activities, whereby an animal may suddenly perform a fixed action pattern in the absence of any suitable releasing stimulus; in this case, presumably the energy associated with a given fixed action pattern has built up to such a level that it essentially overflows its neuronal banks and the relevant brain centers discharge in an apparent vacuum. Although the hydraulic model does not have many current devotees, it still serves as a useful heuristic model.

Tinbergen proposed a similar perspective, one somewhat more consistent with known neurobiological mechanisms. He suggested that various major instinctive tendencies (e.g., reproduction, migration, food-getting) were organized hierarchically, such that reproduction, for instance, was subdivided into fighting, nest-building, mating, and care of offspring, each of which, in turn, was further subdivided. Thus, depending on the species, fighting might involve chasing, biting, and threatening, whereas care of offspring might involve provisioning the young, feeding them, defending them from predators, and providing various kinds of learning opportunities.

Ethology in the Twenty-first Century

Despite the ethological focus on animal behavior that can loosely be labeled "instinctive," an important realization characterizes all studies of behavior, whether conducted by ethologists, sociobiologists, or comparative psychologists: Behavior always derives from the interaction of genetic and experiential factors. Variously labeled instinct/learning, genes/experience, or nature/nurture, contemporary researchers widely acknowledge that these dichotomies are misleading. Just as it is impossible for an organism to exist or behave without some influence from its environment (the extreme case of "pure instinct"), it is impossible for environmental factors acting alone to produce behavior (the extreme case of "pure learning"). Every situation must involve both factors: there must always be an organism to do the behaving, and, moreover, organisms with different experiences exposed to the same situations always respond somewhat differently.

Ethologists have branched out substantially from their earlier focus on careful naturalistic descriptions of animal behavior, increasingly blurring the distinction between ethology and various related disciplines. Thus, neuroethologists concern themselves with the brain regions and precise neuronal mechanisms that govern, for example, animal communication as well as the reception of auditory, olfactory, visual, and even tactile signals. Behavior genetics incorporates an amalgam of ethology and precise genetic techniques to unravel the genetic influence on various behavior patterns; such research may range from the creation of cross-species hybrids to the detailed analysis of DNA sequences in identified genes responsible for specific behavioral tendencies. Behavioral endocrinology investigates the role of hormones in predisposing animals toward courtship, aggressive, migratory, and other behaviors, as well as the environmental and social situations responsible for releasing the relevant hormones. Mathematically inclined ethologists have been increasingly interested in applying concepts derived from game theory in seeking to understand how behavior has evolved, especially in situations such that the benefit to each individual depends not only on what he or she does, but also on the behavior of another individual.

Ethology and Ethics

Researchers increasingly have been applying the basic ethological techniques of detailed, objective, nonjudgmental observation to human behavior as well. Human ethology is essentially an organized form of "people watching," whereas human sociobiology (sometimes called *evolutionary psychology*) seeks to apply the principles of evolution by natural selection to *Homo sapiens*. Critics assert that the former approach consists of a kind of empty empiricism, lacking powerful theoretical roots; others attack the latter for being overly driven by theory, occasionally lacking in adequate empirical findings.

The conduct of ethology occasionally raises ethical issues concerning the treatment of animal subjects, but generally such matters are more controversial in the laboratory-oriented disciplines such as comparative psychology and neuroethology. Because ethologists study undisturbed, natural populations, or—when conducting laboratory research—strive to maintain their subjects under naturalistic conditions, the major ethical dilemma facing ethologists tends to center around whether or not to intervene in the events of the normal lives of their study animals. For example, is it appropriate to prevent a forthcoming act of predation? (Ethologists nearly always answer in the negative, because they are typically committed to nonintervention on the lives of their subjects.) Moreover, because the goal of ethological research—unlike that of comparative psychology—is to understand behavior rather than to control it, and because—unlike evolutionary psychology—ethologists generally do not directly employ controversial assumptions about evolutionary factors currently operating on human behavior, ethology is generally free of the moral conundrums often attending its sister disciplines.

DAVID P. BARASH

SEE ALSO *Aggression; Animal Tools; Dominance; Nature versus Nurture; Selfish Genes; Sociobiology.*

BIBLIOGRAPHY

Alcock, John. (2001). *Animal Behavior: An Evolutionary Approach*. Sunderland, MA: Sinauer. The standard college textbook of animal behavior, which includes a good, if brief, treatment of ethology.

Barash, David P. (1982). *Sociobiology and Behavior*. New York: Elsevier. A wide-ranging introduction to sociobiology, emphasizing its distinction from classical ethology.

Goodenough, Judith; Betty McGuire; and Robert A. Wallace. (1993). *Perspectives on Animal Behavior*. New York: Wiley. A solid introduction to animal behavior that seeks to introduce both ethological and sociobiological approaches.

Gould, James L. (1982). *Ethology: The Mechanisms and Evolution of Behavior*. New York: Norton. A technical but rewarding early account of animal behavior, especially strong on physiological mechanisms.

Lorenz, Konrad Z. (1982). *The Foundations of Ethology*. New York: Simon and Schuster. Technical articles by one of the founders of ethology.

Tinbergen, Niko. (1989). *The Study of Instinct*. Oxford, UK: Clarendon Press. An early and now-classic account of ethology as a scientific discipline distinct from comparative psychology.

EUGENICS

Eugenics was an ideology that arose in the late nineteenth century to promote improving human heredity. It posed as a scientific enterprise, but combined ethical presuppositions and political action with research on human heredity. For example, there was no scientific way to determine what constituted "improvement." Progress and improvement, however, were the watchwords of many nineteenth-century intellectuals who often failed to recognize how such concepts can be culturally loaded. Indeed, many eugenicists supposed that health, strength, intellectual acuity, and even beauty were undeniably favorable traits and should be promoted in human reproduction. Another closely related ideology was that of Social Darwinism, which nevertheless has its own distinctive if interactive history. While Social Darwinism stressed natural selection and thus human competition, eugenics focussed on artificial selection. Though some eugenicists saw eugenics as a way to evade Social Darwinism, others were avid Social Darwinists.

Classic Eugenics

The basic idea of eugenics came to Francis Galton (1822–1911), the father of the eugenics movement, in the 1860s while reading Charles Darwin's *The Origin of Species*. Galton claimed that Darwin's theory "made a marked epoch in my own mental development, as it did in human thought generally" (Gillham 2001, p. 155). In 1869 Galton published his most famous book, *Hereditary Genius*, in which he traced the lineages of prominent men in British society in order to demonstrate that not only physical characteristics but also mental and moral traits were hereditary. Galton coined the phrase "nature and nurture" to describe the conflict between biological determinism and environmental determinism, and came down decidedly on the side of nature.

Galton's views on heredity not only drove him to engage in scientific research, but also motivated him to propose conscious planning to help speed up human evolution. He stated, "What nature does blindly, slowly, and ruthlessly, man may do providently, quickly and kindly" (Gillham 2001, p. 328). He favored measures to encourage the "most fit" people to reproduce. This is called positive eugenics. However, he also advocated negative eugenics: restricting the reproduction of those deemed "inferior." He thought inferior people should be branded enemies of the state and "forfeited all claims to kindness" if they procreated. Further, he believed that "inferior races always disappear before superior ones" (Gillham 2001, p. 197). Galton, like subsequent eugenicists, stressed human inequality and devalued the life of those considered inferior. When Galton died, he left a bequest to endow a chair in eugenics at the University of London, which was filled by Karl Pearson (1857–1936), his hand-picked successor as leader of the eugenics movement in Britain.

The eugenics movement blossomed in the 1890s and early twentieth century, partly fueled by fears of biological degeneration. By the 1890s many Darwinists were concerned that some of the improvements of modern civilization were a mixed blessing. Ernst Haeckel (1834–1919), the leading Darwinist in Germany, already warned in the 1870s that modern medical advances allowed those with weaker physical conditions to survive and reproduce, while in earlier ages they would have perished without leaving progeny. Other Darwinists also warned that the weakening of natural selection by modern institutions would bring biological decline. However, while embracing Darwinian principles, eugenicists did not want to abandon scientific, technological, and medical progress. Rather they sought to escape the negative consequences by consciously controlling human reproduction.

Simultaneous with this fear of biological decline, many psychiatrists by the 1890s were abandoning earlier optimistic beliefs that they could provide cures for many mental illnesses. Instead, they began viewing mental illnesses as often hereditary and beyond influence. Many psychiatrists began to push for control of human reproduction as the most effective means to prevent mental illness. August Forel (1848–1931), a famous psychiatrist at Burghölzi Clinic in Zurich, began promoting eugenics in the late nineteenth century, and he decisively influenced many other psychiatrists and physicians. One medical student in Zurich who imbibed eugenics from Forel was Alfred Ploetz (1860–1940), who in 1904 began editing the first eugenics journal in the world. The following year he founded the Gesellschaft für Rassenhygiene (Society for Race Hygiene), an organization dedicated to improving human heredity. He quickly recruited many leading scientists, psychiatrists, and physicians to the cause.

Eugenics in the Early Twentieth Century

In the ensuing two decades, eugenics organizations also formed in many other countries, not only in the United States and Europe, but also in Latin America and Asia. The prominent geneticist Charles Davenport (1866–1944) founded the Eugenics Record Office in Cold Springs Harbor, New York, which became one of the leading institutions in the United States promoting eugenics by compiling family medical histories. Many wealthy patrons, including Andrew Carnegie and John D. Rockefeller, funded eugenics organizations.

Eugenics also stimulated the rise of birth control organizations. Indeed, one of the primary goals of the pioneers in the birth control movement—including Margaret Sanger (1879–1966) in the United States and Marie Stopes (1880–1958) in Britain—was to diminish the reproductive rates of those members of society they considered inferior. In 1919 Sanger stated, "More children from the fit; less from the unfit—that is the chief issue of birth control" (Paul 1995, p. 20). Nonetheless, most eugenicists opposed the easy availability of birth control, because they feared it would lead to a decline in natality rates among the upper and middle classes, which they wanted to increase. They wanted birth control, of course, but under the control of physicians making decisions in the interests of society, not freely available to individuals.

The eugenics movement had clout far greater than reflected by the small number of people in eugenics organizations, because its influence in the medical profession, especially among psychiatrists, was strong. In some countries the eugenics movement exerted enough influence to pass legislation aimed at restricting reproduction of individuals considered "defective." The first eugenics legislation in the world was a compulsory sterilization law passed by the state of Indiana in 1907. Other states followed suit, allowing doctors to sterilize patients who had various hereditary illnesses, especially mental illnesses. On the basis of these laws, from the 1920s to the 1950s, about 60,000 people were compulsorily sterilized in the United States. The Supreme Court upheld the right of states to sterilize those with hereditary illness in the *Buck* v. *Bell* case in 1927. Denmark was the first European country to enact a sterilization law in 1929, but it was voluntary until new legislation in 1934 made it compulsory in some cases.

Nazi Eugenics and Afterward

The Nazi regime passed the most sweeping eugenics measures in the world, because Adolf Hitler and other leading National Socialists were fanatical about trying to produce a healthy master race in Germany. In 1933 the Nazis passed a compulsory sterilization law that resulted in more than 350,000 sterilizations during their twelve years in power. In 1939 Hitler secretly ordered the beginning of a "euthanasia" campaign, killing 70,000 mentally handicapped Germans within two years. The Nazis also considered the mass killing of those of races they deemed inferior—especially Jews, but also Gypsies and others—part of their eugenics program, because they believed that this would improve the human race. Many German physicians, imbued with eugenics ideals, participated in the Nazi euthanasia program and the Holocaust.

Since the Nazi era many people have mistakenly associated eugenics with right-wing, reactionary politics. However, in its early phases, most eugenicists were progressive politically, and eugenics was popular in leftist circles. Most of the early German eugenicists were non-Marxian socialists or at least sympathetic with socialism. Many anarchists, such as Emma Goldman (1869–1940), promoted eugenics, as did most Fabian socialists in Britain. The Danish government that enacted the 1929 and 1934 sterilization laws was socialist. Many liberals and conservatives supported eugenics as well, so it cut across political lines.

Despite the movement's successes, many countries rejected attempts to enact eugenics legislation, and critics of eugenics arose, challenging its premises. The Catholic Church was the staunchest adversary of eugenics, and the pope issued an encyclical in 1930 opposing eugenics, especially measures such as compulsory sterilization. Catholics and some conservative Protestants recognized that eugenics contradicted the traditional Christian attitudes toward sexual morality, compassion for the handicapped, and human equality. However, most liberal Protestants jumped on the eugenics bandwagon, seeing it as a progressive, scientific movement. By the late 1920s many German Protestant leaders supported eugenic sterilization, and Protestants in the United States sponsored prizes for the best sermons on eugenics.

By the 1960s the eugenics movement seemed dead, and the term itself had negative connotations. Eugenics suffered from its association with Nazism, but this was only one factor. The decline of biological determinism in most scholarly fields, especially psychology and the social sciences, made people suspicious of the claims of eugenics. Also, the individualism of the 1960s, along with calls for reproductive autonomy, undermined the collectivist mentality of eugenics and its desire to control reproduction. As the abortion debate heated up in the 1970s, pro-life forces and pro-choice advocates both opposed eugenics, the former because they saw it as devaluing human life, and the latter because it violated reproductive freedom.

The New Eugenics

However, advances of medical genetics in the late twentieth century led to a "new eugenics." New reproductive technologies, including amniocentesis, ultrasound, in vitro fertilization, sperm banks, genetic engineering, and cloning, opened up new possibilities to control human fertility and heredity, especially because the human genome project has now mapped human DNA. Some proponents want to use these new technologies not only to rid the world of congenital disabilities, but also to produce "designer babies." Intense debates are raging in the early 2000s over "designer babies" and reproductive cloning, because most people consider these unethical interventions in reproduction. The legalization of abortion in most countries and the widespread practice of infanticide, even though illegal, are other factors fostering the new eugenics, because this allows parents the opportunity to decide whether they want a child with particular characteristics. The big difference between this new eugenics and the old eugenics is that in most countries the decision making about human heredity is in the hands of the individual (though physicians and society often apply pressure). However, in 1995 China passed a eugenics sterilization law, which was ostensibly voluntary; especially in light of that government's one-child policy, the pressure to abort fetuses deemed defective is great.

RICHARD WEIKART

SEE ALSO *Birth Control; Chinese Perspectives: Population; Galton, Francis; Health and Disease; Holocaust; Human Cloning; In Vitro Fertilization and Genetic Screening; Nazi Medicine; Race; Rights and Reproduction; Sanger; Margaret; Social Darwinism; Wells, H. G.*

BIBLIOGRAPHY

Broberg, Gunnar, and Nils Roll-Hansen, eds. (1996). *Eugenics and the Welfare State: Sterilization Policy in Denmark, Sweden, Norway, and Finland.* East Lansing: Michigan State University Press. Five scholars examine eugenics sterilization policies in twentieth-century Scandinavia.

Buck v. Bell, 274 US 200 (1927). This was the Supreme Court decision allowing compulsory sterilization for eugenic purposes.

Dikötter, Frank. (1998). *Imperfect Conceptions: Medical Knowledge, Birth Defects and Eugenics in China*. New York: Columbia University Press. Discusses attitudes toward the disabled and eugenics in medical circles and its impact on governmental policy from the nineteenth century to the present.

Gillham, Nicholas Wright. (2001). *A Life of Sir Francis Galton: From African Exploration to the Birth of Eugenics*. Oxford and New York: Oxford University Press.

Kevles, Daniel J. (1985). *In the Name of Eugenics: Genetics and the Uses of Human Heredity*. Berkeley: University of California Press. This is the best comprehensive survey of eugenics ideology and policy in the Anglo-American world.

Paul, Diane B. (1995). *Controlling Human Heredity: 1865 to the Present*. Atlantic Highlands, NJ: Humanities Press. The best brief survey of the eugenics movement, focussing primarily on the United States, but also touching on other countries.

Proctor, Robert. (1988). *Racial Hygiene: Medicine under the Nazis*. Cambridge, MA: Harvard University Press. Proctor shows how the German medical community embraced eugenics and collaborated with Nazi eugenics policies, including sterilization and genocide.

Schneider, William H. (1990). *Quality and Quantity: The Quest for Biological Regeneration in Twentieth-Century France*. Cambridge, UK: Cambridge University Press. Provides excellent coverage of the eugenics movement in France in the first half of the twentieth century.

Stepan, Nancy L. (1991). *The Hour of Eugenics: Race, Gender and Nation in Latin America*. Ithaca, NY: Cornell University Press. Stepan shows that medical elites in Latin America embraced eugenics, just as their counterparts in Europe and the United States.

Weikart, Richard. (2004). *From Darwin to Hitler: Evolutionary Ethics, Eugenics, and Racism in Germany*. New York: Palgrave Macmillan. Demonstrates how the German eugenics movement (and Hitler) used Darwinian principles to devalue the life of the disabled and those of non-European races.

Weindling, Paul. (1989). *Health, Race and German Politics between National Unification and Nazism, 1870–1945*. Cambridge, UK: Cambridge University Press. Weindling shows that the collectivist and technocratic thrust of the German eugenics movement helped prepare the way for the authoritarian policies of the Nazi regime. This is the most detailed study of the German eugenics movement available in English.

EUTHANASIA

Strictly speaking, *euthanasia* is Greek for "good death," but it has come to be applied to cases of an ill or disabled person being helped to die or deliberately killed by another for the ill or disabled person's benefit. It is thus distinguished from murder. Euthanasia is also to be distinguished from mercy killing. Whereas *mercy killing* normally refers to an act on the part of a friend or relative, euthanasia is typically discussed in relation to health care professionals. A number of further distinctions are drawn between different types of euthanasia: between active and passive euthanasia, and between voluntary, non-voluntary, and involuntary euthanasia. Whereas active euthanasia implies a deliberate act of killing, passive euthanasia means causing death by *not* doing something: allowing to die by withdrawing or withholding treatment. Not all forms of withdrawing treatment count as euthanasia, as when the treatment is futile or constitutes an "extraordinary" means of maintaining life.

Indeed, advances in medical science and technology have intensified concern for euthanasia because of the increased power to keep persons alive who nevertheless become dependent on various treatments. Examples range from cases of feeding tubes and artificial respiration to kidney dialysis and organ transplants. In all such instances, science and technology sometimes lead to deteriorations in the quality of life or costs that lead patients, those closest to them, and health care givers and policy makers to raise questions about continuation of treatment. Such questions often focus on whether and under what circumstances euthanasia might be a proper alternative.

Voluntary euthanasia is a response to a request on the part of a competent individual who regards death as preferable to continuing to live: The individual in question must be in a position to understand the nature of what he or she is asking and to consent to it. Non-voluntary euthanasia occurs in cases where the individual is not in a position to make a euthanasia request, such as because of a lack of competence. Competence is context-specific, so it is not necessarily the case that the individual in question is unable to make any decisions at all. As a matter of fact, several of the most-discussed issues in euthanasia do concern cases of such total incompetence, as illustrated by the following.

Non-voluntary cases fall into different types. There are adults who have lost the capacity to make an informed choice—for example, because they are in a coma or persistent vegetative state. For such persons, the living will or advance directive is one way of stating a preference should such an eventuality arise. These are subject to criticism, though, on the grounds that people may be unable to anticipate how their preferences might change over time.

Alternatively, there are those who have not yet developed to the stage at which they have acquired the capacity to state a preference, such as infants. In some cases, newborns who are born with severe medical problems are rejected by their parents, and then decisions have to be made by health care professionals about how to deal with this situation. High profile cases such as the Arthur case in the United Kingdom (see Kuhse and Singer 1985) have dealt with the question of whether it is appropriate to allow such infants to die.

In contrast to non-voluntary euthanasia, involuntary euthanasia refers to ending people's lives against or in spite of their wishes. The distinction between involuntary euthanasia and murder is more difficult to draw than in the case of other types of euthanasia, but there are some possible instances; for example, where someone is critically injured on a battlefield, cannot be saved, and a military doctor who is present, having no morphine, shoots the injured person dead.

Arguments for Euthanasia

There is controversy both about the ethics of euthanasia *per se* and about the moral distinction between active and passive versions. The moral argument for euthanasia is normally put in terms of voluntary active euthanasia—that is, when persons are terminally ill and no longer have any hope of recovery, are in pain or distress, are considered competent, and ask for someone to end their lives, the argument is that these individuals have a right to die based on respect for their autonomy. Surely, the argument goes, if individuals should have control over anything, they should have it over their own bodies, although it may be argued that there is an inconsistency in using an autonomy argument to bring to an end the conditions of exercise of autonomy, namely bodily life.

Euthanasia can also be argued for on the grounds of beneficence, or on consequentialist grounds (that is, as a means to reduce suffering by removing conditions of the possibility of that suffering persisting). This type of argument can be used to justify non-voluntary euthanasia as well as voluntary euthanasia. Where the individual is unable to express a choice, then the incompetent individual could be denied access to help if autonomy were the only type of argument appealed to; they may be granted help if an argument of beneficence or consequentialism is relied upon. Whether the consequentialist argument could be used to justify involuntary euthanasia is much more contentious.

Arguments Against Euthanasia

The autonomy and beneficence arguments are strong, but may be deployed in a different way on the other side of the debate. If what is regarded as important is autonomy, then the autonomy of persons asked to carry out euthanasia must also be considered. They have to agree that this is a course of action they are prepared to undertake. So the fact that someone of sound mind requests euthanasia does not settle the question if the person who is being asked to perform the action does not agree.

From a consequentialist perspective, it has to be admitted that while in individual cases the best result may appear to be achieved by euthanizing someone whose life has become not worth living, this judgment is fraught with difficulty. In the case of non-voluntary euthanasia, a judgment is made in the absence of a person's own request, when it might well be argued that the benefit of the doubt should count for life. To make the judgment that another person's life is not worth living invites the charge of "playing God."

Partly for this reason, involuntary euthanasia has few supporters: The autonomy argument speaks against it. In the battlefield case it is necessary to assume, if it is to count as involuntary, that the doctor is acting against the express wishes of a soldier, who may be begging for help to save his life. In such a case the doctor may be presumed to make a decision based on the realization that this is not possible.

Apart from the consequences of euthanasia of whatever type for the individual killed, there may be side effects on others. These include worries about hardening the attitudes of those involved in the killing and a gradual lessening in society of respect for life. If euthanasia were widely practiced (as has been the case in some societies), there might be pressure on some people (for example, the elderly and infirm) to agree to request "voluntary" euthanasia. This may be regarded as evidence of a "slippery slope" from voluntary to what could be construed as involuntary euthanasia, because if people feel pressured to consent then their voluntariness is undermined.

In addition, there is the argument based on professional roles. Should health care professionals, who have been trained to cure and to care, use their skills for killing?

The strongest objection to euthanasia, however, derives from the view that killing is wrong *in itself*, on the grounds of the sanctity of life. If life is sacred, then it is wrong deliberately to take a human life. Of course this principle is very difficult to uphold in all circumstances, although people differ about the nature of potential exceptions such as self-defense, war, and capital punishment. Because of the difficulty of upholding an absolute prohibition on taking the life of another, various distinctions have been proposed, including the active-passive distinction already mentioned, and the doctrine of double effect.

A Moral Distinction Between Active and Passive Euthanasia?

According to the active-passive distinction, there is a moral difference between a deliberate act to end someone's life and allowing them to die. To a certain extent the issues here have increased in complexity with medical knowledge and scientific advance, for example, in the light of greater sophistication of use of drugs to control pain, which may at the same time hasten death. From a consequentialist perspective it has been argued that there is no moral difference between killing and allowing to die, because the ultimate outcome is the same—the person is dead. In fact, when side effects are taken into account, the consequences of allowing to die rather than killing might be worse in terms of distress to all concerned. If what is aimed at is a kind and peaceful death, a quick deliberate act may be more merciful than a long-drawn out "allowing to die."

From the perspective of a deontological tradition, however, the quality of the act is what is important. One case is a deliberate killing. The other allows nature to take its course. In some cases, however, it is clear that more than "allowing nature to take its course" is involved, even where it is claimed that deliberate killing is avoided. It is here that the doctrine of the double effect becomes relevant.

Doctrine of the Double Effect

The doctrine of the double effect presupposes that an action can have two kinds of effect: intended and foreseen. Whereas it is claimed that it is always wrong intentionally to do a bad act, it is sometimes permissible to do an act *foreseeing* that bad consequences will ensue. As applied to euthanasia, the point would be that while it is always wrong intentionally to kill, it may be permissible to give drugs to relieve pain, even foreseeing that death will be hastened as a result.

While in some cases this doctrine may appear to give intuitively the right result, and while it has indeed influenced medical practice to a considerable extent, it poses several problems. First, how does one know what constitutes the class of bad acts to be absolutely prohibited? There is no agreement that deliberate killing is ruled out in all circumstances. Second, how does one distinguish between an intended and a foreseen consequence, and indeed between an act and its consequences? There need to be some limits to the freedom to describe the action in certain ways, otherwise it could be open to an agent to deny that any undesirable consequences were intended. The British case of Dr. Cox (Rv Cox [1992] 12 BMLR 38) concerned a physician who administered potassium chloride to a patient who was suffering from intractable pain. That drug does not have pain-relieving properties, so it was not open to the doctor to claim that it was given for that purpose. Had he administered morphine, he might have been able to rely on the doctrine of double effect. While philosophers have heavily criticized the doctrine, it has been influential in law.

Conclusion

From a moral point of view the strongest arguments in favor of euthanasia are to benefit an individual, whether to respect their autonomy or to prevent suffering. At the societal level, however, there are serious concerns about abuse of euthanasia for the benefit not of those killed, but of third parties or society especially in the light of issues about scarce health resources and health inequalities and concerns about these as influencing factors. So controversy continues about the practice of voluntary euthanasia according to guidelines such as in the Netherlands, for example. Despite widespread acknowledgement of the benefit to those with intractable suffering, there are also historical precedents of abuse, which lead opponents to argue that one should err on the side of preserving life. These concerns have to be taken into account in considering proposals for legalization.

RUTH CHADWICK

SEE ALSO *Death and Dying; Dignity; Euthanasia in the Netherlands; Nazi Medicine; Right to Die.*

BIBLIOGRAPHY

Dworkin, Ronald. (1993). *Life's Dominion: An Argument about Abortion, Euthanasia, and Individual Freedom.* New York: Knopf.

Foot, Philippa. (1978). *Virtues and Vices: And Other Essays in Moral Philosophy.* Oxford: Blackwell.

Kuhse, Helga. (1991). "Euthanasia." In *A Companion to Ethics*, ed. Peter Singer. Oxford: Blackwell.

Kuhse, Helga, and Peter Singer. (1985). *Should the Baby Live?: The Problem of Handicapped Infants*. Oxford: Oxford University Press.

Rachels, J. (1986). "Active and Passive Euthanasia." In *Applied Ethics*, ed. Peter Singer. Oxford: Oxford University Press.

Singer, Peter. (1995). *Rethinking Life and Death: The Collapse of Our Traditional Ethics*. New York: St. Martin's Press.

EUTHANASIA IN THE NETHERLANDS

In the Netherlands, euthanasia is understood to mean termination of life by a physician at the request of a patient. It is to be clearly distinguished from withdrawing from treatment when further medical intervention is pointless, allowing nature to take its course. The latter is normal and accepted medical practice, as is the administration of drugs necessary to relieve pain even in the knowledge that they may have the side effect of hastening death. It should be emphasized that both termination of life upon request and assisting at a suicide are prohibited in the Netherlands. But in the Dutch penal code a special ground for exemption from criminal liability has been developed for physicians who terminate a patient's life on request or assist in a patient's suicide, provided they satisfy the due-care criteria formulated in an act that went into effect in April 2002. This regulation on euthanasia—called the Termination of Life on Request and Assisted Suicide (Review Procedures) Act—is clearly a political compromise between Dutch liberals and Social Democrats, on the one hand, and the Christian Democrats, on the other. If this act had wholly decriminalized euthanasia it would not have received Christian Democrat support. In Belgium, the second country with legislation on euthanasia, the practice is not very different from that in the Netherlands with one exception: Premature termination of life is not considered a criminal act.

Theory and Practice

Pain, degradation of life, and the longing to die with dignity are the main reasons why patients request euthanasia. The initiative is on the part of the patient. To put it bluntly, without such a request it is a matter of murder. People in the Netherlands, as in other advanced countries, are living longer lives, so that, for example, cancer and its pains claim a rising proportion of victims. It should be emphasized that people in the Netherlands do not request euthanasia out of concern at the cost of treatment, because everyone is fully insured under the social security system.

When dealing with a patient's request for euthanasia, physicians must observe the following due-care criteria. They must (1) be satisfied that the patient's request is voluntary and well-considered; (2) be satisfied that the patient's suffering is unbearable and that there is no prospect for improvement; (3) inform the patient of his or her situation and further prognosis; (4) discuss the situation with the patient and come to the joint conclusion that there is no other reasonable solution; (5) consult at least one other physician with no connection to the case, who must then see the patient and state in writing that the attending physician has satisfied the due-care criteria listed in the four points above; and (6) exercise due medical care and attention in terminating the patient's life or assisting in his or her suicide.

Regional review committees (appointed by the Minister of Justice and the Minister of Health, Welfare and Sport) assess whether physicians' actions satisfy these criteria. If the assessment is positive, the Public Prosecution Service will not be informed and no further action will be taken. But if a review committee finds that a physician has failed to satisfy the statutory due-care criteria, the case will be referred to the Public Prosecution Service and the Health Inspectorate. These two bodies will then consider whether the physician should be prosecuted. The existence of a close physician–patient relationship is taken as premise. Physicians may perform euthanasia only on patients in their care. They must know their patients well enough to be able to determine whether the request for euthanasia is both voluntary and well-considered, and whether the suffering is unbearable and without prospect for improvement.

Even in cases in which patients are receiving care of the highest quality, they may still regard their suffering as unbearable and plead with their physicians to terminate their lives. In such cases, euthanasia could represent a dignified conclusion to good palliative care. There is, however, no requirement that physicians comply with the requests for euthanasia. Physicians can refuse to terminate life; after all it is not a normal medical procedure. The ability to refuse a request for euthanasia or assisted suicide guarantees physician's freedom of conscience. If a physician does not want to be involved, he or she is obligated to refer the patient to a colleague.

It is the task of the physician to try to imagine what the patient is feeling and based on his or her medical experience attempt to assess the patient's suffering objectively. Unbearable suffering also includes psychological suffering. If a patient has a psychological illness and his or her suffering is not primarily caused by a physical complaint, it is difficult to assess objectively whether a request for euthanasia is voluntary and well-considered. In such cases, the attending physician should consult two independent specialists, at least one of whom must be a psychiatrist, and they must personally examine and interview the patient. The presence of dementia or some other such condition is not in itself a reason to comply with a request for termination of life or assisted suicide. For some people, however, the very prospect of one day suffering from dementia and the eventual associated loss of personality and dignity is sufficient reason to make an advance directive covering this possibility. Each case needs to be individually assessed to decide whether, in the light of prevailing medical opinion, it can be viewed as entailing unbearable suffering for the patient with no prospect for improvement. In response to questions on this subject in the Dutch Parliament, the Minister of Health, Welfare and Sport stated that dementia can make the patient's quality of life unacceptable if the patient him- or herself regards his or her condition in this way, but that even then the physician must decide whether the patient's suffering is unbearable and without prospect for improvement in the light of prevailing medical opinion.

The aim of the Dutch policy is to bring matters into the open, to apply uniform criteria in assessing cases of euthanasia, and hence to ensure that maximum care is exercised in such cases. The price for this openness is a lot of formalistic procedures with no respect to content or guarantee of care. In this area the regional review committees function quite adequately. But not all end-of-life issues are covered by the issue of euthanasia. In the concentration on euthanasia and assisted suicide all forms of sedation with and without consent of the patient fall outside the scope and competence of the assessing committees. Palliative care is not concentrated on recovery but on alleviation of pain and other symptoms. Palliative and in particular terminal sedation may come close to euthanasia. For physicians who do not want to get involved with euthanasia for religious, bureaucratic, or whatever reasons these forms of sedation are a refuge.

Reflective Implications

Traditionally, as specified in the Hippocratic oath, physicians ended their care at the deathbed. Once death was inevitable, the office of the physician—which was to help people avoid the evils of sickness, physical deficiencies, the ailments of old age, and a premature death—had come to an end. In modern society the physician's task has been enormously extended so that the entire life of a human has been brought under a medical regime. Medical examinations are the order of the day. It is impossible to avoid the physician when going to school, participating in sports, holding down a job, taking out life insurance, and so on. Whomever is unwell hurries to make at least a short visit to the doctor or hospital in order to make use of the paraphernalia of modern medicine. Human health is controlled as a matter of routine. Not only has life undergone medicalization, but dying has also been brought under the medical regime. The result is that human death has become artificial. Many bitter deaths might be a product of modern medical science because postponement of death as a result of medical monitoring in a sense requires its toll. In the early twenty-first century, a natural death is likely an exception to the norm. Thus in normal cases the physician swings the scepter at a person's last bed by prompting the possibilities and impossibilities left to him or her. In some municipalities in the Netherlands in the early twentieth century, more than half of all deceased had no medical intervention while dying. That is now inconceivable.

Physicians play the role of experts in the end-of-life decisions. In some sense they act as examiners, while their patients attempt to pass an exam. A physician scrutinizes whether the wish to die is voluntary, whether it is well considered, whether the wish has been longstanding, whether it is not liable to emotions, whether the suffering is unacceptable to the patient, and so on. What at first sight seems to be a matter of self-determination turns out to be a matter of complete dependency. It is not surprising that well-educated people stand a better chance of having their request granted than those who are less educated. Physicians—in former times absent at the deathbed but now prominently present—find themselves in the position of the expert only because they have access to lethal drugs. This technologically privileged position maneuvers them at the same time into the role of moral examiner. For patients, the inaccessibility of lethal drugs makes the whole procedure into a technological adventure in which they are incompetent. Being alienated from nature, patients have no knowledge about the herbs and fruits in their own garden. Confronted with these final questions they have to throw themselves into the arms of the experts. Tried and tested methods out of ancient times have been blotted out.

The issue of unbearable pain on the deathbed is often technologically transformed into a mild death. Physician and patient talk about pain and how to get rid of it along technological lines. In contemporary technological society humans cannot deal with pain in another way. The opinion that pain should be tolerated, alleviated, and interpreted is no longer widely held. The medicalization of pain robs a culture of an integrative program of pain treatment. In traditional societies opium, acupuncture, or hypnosis were means of alleviating pain, but they were always put into practice in combination with language, rites, and myth. Most people who are morally against euthanasia support sedative treatment. Their position shows how difficult it is to leave the technological society behind, because from a technological point of view euthanasia is not very different from sedative treatment. In practice the outcome is often the same, but only in the mind of the physician does one find the difference between euthanasia and sedative treatment.

A society that denies a patient's request for euthanasia would best abstain from modern technological medical care. Living in a technological society may be compared with climbing mountains. People who have ascended too high must descend very carefully. Under some circumstances a descent may be more difficult than the ascent. When patients cannot tolerate pain any longer, who dares to ask them to interpret the meaning of their pain? Has the modern technological society not abandoned such questions or left them to personal decisions?

PIETER TIJMES

SEE ALSO *Bioethics; Death and Dying; Euthanasia; Medical Ethics; Right to Die.*

BIBLIOGRAPHY

Griffiths, John; Alex Bood; and Heleen Weyers. (1998). *Euthanasia and Law in the Netherlands*. Amsterdam: Amsterdam University Press.

van der Heide, Agnes; Luc Deliens; Karin Faisst; et al. (2003). "End-of-Life Decision-Making in Six European Countries: Descriptive Study." *Lancet* 362(9381): 345–350. Includes discussion of euthanasia in the Netherlands.

van Hees, Martin, and Bernard Steunenberg. (2000). "The Choices Judges Make: Court Rulings, Personal Values, and Legal Constraints." *Journal of Theoretical Politics* 12(3): 305–324.

Weyers, Heleen. (2003). *Euthanasie: Het proces van rechtsverandering* [Euthanasia: The process of legal change]. Amsterdam: Amsterdam University Press. The best survey of the Dutch discussion on euthanasia.

EVOLUTIONARY ETHICS

Evolutionary ethics rests on the idea that ethics expresses a natural moral sense that has been shaped by evolutionary history. It is a scientific understanding of ethics as founded in human biological nature.

The first full development of evolutionary ethics came from Charles Darwin (1809–1882) and Herbert Spencer (1820–1903) in the nineteenth century. At the beginning of the twentieth century, the Darwinian theory of ethics was renewed and deepened by Edward Westermarck (1862–1939). At the end of the twentieth century, this Darwinian tradition of ethical philosophy was reformulated by Edward O. Wilson, Robert McShea, Frans de Waal, and others.

Philosophers arguing over the ultimate grounds of ethics have been divided into Aristotelian naturalists and Platonic transcendentalists. The transcendentalists find the ground of ethics in some reality beyond human nature, while the naturalists explain ethics as grounded in human nature itself. In this enduring debate, proponents of evolutionary ethics belong to the Aristotelian tradition of ethical naturalism, while their strongest opponents belong to the Platonic tradition of ethical transcendentalism. (Of course, Aristotelians who reject evolutionary reasoning would also reject evolutionary ethics.)

The history of evolutionary ethics can be divided into three periods, with Darwin initiating the first period, Westermarck the second, and Wilson the third.

Darwin's View

As part of his theory of the evolution of life by natural selection, Darwin wanted to explain the evolution of human morality. From his reading of Adam Smith (1723–1790), David Hume (1711–1776), and other philosophers who saw morality as rooted in moral emotions or a moral sense, Darwin concluded that this moral sense could be understood as a product of natural selection. As social animals, human beings evolved to have social instincts. As rational animals, human beings evolved the rational capacity to reflect on their social instincts and formulate those moral rules that would satisfy their social instincts. Human survival and reproduction required that parents care for their offspring, and the social nature of human beings could be explained as an extension of parental feelings of sympathy to embrace ever larger groups of individuals. In his *Descent of Man* (1871), Darwin concluded: "Ultimately our moral sense or conscience becomes a highly complex sentiment—originating in the social instincts, largely guided by the approbation of our fellow-men, ruled by reason, self-interest, and in later times by deep religious feelings, and confirmed by instruction and habit" (Darwin 1871, Vol. 1, pp. 165–166).

Herbert Spencer (1820–1903) generally agreed with Darwin's evolutionary ethics, yet Spencer put more emphasis than did Darwin on evolution through the inheritance of acquired traits. And unlike Darwin, Spencer saw all of evolutionary history as moving toward a pre-determined end of perfection in which human societies would become so cooperative that they would achieve perpetual peace.

When *The Descent of Man* was published, Darwin's naturalistic theory of morality was attacked by biologist George Jackson Mivart (1827–1900), who claimed that there was an absolute separation between nature and morality. Although Darwin's theory of evolution could explain the natural origins of the human body, Mivart insisted, it could not explain the human soul as a supernatural product of divine creation, and therefore it could not explain human morality, which depended on the soul's freedom from natural causality. Mivart followed the lead of Immanuel Kant (1724–1804) in arguing that the realm of moral duty must be separated from the realm of natural causality, thus adopting a version of the distinction between values and facts.

This dispute between Darwin and Mivart shows the conflict between the naturalistic tradition of moral thought and the transcendentalist tradition that runs throughout moral philosophy and throughout the debate over evolutionary ethics. According to Plato (in *The Republic*), one cannot know what is truly good until one sees that all of the diverse goods of life are only imperfect imitations of the Idea of the Good, which is universal, absolute, and eternal. In Plato's theological version of this teaching, God as the Creator of the cosmos is said to be a providential caretaker of human affairs who judges human beings after death, rewarding the good and punishing the bad. Aristotle (in the *Nicomachean Ethics*) rejected this Platonic Idea of the Good, because he could not see any sense in saying there is a transcendent good separated from all the diverse natural goods that human beings seek. Looking to the common-sense experience of human beings, Aristotle thought that the ultimate end for which human beings act is happiness, and happiness would be the human flourishing that comes from the harmonious satisfaction of human desires over a whole life. Like Smith and Hume, Darwin followed the Aristotelian tradition in rooting morality in natural desires and emotions. Like Kant, Mivart followed the Platonic tradition in positing a moral *ought* belonging to a transcendent world of moral freedom beyond the empirical world of natural causes.

Thomas Huxley (1825–1895), one of Darwin's most fervent supporters, initially defended Darwin's evolutionary ethics against Mivart's criticisms. But eventually, in his 1893 lecture on "Evolution and Ethics," Huxley adopted Mivart's transcendentalist position. Because of the "moral indifference of nature," Huxley declared, one could never derive moral values from natural facts. He argued that "the ethical process of society depends, not on imitating the cosmic process, still less in running away from it, but in combating it," and thus building "an artificial world within the cosmos (Paradis and Williams 1989, pp. 117, 141)."

Westermarck's Views

After Huxley's attack, Darwin's naturalistic ethics was kept alive in the early-twentieth century by philosophers such as Westermarck. In his *History of Human Marriage* (1889), Westermarck explained the desires for marriage and family life as founded in moral emotions that had been shaped by natural selection as part of the biological nature of human beings. His most famous idea was his Darwinian explanation of the incest taboo, which can be summarized in three propositions. First inbreeding tends to produce physical and mental deficiencies in the resultant offspring, which lowers their fitness in the Darwinian struggle for existence. Second, as a result of the deleterious effects of inbreeding, natural selection has favored the mental disposition to feel an aversion toward sexual mating with those with whom one has been an intimate associate from early childhood. Third this natural aversion to incest has been expressed culturally as an incest taboo. Consequently, in all human societies, there is a strong tendency to prohibit fathers marrying daughters, mothers marrying sons, and brothers marrying sisters, although there is more variation across societies in the rules governing the marriage of cousins and others outside the nuclear family. (In 1995 Anthropologist Arthur Wolf surveyed the growing evidence confirming Westermarck's Darwinian theory of incest avoidance.)

Westermarck believed all of the moral emotions could be ultimately explained in the same way he had explained the abhorrence of incest. As animals formed by natural selection for social life, humans are inclined to feel negative about conduct perceived as painful, and positive toward conduct perceived as pleasurable. The mental dispositions to feel such emotions evolved in animals by natural selection because these emotions promote survival and reproductive fitness: Resentment helps to remove dangers, and kindly emotion helps to secure benefits. For the more intelligent animals, these dispositions have become conscious desires to punish enemies and reward friends.

Moral disapproval, Westermarck argued, is a form of resentment, and moral approval is a form of kindly emotion. In contrast to the non-moral emotions, however, the moral emotions show apparent impartiality. (Here he shows the influence of Smith's idea that the moral sentiments arise when we take the perspective of the *impartial spectator*.) If a person feels anger toward an enemy or gratitude toward a friend, these are private emotions that express personal interests. In contrast, if a person declares some conduct of a friend or enemy to be good or bad, he or she implicitly assumes that the conduct is good or bad regardless of the fact that the person in question is a friend or enemy. This is because it is assumed that when conduct is determined to be good or bad, a person would apply the same judgment to other people acting the same way in similar circumstances, independently of the effect on that individual. This apparent impartiality characterizes the moral emotions, Westermarck explained, because "society is the birth-place of the moral consciousness" (1932, p. 109). Moral rules originated as tribal customs that expressed the emotions of an entire society rather than the personal emotions of particular individuals. Thus moral rules arise as customary generalizations of emotional tendencies to feel approval for conduct that causes pleasure and disapproval for conduct that causes pain.

Although Westermarck stressed the moral emotions as the ultimate motivation for ethics, he also recognized the importance of reason in ethical judgment. "The influence of intellectual considerations upon moral judgments is certainly immense" (1932, p. 147). Emotions, including the moral emotions, depend upon beliefs, and those beliefs can be either true or false. For example, a person might feel the moral emotion of disapproval toward another that he or she believes has injured a friend, but if that same person discovers by reflection that an injury was accidental and not intentional, or that an action did not actually cause any injury at all, the disapproval vanishes. Moreover, because moral judgments are generalizations of emotional tendencies, these judgments depend upon the inductive use of human reason in reflecting on emotional experience.

Wilson's View

By the 1970s, however, there was little interest in the ethical naturalism of people such as Westermarck, and the transcendentalist tradition had largely conquered the intellectual world of philosophers and social scientists. Ethics and politics were assumed to belong to an autonomous human realm of reason and culture that transcended biological nature. This could be explained as a reasonable reaction against the morally repulsive conduct associated with "Social Darwinism" in the first half of the twentieth century.

This also explains why the publication of Wilson's book *Sociobiology* in 1975 provoked great controversy. Wilson defined *sociobiology* as the scientific study of the biological bases of the social behavior of all animals, including human beings. On the first page of the book, he claimed that ethics was rooted in human biology. He asserted that the deepest human intuitions of right and wrong are guided by the emotional control centers of the brain, which evolved through natural selection to help the human animal exploit opportunities and avoid threats in the natural environment.

One of the first serious responses to Wilson's proposal for sociobiological ethics was a conference in Berlin in 1977 titled "Biology and Morals." The material from this conference was later published as a book edited by Gunther Stent. In his introduction, Stent began by contrasting the "idealistic ethics advocated by Plato" and the "naturalistic ethics advocated by Aristotle." He suggested that those people who belonged to the *idealistic* tradition would reject Wilson's sociobiological ethics, while those belonging to the *naturalistic* tradition would be more inclined to accept it.

In this book Thomas Nagel, a philosopher, showed the reaction of the Platonic transcendentalist. He rejected sociobiological ethics because it failed to see that ethics is "an autonomous theoretical subject" (Nagel 1978) such as mathematics that belongs to a transcendent realm of pure logic. On the other side of this debate, Robert McShea, a political scientist, independently welcomed Wilson's sociobiological ethics as providing scientific confirmation for the insight of Aristotle and Hume that ethics is rooted in the emotions and desires of human biological nature (Mcshea 1978). All writing on this subject that followed, as of 2004, fell into one of these two intellectual camps.

The transcendentalist critics of evolutionary ethics include most of the leading proponents of evolutionary psychology, which applies Darwin's theory of evolution in explaining the human mind as an adaptation of human nature as shaped in evolutionary history. Evolutionary psychologists such as George Williams (1989) claim that ethics cannot be rooted in human nature because of the unbridgeable gulf between the selfishness of our natural inclinations and the selflessness of our moral duties. As the only rational and cultural animals, human beings are able to suppress their natural desires and enter a transcendent realm of pure moral duty. Like Huxley, Williams and other theorists of evolutionary psychology reject Wilson's sociobiological ethics because they think that ethics requires a transcendence of human biology through culture and reason. Unlike Wilson and Darwin, therefore, the proponents of evolutionary psychology do not believe that biological science can account for the moral conduct of human beings.

Objections and Replies

There are at least three major objections to this Darwinist view of morality. One common criticism of evolutionary ethics is that it promotes genetic determinism. If all choices are ultimately determined by genetic causes, that would seem to deny that human actions can be freely chosen, which would deny the fundamental presupposition of moral judgment that people can be held responsible for their moral choices.

But if genetic determinism means that behavior is rigidly predetermined by genetic mechanisms, so that neither individual learning nor social culture has any influence, then defenders of evolutionary ethics are not genetic determinists. What the genes prescribe, Wilson would say, is certain propensities to learn some behaviors more easily than others. Human nature, Wilson explains in his 1998 book *Consilience*, is not a product of genes alone or of culture alone. Rather, human nature is constituted by "the epigenetic rules, the hereditary regularities of mental development that bias cultural evolution in one direction as opposed to another, and thus connect the genes to culture" (p. 164). Consequently human behavior is highly variable across individuals and across societies, but the genetic nature of the human species is manifested in the general pattern of behavior.

So, for example, the natural human propensity to incest avoidance is actually a propensity to learn a sexual aversion to those with whom one has been raised. The precise character of the incest taboo will vary greatly across societies depending on the diversity in family life and kinship systems. For instance some societies will forbid marrying first cousins, while others will not. Yet the tendency to forbid the marriage of brother and sister or of parent and child will be universal or almost universal. Moreover one can deliberate about the rules of incest avoidance by reflecting on the relevant facts and emotions. When the incest taboo is formally enacted in marriage law, legislators must decide what counts as incest and what does not.

Proponents of evolutionary ethics would say that people are not absolutely free of the causal regularities of nature. Exercising such absolute freedom from nature—acting as an uncaused cause—is possible only for God. But human beings are still morally responsible for their actions because of the uniquely human capacity for reflecting on motives and circumstances and acting in the light of those reflections.

A second criticism of evolutionary ethics is that it promotes a crudely *emotivist* view of ethics as merely an expression of arbitrary emotions. After all, from the first paragraph of *Sociobiology*, Wilson speaks of ethics as controlled by "the emotional control centers in the hypothalamus and limbic system of the brain" (1975, p. 31). He repeatedly identifies the ultimate foundation for ethical codes as "our strongest feelings of right and wrong" (Ruse and Wilson 1994, p. 422). "Murder is wrong" might be just another way of saying "I don't like murder." Does that deny the sense of moral obligation as something more than just an expression of personal feelings?

People might also wonder how an emotivist ethics would handle the response of those with deviant emotions, such as that of psychopaths who do not show the normal emotions of guilt, shame, or sympathy. How can society condemn them if there are no objective moral norms beyond emotion? Moreover, how does society resolve the emotional conflicts that normally arise within and between individuals? How does society rank some emotional desires as higher than others? Such problems lead many philosophers to dismiss emotivist ethics as incoherent.

In reply to this criticism, the defender of evolutionary ethics might again consider the case of the incest taboo. If Westermarck is right, moral condemnation of incest arises from an emotion of sexual aversion toward those with whom one has been raised in early childhood. This personal emotion of disgust becomes a moral emotion of disapprobation when generalizing emotional experience into an impartial social rule: People judge that incest is bad not just for themselves but for all members of society in similar circumstances. Reason plays a part in generalizing these emotions. By reason people must formulate what counts as incest. Generally society condemns the sexual union of siblings or of parents and children. But whether one condemns the marriage of cousins will depend on the circumstances of kinship and judgments about whether the consequences are good or bad for society.

Normally most human beings will feel no sexual attraction to their closest kin. Those who do will usually feel a conflict between their sexual desire and their fear of violating a social norm that expresses deep emotions, and this fear of social blame will usually override their sexual interest. Those who do violate the incest taboo will be punished by a disapproving society. A few human beings might feel no emotional resistance to incest at all. They might be psychopathic in lacking the moral emotions of guilt and shame that are normal for most people. If so then society will treat them as moral strangers, as people who are not restrained by social persuasion, and who therefore must be treated as social predators.

The main point for those favoring evolutionary ethics is that although the moral emotions are relative to the human species, they are not arbitrary. One can easily imagine that if other animal species were to develop enough intellectual ability to formulate moral rules, some of them might proclaim incest to be a moral duty, because the advantages of inbreeding for bonding between kin might be greater than the disadvantages. But human beings are naturally inclined to acquire an incest taboo, and therefore to condemn those individuals who deviate from this central tendency of the species.

Emphasizing emotion in moral experience denies the transcendentalist claim that morality depends on pure reason alone. The 1994 work of Antonio Damasio and that of other neuroscientists suggests that the emotional control centers of the brain are essential for normal moral judgment. Psychopathic serial killers can torture and murder their victims without feeling any remorse. Yet they are often highly intelligent people who suffer no deficits in their cognitive capacities. Their moral depravity comes not from any mistakes in logical reasoning but from their emotional poverty in not feeling moral emotions such as guilt, shame, love, and sympathy.

A third objection to evolutionary ethics is that it fails to recognize the logical gap between *is* and *ought*, between natural facts and moral values. Determining that something is the case does not say that it ought to be so. A scientific description of a behavior is not the same as a moral prescription for that behavior.

In reply to this objection, proponents of evolutionary ethics might agree with Hume's interpretation of the is/ought dichotomy, which claims that pure reasoning about factual information cannot by itself move people to moral judgments. Moral motivation requires moral emotions. Those moral emotions, however, manifest propensities of human nature that are open to scientific study.

The incest taboo illustrates this. The factual information about inbreeding does not by itself dictate any moral judgment. If society did not feel moral emotions of disgust toward inbreeding among human beings, it would not be condemned as immoral. Even the factual information about the deleterious effects of inbreeding would not incur moral condemnation if people did not feel sympathy for human suffering.

The move from facts to values is not logical but psychological. Because people have the human nature that they do, which includes propensities to moral emotions, they predictably react to certain facts with strong feelings of approval or disapproval, and the generalization of those feelings across a society constitutes moral experience.

If society decided that evolutionary ethics was correct about ethics being grounded in emotions, this would influence assessment of the technologies of emotion. People might decide, as many science fiction authors have suggested, that robots could become moral beings only if they could feel human emotions. Society might also wonder about the moral consequences of new biomedical technologies for manipulating emotions through drugs and other means. People might question whether the technology of birth control could obviate the need for the incest taboo.

LARRY ARNHART

SEE ALSO *Aristotle and Aristotelianism; Darwin, Charles; Determinism; Emotion; Evolution-Creationism Debate; Plato; Sociobiology; Spencer, Herbert.*

BIBLIOGRAPHY

Arnhart, Larry. (1998). *Darwinian Natural Right: The Biological Ethics of Human Nature*. Albany: State University of New York Press.

Arnhart, Larry. (2001). "Thomistic Natural Law as Darwinian Natural Right." In *Natural Law and Modern Moral Philosophy*, eds. Ellen Frankel Paul, Fred D. Miller, and Jeffrey Paul. Cambridge, UK: Cambridge University Press.

Casebeer, William D. (2003). *Natural Ethical Facts: Evolution, Connectionism, and Moral Cognition*. Cambridge, MA: MIT Press.

Damasio, Antonio R. (1994). *Descartes' Error: Emotion, Reason, and the Human Brain.* New York: G. P. Putnam's Sons.

Darwin, Charles. (1871). *The Descent of Man,* 2 vols. London: John Murrray.

Farber, Paul Lawrence. (1994). *The Temptations of Evolutionary Ethics.* Berkeley: University of California Press.

McShea, Robert J. (1978). "Human Nature Theory and Political Philosophy." *American Journal of Political Science* 22: 656–679.

Mivart, George Jackson. (1973). "Darwin's *Descent of Man.*" In *Darwin and His Critics,* ed. David Hull. Chicago: University of Chicago Press.

Nagel, Thomas. (1978). "Morality as an Autonomous Theoretical Subject." In *Morality as a Biological Phenomenon,* ed. Gunther Stent. Berkeley: University of California Press.

Paradis, James, and George C. Williams, eds. (1989). *Evolution and Ethics.* Princeton, NJ: Princeton University Press.

Ruse, Michael, and Edward O. Wilson. (1994). "Moral Philosophy As Applied Science." In *Conceptual Issues In Evolutionary Biology,* ed. Elliott Sober. Cambridge, MA: MIT Press.

Stent, Gunther, ed. (1978). *Morality as a Biological Phenomenon.* Berkeley: University of California Press.

De Waal, Frans. (1996). *Good Natured: The Origins of Right and Wrong in Humans and Other Animals.* Cambridge, MA: Harvard University Press.

Westermarck, Edward. (1922). *The History of Human Marriage,* 5th edition, 3 vols. New York: Allerton.

Westermarck, Edward. (1932). *Ethical Relativity.* London: Kegan Paul, Trench, Trubner and Company.

Williams, George. (1989). "A Sociobiological Expansion of Evolution and Ethics." In *Evolution And Ethics,* eds. James Paradis and George C. Williams. Princeton, NJ: Princeton University Press.

Wilson, Edward O. (1975). *Sociobiology: The New Synthesis.* Cambridge, MA: Harvard University Press.

Wilson, Edward O. (1998). *Consilience: The Unity of Knowledge.* New York: Alfred A. Knopf.

Wolf, Arthur P. (1995). *Sexual Attraction and Childhood Association: A Chinese Brief for Edward Westermarck.* Stanford, CA: Stanford University Press.

EVOLUTION–CREATIONISM DEBATE

• • •

The evolution-creationism debate deals with attempts to explain the ultimate causes of order in the living world. Some people think that order arose from natural evolutionary causes. Others think it arose from divine creative intelligence. A third group thinks it arose from divine intelligence working through natural causes.

Nature of the Debate

This debate can be traced back as far as ancient Greece, where it appears in Plato's philosophical dialogues. More recently the debate has been between followers of the Bible and followers of the scientist Charles Darwin (1809–1882). The opening chapters of the Bible relate how God created the world in six days and created human beings in his image. In *The Origin of Species* (1859) and *The Descent of Man* (1871) Darwin discusses how all the forms of life could have evolved by natural law, in which the heritable traits that enhanced reproductive success were naturally selected over long periods. The evolution-creationism debate entails comparing these two scenarios of the origins of life. Some people believe that both histories are true and therefore can be compatible. Some believe that if one of the two is true, the other must be false.

This becomes a debate over the ethical implications of modern science because much of the disagreement turns on judgments about the ethical consequences of accepting one or both views as true. On one side many of those who defend creationism fear that Darwinian evolution promotes a materialistic view of the world that is ethically corrupting, because it denies the moral dignity of human beings as created in God's image. On the other side, some see creationism as promoting fundamentalist religion and attacks on science.

This has also become a legal and political debate, particularly in the United States, where people have argued about whether creationism should be taught to students in public schools as an alternative to Darwinian evolution. Some public opinion surveys have reported that about half the people in the United States believe that human beings were created by God approximately 10,000 years ago; that would deny the Darwinian belief that the human species evolved from an apelike ancestral species millions of years ago.

History of the Debate

In Plato's dialogue *The Laws* (Book 10) the Athenian character warns against natural philosophers who teach that the ultimate elements in the universe and the heavenly bodies were brought into being not by divine intelligence or art but by natural necessity and chance. These natural philosophers teach that the gods and the moral laws attributed to the gods are human inventions. That form of scientific naturalism appeared to subvert the religious order by teaching atheism, subvert the moral order by teaching moral relativism, and subvert the political order by depriving the laws of religious and moral sanction. Plato's Athenian character responds to that threat by arguing for divine intelligent design as the ultimate source of order.

In a later period those influenced by biblical religion adopted Plato's arguments to defend the claim that the divinely intelligent designer of the world was the God of the Bible. However, in the nineteenth century Darwin's theory of evolution by natural selection seemed to explain the apparent design in the living world as arising from purely natural causes without the need for divine creation. This led to the modern debate between evolution and creationism.

In the United States that debate falls into three periods. The first period began in the 1920s when William Jennings Bryan (1860–1925) launched a Christian fundamentalist attack on Darwinism. Bryan was a leading politician, having run three times for the presidency as the Democratic Party's candidate. In 1925 the state legislature in Tennessee made it illegal for any teacher in a public school "to teach any theory that denies the story of the Divine creation of man as taught in the Bible, and to teach instead that man has descended from a lower order of animals" (Larson 1997, p. 50). When John Scopes, a public high school teacher in Dayton, was charged with violating this law, Clarence Darrow (1857–1938), a prominent lawyer who promoted scientific atheism, led the legal team defending Scopes, and Bryan joined the lawyers prosecuting Scopes.

The trial in July 1925 drew public attention around the world. Although Scopes was convicted, his conviction was overturned by a higher court on a technical issue. Bryan died shortly after the trial. Creationist opponents of Darwinian evolution continued to argue their case, although many of them, like Bryan, argued that the six days of Creation in the Bible were not literally six days but rather "ages," so that long periods of time could have elapsed. Some creationists followed Bryan in accepting Darwin's account of evolution by natural law as generally true but still insisted that the emergence of human beings required a miraculous intervention by God to endow them with a spiritual soul that made them superior to all animals.

The second period of the debate was initiated by the publication in 1961 of John Whitcomb and Henry Morris's *The Genesis Flood*. Those authors interpreted the biblical story of Creation as occurring during a literal six-day period that occurred no more than 10,000 years ago. They also argued that the geological record of fossils had been laid down during the worldwide flood reported in the Bible in the story of Noah's ark. Morris and others identified themselves as "scientific creationists," claiming that the Bible as literally interpreted was scientifically superior to Darwin's theory. They supported legislation in some states to require the teaching of "creation science" in public high schools. However, when this was done in Arkansas and Louisiana, federal courts struck down those laws as violating the constitutional separation of church and state because the biblical story of Creation seemed to be a religious doctrine rather than a scientific theory.

The third period of the debate began in 1991 with the publication of Phillip Johnson's *Darwin on Trial*. Johnson, a lawyer and law professor, argued that the scientific evidence is against Darwin's theory and that Darwinians believe the theory only because it supports their atheistic belief that the order in life can be explained by natural laws without the need for divine creation. Johnson also claimed that the complexity of the living world can only be explained as the work of an "intelligent designer" such as the God of the Bible.

Other writers joined this intellectual movement for "intelligent design" as an alternative to Darwinian evolution. In 1996 the biologist Michael Behe published *Darwin's Black Box*, in which he surveyed the evidence for "irreducibly complex" mechanisms in the living world that could not have evolved gradually by Darwinian evolution but could show the work of an "intelligent designer." Later the mathematician and philosopher William Dembski elaborated the formal criteria by which "design" could be detected in nature (Dembski and Kushiner 2001). Since the late 1990s proponents of "intelligent design" have tried to convince public school boards that "intelligent design theory" should be taught in high school biology classes as an alternative to Darwinian science or at least that the weaknesses in the Darwinian arguments should be discussed in schools.

Four Arguments

Beginning with Bryan, the creationist critics of Darwinian science have made four types of arguments: a scientific argument, a religious argument, an ethical argument, and a political argument. Similar kinds of arguments can be found in Plato's *Laws*.

The scientific argument of the creationists is that Darwin's theory is not truly scientific because it is based not on empirical evidence but on a dogmatic commitment to materialistic naturalism. They also claim that creationism is a more scientific view because the complex functional order of the living world provides evidence for an intentional design by a divinely intelligent agent. The irreducible complexity of life cannot be explained through the unintelligent causes of random contingency and natural necessity.

The common mousetrap is Behe's primary example of an irreducibly complex mechanism. It requires at least five parts—a platform, a spring, a hammer, a catch, and a holding bar—and those parts must be arranged in a specific way. If one part is missing or if the arrangement is wrong, the mechanism will not achieve its functional purpose of catching mice. It is known that such a device did not arise by chance or natural necessity; human intelligent agents designed it to catch rodents. Behe claims that many biological mechanisms show the same purposeful arrangement of parts found in human devices such as the mousetrap. This, he thinks, points to an intelligent designer outside nature.

Darwinians would agree with Behe that from an apparently well-designed mousetrap one plausibly can infer the existence of a human intelligent designer as its cause because people have common experience of how mousetraps and other artifacts are designed. However, Darwinians would insist that from an apparently well-designed organic process or entity one cannot infer the existence of a divinely intelligent designer as its cause, because people have no common experience of how a divine intelligence designs things for divine purposes. Religious belief depends on faith in a supernatural reality beyond the world, whereas scientific knowledge depends on reasoning about humankind's sense experience of the natural world. Furthermore, Darwinians would note that creationists or intelligent design theorists never explain the observable causal pathways by which the divine intelligence creates irreducibly complex mechanisms.

The religious argument of the creationists is that Darwinism promotes dogmatic atheism and therefore must be rejected by religious believers. This argument seems to be confirmed by the bold declarations of Darwinian scientists such as Richard Dawkins (1986) that Darwinian science proves the truth of atheism. But it is hard to see how explaining the world through natural causes denies the possibility that God is the ultimate ground of those natural causes. Some Darwinians present evolution as a substitute for religion. Even such a strong defender of evolution as Michael Ruse (2003) has admitted that museums of science that promote evolutionary theory often function as secular temples.

Creationists assume that God was unable or unwilling to execute his design through the laws of nature as studied by Darwinian biologists. However, Christian evolutionists such as Howard Van Till (1999) and others have argued that the Bible presents the divine designer as having given his Creation from the beginning all the formational powers necessary for evolving into the world as it is today. Catholic theologian John Haught (2001) has defended a "theology of evolution" based on ideas from the French Jesuit priest Pierre Teilhard de Chardin (1881–1955) and the British philosopher Alfred North Whitehead (1861–1947). In Haught's theology, evolution suggests that the universe is always in the process of being created as God allows a self-creating world to evolve towards him through time. If this is so, Darwinian science and religious belief are compatible.

The ethical argument of the creationists is that the reductionistic materialism of Darwinian science is ethically degrading. If Darwinians persuade people that they are nothing but animals and therefore are not elevated above other animals by having been created in God's image, people will not respect God's moral law or see the unique moral dignity of human beings. Instead they will become selfish hedonists in the pursuit of their animal desires.

Darwinians respond to this argument by noting that Darwin thought his account of human evolution supported a biological theory of morality rooted in a natural moral sense. As naturally social and rational animals human beings have social instincts that incline them to care for others and have a rational capacity to deliberate about the moral rules that would satisfy their social needs. For example, the human species could not survive if children were not cared for by their parents or by people assuming parental roles. Therefore, one can understand how natural selection has endowed human beings with a natural desire for parental care that supports the moral bond between parent and child. Consequently, Darwinian science sustains morality by showing that it is rooted in human nature.

The political argument of the creationists is that teaching Darwinism in public schools without teaching the creationist criticisms of Darwinism denies the freedom of thought required in a democratic society. Surely, creationists claim, promoting an open discussion in the public schools of the scientific, religious, and ethical debates surrounding Darwinian evolution would help students think for themselves about those important issues.

Some Darwinians reject this argument by claiming that creationism is not science but religion and that the teaching of science should be kept separate from the teaching of religion. However, other Darwinians welcome an open debate. If high school students were free to read writers who defend Darwin's theory along with writers who criticize it, the students could make up their own minds. In the process students might learn how to think through scientific debates and weigh the evidence and arguments for themselves rather than memorizing the conclusions given to them by textbooks and teachers.

LARRY ARNHART

SEE ALSO *Christian Perspectives; Darwin, Charles; Evolutionary Ethics.*

BIBLIOGRAPHY

Beckwith, Francis J. (2003). *Law, Darwinism, and Public Education: The Establishment Clause and the Challenge of Intelligent Design.* Lanham, MD: Rowman and Littlefield. An argument for the constituionality of teaching intelligent design theory in public schools.

Behe, Michael. (1996). *Darwin's Black Box: The Biochemical Challenge to Evolution.* New York: Free Press.

Dawkins, Richard. (1986). *The Blind Watchmaker.* New York: Norton.

Dembski, William A., and James M. Kushiner, eds. (2001). *Signs of Intelligence: Understanding Intelligent Design.* Grand Rapids, MI: Brazos Press. A collection of essays by proponents of intelligent design theory.

Forrest, Barbara, and Paul R. Gross. (2004). *Creationism's Trojan Horse: The Wedge Of Intelligent Design.* New York: Oxford University Press. A history of the intelligent design movement by two opponents.

Haught, John F. (2001). *Responses to 101 Questions on God and Evolution.* New York: Paulist Press.

Johnson, Phillip. (1991). *Darwin on Trial.* Downers Grove, IL: Intervarsity Press.

Larson, Edward J. (1997). *Summer for the Gods: The Scopes Trial and America's Continuing Debate over Science and Religion.* New York: Basic Books.

Miller, Kenneth R. (1999). *Finding Darwin's God: A Scientist's Search for Common Ground between God and Evolution.* New York: HarperCollins. A Christian and a biologist, Miller defends Darwinism as compatible with religious belief.

Numbers, Ronald L. (1992). *The Creationists: The Evolution of Scientific Creationism.* New York: Knopf. A comprehensive history of scientific creationism in the United States up to 1990.

Pennock, Robert T., ed. (2001). *Intelligent Design Creationism and Its Critics: Philosophical, Theological, and Scientific Perspectives.* Cambridge, MA: MIT Press. A collection of statements by both proponents and opponents of intelligent design theory.

Ruse, Michael. (2003). "Is Evolution A Secular Religion?" *Science* 299: 1523–1524.

Van Till, Howard. (1999). "The Fully Gifted Creation." In *Three Views on Creation and Evolution,* ed. J. P. Moreland and John Mark Reynolds. Grand Rapids, MI: Zondervan.

Whitcomb, John C., and Henry Morris. (1961). *The Genesis Flood.* Grand Rapids, MI: Baker Books.

EXISTENTIALISM

Existentialism came to prominence shortly after World War II as a philosophical and literary movement stressing individual human experience in a hostile or indifferent world and highlighting freedom of choice and personal responsibility. As a word, *existentialism* has roots in the Latin *existere,* meaning to stand forth. Indeed existentialists argue that human beings stand out from other things because of the way humans stand consciously and freely in relation with things and with one another. Existentialists developed criticisms of science and technology especially insofar as they deny or obscure this uniqueness.

Historical Development

In the nineteenth century, Søren Kierkegaard (1813–1855) first used the word *existence* to designate a deep individuality that escaped the grip of bourgeois society and religion, and rationalistic philosophy. Though Friedrich Nietzsche (1844–1900) did not use the word, his radical analyses and demands for self-creation influenced later existentialist thinkers. Nineteenth-century Romanticism can be seen as proto-existentialist, and writers such as Ralph Waldo Emerson (1803–1882) and Fyodor Dostoevsky (1821–1881) (who both influenced Nietzsche) sought to redefine the self and called for new levels of choice and new social relations.

In part this was a response to industrial and social revolutions that shook traditional values. Writers were aghast at poverty and social dislocation amid the optimistic complacency of a society that seemed to offer no place to be fully human. The dislocations and wars of the twentieth century increased this tension, and the triumphs of technological rationality and the growth of the psychological and social sciences threatened those dimensions of human existence that cannot be reduced to relations among law-governed objects. The twentieth-century tone is more despairing in authors such as Franz Kafka (1883–1924) who chronicle human imprisonment and lack of possibilities.

Along with Nietzsche and Kierkegaard, the German philosopher Edmund Husserl (1859–1938) also influenced the French generation that created existentialism as an explicit philosophical school. Husserl tried to reveal the acts and necessities that lay beneath and make possible our ordinary perceptions and actions. Seeking to go behind science to reveal it as a construction within a more fluid lived experience, Husserl showed how science's power could nonetheless transform human life and be readily accepted. Max Scheler (1874–1928), Martin Heidegger (1889–1976), and others extended Husserl's analyses in more practical and dramatic directions. The most influential work before World War II was Heidegger's *Being and Time* (1927), which proclaimed a new mode of analysis of the self and a new conception of our relation to time and history. After the war, existentialism as such manifested itself in the work of Jean-Paul Sartre (1905–1980). Soon the label "existentialist" was also given to the work of Gabriel Marcel (1889–1973), Albert Camus (1913–1960), Maurice Merleau-Ponty (1908–1961), and others, though Marcel and Merleau-Ponty later rejected the term. Although these thinkers had been forming and writing their ideas before the war, the experience of the Nazi occupation and the problems of postwar reconstruction intensified the urgency of their thought.

Common Threads

The common thread of the existentialist critiques of science and technology is that human existence has dimensions that cannot be scientifically or technologically grasped. In a technoscientific world, humans are in danger of being imprisoned in an impoverished mode of living that denies their deepest possibilities. This situation calls for a deeper analysis of the structures of human experience, and for the assertion of human freedom through new ethical values and new projects, or avant-garde art, or political action, or religion; these all escape an everydayness that hides who human beings really are or can be.

Existentialists refuse technological determinism even while they admit that for the most part humans may be determined by received values and orientations that deny them the chance to revise basic choices. Rational calculation is an inadequate approach to policy issues because it avoids questioning the framework within which calculations will be performed.

The existentialists demand self-creation that goes beyond everyday and rationally analyzed frameworks. To bring their message of a more than rational criticism and creativity, existentialists produced novels, plays, autobiographies, journals, and literary criticism as well as philosophical tracts. Some were politically radical, some conservative, some religious, and some atheistic, but they shared a sense that self and society faced a crisis that was all the more serious for its general invisibility. Crucial dimensions of selfhood and social life were being ignored, and the need for self-creative decision was being denied even while such decisions were made but covered over in what Sartre called *bad faith*.

Contra Science and Technology

For issues relevant to science and technology the two most important existentialist writers are Sartre and Heidegger. Sartre demands that human individuals realize that their freedom is the sole source of meaning, and act resolutely in an inherently meaningless world. Though Sartre himself did not write extensively about science or technology until his later more Marxist period, his early existentialist ideas fit well with technological ambitions to control the world and decide its significance. Sartre refuses any appeal to social roles or to a given human nature. Things acquire meaning when humans project possible courses of action and language involving them. Human selves and personalities acquire meaning in the same way, within a projected net of values and activities, that projection is totally free and need not be consistent with the past; people are bound only by how they choose to bind themselves. Individuals fear this totally open freedom, and cling to rigid self-definitions as if they were natural things with a fixed nature. Sartre's ideas resemble those technological optimists and some posthumanists who find no limits to what people might make of themselves.

In his later writings Sartre saw the expansion of science and technology as part of a larger thinning of life and denial of freedom due to the capitalist mode of production, which attempts to reduce humans to docile subjects of serial processes. The image of technological progress seduces people away from collective free responsibility for the future. Social processes seem fixed and unavoidable; changing them requires cooperative revolutionary action, not just Sartre's earlier individualistic choice.

Denying that objects dictate their own meaning and human possibilities, the existentialists denied the adequacy of reductions of human activity to physiology, and the reduction social connections to economic and technological relations. They saw science as science reducing experience to static abstractions and collected data. They saw capitalist industrial systems as increasing the dominance of impersonal routine in human life, and condemned the technologization of war, as in the atom bombing of Hiroshima, associating it with the mechanization of death in the holocaust.

Heidegger feared the technological impulse to control and wrote in opposition to it. He wrote not about the choice of values but about finding creative and resolute new paths within the network of projects and significations that make up the lived world. No free Sartrean choice will allow individuals to escape their time's overall basic meanings, but they can invent creative responses that find unexpected possibilities within those basic meanings.

Heidegger argues that people are mistaken when viewing technology as a neutral tool or as an application of disinterested science. Scientific research and technology are expressions of a more basic way of interpreting-revealing things as raw material to be manipulated efficiently. He claimed that this differs from older ways of understanding the being and meaning of things. It also differs from any simple anthropocentric view, because in the completed technological world human persons too join the *standing reserve* ready for manipulation and service. No one profits from this and no one escapes it.

Heidegger protests the spoliation of the environment and the technologization of life. Yet for Heidegger there is no return to an earlier world. Any active human choice will replay the technological game. Individuals can only wait for some new way of valuing and interpreting to come about. In that waiting, though, they are redefining themselves as resolutely receptive and creatively open to the coming of a new basic meaning of reality, which brings a deeper sense of human existence than the image of themselves as manipulated manipulators that technology offers.

Between them Heidegger and Sartre raise the question of how projects for the future link to past frameworks and values. Both deny that the past merely continues due to inertia; they argue that open temporal existence means that the influence of the past is carried on in human freedom, so the future is open to more authentic choices. They deny that rational analysis of the past can legislate future values. For Sartre human choices are always separated from the past by a moment of indeterminate freedom. For Heidegger human choices are always within a net of meanings and projects that individuals did not originate and cannot eliminate, but which they can creatively reread and reform by discovering new depths and new possibilities.

Both these alternatives stand opposed to the idea that a completed social and psychological science could provide a whole explanation of human life and a guide to its values. The project for such a complete explanation threatens to create a society where other dimensions of self or society can neither be expressed nor thought of, a society that has lost the ability to question its own values and directions.

Other existentialists who rejected Sartre's pure freedom followed Kierkegaard in seeing authentic choices arising in free receptivity to a call from beyond the ordinary, from God, one's deepest self, or the unrevealed possibilities of a particular time and tradition. Camus struggled to develop a position that was more socially engaged than the early Sartre while still affirming individual freedom in a world devoid of both traditional religious and scientifically rational meanings. Gabriel Marcel stressed interpersonal encounter and dialogue, arguing that freedom and true personhood happen amid the active receptivity of mutual commitment, fidelity, and hope. This space of mutual encounter is fundamentally open to include God. Scientifically objectivist and technologically manipulative approaches to humanity deny the deepest human possibilities when they reduce persons to calculable units and human excellence to "having" rather than "being."

Maurice Merleau-Ponty developed existentialist issues through dialogue with scientific developments in biology and experimental psychology. He used ideas from Gestalt psychology and added his own analysis of the relation of animal to environment and perceiving body to objects. He claimed that scientific materialism paradoxically reinforces a split between subject and object when it mistakenly presumes that perception is the presentation of discrete data that is then subjectively interpreted. He argued that the perceived world and the perceiving bodily person are intertwined, revealing each other in perception and practical activity, without the need for a middle layer of data or representations. His ideas have become part of attacks that question the adequacy of computer models for the mind and fault cognitive theory for clinging to a theory of mental representations.

Merleau-Ponty's ideas about embodiment have been taken up by those trying to develop an environmental ethics that questions any purely manipulative approach to nature and seeks to foster more connectedness with non-human creatures.

Human Nature and Authenticity

Existentialists encourage choosing more *authentic lives*. The English *authentic* comes from the French *autentique*, meaning authored. An authentic life is not one attained through social conditioning or everyday expectations but is authored by the individual's own deep choice and self-creation. An authentic choice need not be restricted to the social roles commonly available. While Kierkegaard thought that individuals might choose to lead authentic lives that were to all outside appearances totally humdrum and ordinary, Sartre and especially Heidegger thought that authenticity could require dramatic new commitments and modes of action.

Existentialism denies traditional pictures of a fixed human nature, and also denies programs for a rational foundation of values derived from Kantian, Hegelian, or Marxist philosophy, or in a different way from economics and game theory. Existentialists agree with Max Weber (1864–1920) that ultimate values cannot have a rational foundation, but they make these choices subject to the criterion of authenticity, rather than arbitrarily. The crucial question becomes just what ethical import the criterion of authenticity can have. Can it provide limits on self-invention? Can one say that some authentic choices would be *wrong?* Could individuals make *authentic* choices to be fully conscious Nazis? Could people sacrifice others to their own projects? Must every situation be approached with the possibility that it may call for extreme measures that will seem unethical?

Nietzsche thought so, and he took seriously the idea that individuals would have to move beyond standard notions of good and evil. Facing this issue and wanting to find some limits through a sense of justice, Sartre and Camus both wrote dramas where characters confronted violence and the choice of becoming assassins and terrorists. These plays derived from the demand for self-sacrifice in the French Resistance against the Nazis, and from the terror on both sides of the 1950s Algerian liberation struggle. Twenty-first-century society faces this issue not only in its struggles with violent movements, but also in making decisions about the use of powerful weapons, and about the biotechnology revolution that will allow humankind to redefine itself, perhaps reshaping human potentials with no consideration for freedom and authenticity. Existentialists would argue that such issues demand active choice, lest humanity be carried along an unthinking path of automatic supposed "progress" that avoids the central choices of humans as self-making.

Existentialists ask about the limits of rationality in fundamental decisions. How do individuals determine the values that should guide their ethical choices about the limits of technology, or its application in situations of scarcity? They also urge reevaluating the success of social scientific explanations of self and society. Could a total scientific explanation really guide human choices, or would its application depend upon values that are not the outcome of scientific investigations? This leads to more general questions that get overlooked in the technological rush for efficiency and comfort: What is science for? Can one have choices about its meaning? Are there directions built into technology that ought to be questioned? Heidegger argues that individuals are caught within the technological dynamic and must learn to resist its onward rush while understanding themselves more deeply and waiting for a new basic meaning. Sartre argues that individuals should shake off the past, take the future in their hands, and choose anew. Merleau-Ponty urges a reexamination of the basic experience of bodily inhabiting the world and a consequent redefinition of individuals and their possibilities.

For all existentialists, the real question is: What will people choose to become? Do they have more freedom than they imagine in relation to the past, traditions, and social conditions? Modernist writers extol freedom, but think of it mainly in terms of linear progress in already obvious directions. Existentialists argue that issues of authentic choice open more possibilities than such standard options.

DAVID KOLB

SEE ALSO *Alienation; Heidegger, Martin; Husserl, Edmund; Kierkegaard, Søren; Nietzsche, Friedrich W.; Neutrality in Science and Technology; Values and Valuing.*

BIBLIOGRAPHY

Abram, David. (1966). *The Spell of the Sensuous: Perception and Language in a More-Than-Human World.* New York: Pantheon Books. Ecological discussion influenced by Merleau-Ponty's ideas.

Camus, Albert. (1972). "The Just Assassins" [*Les justes*]. In *Caligula and Three Other Plays*, trans. Stuart Gilbert. New York: Vintage Books. Camus's play examines the experience of self-righteous terrorists.

Heidegger, Martin. (1996). *Being and Time*, trans. Joan Stambaugh. Albany: State University of New York Press. Originally published in German in 1929. Heidegger's most influential work, rethinking humans' relation to time and history, and the need for authenticity.

Heidegger, Martin. (1977). *The Question Concerning Technology, and Other Essays*, trans. William Lovitt. New York: Harper and Row. Includes: "The Question Concerning Technology," "The Turning," "The Word of Nietzsche: *God is Dead*," "The Age of the World Picture," "Science and Reflection." Heidegger's major critical writings on science and technological civilization.

Husserl, Edmund. (1970). *The Crisis of European Sciences and Transcendental Phenomenology*, trans. David Carr. Evanston, IL: Northwestern University Press. Posthumously published in German in 1954. Husserl's examination of science and the origin of the modern experience of nature out of the more basic flow of bodily and temporal perception and meaning.

Kierkegaard, Søren. (1974). *Fear and Trembling, and the Sickness unto Death*, trans. Walter Lowrie. Princeton, NJ: Princeton University Press. Anxiety, despair, and their healing in an authentic selfhood in relation to God.

Marcel, Gabriel. (1965). *Being and Having: An Existentialist Diary*, trans. Katharine Farrer. New York: Harper and Row. Originally published in French in 1935.

Merleau-Ponty, Maurice. (1962). *Phenomenology of Perception*, trans. Colin Smith. New York: Humanities Press. Originally published in French in 1945. Merleau-Ponty's study of the bodily intertwining of subject and object.

Nietzsche, Friedrich. (2001). *The Gay Science*, trans Adrian Del Caro. New York: Cambridge University Press. Nietzsche's most accessible presentation of his views; in the fifth part he discusses and critiques science.

Sartre, Jean-Paul. (1956). *Being and Nothingness*, trans. Hazel Barnes. New York: Philosophical Library. Originally published in French in 1942. The most influential existentialist treatment of individual freedom.

Sartre, Jean-Paul. (1973). "Dirty Hands" (*Les mains sales*). In *No Exit, and Three Other Plays*, trans. Stuart Gilbert and Lionel Abel. New York: Vintage Books. In the play Sartre asks whether there can be an authentic act of violence.

Sartre, Jean-Paul. (1983). *The Critique of Dialectical Reason*, trans. Alan Sheridan-Smith. New York: Schocken Books. Originally published in French in 1960, with a second volume published posthumously in 1982. In this work Sartre reformulated existentialism, taking more account of social and economic relations in modern routinized society.

Zimmerman, Michael E. (1994). *Contesting Earth's Future: Radical Ecology and Postmodernity*. Berkeley: University of California Press. Deep ecology that borrows from Heidegger's ideas.

EXPERIMENTATION

Experimentation is a foundational activity in modern science. Although several Renaissance thinkers prepared the way toward modern concepts of experimentation, Francis Bacon's *Novum Organum* (1624) was the first systematic attempt to articulate and justify and articulate the proper method of experimental scientific inquiry. Bacon envisioned scientific experimentation as a form of recursive knowledge production that both interprets nature and intervenes in it. Yet efforts to fully define experimentation in a consistent, comprehensive, and prescriptive way have been unsuccessful because of the diverse subject matter and disciplines, as well as instrumental developments, that continually create new variants. An alternative conception of experimentation construes it as an integral part of the actual formation and development of modern society, rather than as just a series of operations conducted in laboratories. Experimentation in the real world requires public participation; risk and uncertainty replace the ideal of an experimental world isolated from society.

Renaissance Roots of Experimentation

Two intellectual sources of Renaissance culture nurtured the idea of experimentation: humanistic values and the practices of superior artisans. In her historical-philosophical study *The Human Condition* (1958), Hannah Arendt demonstrated a deep break between Renaissance thinking and the received preeminence of the contemplative life in classical and medieval traditions. Claims for the superiority of *theoria* over utility were rooted in the Platonic and Christian visions of an eternal, unchanging world that could be known in the futile human life-world only by intuitive reason or spiritual contemplation. In the prosperous and independent city republics of the Renaissance, however, humanist writers questioned this hierarchical order and proposed a more balanced appraisal of the *vita active* in relation to the *vita contemplativa*. Beginning with the Florentine chancellors Coluccio Salutati (1331–1406) and Leonardo Bruni (1369–1444), humanists became advocates of worldly learning and dispensers of fame and glory in the services of cities, merchant families, princes, and popes.

This humanistic resurgence in *vita activa* was modest and not concerned with understanding or conquering nature but simply with rediscovering the great deeds of antiquity. But its ideals of austere republican virtue, participatory citizenship, and Machiavellian power communicated to the *vita activa* a new value of its own, paving the way for the Baconian *scientia activa*. Pico della Mirandola's famous oration "On the Dignity of Human Beings" (1486) is the literary highlight of the attempt to define humans not by some fixed location in the great chain of being, but by their ability and duty to determine their position outside the natural order *as a free and extraordinary shaper* of themselves. This is echoed in Arendt's interpretation of the *vita activa* as part of the "rebellion against human existence as it has been given" (Arendt 1958, p. 2). At the heart of the urge toward modern experimentation is a restless overturning of the primacy of the *vita contemplativa*, which holds that "no work of human hands can equal in beauty and truth the physical kosmos" (Arendt 1958, p. 15).

The unpolished vernacular writings of craftsmen, artist-engineers, instrument makers, and other practitioners who tried to escape the constraints of the guilds provide a different and clearer origin for experimentation and—again in the services of cities and princes—offered new devices, procedures, and designs apt to increase the power, fame, and delight of the patrons. Leonardo da Vinci (1452–1519) was the outstanding genius of this new social stratum of technological intellectuals. In a letter to the Duke of Milan, documented in the *codex atlanticus,* he offered new military, civil, and artistic technologies, concluding that "if any of the aforesaid things should seem impossible or impractical to anyone, I offer myself as ready to make a trial of them in your park or in whatever place shall please your Excellency" (Da Vinci 1956, p. 1153).

Renaissance texts show that the design of new technologies was viewed as an achievement with its own merits and reputation. William Norman, a mariner and instrument maker, wrote a treatise, "The New Attractive" (1581), on magnetic experiments that greatly influenced William Gilbert's "De Magnete" (1600). For the historian of science Edgar Zilsel (1881–1944), this episode served as a solid illustration of his general thesis that modern science developed from breaking down the barriers between three distinct strata of intellectuals (Zilsel 2000). While the university scholars contributed conceptual strength and logical argument, the humanists promoted a reappraisal of worldly affairs and secular thinking, and artisans supplied the experimental spirit in their intent to discover new and useful things. However the first outstanding and most fruitful field shaped by these components was not science proper, but Renaissance art, which brought together the Pythagorean-Platonic understanding of the world, the technical skills of the artists, and the humanist values of glory and fame (Panofsky 1960).

Francis Bacon on Experimentation and Modernization

Philosophers have since struggled with the question of whether experimental action is a subservient function of discovering the laws of nature, or a powerful strategy for giving unforeseen features to nature. For Francis Bacon (1561–1624), this interplay of conceptual understanding and experimental intervention signifies a recursive learning process termed *scientia active* (or *operative*). This kind of knowledge production would profoundly alter technology, nature, and society. The most provocative pronouncement Bacon offered was that approval of the experimental method in philosophy and science implied turning society itself into an experiment, a proposition developed in his fragmentary *Great Instauration* (1620).

When Bacon was unable to use his position in the highest administrative ranks of the British Empire to advance the new science, he resorted, in the Preface to *Novum Organum,* to publicity: "I turn to men; to whom I have certain salutary admonitions to offer and certain fair requests to make." After having pondered the pros and cons of the new experimental method, he declared: "Lastly, even if the breath of hope . . . were fainter than it is and harder to perceive; yet the trial (if we would not bear a spirit altogether abject) must by all means be made" (*Novum Organum*book I, aph. 114). The Latin original is *experiendum esse.* Society should give the experimental method an experimental chance. The promises of gains cannot be justified by anticipatory argument, but only by the outcomes of a test. Skeptics are invited to consider the deal in terms of risk assessment: "For there is no comparison between that which we may lose by not trying and by not succeeding; since by not trying we throw away the chance of an immense good; by not succeeding we only incur the loss of a little human labor. . . . It appears to me . . . that there is hope enough . . . not only to make a bold man try [*ad experiendum*], but also to make a sober-minded and wise man believe." (*Novum Organum,* xxbook I, aph. 114).

Bacon's assessment of the societal risks of politically authorizing the experimental method was founded on an important assumption about the relationship between science and society: Experimental failure as well as errors of hypothetical reasoning are acceptable because they affect only the internal discourse of science, not its social environment. Mistakes in the laboratory can be easily corrected and society is only affected by its choice of options offered by approved scientific knowledge. In this sense, Bacon's notion of experimentation foreshadowed latter distinctions between basic and applied research.

Such conditioning of experimental science became institutionalized in the founding charters of scientific academies and learned societies, and has served as the backbone of the dominant ideology for supporting scientific progress. It makes scientific research and technological invention central aspects of organizing and modernizing society and its institutions. In other words, Bacon's conception of experimental science was the foundational element in the contract between science and society (Gibbons et al. 1994) and between society and nature (Serres 1995).

It is pointless to deny the epistemic and institutional advantages of laboratory science. But they have their price. Epistemologically laboratory science tends to develop ideals of constraint, abstraction, simplicity, and purity that are at odds with the course of nature and society, and give rise to a worldview that interprets space, time, things, and people as faint approximations of the abstractions that make up the laboratory world (Cartwright 1999). It fosters a view of scientific knowledge as objective, neutral, disposable, and instrumental, and research as socially independent and pure. However from the early beginnings of industrial society through the most recent development of the knowledge society, there is evidence of a recursive rather than a linear relation between the trials and errors experienced in the social dynamics of change and the failures and successes of experimental strategies. Both the intended and unintended consequences of scientific experimentation impact the development of society, which in turn influences scientific research. This has sparked several reinterpretations of the contract between science and society.

The Experimental Mode of Industrial Society

John Dewey (1859–1952) was prominent in this quest to reenvision the recursive relationship between the experimental production of knowledge and the activities of society: "The ultimate objects of science," he wrote, "are guided processes of change," and truths are "processes of change so directed that they achieve an intended consummation" (Dewey 1925, p. 133–134). In this way, Dewey married the search for certainty in knowledge to the struggle for reliability in action. Influenced by the epistemology of William James (1842–1910), Dewey asserted that truth is something that happens to an idea as it is tried out successfully in practical situations.

This vindicated Bacon's supposition that the experimental method (as one of the key features of science) would be writ large and institutionalized as societal experimentation. However Bacon's neatly drawn boundary separating pure knowledge experiments from an experimental society mobilized by and mobilizing new technologies has become increasingly blurred. Controversies about the legitimate basis of scientific experimentation arose. Among the most fiery and permanently debated vivisection, in support of which Claude Bernard (1813–1878) wrote his famous "Introduction to the Study of Experimental Medicine" (1865). While he declared vivisection indispensable for progress in medical research and proclaimed that mutilating living beings is justified by the noble goals of science, his opponents considered such research to be driven by perverse instincts intolerable to a humane society. Shortly thereafter the public discussion extended to questioning the scientific practice of victimizing ethnic minorities, criminals, patients, pregnant women, prostitutes, and soldiers. (Foucault 2003).

In the industrialization process of the nineteenth century, scientific experimentation became closely linked with experimental practices of innovation in various economic sectors. The distinguished chemist Justus von Liebig (1803–1873) promoted agricultural chemistry. His experiments clarified the chemical cycles involved in biological reproduction. Liebig applied this knowledge in agriculture to improve productivity. He realized that laboratory chemistry needed to be complemented by experiments located in complex natural systems. His seminal *Chemistry in its Application to Agriculture and Physiology* (1862) states: "Our present research in natural history rests on the conviction that laws of interaction not only exist between two or three, but between all the phenomena of the animal, vegetable, and mineral spheres which determine life on the surface of the earth" (Liebig 1862, p. 167–168). Louis Pasteur (1822–1895) attempted to convince farmers and ranchers of the efficiency and usefulness of animal vaccination. Under both Liebig and Pasteur, scientific experiments became closely allied with practical applications. The recursive learning process depends on opening the laboratory to the complexity of the world and, in turn, targeting scientific knowledge to relatively narrow applications.

Agriculture became standardized through the application of chemistry and microbiology. Similar processes of intertwined experimental learning can be observed in the fields of electrical and mechanical engineering, communication technology, and industrial chemistry. In all these areas, laboratories continue to be important sources of inventions, but are no longer the exclusive domain of the academic sciences. Science has permeated industry, commerce, and the military and is inextricably linked with market forces, production processes, and governmental decisions. Thomas Edison's (1874–1931) *invention factories* at Menlo Park and other places have served as models for modern industrial research laboratories.

Experimental Society

The social sciences have brought another aspect of societal experimentation into focus. Sociologists in the United States interpreted the dramatic growth of cities as collective self-experiments, guided both by planning and design and by unforeseen outcomes and surprises. Albion W. Small (1854–1926) described his *Introduction to the Study of Society* (1894) as a *laboratory guide*, whereby settlements and cities are ready-made experiments that are available to the sociological observer:

> All the laboratories in the world could not carry on enough experiments to measure a thimbleful compared with the world of experimentation open to the observation of social science. The radical difference is that the laboratory scientists can arrange their own experiments while we social scientists for the most part have our experiments arranged for us. (Small 1921, p. 187–88)

Small located the idea of experimentation in social life, not the scientific method. This notion of experimentation became influential in American sociology, especially within the Chicago School developed by Robert Park (1864–1944), but it lacked a precise specification of the societal and cultural conditions that give social life its experimental characteristics.

Donald Campbell (1969) presented an elaborated methodology of sociological real-world experiments. Reliable prediction of the success of social reform projects in areas such as education, youth delinquency, taxes, and housing is not possible, but a careful design of reforms as experiments would allow planners to learn about the acceptance and efficiency of strategies so that outcomes could be used to adjust future reforms. Although objections have been raised against the technocratic attitude of this approach (as reforms are more or less superimposed on the people concerned), it has also had great influence in the field of adaptive management.

Later discussions of real-world experimentation centered on the notion of acceptable risk, that is, the paradox of not knowing before the experiment whether the social and ecological risks are acceptable. One good example is the large-scale release experiments involving genetically modified organisms. The increased power of modern science and technology qualifies Bacon's original optimism about societal experimentation because the losses involved in failed experiments are potentially much greater than *a little human labor*. Experimentation in the real world unavoidably leads to surprises, which causes problems and provides opportunities for learning. Science involved in such endeavors renders the ideal of detached and austere knowledge production obsolete and makes public involvement necessary in order to enhance acceptance and legitimation of projects. Ecological experimentation in particular has gained support by incorporating local knowledge and by making the risks and uncertainties of theoretical models more transparent. Hearings, volunteer and stakeholder groups, and other methods of making experiments participatory entail costs in time and money yet fail to guarantee support or consensus. But the risks of experimentation can no longer be hidden from view. The production of knowledge in a democratic society requires public discourse and participatory involvement, and these are the features with which real-world experimentation must experiment.

WOLFGANG KROHN

SEE ALSO *Bacon, Francis.*

BIBLIOGRAPHY

Arendt, Hannah. (1958). *The Human Condition*. Chicago: University of Chicago Press.

Bacon, Francis. (1857–1874). *Works of Francis Bacon*, ed. James Spedding, Robert Leslie Ellis, and Douglas Denon Heath. London: Longman.

Bernard, Claude. (1957). *An Introduction to the Study of Experimental Medicine*, trans. Henry Copley Green. New York: Dover. First analysis of the meaning of experimentation with living substances; originally published in1865.

Campbell, Donald. (1969). "Reforms as Experiments." *American Psychologist* 24 (4): 409–429.

Cartwright, Nancy. (1999). *The Dappled World: A Study of the Boundaries of Science*. Cambridge, UK: Cambridge University Press. Offers a sceptical view of the scientific prospect to understand the reality completely by the means and models of natural laws.

Da Vinci, Leonardo. (1956). *The Notebooks of Leonardo da Vinci, Arranged, Rendered into English and Introduced by Edward MacCurdy*. New York: Braziller.

Dewey, John. (1925). *Experience and Nature*. Chicago: Open Court. Dewey's comprehensive attempt to understand knowledge, values, action, and facts in their natural connectivity.

Foucault, Michel. (2003). *Abnormal: Lectures at the College de France, 1974–1975*. New York: Picador. The lectures refer to Foucault's central theme of power, knowledge, and social exclusion.

Gibbons, Michael; Limoges, Camille; Nowotny, Helga; et al. (1994). *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*. London and Thousand Oaks, CA: Sage.

Gilbert, William. (1958). *De magnete*, trans. P. Fleury Mottelеy. New York: Dover. Considered to be the first textbook on experimental natural science, published 1600; Gilbert was physician to Elizabeth I and James I.

Lederer, Susan E. (1995). *Subjected to Science: Human Experimentation in America before the Second World War*. Baltimore: Johns Hopkins University Press.

Liebig, Justus, Freiherr von. (1855). *Principles of Agricultural Chemistry: With Special Reference to the Late Researches made in England.* New York: Wiley.

Liebig, Justus, Freiherr von. (1862). *Die organische Chemie in ihrer Anwendung auf Agricultur und Physiologie* [Chemistry in its application to agriculture and physiology]. Braunschweig: Vieweg.

Panofsky, Erwin. (1960). *Renaissance and Renascenses in Western Art.* Stockholm: Almquist & Wiksell. Classical studies of the symbolic meaning and relevance of the arts at the beginning of the modern era.

Pico della Mirandola, Giovanni. (1986). *De hominis digitate,* trans. Douglas Carmichael. Lanham, MD: University Press of America. Pico lived from 1463–1494. The oration was first published in 1496 and reckons as the "manifesto" of the humanist movement.

Radder, Hans, ed. (2003). *The Philosophy of Scientific Experimentation.* Pittsburgh, PA: University of Pittsburgh Press.

Serres, Michel. (1995). *The Natural Contract,* trans. Elizabeth MacArthur and William Paulson. Ann Arbor: University of Michigan Press.

Small, Albion Woodbury, and George E. Vincent. (1971 [1894]). *An Introduction to the Study of Society.* New York: American Book Co.

Small, Albion Woodbury (1921). "The Future of Sociology." *Publications of the American Sociological Society* 15: 174–193.

Zilsel, Edgar. (2000). *Social Origins of Modern Science,* ed. Diederick Raven, Wolfgang Krohn, and Robert S. Cohen. Dordrecht, Boston and London: Kluwer Academic Publishers. Classical work proposing the relevance of superior artisans for the origins of experimental science.

EXPERTISE

The question of expertise—its nature, scope, and application—is one of the most urgent issues in the modern world. The recognition of expertise as an important issue and the analyses of its problems are firmly embedded in the Western tradition. Plato's discussions of *techné* and of the difference between philosophy and sophistry, for instance, are best characterized as discussions of expertise. "When Socrates seeks moral knowledge," Julia Annas writes, "it is only to be expected that this will be seen on the model of practical expertise, since this is the model for knowledge in general" (Annas 2001, p. 245).

In its modern usage, the word *expert* derives from the Latin *expertus,* the past participle of *experiri,* "to try"; an expert is one who has been tested and become skilled or knowledgeable through experience. Although this definition seems straightforward, in the real world experts are not always easy to identify or deal with. Although they are a familiar and indispensable element of the contemporary world, experts are also the object of widespread controversy and hostility; experts are capable of generating both trust and skepticism.

Reliance on Experts

In practical matters modern life is permeated by experts and expertise, a situation that is also central to scientific disciplines. Contemporary scientific research depends on evidence being generated, integrated, disseminated, evaluated, and reviewed by overlapping networks of investigators (Hardwig 1985). Nonscientific professions also are constituted by the need to reproduce, maintain, and supervise expertise. The defining character of both the public and private spheres thus is determined largely by the kinds of experts who are deferred to (including self-professed experts, "hired gun" experts, and faux experts), the circumstances in which such deference occurs, and the reasons that can be provided to justify that deference.

Experts shape not only professional disciplines but also everyday life. Citizens routinely defer to experts not only in issues involving a scientific-technological dimension but in "all sorts of common decisions" about anything and everything (Walton 1997, p. 24). The extent of routine deference to experts is staggering. Politicians, judges, businesspersons, and ordinary citizens rely on experts. Many activities once left as a matter of nature or common sense to clan, community, or culture, such as childbearing and child rearing, have become the province of experts (Hulbert 2004). As the cultural critic Neil Postman notes: "[E]xperts claim dominion not only over technical matters, but also over social, psychological, and moral affairs. There is no aspect of human relations that has not been technicalized and therefore relegated to the control of experts" (Postman 1993, p. 87).

Contemporary reliance on experts has a historical dimension. Around the beginning of the twentieth century demographic changes such as the massive influx of immigrants, the concomitant weakening of the authority of traditional cultural practices, and the accompanying fascination with being "modern" helped foster the view that scientific approaches could make many human activities previously governed by culture, community, and religion more effective and efficient. Meanwhile, new technologies arose whose principles could not be mastered by nonexperts and thus had to be delegated to specialists. Inevitably, with that new reliance on experts controversies arose over who was a genuine expert, how an expert was trained and legitimated, and the objectivity of certain fields of expertise. Thus, whereas the problem of expertise is as old as the ancient quarrel between philosophy and sophistry, the permeation by and dependence of modern life on expertise has made this question increasingly important.

Domains of Expertise

A brief look at the ways in which controversies have arisen in different domains can help illuminate different aspects of the issue of expertise.

GOVERNMENT. Democracy depends not only on an educated citizenry but also on educated decision making. Most countries attempt to establish this by incorporating experts into government operations through agencies, regulatory and review panels, committees, and advisory capacities. From the governmental perspective the use of expertise generally implies a distinction between the social and technical aspects of policy and its instruments: Although decisions about the social aspects are the province of elected representatives of the public, decisions about the technical aspects are relegated to experts. However, this separation is never clean because technical aspects are seldom neutral with respect to social ones. The sometimes murky boundary between the social and technical aspects of policy periodically leads to controversies over the governmental selection of experts and the advice they provide, along with attempts to reduce the influence of experts on policy.

A dramatic and instructive episode was the 1954 hearing on the scientist J. Robert Oppenheimer's (1904–1967) security clearance (Thorpe 2002). In his role as chairman of the General Advisory Committee (GAC), which was charged with advising the Atomic Energy Commission (AEC) "on scientific and technical matters," Oppenheimer had opposed the development of the "Super," an early impractical attempt to build a hydrogen bomb. Oppenheimer was not the only GAC member to oppose it, but his influence galvanized adversaries to seek his removal from a position in which he could influence the government, and his clearance was suspended.

At the end of a four-week hearing AEC counsel Roger Robb said bluntly to Oppenheimer, "You of course don't conceive yourself to be an expert in war, do you, or military matters?" No, was the reply. Then, continued Robb, did you not perhaps go "beyond the scope of your proper function as a scientist in undertaking to counsel in matters of military strategy and tactics?" Would this not, Robb added, be as absurd as deeming John Ericsson to be qualified in naval strategy merely because he had designed the *Monitor*? Robb was challenging not only Oppenheimer's authority to address social issues such as military policy but in effect that of any scientist.

That challenge went unanswered and highlights the contentious nature of the border between technical and social issues as well as the discretionary power and potential ideological biases involved both in the selection of experts and in the advice they offer. Although controversies over such issues arise in almost every administration, the handling of experts and expertise by the government became a salient campaign issue in the U.S. presidential election of 2004. Organizations such as the Union of Concerned Scientists hosted websites that documented instances in which the Bush administration was declared guilty of abusing, distorting, and suppressing the advice of experts on issues ranging from abortion to stem cell research.

MEDIA. The use of experts in the media entails a different set of issues. The media not only rely heavily on experts for information but also frequently quote or interview them in the process of conveying content to the public. The experts who gain "standing" thus acquire an influential role in shaping public perception about what information is authoritative and in generating, perpetuating, and even resolving controversies. Media-designated experts, however, often are chosen to a large extent because of factors such as accessibility, skill at communicating, charisma, and even the particular positions they have adopted. The result is that these experts are not necessarily the ones who would be recognized by most or even many professionals of the field in question; the positions they advocate also may not be shared generally.

Moreover, the qualities required to gain standing vary from medium to medium: The kind of person cited as an expert in the print media differs from the kind who appears on television. A major difference between media-appointed and other kinds of experts is a sharply diminished incentive to define and rigorously police the difference between real experts and charlatans. The media often are encouraged to promote "balanced" voices, particularly colorful and charismatic ones, that advocate positions outside the mainstream. As a result individuals who have questionable credentials, who are being promoted by those with certain agendas, or whose conduct or methodology is not generally representative of those in their professions can be anointed experts.

A classic illustrative episode is Bailey Willis's role in the controversy over the construction of the Golden Gate Bridge. Willis had worked for the U.S. Geological Survey from 1898 to 1916 and then became a professor of geology at Stanford University, retiring as an emeritus professor in 1922. In the early 1930s he joined a fierce controversy about the Golden Gate Bridge, whose construction was in progress, when he claimed that the collapse of the bridge was inevitable because the bedrock of the south tier was too soft. The bridge had been opposed strongly by the local ferry company, the shipping industry, and landowners afraid of declining property values and increasing tourism. To those groups Willis was a godsend, and they used him as a point person. He was flamboyant and quotable, preached a doomsday scenario, and was credentialed as a professor and ex-employee of the U.S. Geological Survey. It thus is not surprising that he was cited regularly as an authority on the front pages of newspapers. To his scientific colleagues, however, Willis's methodology and behavior were abominable: His arguments were easy to refute, he was shown to have misread maps, and he refused to inspect the rocks firsthand. To those colleagues his credentials did not matter. Expertise requires possession of the appropriate skill, Willis lacked that skill, and any claim made for his having it was fraudulent.

Similar complaints about media-designated experts frequently surface in more recent controversies involving a scientific-technological dimension, such as those over breast implants, the dangers of chemical toxins, and the health effects of low levels of radiation. These episodes highlight the question of whether it is possible to describe and recognize what is involved in the "intuitive," first-person possession of expertise.

LAW. In the modern world controversial social issues often wind up in the law courts, which are forced to impose a cease-fire on terms that are frequently tentative, vague, imperfect, and open to revision. Nevertheless, these flawed practical resolutions often contain signposts indicating why it is so difficult to integrate conceptual and practical issues, a situation in which the use of experts is no exception (Golan 2004, Feigman 2004, Foster and Huber 1997).

Experts play a pivotal role in the courtroom, where their use turns on the distinction between evidence and opinion; nevertheless, what constitutes an expert in science and in law "is as far apart as day and night" (Angell 1996, p. 116). The introduction of expert testimony by the prosecution tends to increase conviction rates (Brekke and Borgida 1988, Kovera, Levy, Borgida, and Penrod 1994), whereas testimony from a defense expert tends to lessen the likelihood of a conviction (Hosch 1980, Schuller and Hastings 1996) even though jurors have proved themselves incapable of understanding the implications of much scientific testimony (Selinger 2003).

Tal Golan (2004), for instance, traces controversies involving the use of experts in court back to a late eighteenth-century case concerning the causes of the decline of the harbor in Wells, England, in which each party hired expert witnesses. The result was a much wider use of scientists as expert witnesses in the courtroom, and this paved the way to abuses. By the mid-nineteenth century Attorney General Sir Alexander Cockburn was expressing a widely held view, at a poisoning trial in 1856, when he remarked, "I abhor the traffic in testimony to which I regret to say men of science sometimes permit themselves to condescend."

Whereas poisoning trials were a common forum for clashes between scientific experts, twentieth-century medical technologies have expanded the opportunities for scientific expert testimony vastly not only in the areas mentioned here but also in lie detector evidence, insanity defenses, and DNA analysis. The use of expert witnesses in the courtroom has burgeoned, along with the burden placed on the legal system. One early decision, *Frye v. U.S.* (1923), stated that expert testimony must assist the jury in its decision making, that the testimony must be based on scientific principles that are accepted generally in the field, and that an expert witness must be suitably qualified. However, the rules established by *Frye* were found to be too broad, and the continuing legal controversy culminated in a landmark and still controversial 1993 decision by the U.S. Supreme Court, *Daubert v. Merrell Dow Pharmaceuticals*.

The *Daubert* decision sought a practical solution to these difficulties, attempting to take the role of assessing scientific testimony out of the hands of juries and putting judges in the role of gatekeepers for the admissibility of scientific evidence in federal courts. It also attempted to lay out guidelines of reliability and relevance for judges in evaluating technical data possibly beyond their expertise for courtroom use. Questions about its effectiveness, however, remain.

Although informed by both the philosophy of science (particularly the work of the philosophers Karl Popper [1902–1994] and Carl Hempel [1905–1997]) and the sociology of science, the *Daubert* decision has had a tendency to produce expensive and time-consuming pretrial hearings that have been viewed as discouraging the kind of sound gatekeeping that the decision was intended to establish. It has been elaborated by two further cases, *General Electric v. Joiner* (1997) and *Kumho Tire v. Carmichael* (1999), and the issue continues to generate much discussion and writing.

The continuing controversy over expertise in the courtroom has served to highlight in particular the question of how to integrate the possessors of scientific expertise with the needs of a particular arena, such as the courtroom, in which it is required.

Interdisciplinary Structure

Each of these controversies involving the use of experts in government, media, and the law poses a different set of questions involving expertise that call for conceptual clarification. Those questions include the following: How does one become an expert? Can experts be recognized by nonexperts? Is it possible for a consumer of expertise to detect the presence of hidden agendas, biased or tainted testimony, and incompetence in expert testimony? Is it possible to train experts in such a way that these contested problems do not arise? The inability to answer such questions definitively, especially in high-profile controversies, has contributed to a general skepticism regarding experts and to doubts about whether it is possible to achieve a pragmatic, effective, and permanent solution to the problem of expertise.

An essential first step would be greater conceptual clarification of the problem. Recent technological issues highlight the need for such clarity: Debates about the value of shifting expertise away from individual and credentialed content experts to a community of self-policing but not necessarily credentialed contributors have plagued *Wikipedia,* an online encyclopedia whose entries can be altered by essentially anyone who desires to change them; debates about reports occurring on blogs have brought traditional reporting to the threshold of a crisis; and debates about the collaborative categorization of information through the use of simple tags in social software have raised powerful questions concerning who has the right to manage data. (Social software designates software that is designed to support one or more of the following goals: (1) support conversational interactions between individuals or groups, (2) supports social feedback (i.e. rating of goods and services to create digital reputation), and (3) support and manage social networks (i.e., programs such as Friendster which allow you to network with people who you do not know, but who are acquainted with people you do know.)

No single key can unlock the problem of expertise all at once. Its analysis requires crossing several disciplinary boundaries: philosophical, sociological, political, and even rhetorical. Philosophically, the question of expertise broaches the philosophy of mind—of what it means to know something and to be someone capable of acquiring knowledge—and is inextricably interwoven with issues of embodiment, apprenticeship, and artificial intelligence, among others. However, expertise has a social character as well inasmuch as the question of who is an expert is not a matter of training or skill alone but of definition and recognition. Politically, the authority conferred on experts collides with participatory democracy, with the democratic and antielitist urge to accord equality to all citizens. As media experts reveal, who "counts as" an expert often depends on rhetorical ability. Thus, "expertise" rarely is addressed comprehensively from more than one perspective at a time. It lurks, implicitly and usually uncritically, beneath discussions of concepts such as authority, colonization, power, skill, and even science. Nevertheless, anything short of a full interdisciplinary analysis runs the risk of producing a naive and overly simplistic account.

The practical and the conceptual problems of expertise are clearly related, and it is hard to imagine that a better, more synoptic understanding of expertise would not shed light on pragmatic decision making about expertise. This requires the recognition that expertise is not a simple property or relation but arises from a dynamic set of interactions whose two poles are the production and the consumption of knowledge: At one pole expertise is produced or possessed, at the other it is consumed or used, and a dynamic interaction takes place between the two. Literature on expertise has adopted different approaches to integrating these elements. Some research studies have emphasized the discretionary power and ideology of expertise, others its intuitional and interactive nature, and still others its distributive character.

Discretionary Power and Ideology

In a society strongly shaped by and dependent on advanced technology the most commonsense approach to expertise is via the idea that experts possess a special kind of knowledge and skill that nonexperts do not have but need for ordinary and extraordinary activities. Not only do nonexperts routinely find themselves needing expert advice, the thought continues, but nonexperts would be acting irrationally if they failed to recognize the value of interacting with experts to acquire such epistemic counseling and defer to such advice. Thus, the philosopher John Hardwig argues, "The rational layman will recognize that in matters about which there is good reason to believe that there is expert opinion, he ought (methodologically) not to make up his own mind. His stance on these matters will—if he is rational—usually be rational deference to the epistemic authority of the expert" (Hardwig, 1985, p. 343).

A host of issues arise concerning how and in what conditions a nonexpert can decide which expert to trust. After all, the epistemic inequality that seems to distinguish experts from nonexperts in principle prevents nonexperts from making a justified epistemic decision. A nonexpert could choose who among available experts has the best credentials. However, that decision would be of limited value; it would not address adequately the potential differences between the quality of an institution and the quality of an individual. Hence, in "Experts: Which Ones Should You Trust?" the philosopher Alvin Goldman contends that looking for a track record of success is the best way for a nonexpert to make a sound decision when selecting an expert to turn to for advice (Goldman 2001).

Steve Fuller, Paul Feyerabend, and Herbert Marcuse, among others, have countered that this commonsense position fails to address the way expert knowledge and skill is tainted by special interests, conceptual biases, and ideology and link the production of expertise to discretionary power and even to the aims of technocracy. In "The Constitutively Social Character of Expertise," for instance, Fuller (1994) contends that the significant dimensions of expertise can be specified when a social field is circumscribed. Fuller's work suggests that normative and epistemological implications would follow if people focused their attention on the ways experts create, maintain, and reinforce an interface in which their claims to cognitive authority are bolstered through networking and rhetorical persuasion. A consumer's apparent need for an expert's knowledge or skills could turn out to be a manufactured desire, created and maintained by a class of experts who want their services to be perceived as necessary or useful. Expert authority would be seen to emerge from nontransparent and sometimes deceptive interactions with consumers. If Fuller's account of discretionary power is accurate, the prestige and deference accorded to experts from every field must be tempered.

The philosopher of science Paul Feyerabend (1999) characterized modern scientific experts as "ideologues." From Feyerabend's perspective the more time and energy experts devote to advancing a position that accords with the tenets of Western science, the more difficult it becomes for them to be open-minded to points of view that call their core beliefs into question.

Still more radically Herbert Marcuse (1998) combines a Marxist approach to expertise with the Frankfurt School's use of Freudian psychological insights to critique the role of expertise in the aspirations and methods of technocracy. Modern occupations are characterized by an absence of socialization, in contrast with traditional skilled work, which involved socialization into a craft culture, and technical professions are geared toward producing instruments to serve the state. This process is made acceptable and desirable by the introjection of social demands in personality structures through processes of sublimation, reinforcement, and rationalization. Technical skills are not added to a preformed personality; instead, the personality is altered at its seemingly private core, the subject's very basis of self-understanding. This alteration of subjectivity, Marcuse finds, is integral to the perpetuation of the technological state. Experts and other trained professionals not only contribute to specific tasks and particular jobs but serve the "interest of autocratic power"; they assume the role of "social leaders" and "captains of industry" by virtue of being "technological leaders" (Marcuse 1998, pp. 54–55). Expert training is only one of the many factors in the environment of advanced capitalism that reduce the capacity for individuality in this positive sense, reducing the subject's capacity to exercise free judgment and proffer original or subversive criticism.

Intuitive and Interactive Experts

In contrast to an understanding of expertise in terms of discretionary power, ideology, and capitalist production, other approaches seek to access expertise through the process by which individuals acquire and maintain it. Hubert Dreyfus (1990), for instance, has analyzed expertise from a first-person perspective and, along with his mathematician brother Stuart (Dreyfus and Dreyfus 1986), has produced a general model of skill acquisition that details the cognitive and affective changes that typical learners experience as they make the transition from having little skill (being novices) to making domain-specific decisions intuitively (being experts). Dreyfus's work makes it clear how extensively the question of skill acquisition is connected with human embodiment and the interaction between human beings and the world.

According to Dreyfus, human beings are not passive objects in or omnipotent manipulators of the world but are caught up in it, even and all the more so in regard to skilled behavior. This perspective reflects the basic phenomenological tenet that all practical and theoretical activities, no matter how abstract their outcomes, need to be understood on a continuum with basic lifeworld practice. Experts, Dreyfus insists, act the way all people do when performing mundane tasks: "We are all experts at many tasks and our everyday coping skills function smoothly and transparently so as to free us to be aware of other aspects of our lives where we are not so skillful" (Dreyfus 1990, p. 243). In other words, just as everyday drivers act intuitively when driving (i.e., their actions are not guided by explicit or implicit rule following, but they develop a contextually sensitive capacity for recognizing and responding to patterns that allows them to respond immediately and effortlessly to changes in traffic and road conditions), all professional experts act intuitively when making decisions in their fields: Fighter pilots act intuitively when engaged in combat situations; nurses act intuitively when caring for their patients; environmental scientists act intuitively when assessing whether building a dam will affect the local wildlife in a particular way; and judges act intuitively when deciding which precedent it is appropriate to appeal to in a case.

This phenomenological position potentially has profound implications for the ways in which experts should be trained, communicated with, and utilized. First, if experts solve problems intuitively, educational programs that fail to train students to make intuitive decisions will fail to produce expert graduates. The bias against treating intuition as a serious epistemic resource—one that permeates much of Western intellectual and scientific history and underwrites much of modern management theory—thus is called into question precisely because it impedes the cultivation of the highest form of problem solving and fosters a misleading sense that the human mind can be modeled on computational machines. Similar suspicion is cast on technologically mediated forms of pedagogy that inhibit instructors in relating to their classes intuitively. From Dreyfus's perspective instructors who are trained to view teaching primarily as an opportunity to convey content on the Internet will not be able to develop the expertise that emerges from face-to-face educational interaction, such as learning to read a class's body language to discern whether the presented material has been found to be comprehensible, interesting, or useful. Instructors also will be discouraged from developing the wisdom that comes from dealing reflexively with finitude (e.g., looking a student in the eye and admitting that one does not know the answer to a well-posed question). Students subjected to such an educational process will be trained inadequately.

Second, if experts solve problems intuitively, the social policies and expectations that require experts to translate intuitive decisions into general procedural rules, such as the protocols followed routinely by expert witnesses, should be reevaluated. According to Dreyfus's model, those protocols force experts to provide misleading narratives that distort the ways in which their judgments were formed. Not only does such distortion threaten to transform experts into an "endangered species," it also places the United States at an economic disadvantage: "Demanding that its experts be able to explain how they do their job can seriously penalize a rational culture like ours, in competition with an intuitive culture like Japan's" (Dreyfus and Dreyfus 1986, p. 196).

Third, if experts act intuitively, attempts to export human expertise into nonintuitive technologies such as expert computer systems will fail. This issue will become more important as an increasing amount and variety of medical decisions are delegated to expert computer systems.

Others, however, have noted that despite its benefits Dreyfus's account seems to downplay or even ignore the possibility that ideology and hidden agendas can creep into expert opinion. It therefore is critical to correct this account by exploring how such things are possible (Selinger and Crease 2002). Dreyfus's account also overlooks the different varieties of expertise in performers, critics, and sociologists. For instance, although an expert musician such as a first violin would have to play well, an expert in music might be a musicologist who did not play music at all.

The sociologists Harry Collins and Robert Evans (2002) distinguish between two types of expertise: "interactional expertise" and "contributory expertise." A contributory expert is a practitioner who learns to make contributions to the field by being physically immersed in its corresponding "form-of-life." Medical doctors, for example, develop medical expertise by attending medical school; they then contribute to the development of medicine by publishing medical papers that are based on their clinical experiences. By contrast, an interactional expert is someone who can talk competently about aspects of a field (e.g., pass on information, assume a devil's advocate position, understand and tell insider jokes, and make judgments on a peer review committee) but learns about the field only by talking with people who have acquired contributory expertise. In other words, whereas interactional experts have quite a bit of tacit (nonpropositional) knowledge, they are not direct practitioners in the fields they study. This means that someone who lacks full physical immersion in a field can become so conversant about that field through linguistic socialization that under the conditions of a Turing test (two people who have not met face to face communicating to one another by typing electronic text messages back and forth) it would be hard for authorities to decide whether that person was an interactional expert or a contributory one. A sociologist of medicine who never performed surgery could become so conversant about surgical procedures as to have the kinds of conversations that could convince practicing surgeons that the sociologist was actually a physician.

This position on interactional expertise has implications for the ways in which experts should be identified and treated. First, if interactional expertise fits the criteria Collins and Evans provide, many of the social scientific and humanities disciplines that typically are looked down on by practitioners of the natural sciences (as well as critics and coaches who are looked down on by primary practitioners) should be viewed in a new light; these are indeed real experts, albeit experts who possess interactional expertise.

Second, there may have to be additional legal discussions about who qualifies as an expert witness. Collins and Evans discuss the case of their sociologist colleague Simon Cole (Collins and Evans 2002). Although Cole does not analyze fingerprints, he has studied the methods and conventions of fingerprint analysis rigorously and, as a result of his sociological work, has come to serve as an expert witness. However, Cole's credibility could be contested by the opposing lawyers; after all, he is not a contributory expert. The key consideration, Collins and Evans insist, is that Cole's interactional expertise should be understood as entitling him to make authoritative pronouncements on fingerprinting.

Third, if interactional expertise fits the criteria Collins and Evans provide, political activists who are linguistically socialized into an expert discourse, such as AIDS activists who are socialized in that manner into medical discourse, have a new vocabulary from which they can justify their demands for social change (Selinger and Mix 2004).

Distributed Expertise

Yet another approach to expertise is to focus neither on the forces that shape it nor on its acquisition and various forms but on how it is distributed. Although other accounts address different types of agents as experts and different types of contexts that influence such displays of agency, they fail to reckon with the ways in which expertise is "distributed"—externalized into a network of tools and practices in particular settings such as the laboratory and social networks, standardized in technologies, and more (Mialet 1999).

Bruno Latour's discussion of the Association Française contre les Myopathies (AMF, or French Muscular Dystrophy Association) is a case in point (Latour 1998). The AFM acquired enough funds through charitable donations to contribute more than did the French government to basic research on the human genome. The supported scientists became world players in molecular biology and published some of the first genomic maps in the journal *Nature*. Once their basic research was completed, the AFM-sponsored scientists disbanded the mapping laboratories and turned their attention to the risky field of gene therapy. Latour describes AFM's headquarters as follows:

> The very building at Ivry, south of Paris, where the AFM has its headquarters, illustrates the limit of a metaphor that would separate science from a society left outside: on the first floor, patients in wheelchairs; on the next floor, laboratories; on the third, administration. Everywhere the posters mark the next telethon while contributors visit the premises. Where is the science? Where is the society? They are now entangled to the point where they cannot be separated any longer" (Latour 1998, p. 208).

Latour's point is that what is happening at AFM is neither pure knowledge spilling over into application nor social pressure generating scientific research but represents a far more complex process in which expertise is inextricably bound up in network activity and a wide variety of events and interests can create and destroy its social stability.

The AFM research network may or may not prove to be a suitable model for science elsewhere or even a suitable model for molecular biology in the long run. Nevertheless, Latour claims that this case illustrates the fact that theorists of expertise need to be attentive to cases in which experts prove themselves capable of being (1) flexible because they are willing and able to adapt to, compromise with, and even change their intentions on the basis of the way unexpected network occurrences influence their initial goals; (2) selective because they are able to discern which elements of adaptation and compromise are important and which are inconsequential; (3) perseverant because they are able to endure the setbacks that occur when they attempt to enlist allies; (4) tactful because they are able to maximize other people's interests while remaining unobtrusive; (5) communicative because they are able to transcend the technical jargon concerning their specialization in order to bridge the gap between different people's interests; (6) creative because they are able to recruit likely as well as unlikely allies; and

(7) cooperative because they are willing to accept compromise as an essential feature of network interactions.

Solutions

Far more work needs to be done in exploring the role of discretionary power and potential ideological biases, the role of intuitive and interactive elements, and the distribution of expertise not only in analyzing the issues that arise within each of these perspectives but in seeing how these approaches overlap and differ. More work also needs to be done in approaching expertise in the light of other issues, such as participation.

However, the greatest obstacle to elucidating the nature, scope, and application of expertise is not the complexity of the process; complex phenomena are still amenable to description and analysis. The difficulty stems from how tightly expertise is woven into contemporary life and in how many different ways, making it difficult to place the subject at a manageable distance.

On the one hand, it is tempting but impossible to approach experts as one social class nested among others, such as engineers or doctors or lawyers, or as a subgroup within each social class whose activities may be defined and classified neatly and whose members are governed and disciplined by legislative bodies or citizen groups. However, the use of expertise ripples through modern life in so many forms that this is impossible. On the other hand, it might seem that the scope of expertise is too wide and too protean to lend itself to meaningful analysis. These problems have led some scholars to back away from the subject or to claim that it is ultimately without conceptual substance. Michel Callon, for instance, has described his research as challenging the distinction between expert and layperson, whereas Latour suggests that the concept of the expert is outmoded and is being replaced by that of the spokesperson. However, such cooptations, subversions, and replacements of the concept are unlikely to succeed. The problem of expertise will remain one of pressing issues of the twenty-first century.

ROBERT P. CREASE
EVAN M. SELINGER

SEE ALSO *Authoritarianism; Citizenship; Constructive Technology Assessment; Democracy; Dewey, John; Participation; Peer Review; Pragmatism; Profession and Professionalism; Science, Technology, and Law; Technocracy.*

BIBLIOGRAPHY

Angell, Marcia. (1996). *Science on Trial: The Clash of Medical Evidence and the Law in the Breast Implant Case*. New York: W.W. Norton.

Annas, Julia. (2001). "Moral Knowledge as Practical Knowledge." *Social Philosophy & Policy* 18: 236–256. This article examines Socrates' conception of expertise, and in so doing, shows why contemporary moral theorists have found it difficult to interpret ancient conceptions of ethics properly.

Brekke, Nancy, and Eugene Borgida. (1988). "Expert Psychological Testimony in Rape Trials: A Social Cognitive Analysis." *Journal of Personality and Social Psychology* 55: 372–386.

Collins, Harry. (2004). "Interactional Expertise as a Third Kind of Knowledge." *Phenomenology and the Cognitive Sciences* 3: 125–143.

Collins, Harry, and Robert Evans. (2002). "The Third Wave of Science Studies: Studies of Expertise and Experience." *Social Studies of Science* 32(2): 235–296. The authors analyze some of the problems that have arisen from the pervasive historical and sociological deconstructions of expertise.

Collins, Harry, and Robert Evans. (2003). "King Canute Meets the Beach Boys: Responses to the Third Wave." *Social Studies of Science* 33(3): 435–452.

Dreyfus, Hubert. (1990). "What Is Morality? A Phenomenological Account of the Development of Ethical Expertise." In *Universalism vs. Communtarianism: Contemporary Debates in Ethics*, ed. David Rasmussen. Cambridge, MA: MIT Press. In this article Dreyfus argues that ethics is a skill, one that can best be explained according to his developmental model of expertise. On this basis, he takes issue with leading philosophical and psychological accounts of moral decision-making.

Dreyfus, Hubert, and Stuart Dreyfus. (1986). *Mind over Machine: The Power of Human Intuition and Expertise in the Era of the Computer*. New York: Free Press. In this book the Dreyfus brothers provide a developmental model of human expertise, and in so doing, make the case that expert intuition is endangered by both contemporary practices of simulating expertise in computer programs and by contemporary expectations of what kinds of explanations experts can offer.

Feigman, David. (2004). *Laboratory of Justice: The Supreme Court's 200-Year Struggle to Integrate Science and the Law*. New York: Times Books.

Feyerabend, Paul. (1999). "Experts in a Free Society." In *Knowledge, Science and Relativism, Philosophical Papers*, vol.3, ed. John Preston. Cambridge, MA: Cambridge University Press.

Foster, Kenneth, and Peter Huber. (1997). *Judging Science: Scientific Knowledge and the Federal Courts*. Cambridge, MA: MIT Press. The main goal of this book is to reconcile the law's need for workable rules of evidence with the views of scientific validity and reliability that emerge from the sciences as well as from social scientific and humanities disciplines that have contribution to our understanding of scientific validity and reliability.

Fuller, Steve. (1994). "The Constitutively Social Character of Expertise." *International Journal of Expert Systems* 7: 51–64.

Golan, Tal. (2004). *Laws of Men and Laws of Nature: The History of Scientific Expert Testimony in England and America*. Cambridge, MA: Harvard University Press.

Goldman, Alvin. (2001). "Experts: Which Ones Should You Trust?" *Philosophy and Phenomenological Research*. 63(1): 85–110.

Hardwig, John. (1985). "Epistemic Dependence." *Journal of Philosophy* 82: 335–349.

Hosch, Harmon. (1980). "A Comparison of Three Studies of the Influence of Expert Testimony on Jurors." *Law and Human Behavior* 4: 297–302.

Hulbert, Ann. (2004). *Raising America: Experts, Parents, and a Century of Advice about Children*. New York: Knopf.

Kovera, Margaret; Robert Levy; Eugene Borgida; and Steven Penrod. (1994). "Expert Testimony in Child Abuse Cases: Effects of Expert Evidence Type and Cross Examination." *Law and Human Behavior* 18: 653–674.

Latour, Bruno. (1998). "From the World of Science to the World of Research?" *Science* 280(5361): 208–209.

Marcuse, Herbert. (1964). *One Dimensional Man*. Boston: Beacon Press Books.

Marcuse, Herbert. (1998). "Some Social Implications of Modern Technology." In *Technology, War, Fascism: Collected Papers of Herbert Marcuse*, vol. 1, ed. Douglas Kellner. New York: Routledge.

Mialet, Hélène. (1999). "Do Angels Have Bodies: The Cases of William X and Mr. Hawking." *Social Studies of Science* 29: 551–582.

Postman, Neil. (1993). *Technopoly: The Surrender of Culture to Technology*. New York: Vintage. This book is a polemic against many of the dangers of technology, including the dangers of allowing experts to have more authority than they sometimes claim to deserve.

Selinger, Evan. (2003). "Feyerabend's Democratic Argument against Experts." *Critical Review* 15(3–4): 359–373.

Selinger, Evan, and Robert P. Crease. (2002). "Dreyfus on Expertise: The Limits of Phenomenological Analysis." *Continental Philosophy Review* 35: 245–279.

Selinger, Evan, and Robert P. Crease, eds. (2006). *The Philosophy of Expertise*. New York: Columbia University Press. This is the first edited volume in which the topic of the philosophy of expertise is treated as a central concern.

Selinger, Evan, and John Mix. (2004). "On Interactional Expertise: Pragmatic and Ontological Considerations." *Phenomenology and the Cognitive Sciences* 3: 145–163.

Schuller, Regina, and Patricia Hastings. (1996). "Trials of Battered Women Who Kill: The Impact of Alternative Forms of Expert Evidence." *Law and Human Behavior* 16: 597–620.

Thorpe, Charles. (2002). "Disciplining Authority and Liberal Democracy in the Oppenheimer Case." *Social Studies of Science* 32: 525–562.

Walton, Douglas. (1997). *Appeal to Expert Opinion: Arguments from Authority*. University Park: Pennsylvania State University Press. This book examines the appeal to expert authority from a historical as well as logical perspective.

Weinstein, Bruce. (1993). "What Is an Expert?" *Theoretical Medicine* 14: 57–73.

EXPOSURE LIMITS

Exposure limits specify the maximal allowed exposures for individuals to chemical substances or other obnoxious influences such as noise or radiation. Such limits are usually expressed as environmental concentrations (e.g., 0.1 mg/m3 [milligrams per cubic meter] of atmosphere). Biological limits, expressed as blood concentrations, are used for some substances.

Exposure limits apply to all persons in regard to the environment, food, water, and consumer products. Public health, agricultural, and environmental protection agencies in most countries determine public exposure limits covering a wide variety of natural and nonnatural circumstances. The exposure limits that most affect us in our daily lives are probably those that limit the intake of toxic substances through food and drinking water. The area in which exposure limits have been most fully developed, however, are in relation to occupational health regulations.

Occupational Exposure Limits

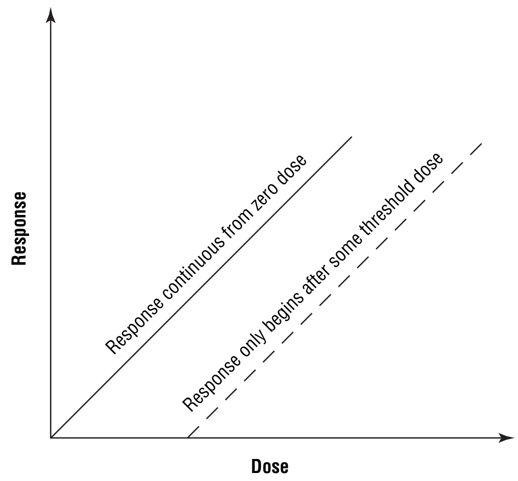
Occupational exposure limits depend on specific theories about relations between exposures and harms, and on empirical data that can be brought to bear on particular cases. In some cases harms or responses do not begin until a certain threshold of exposure or dose is reached. The other argues that response is continuous from the most minimal exposure (see Figure 1).

There are also different ethical viewpoints about the degree to which workers should be protected in the workplace. One view, for instance, argues that workers are compensated for their exposure to certain possible harms by their wages and salaries, and that the only issue at most is educating them about their exposures. Another view is that workers should be no more exposed to environmental harms in the workplace than out of it. Disagreements between these two ethical views, combined with disagreements about dose–response relations, can lead to quite different interpretations of empirical data relevant to the establishment of occupational exposure limits.

The first occupational exposure limits were proposed by individual researchers in the 1880s. In the

FIGURE 1

Alternative Dose-Response Models



SOURCE: Courtesy of Carl Mitcham.

1920s and 1930s several lists of exposure limits were published in both Europe and the United States, not always with clear identification of the dose–response relations or ethical views on which they were based. The term *occupational exposure limit* (OEL) was introduced in 1977 by the International Labour Organization (ILO). Other names for occupational exposure standards include threshold limit value (TLV), maximum allowed concentration (MAC), and permissible exposure limit (PEL).

Threshold Limit Values

The American Conference of Governmental Industrial Hygienists (ACGIH) was founded in 1938. In 1941 it set up the Threshold Limit Values for Chemical Substances Committee, which in 1946 issued the first list of TLVs covering around 140 chemical substances. This annually revised list has a dominant role as a standard reference for official lists all over the world.

The first TLV committee was dominated by industrial hygienists and included no physicians. Gradually, medical and scientific expertise was incorporated in the committee. In 1962 the first "Documentation of the TLVs" was published. It contained, for each substance on the list, a brief summary of its effects, with references and with grounds for the TLV that had been chosen.

In the 1940s and 1950s the ACGIH and the American Standards Association (ASA; now the American National Standards Institute [ANSI]) competed for the position of leading setter of occupational exposure limits. The exposure limits of the ASA and those of the ACGIH did not differ much in numerical terms, but the ASA values were ceiling values below which all workplace concentrations should fluctuate, whereas the ACGIH values were (and still are, with few exceptions) upper limits for the average during a whole working day. Therefore, the ASA standards were more expensive for industry but provided greater protection for exposed workers.

The ACGIH won the struggle and emerged in the early 1960s as virtually the only source of exposure limits that practitioners looked to for guidance. In 1969 the U.S. federal Occupational Safety and Health Administration (OSHA) adopted the ACGIH's exposure limits as an official standard. Because of the sluggishness of legal processes, however, OSHA has not always adopted the updated values subsequently issued by the ACGIH.

In the 1980s, the ACGIH was again challenged. The National Institute for Occupational Safety and Health (NIOSH) criticized its TLVs for being too high, and therefore not protecting workers against potential disease. The alternative values proposed by NIOSH were often many times lower than the TLVs. At the same time, OSHA was criticized for being too harsh on industry. Once again, attacks on the ACGIH were unsuccessful, and the organization retained its position as the leading setter of occupational exposure limits.

Several explanations have been given about why the ACGIH and its TLVs have been so successful. The ACGIH was first with a comprehensive listing of all-important chemicals for which measurement methods were available. As a voluntary body it has been able to update its list annually without the time- and resource-consuming legal procedures that precede revisions of OSHA standards. Furthermore, the comparative ease with which the TLVs can be implemented has probably contributed to their success. Most competing exposure limits, such as those of NIOSH, are more costly and therefore give rise to more opposition from industry.

At the same time, the TLVs have been criticized for being insufficiently protective. Examples of harmful effects at levels below the TLVs are easily found. Grace E. Ziem and Barry I. Castleman (1989) reviewed the contents of four major peer-reviewed journals in occupational medicine for thirty-three months, from January 1987 to September 1989, and found thirty-one papers that described harmful effects at or below the TLVs.

Another common criticism is that the ACGIH has relied too much on unpublished corporate information. Many values have been based on information from a company to the effect that a certain level has been found to be safe, or that no evidence of damage to health has been found at a certain level. This type of information does not satisfy modern criteria for science-based health assessment. Nevertheless, ACGIH's list of TLVs would have covered many fewer substances if such corporate information had not been used. The present policy of the ACGIH is that TLVs "represent a scientific opinion based on a review of existing peer-reviewed scientific literature" (ACGIH website).

Exposure Limits in Other Countries

Since the 1970s most industrialized countries have official lists of occupational exposure limits. In many cases, these lists developed out of the ACGIH list. Because of the less litigious legal culture in Europe, many European countries have national lists of occupational exposure limits that are updated regularly. In some countries such as Sweden and Denmark, the national list has significantly lower values than the ACGIH list.

Developing countries often use the ACGIH list with few or no modifications. As the ACGIH has itself pointed out, however, some TLVs may be unsuitable for use in countries with different conditions from those in the United States, for instance in terms of the nutritional status of workers. The ACGIH also points out that the TLVs "are not developed for use as legal standards and ACGIH does not advocate their use as such."

Some countries, such as the Netherlands and Sweden, have developed an elaborate bipartition of the regulatory task into scientific and policy components. The scientific component is performed by experts in the relevant scientific fields. It derives its legitimacy from the expertise of those who perform it. The policy component is performed by decision makers in government agencies. This component of the process can, in a democratic society, derive its legitimacy only from the same source as other political or administrative processes, meaning that those who perform it must represent the people.

Difficulties in Setting Exposure Limits

The two major sources of knowledge for setting exposure limits are epidemiological studies and animal experiments. In an epidemiological study, groups of humans are statistically compared in search of associations between disease incidence and environmental or other causal factors. The effects of major workplace hazards, such as asbestos, lead, and vinyl chloride, have been convincingly identified and quantified in epidemiological studies. At the same time many epidemiological studies are inconclusive because of the multiplicity of factors that can influence the prevalence of disease in human populations. Epidemiology also has the crucial disadvantage that the toxic effects of a substance can be discovered only when workers have already been subjected to these effects.

In animal experiments, the health status of exposed animals is compared to that of an unexposed control group. Because of the high degree of biochemical and physiological similarity between humans and the common experimental animals, animal experimentation has predictive power, but unfortunately the predictions are far from perfect. There are substances to which humans are much more, or much less, sensitive than the common laboratory animals.

Because of the uncertainty inherent in both epidemiology and animal experiments, it is in practice virtually impossible to determine with certainty absolutely safe nonzero levels of toxic exposure. Furthermore, for genotoxic carcinogens, it is generally believed that although the risk diminishes with the exposure, it is not completely eliminated until the exposure has been reduced to zero. Accordingly, the ACGIH has stated that the TLVs "represent conditions under which ACGIH believes that nearly all workers may be repeatedly exposed without adverse health effects. They are not fine lines between safe and dangerous exposures, nor are they a relative index of toxicology" (ACGIH website). Other setters of exposure limits have made similar statements.

To set occupational exposure limits is no easy task. Workers exposed to potentially dangerous substances expect exposure limits to fully protect their health. Employers expect the exposure limits to impose only such costs as are necessary to protect employee health. It is in practice impossible to set OELs that fully satisfy both demands. The task of standard setters is to find a reasonable compromise. To achieve this is a science-based enterprise in the sense of making use of scientific information, but not in the sense of being based exclusively on science. It is in fact both science-based and value-based.

As already indicated, the determination of exposure limits involves not just empirical data but also scientific theories about how this data should be interpreted and ethical views about how it should be applied. In some cases the application of very safe exposure limits can put an industrial operation out of business, so that workers are fully protected but only at the cost of losing their jobs. In other cases, not to apply strong exposure limits can have deadly consequences. The adjudication of exposure limits in the workplace, as outside the workplace, is an issues that involves scientific and ethical education on the part of workers, employers, politicians, and citizens.

SVEN OVE HANSSON

SEE ALSO *Limits; Radiation; Risk-Cost-Benefit Analysis.*

BIBLIOGRAPHY

Cook, Warren A. (1985). "History of ACGIH TLVs." *Annals of the American Conference of Governmental Industrial Hygienists* 12: 3–9.

Hansson, Sven Ove. (1998). *Setting the Limit: Occupational Health Standards and the Limits of Science.* New York: Oxford University Press. Comparative study of practices in Germany, Sweden, and the UK.

Paull, Jeffrey M. (1984). "The Origin and Basis of Threshold Limit Values." *American Journal of Industrial Medicine* 5(3): 227–238. Early history of TLVs.

Ziem, Grace E., and Barry I. Castleman. (1989). "Threshold Limit Values: Historical Perspectives and Current Practice." *Journal of Occupational Medicine* 31(11): 910–918. Critical appraisal of TLVs.

INTERNET RESOURCE

American Conference of Governmental Industrial Hygienists (ACGIH). 2005. "Statement of Position Regarding the TLVs and BEIs" Available from http://acgih.org/TLV/PosStmt.htm.

F

FACT/VALUE DICHOTOMY

Representatives of modern science and its social institutions have repeatedly claimed that science is *value free,* and this claim has contributed to marginalizing serious discussion of the relations among science, technology, and values. Lying behind this claim is the philosophical view that there is not just a distinction but a sharp separation, an unbridgeable gap or *dichotomy,* between *fact* and *value.* The supposed fact/value dichotomy arose at the beginning of the seventeenth century, accompanying the early works of modern science, underpinning an interpretation of their character and epistemic status and became part of the mainstream tradition of modern science (Proctor 1991). Prior to that, it was not a major issue in philosophical thinking about science.

Science and Technology as Value Free

The claim that science is value free is that science deals exclusively with facts and—*at its core*—admits of no proper place for ethical (and social) values. This is not to deny that important relations between science and values exist—for example, that scientific knowledge is a value (even a universal one), that the conduct of scientific research requires the commitment of scientists to certain virtues—such as honesty and courage to follow the evidence where it leads (Merton 1973), and that experimental activities are subject to ethical restraint. Rather, elaborating what it is to keep values out of the core of science, it is to affirm four theses: (1) Scientific knowledge is *impartial:* Ethical values should not be among the *criteria* for accepting or rejecting scientific theories and appraising scientific knowledge. (2) Ethical values have no fundamental role in the *practices* of gaining and appraising scientific knowledge, because the broad characteristics of scientific methodology should be responsive only to the interest of gaining understanding of phenomena. (3) Similarly, research priorities should not be shaped systematically by particular values. The point of both (2) and (3) is that scientific practices are *autonomous.* (4) Scientific theories are *neutral:* Value judgments are not among the logical implications of scientific theories (*cognitive neutrality*); and, on application (e.g., in technology), in principle these theories can evenhandedly inform interests fostered by a wide range of value outlooks (*applied neutrality*) (Lacey 1999). The theses of impartiality and applied neutrality have counterparts regarding the claim that technology is value free. This claim involves the theses: (1) The characteristic criterion of appraisal for technological objects is *efficacy,* the factual issue of whether they work or not. (2) Technology progressively makes it possible to effectively achieve more ends, but it does not privilege any particular ends; its products are available to be used to serve the interests of a wide range of value outlooks (Tiles and Oberdiek 1995).

Sources of the Fact/Value Dichotomy

Materialist metaphysics constitutes one source of the fact/value dichotomy. In the words of Alexandre Koyré (1957), one of the most authoritative historians of early modern science, it—by rationalizing the mathematical and experimental character of science—led to the "discarding by scientific thought of all considerations based upon value-concepts, such as perfection, harmony, meaning and aim, and finally the utter devalorization of being, the divorce of the world of value from the world of facts" (p. 4).

According to materialist metaphysics, the "world of facts" is identical to the "world as it really is in itself." This world consists of the totality of the underlying (normally unobservable) structure and its components, processes, interactions, and mathematically expressed laws, whose generative powers explain phenomena, in a way that dissociates them from any relation to human experience, social and ecological organization, or values—the totality of *bare facts*, purely material facts. On this view, because its aim is to gain understanding of the world, science will attend to grasping the bare facts. Thus, scientific theories should deploy only categories that are devoid of evaluative connotations or implications, such as the quantitative ones (force, mass, velocity, etc.) characteristically used in physical theories. No value judgments follow, for example, from Isaac Newton's law of gravitation, and it makes no sense to ask whether it is good or bad, or whether one ought to act in accordance with it or not. Newton's law expresses a bare fact; faithful to the way the world is, it makes an *objective* statement.

Representatives of modern science often argue that value judgments, by contrast, do not make true or false statements about objects of the world. Rather they serve as expressions of *subjective* preferences, desires, or utilities (perhaps grounded in emotions). In this way, the fact/value dichotomy is reinforced by the objective/subjective dichotomy. Science deals with facts; it is objective. Ethics deals with preferences; it is subjective. The efficacy of technological objects, attested to by confirmed scientific theories, stands on the side of facts. Legitimating their uses, however, involves ethical judgments, which cannot be derived from the bare facts that account for the technology's efficacy and the material possibilities that it makes available.

Epistemology is a further source of the fact/value and objective/subjective dichotomies. Scientific epistemologies identify facts—*confirmed facts*—with what is well supported by empirical data, and the results of established scientific theories. Those that inform technological practices are exemplary instances. Confirmed facts derive from *intersubjectivity*, that is, replicability and agreement, which cuts across value outlooks and cultural norms. Value judgments are not considered intersubjective. Whereas from the metaphysical source, objectivity derives from faithfully representing objects of the world in statements that express bare facts; from the [other] from the epistemological, it derives from the intersubjectivity of confirmed facts. In practice the two notions of fact tend to fuse together and, from both sources, value judgments appear to be subjective, unlike scientific results that are objective. Hilary Putnam (2002) reviews and criticizes much of the vast philosophical literature on the subjectivity of value judgments.

Finally, *logic* constitutes a third source of the fact/value dichotomy, and for many philosophers it is the principal one. David Hume, in *A Treatise of Human Nature* (1739–1740), is argued to have demonstrated an unbridgeable logical gap between fact and value, because factual statements cannot logically entail value judgments; *ought* is not logically entailed by *is*. The mark of a fact in Hume's argument is a linguistic one: the role of *is* and grammatically related verbs, and the absence of such terms as *good* and *ought*. Less discussed is the complementary thesis, defended by Francis Bacon in *The New Organon* (1620), with his famous injunction to avoid "sciences as one would," to avoid inferring *is* from *ought*, or *good*, or from what serves one's interests; for example, it may serve the interest of legitimating the use of a particular technology that it not occasion serious risks to human health, but that interest is irrelevant to determining what the facts are about the risks.

The Entanglement of Fact and Value

Many criticisms have been made of the fact/value dichotomy, including those of pragmatists and critical theorists. But they all come down to one basic argument, that rather than dichotomy there is some kind of *entanglement* (Putnam 2002) between facts and values. Some (not all) aspects of the entanglement, most of which were discussed by Dewey (1939), are identified below.

NO UNBRIDGEABLE GAP. Many significant factual statements are articulated in scientific theories (such as Newton's law of gravitation). Whether or not a theory is rationally accepted, and thus whether or not statements articulated in it represent confirmed facts, depends on the satisfaction of criteria that require that certain relations obtain between the theory and relevant *observed facts*. Exactly what these relations should be (inductive, abductive) remains disputed; nevertheless, it is clear that the theories are not logically entailed by the observed facts. the criteria that must be satisfied are those for *evaluating* the scientific knowledge and the understanding of phenomena represented in theories.

These criteria have been called *cognitive values* (McMullin 2000); they are a species of values in general, and include empirical adequacy, explanatory power, and consilience. Cognitive values are held to be distinct from ethical, social, and other kinds of values (Lacey 2004), although this is disputed (Longino 1990). Cognitive value judgments concern how adequately cognitive values are manifested in a theory in the light of available observed facts. Soundly accepting that a statement represents a confirmed fact amounts to making the cognitive value judgment that the cognitive values are manifested in the theory to a high enough degree. Far from there being an unbridgeable gap between fact and value, confirmed facts are partly constituted by cognitive value judgments.

FACTS AS PRESUPPOSITIONS AND SUPPORT FOR VALUES. Hume's argument by itself does not rule out that factual statements may provide support for value judgments; otherwise, it would also rule out that observed facts can provide evidential support for facts confirmed within scientific theories, for the fundamental hypotheses of scientific theories are not logically entailed by facts. Logical entailment need not be a particularly important relation in analyzing how facts may support other facts or other kinds of judgments. Consider, for example, the statement: "Recently enacted legislation is the principal cause of the current increase in hunger and child mortality rates." This is a factual statement, because it has the relevant linguistic marks, and empirical inquiry may confirm it to be true or false. At the same time, accepting that it is well confirmed would support holding the value judgment that the legislation should be changed, because, unless there are other factors to consider, it would make no sense to deny that the legislation should be changed, if it is accepted that the factual statement about the causes of hunger has been confirmed. Linked to this, the ethical value of the legislation *presupposes* that it does not have ethically undesirable causal consequences such as increased hunger (Lacey 2004; for a variant of this argument, see Bhaskar 1986).

SOME SENTENCES MAKE BOTH FACTUAL STATEMENTS AND VALUE JUDGMENTS. Declaring that legislation is the cause of hunger may be intended as the statement of a confirmed fact. Alternatively it may serve to express a value judgment, that is, ethical disapproval of the legislation. The logical and linguistic form of the declaration permits it to be used in either role, showing that there is an overlap of the predicates used in factual and ethical discourse. What have been called *thick ethical terms*, terms such as *honest* and *unjust* (also *hunger* and *high child mortality*)—in contrast to *thin ethical terms*, such as *good* and *ought*—may be used simultaneously to serve factual and evaluative ends (Putnam 2002).

Declaring that legislation causes hunger is simultaneously to describe it and normally to criticize it ethically. Using thick ethical terms in factual discourse is no barrier to arriving at results that are well confirmed in the light of the cognitive values and available empirical data; and when such results are obtained, the ethical appraisal is strengthened. Theories that contain such results are not cognitively neutral; they lend support to particular ethical appraisals. Of course, the ethical values of the investigators may explain why they engaged in the relevant research and used the thick ethical terms as their key descriptive categories. Ethical values may influence what facts a person comes to confirm; but they have nothing to do with their appraisal as facts.

SCIENTIFIC APPRAISAL MAY INEXTRICABLY INVOLVE EMPIRICAL CONSIDERATIONS AND VALUE JUDGMENTS. Empirical appraisal never provides certainty; in principle, even the best confirmed statements might be disconfirmed by further investigation. Thus, when a hypothesis is applied, the appraisal made is that it is sufficiently well confirmed by available empirical evidence so that, in considerations about the legitimacy of its application, it is not necessary to take into account that it might be disconfirmed by further investigation, and that, if it were, it might occasion negatively valued outcomes. In the light of this, the standards of confirmation that need to be satisfied depend upon how valuatively significant are these outcomes (Rudner 1953).

MODERN SCIENCE HAS FOSTERED THE VALUE OF EXPANDING HUMAN CAPACITIES TO EXERCISE CONTROL OVER NATURE. Because there are confirmed facts—that is, facts that reliably inform human action—that deploy thick ethical terms, not all confirmed facts are bare facts. This challenges the metaphysical view that the world "as it really is" is identical to the totality of bare facts; and, indeed, it is neither a bare fact, nor a confirmed fact, that the world "really" is that way. Scientists may make the choice to attend only to bare facts. Although this is not the only way to gain factual knowledge, it has generated an enormous amount of knowledge of inestimable social and technological importance. Moreover, because its categories are (by design) chosen to describe facts without the use of thick ethical terms, this knowledge has no ethical judgments at all among its implications. Approaching scientific research, attending only to bare facts, produces results that are cognitively neutral.

At the same time, the contribution of scientific knowledge to enhancing human capacities to exercise control over nature has been highly valued throughout the modern scientific tradition. It has been argued (Lacey 1999) that the approach to scientific research that attends principally to bare facts gained virtual hegemony because of its dialectical links with according high ethical value to enhancing human capacities for control, as well as the exercise of these capacities in ever more domains of life. Bare facts are especially pertinent for informing projects of technological control. Furthermore, sometimes the results of modern science (for example, the developments that have produced transgenic crops) have little application where competing values are held (such as the values of simultaneously gaining high productivity, ecological sustainability, protection of biodiversity, and empowerment of local producers [Altieri 2001]). Thus, while the results gained in this approach of modern science are cognitively neutral, they do not, on the whole, display applied neutrality. (For a variant of this point, see Kitcher 2001.) Humans have considerable knowledge of bare facts (in part) because the values about control are widely held in society and shape scientific institutions. It is not the nature of the world that leads humans to search out such facts but, contrary to the claim of autonomy, a choice highly conditioned by social and ethical values, one that Robert N. Proctor (1991) refers to as "political."

Assessment

Not all the components of the claim that science is value free can be sustained. While there are important results that are cognitively neutral, that is, results that do not logically entail value judgments, in general results do not fit applied neutrality; that is, they are not evenhandedly applicable for a wide variety of value outlooks. Moreover, because applied neutrality does not hold in general, the claim that technology is value free cannot be sustained. There is no objection, then, to engaging in research for the sake of obtaining results that could inform one's ethically favored projects. What confirmed facts are actually obtained reflect these values. That they are confirmed facts does not. The ideal of impartiality remains intact. Ethical values are not among the cognitive values, so that ethically laden commitments (ideological, religious, political, entrepreneurial) are irrelevant to appraising knowledge claims. Science does not need the strong separation of facts and values in order to protect the ideal of impartiality. It needs only a nuanced account of their entanglement.

HUGH LACEY

SEE ALSO *Scientific Ethics*.

BIBLIOGRAPHY

Altieri, Miguel. (2001). *Genetic Engineering in Agriculture: The Myths, Environmental Risks, and Alternatives*. Oakland, CA: Food First. Provides an example showing that developments of transgenic crops do not fit the thesis of applied neutrality.

Bhaskar, Roy. (1986). *Scientific Realism and Human Emancipation*. London: Verso. Qualified argument that factual statements may logically imply value judgments.

Dewey, John. (1939). *Theory of Valuation, in Foundations of the Unity of Science: Toward an Encyclopedia of Unified Science*, ed. Otto Neurath, Rudolf Carnap and Charles Morris. Chicago: University of Chicago Press. Primary source of arguments for the entanglement of fact and value.

Kitcher, Philip. (2001). *Science, Truth, and Democracy*. New York: Oxford University Press. Analysis of the interaction between the cognitive and value aspects of science.

Koyré, Alexandre. (1957). *From the Closed World to the Infinite Universe*. New York: Harper Torchbooks. Influential history of the changes that inaugurated modern science.

Lacey, Hugh. (1999). *Is Science Value Free? Values and Scientific Understanding*. London: Routledge. Comprehensive critique of the claim that science is value free.

Lacey, Hugh. (2004). "Is There a Significant Distinction between Cognitive and Social Values?" In *Science, Values, and Objectivity*, ed. Peter Machamer and Gereon Wolters. Pittsburgh, PA: Pittsburgh University Press.

Longino, Helen E. (1990). *Science as Social Knowledge*. Princeton, NJ: Princeton University Press. Important analysis of the social and value dimensions of science.

McMullin, Ernan. (2000). "Values in Science." In *A Companion to the Philosophy of Science*, ed. W. H. Newton-Smith. Oxford: Blackwell. Important source on cognitive values.

Merton, Robert, ed. (1973). *The Sociology of Science*. Chicago; University of Chicago Press. Contains the classic statement of the "scientific ethos," the virtues required for scientific research.

Proctor, Robert N. (1991). *Value-Free Science? Purity and Power in Modern Knowledge*. Cambridge, MA: Harvard University Press. A comprehensive critique of the thesis of neutrality of science.

Putnam, Hilary. (2002). *The Collapse of the Fact/Value Dichotomy and Other Essays*. Cambridge, MA: Harvard University Press. Provides many arguments, in the spirit of Dewey, against the fact/value dichotomy.

Rudner, Richard. (1953). "The Scientist *qua* Scientist Makes Value Judgments." *Philosophy of Science* 20: 1–6. Famous brief article that argues that value judgments cannot be kept out of science.

Tiles, Mary, and Oberdiek, Hans. (1995). *Living in a Technological Culture*. London: Routledge. Presents a detailed critique of the claim that technology is value free.

FAMILY

The family is one of a number of basic social institutions that have been subjected to scientific study and affected by changes in science and technology. Because of the fundamental role the family plays in socialization, including the inculcation of moral behavior and ethical attitudes, it merits consideration in relation to science, technology, and ethics.

Throughout human history there has been a strong relationship between the family and technology. That relationship can be understood by tracing the successive technological revolutions that began with hunting and gathering societies and the discovery and use of tools and progressed through a series of technological societies, such as horticultural, agricultural, industrial, and postindustrial societies (Ribeiro 1968). Each successive step has altered ways of thinking and doing things by human beings, and this progression has been made possible primarily by new means of environmental adaptation. In the past families provided the organizational structure needed to develop tools and techniques to meet basic human needs, and this has continued in many ways into the present.

Defining the Family

A family may be defined as a group of people linked by descent. However, because descent can be understood in biological or nonbiological terms and is subject to narrow or broad interpretations, the scientific study of the family has led to the recognition of a number of basic distinctions. Indeed, the family has taken different forms throughout history and across cultures, related to diverse functions. In hunting and gathering and horticultural societies the kin group performed all religious, economic, and political functions. Kinship groups were broad enough to include relationships with almost everyone with whom a person interacted (Radcliff-Brown 1930). The kin group remained the major socializing agent, and the production and consumption of material goods continued to be centered in the family.

With the advent of agrarian families inheritance of property, primarily along male lines, became a central concern. The evidence from several studies (Gough 1971) indicates that because of land ownership and a more settled way of life the power of males increased (compared with the situation in hunting societies) at the expense of females. In agrarian families parents had considerable control over their children. However, agrarian families still were concerned about alliances with immediate and distant relatives. Those alliances are known as the extended family.

Industrialization brought the rise of the conjugal family unit. The nuclear family was becoming less embedded in the extended family, bringing a host of changes (Goode 1963). The major changes, according to William J. Goode, included social mobility, specialization, and geographic mobility. The family was no longer economically a producing unit, but its function as a consuming unit was heightened. In addition, many functions were outsourced from the family unit, resulting in greater dependence on the larger society.

The relationship between families and society thus has undergone major changes throughout history. In hunting societies institutions such as the economy and religion were embedded in kin groups. In agricultural society various institutions still were embedded in the extended family, although some institutional differentiation started to appear. In industrial society, disembedding reached a peak and the nuclear family became one of the many institutions that served individuals.

These distinctions are especially important in understanding interactions among families, science, and technology in relation to three social functions: producing and consuming material goods, information technology, and human reproduction.

Producing and Consuming Material Goods

The earliest families used hunting and gathering as their modes of production. Family members were producers of food for sustenance, and most tools were associated with the basic activities of survival: spear and bow and arrow for hunting, stone ax for skinning animals to make clothing, and basketry for food gathering. Hunting tools were made from stone, bone, and wood. Hunting and gathering societies were small and migrated frequently. In the family gender roles were defined clearly: Men had a monopoly on hunting, and women gathered food and raised children. In addition, men, being physically stronger, were expected to defend the tribe, thus accumulating more decision-making power. Once those gender roles became traditional, they were considered not only practical but "natural." Some scholars believe that this is where sexism or gender superiority began, although not in as pronounced a form as was to occur later.

Families continued to be producers of food in horticultural societies. Horticultural societies, a precursor of agricultural societies, were based on hoe agriculture: small-scale farming using a hoe and a digging stick.

Some copper tools and sickles made from clay fired at a high temperature also were used. Horticulture allowed populations to settle and provided some permanence in people's lives, something that had not been possible in foraging societies.

Simple horticultural societies gave way to agrarian societies around 3000 B.C.E. The family remained the primary producer, but agriculture provided the means to move from an existence that was dependent on what was given by nature to one of active participation, utilizing the environment to enhance the potential for a better life. One of the most important innovations in that period was the introduction of plow cultivation, which Gudmund Hatt (1961, p. 218) has called "the prerequisite of civilization." Animals were used to pull a plow. With the introduction of iron, superior plows, weapons, and tools were produced. Male dominance increased because agrarian tasks required greater strength and more intensive labor. Women's status declined further because of economic dependence, which was a result of a lack of direct contribution to the economic activities required in large-scale agriculture.

Families in industrial societies lost many of their production functions and became little more than a source of labor. Gerhard Lenski and Jean Lenski (1987) divided the Industrial Revolution into four phases on the basis of technological innovation. The first phase (1760–1850) began in England with major developments in the textile, iron, and coal industries. The second phase (1850–1900) saw expansion throughout most of Europe and North America. The steam engine was adapted for transportation by railroads and steamships. Agricultural production increased with the use of new kinds of machines and chemical fertilizers. Family ownership of companies began to give way to corporations, and the number of industrial workers increased substantially.

The third phase (1900–1940) was characterized by major advances in energy technology. The use of automobiles increased in most industrialized countries, and with it the demand for petroleum. Most homes were electrified and were connected to others by telephones. The fourth phase (1940–1970) saw major changes in the aviation industry spurred by World War II. The war economy also saw the expansion or development of nuclear power, plastics, and aluminum. Entertainment industries such as television, radio, and films experienced tremendous growth. The industrial sector became automated, and the nature of labor changed considerably. The most important innovation in this phase was the development of electronic computers.

All this technological innovation had a substantial impact on the structure and functions of the family. Home and work were separated. Family members—mostly men—had to work outside the home to purchase goods and services. In the early phase of industrialization the status of women reached its lowest point because women had no role in the economy outside the family. However, that changed after World War II as women entered the workplace in increasing numbers. By contrast, children had to wait longer to enter into the labor market because industrial economies required specialized skills. Hence, their economic dependence on parents increased compared with that of their counterparts in agricultural economies.

Information Technology and the Family

The concept of a "postindustrial society," as developed by Daniel Bell (1973), refers to a new mode of technological and economic production that is based increasingly on information and services. Information technology (IT) has revolutionized almost all aspects of human life.

Although its effects on families vary, family members tend to use IT as often in managing home life as in regulating work-home relationships. Pagers, faxes, cell phones, telephone answering systems, and computers are used to keep track of children, spouses, and other family members. Paging children to find out if they have arrived home safely from school demonstrates parental responsibility. E-mail and cell phones keep family members in constant contact. In addition, family members use answering machines, cell phones, and palm pilots to coordinate complex household schedules. However, not every effect of the use of IT has been positive. The colonization of home time by work is one obvious negative. The technical ability to work from home has blurred the distinction between workplace and family life.

Human Reproduction

Technology also has altered human reproduction, initially by means of birth control. Artificial contraception has disembedded conception from sexual intercourse and made fertility dependent on personal decisions. At the same time, with the growth of genetic research infertile couples now have many options for having a child through assisted reproductive technologies (ARTs). Among the many types of ARTs, artificial insemination is the most common.

The other commonly used procedure is known as in vitro fertilization (IVF), in which a woman's eggs are removed surgically and placed in a petri dish with sperm from her husband or a donor. One or more fertilized eggs then can be implanted directly into the woman's uterus. Sometimes extra fertilized eggs are frozen for possible later use. Surrogate pregnancy is available for women who cannot bear children.

Ethical Considerations

Science and technology not only have altered family life, they have generated fundamental ethical questions. The most controversial are associated with reproductive technology.

Are new technologies redefining previously held notions of family, parent, mother, and father? In embryo transplantation a fertilized egg from a female donor is implanted into an infertile woman. The developing embryos may be tested for genetic abnormalities before implantation. Critics (Benokraitis 2002) have raised concerns about parental rights to reject imperfect fetuses and create "designer babies." In 1999 a wealthy couple placed an ad in the newspapers of universities such as Harvard, Princeton, and Stanford, offering $50,000 for the eggs of a woman who was intelligent (SAT score 1,400 and higher), athletic, and tall. More than 200 college women responded to the advertisement (Weiss 2000). The implications are that rich people can "manufacture" babies and women who are in debt may offer their bodies.

A surrogate mother may decide to keep the baby. In 1987, in the celebrated "Baby M" case, Mary Beth Whitehead was artificially inseminated with the sperm of William Stern. Although Whitehead signed a surrogate contract with Stern, she changed her mind and turned down the $10,000 she had contracted to receive. She lost the case, but the court granted her visitation rights. Many critics who object to surrogacy argue that it exploits poor women because rich couples can afford to "rent a womb" (Benokraitis 2002).

Barbara Rothman raises a larger question in regard to motherhood: Should it always be defined in biological terms? Her answer is no. For Rothman, "Every woman is the mother of the child she bears, regardless of the source of the sperm and regardless of the source of the egg. The law must come to such an explicit recognition of the maternity relationship" (Rothman 1994, p. 201). In another situation surrogacy raised a complicated question of kinship. In 1991 Annette Schwartz served as a surrogate for her daughter, Christa, and gave birth to twins who became Christa's legal children. What kinship term should be applied to the relationship between the twins and Schwartz (Benokraitis 2002)?

Questions also arise about the impact of IT on the family. Information technology has had many unintended consequences. The issues of privacy and security breaches have become a major problem in most advanced countries. For instance, users of cellular phones can have their location tracked and hackers can get into family computers and remove private information. Parents can use IT to keep track of their children.

Does IT create stronger social relationships or distract people because it does not promote face-to-face relationships? Harold Rheingold (1993) and Sherry Turkle (1995) argue that computers and telephones provide emotional support and a sense of belonging. However, skeptics such as Mark Slouka (1995) and Clifford Stoll (1995) think that online relationships are narrow and lacking in quality. Those relationships are also manipulative because making affiliations in an electronic medium teeming with strangers is dangerous for young people. Moreover, "In the office, in their cars, and in their houses, the demands of work come pouring in. Work is so pervasive that conventional boundaries between work and home have all but collapsed" (Rheingold 2002, p. 191).

The fact that the use of technology is never neutral is demonstrated clearly by its impact on the family. Technology has been considered the hallmark of civilization; it has enabled humans to overcome the inertia and entropy of a harsh physical environment. However, dependence on technology has created cultural disorder as well, calling forth ethical reflection and responses.

MURLI M. SINHA

SEE ALSO *Education; Eugenics; Feminist Perspectives; Genetic Counseling; In Vitro Fertilization and Genetic Screening; Natural Law; Psychology.*

BIBLIOGRAPHY

Bell, Daniel. (1973). *The Coming of Post-Industrial Society*. New York: Basic Books. Deals with changes in social structure and the influence of science and technology and society and polity.

Benokraitis, Nijole V. (2002). *Marriages and Families: Changes, Choices, and Constraints*. Upper Saddle River, NJ: Prentice-Hall. A comprehensive analysis of major issues facing families in the twenty-first century.

Goode, William J. (1963). *World Revolution and Family Pattern*. New York: Free Press. Deals with the Industrial Revolution and how it was associated with predictable changes in family patterns.

Gough, Kathleen E. (1971). "The Origin of the Family." *Journal of Marriage and the Family* 33: 760–770. Traces the evolution of the family in various cultures.

Hatt, Gudmund. (1961). "Farming of Non-European People." In *Plough and Pasture: The Early History of Farming*, ed. E. Cecil Curwen and Gudmund Hart. New York: Collier. Studies the history of farming in various cultures.

Lenski, Gerhard, and Jean Lenski. (1987). *Human Societies: An Introduction to Macrosociology*. New York: McGraw-Hill. Attempts to classify human societies from hunting and gathering to industrial societies.

Radcliff-Brown, A.R. (1930). "The Social Organization of Australian Tribes." *Oceania* 1: 44–46. The organization of earlier societies in terms of economy, religion, and polity.

Rheingold, Harold. (1993). *The Virtual Community: Homesteading on the Electronic Frontier*. Reading, MA: Addison-Wesley. Examines the social phenomena emerging from the early days of the Internet.

Rheingold, Harold. (2002). *Smart Mobs*. New York: Basic Books. Studies the impact of mobile communication technology and how people use it.

Ribeiro, Darcy. (1968). *The Civilization Process*. Washington, DC: Smithsonian Institution Press. Presents stages of change from earlier society to the present.

Rothman, Barbara. (1994). "Artificial Means of Production and Our Understanding of the Family." In *Contemporary Issues in Bioethics*, ed. Tom Beauchamp and LeRoy Walters. Belmont, CA: Wadsworth. How technology has changed the reproductive system.

Slouka, Mark. (1995). *War of the Worlds: Cyberspace and the High Tech Assault on Reality*. New York: Basic Books.

Stoll, Clifford. (1995). *Silicon Snake Oil: Second Thoughts on the Information Highway*. New York: Doubleday

Turkle, Sherry. (1995). *Life on the Screen: Identity in the Age of the Internet*. New York: Simon & Schuster.

Weiss, R. (2000). "Limited Pay for Egg Donors Advised." *Washington Post*, August 4.

FASCISM

Fascism played a major role in twentieth-century European and world history, especially in its attempt to develop a particular nonliberal and nonhumanistic modern perspective on science and technology. Fascism, in power, was a form of rule where key societal resources were monopolized by the state in an effort to penetrate and control many aspects of public and private life, through the state's use of propaganda, terror, and technology.

Fascism also remains a highly complex and illusive political phenomenon. Classical fascism (the small *f* for comparative purposes) can be described in terms of a number of loosely-related early-twentieth-century political parties, movements, and regimes, especially in Germany (Adolph Hitler's National Socialism), Italy (Benito Mussolini's *Fascism* proper, from which the generic term fascism is derived), and Spain (Francisco Franco's more radical wing of Falangism).

All fascisms oppose communism, the values of liberal democracy, rationalism, and scientific positivism, with assertions of bellicose nationalism, and each variety of fascism has sought in its own manner and cultural context to adopt advanced military, penal (including in the Nazi variant genocidal), and communication (propaganda) technologies, while criticizing the universalism and humanism of liberal science and technology. Some suggest that a *palingenetic* and inherently revolutionary mythology of rebirth ultimately binds all authentic forms of generic fascism together and separates them from authoritarian and reactionary military dictatorships, and totalitarian regimes such as that of Stalin (Griffin 1993).

In spite of fascisms' ritualistic invocation of an idealized past—the Nazi Aryan myth; the Italian myth of Rome, the preoccupation with the glorious age of Elizabeth I among interwar British fascists—fascism actually emerged from a background steeped in pseudoscience and social Darwinism, and the high-tech myths of futurism, and as such can be seen as an authentically *modern* movement, especially in terms of its attitudes toward, and application of, science and technology.

Fascism has also persisted since the collapse and defeat of the Mussolini and Hitler regimes, in various manifestations of *neo-* or *post-* fascism, operating as a sometimes influential, but often marginalized, opposition movement within liberal democracy. Latter day fascists often deny their fascist roots, or operate clandestinely, because of the negative and reviled nature of fascism because of its well known and understood connection with the systematic process of Nazi war and genocide. Others have been partially absorbed into liberal democracy and deradiclalized.

Fascism in Italy (1922–1943)

In 1932 the fascist dictator Mussolini, with the considerable help of the neo-Hegelian philosopher Giovanni Gentile (1875–1944), contributed an entry to the *Encyclopedia Italiana* on the definition of fascism. Italian conceptions of the work of Georg Hegel derived largely from Benedetto Croce (1866–1952), a philosopher of international repute. Mussolini asked Croce to write this doctrine of fascism for him, but Croce refused. But in Gentile's writings, Mussolini discovered a serviceable philosophical peg of neo-Hegelian idealism on which to hang his brutal, vitalistic doctrines.

The famous entry contains elements of Gentile's personal criticisms of liberal and post-enlightenment science and technology, depicting the state as the source of all ethics, individual as well as collective. A key passage reads:

> The State, as conceived and realized by Fascism, is a spiritual and ethical entity. . . . which in its origin and growth is a manifestation of the spirit. The State . . . safeguards and transmits the spirit of the people, elaborated down the ages in its language, its customs, its faith. The State is not only the present; it is also the past and above all the future. . . . the State stands for the immanent conscience of the nation. The forms in which it finds expression change, but the need for it remains. . . . it transmits to future generations the conquests of the mind in the fields of science, art, law, human solidarity; it leads men up from primitive tribal life to that highest manifestation of human power, imperial rule. . . . Whenever respect for the State declines and the disintegrating and centrifugal tendencies of individuals and groups prevail, nations are headed for decay. (Mussolini 1932, p.26)

Aside from this perverted Hegelian notion that the state equals life itself, the entry usefully emphasizes other core themes of Italian Fascism: a firm belief in the concrete reality of life, anti-individualism, antiliberalism and liberal democratic sentiments, antisocialism, the call for *action* and revolution, a denial that happiness is achieved through comfort and *well-being,* the belief that fascism is ultimately a *spiritual force,* and the idea that fascist ideology was a far stronger ethical basis for existence than any mere rule of law (on this last point see the writings of Carl Schmitt).

A major strand of Italian fascist technologism emerged from the prewar futurist movement in art, founded in 1909 by the poet Filippo Marinetti. Futurism arose as part of the general modernist artistic ferment that characterized the intellectual life of Europe, and particularly France and Italy, in the period before 1914. The futurists' goal was to celebrate modern technology and to free Italian art from the psychology of the past. In 1910 Umberto Boccioni published the *Manifesto of the Futurist Painters*. The cult of the machine age was central to futurism and from the beginning futurist ideology was saturated with violence and aggression. The infatuation with speed, change, and modernity soon became intertwined with ultranationalism and in 1915 Marinetti published *War—the Sole Hygiene of the World,* placing science and technology at the service of war and brutal imperialism. What had started as the rejection of stagnation in art became an all-encompassing, authoritarian political message, in which all *decadent* (code for liberal and leftist) manifestations of the old Italy were to be overthrown. Under Mussolini's regime, futurism lost its radical edge and was largely confined to producing extravagant plans for buildings in the futurist style, very few of which were actually built.

But the tenor and relentless propaganda of the regime remained focused on placing the latest science, technology, and management techniques at the disposal of the Italian people—hence grand public buildings such as the Milan and Florence railway stations, the Autostrada, and electrification of the main railways network. There was also a ceaseless drive to embrace the dynamism of the second industrial revolution embodied in the Fascists' Third Rome, the exploitation of hydroelectric power, the propaganda surrounding the launch of any new Fiat vehicle, and Italo Balbo's daring flying antics in the United States. Fascist propagandists also strove tirelessly to emphasize the link between technology, science, modernization, and the regime. In addition, attempts were made to create new institutions for managing the modernization process, institutions of an authoritarian, technocratic character such as the Confederazione Generale dell'Industria Italiana and the Gruppi di Competenza. In addition, genuinely innovative institutions were created to manage the modernization process: Confederazione Generale dell'Industria Italiana, Gruppi di Competenza, Consigli Tecnici, and Istituto per la Ricostruzione Industriale. The highly technocratic Guiseppi Bottai, Minister of Corporations and also editor of *Critica Fascista,* used every opportunity to emphasize the technocratic and scientific core of the "New Italy" and its third way "Corporate State"—a process that rapidly ran out of steam when he ceased to be Minister in 1932. (For the best account of fascist modernism, see Griffin 1994.)

Germany (1933–1945)

Fascism in Germany was, in almost every aspect, the most radical and extreme manifestation of fascist ideology, putting science and technology to the most unethical of uses, including mass genocide achieved through Ford-style, efficient factory methods The German regime eventually waged a brutal, and for the period, high-tech war through the development of weapons of mass destruction and rocket-propelled delivery systems. From the road construction of the Todt Organization to the development of the V3 rocket bomb, there is no

Benito Mussolini addressing troops. The Fascist dictator was head of the Italian government from 1922 to 1943 and led Italy into three successive wars, the last of which overturned his regime. *(© Bettmann/Corbis.)*

question that Nazi Germany promoted a culture of advanced technology (Griffin 1994). As Roger Griffin cogently puts it, "the Third Reich was saturated with technocratic values.... The V3 rocket bomb could hardly have been developed by an anti-technological culture" (Griffin 1994, p.10).

Part of the reason for this was that Nazism emerged from a cultural climate imbued with the idea that the West was degenerating, a fear dating back to Edward Gibbon's *Decline and Fall of the Roman Empire* (1776–1787), and an associated sense of the urgency of the task of regeneration and rebirth. The rise of Nazism also coincided with the period of the most influential writings of Martin Heidegger (1889–1976) and Schmitt (1888–1985). Heidegger favored a form of antimodern rule that would restore *Being* to its proper role in Western affairs. Mistaking the Nazis as the political basis for a rebirth of technology and humanity, he threw in his lot with Hitler's regime, and never repudiated Nazism, continuing to speak of its *inner truth and greatness*.

It was Friedrich Nietzsche who famously fathered a distinctly Germanic critique of decadent European society. He affirmed that a regenerative instinct for the *Will to Power* realized through the *blond beast* could destroy weak institutions and beliefs, blazing a trail for *the vital, the powerful, and the creative*. German interwar thinkers and public intellectuals adopted Nietzsche's Zarathustra in a bastardized and popularized form, as a symbol for a rejuvenating *Kultur* capable of overcoming the effects of decadent commercial and wasteful technological civilization. Nietzsche's writings influenced many of the leading German cultural pessimists, especially Ernst Junger (1895–1998) and Oswald Spengler (1880–1936) who, in turn, influenced Heidegger.

As Michael Zimmerman has argued, "Jünger claimed that the soft, decadent, and unmanly European bourgeoisie was being displaced by *der Arbeiter* (the Worker), a new type of humanity combining the steely hardness of modern technology with the iron will of a proto-Nietzschean blond beast. Jünger foresaw a powerful new upsurge of Will in the face of Western decrepitude" (p. 14). Adopting Junger's rhetoric of struggle and hardness, Heidegger appeared to the less sophisticated minds to be exhorting all Germans to submit to a technological Will to Power in order to overcome decline and despair (*uberwinden*).

But in fact he criticized the technological Will to Power and argued for its transcendence through Volk politics and *Gelassenheit* (detachment)—a highly misplaced hope in the case of the Nazis. Heidegger's ontological language was pitched at such a high level of linguistic and philosophical abstraction that it was impenetrable to most intellectuals, and his solution was an equally obscure and backward-looking spiritual renewal far too abstract for his Nazi masters to grasp. He was naturally predisposed toward Nazi ultranationalism through the special destiny he assigned to the German people because of their language, which he saw as the natural heir to classical Greek—a pure philosophical language, a quality that had disappeared from all other Western European languages. In addition, Heidegger's key concept of *Dasein* (a combination of the words *being* [*sein*] and *here* [*da*]) was based on the belief that the real is also rational, and, after 1933, the here was nazism and the obvious concrete power of National Socialism was, for him, an *uncovering* of authentic Being.

Heidegger's initial enthusiasm for nazism was soon reduced by the complete lack of interest the Nazis showed in his philosophy. As rector of Freiburg University in 1933, Heidegger delivered a famous address in which he announced that he had the correct philosophical understanding of National Socialism, but the Nazis did not understand him. His exclusive form of philosophical National Socialism was not based on any concept of race or imperial conquest and was, therefore, completely irrelevant to his political bosses.

Schmitt, a pupil of Max Weber, was a leading German thinker on constitutional law who wrote several seminal studies during the Weimar period and became known as *the enemy of liberalism*. Like Heidegger he entered the Nazi university establishment after 1933. Schmitt rejected *cosmopolitan* ideals and the intrinsic goodness of humankind and argued that the law was ultimately subservient to politics. Liberalism, meanwhile, offered a false universalism, which obscured the existentially paramount nature of politics and replaced it with the struggle for abstract notions of *rights*. Political *reality* ultimately transcended all legal norms for Schmitt, who supported the existential over the theoretical. Thus war lacks any normative justification, its reason lying not in ideals of justice, democracy, or economic prosperity, but in preserving the very existence of the sovereign and sacred polity when it is threatened—in this case a Germany threatened by decadent liberals, Jews, and communists.

Despite his openly Nazi ideals, Schmitt's work proved influential on later authoritarian conservatism outside Germany; Raymond Aron referred to him as a great social philosopher in the tradition of Weber. His writings continue to influence the left, as demonstrated by the content of the journal *Telos*, and to fascinate poststructuralists, including Chantal Mouffe (1999) and Jacques Derrida.

Spanish Falangists (1936–1975)

The Falange was a quasi-fascist political organization, which constituted the single official party in Spain between 1939 and 1975, making it the longest-lasting fascist-style regime. This minor party was founded in 1933 by Jose Antonio Primo de Rivera, and, with other parties, became the Spanish Phalanx of the Assemblies of National-Unionist Offensive.

During the Spanish Civil War, the Falangists fought on the *nationalist* side against the left-led Republicans. When Franco seized personal power, he united the Falange with the Carlist monarchists, forming the Movimiento Nacional—thus purging the Falange of its more radical and modernizing fascistic elements. After the war, moderate Falangist ministers had an important role in Francoism, but Franco turned increasingly to younger politicians thus allowing Spain be dominated by the technocratic wing of Falangism, whose policies arguably promoted a return to democracy.

Non-European Fascisms

Minor potential examples of generic fascism and neofascism have existed elsewhere in Europe and around the world both before and since 1945. But the only other continent that has witnessed significant concentrations of quasi-fascist parties, movement, and regimes is Latin America, principally Paraguay, Argentina, and Chile.

Between 1954 and 1989, Alfredo Stroessner's authoritarian Colorado Party made Paraguay a safe haven for Nazi war criminals such as Josef Mengele. However the most significant neofascist regime existed in Argentina under Juan Perón (president from

1946–1955 and 1973–1974) who fostered a powerful populist, authoritarian personality cult initially with the assistance of his beautiful but ill-fated wife Eva.

Islamic Fascism

Some claim that Islamic Fascism exists and is also a phenomenon of modernism (see Wistrich 2001). In this thesis it is basically a twentieth-century totalitarian movement—like fascism and communism. Islam existed before Islamic Fascism, and will exist after it.

Islamic Fascism is designed—like fascism and communism—to appeal to idealistic young people with a utopian future where the world will be *cleansed*. It really started with the Iranian revolution in 1979, and was formerly called *Islamic fundamentalism*. Other names for it include *Islamofascism* or *Islamism*. And—like fascism and communism—its only solution, according to its adherents, is the total and utter destruction of western liberal and Christian culture and philosophy. This may, of course, require a long cold war, lasting for perhaps the next two or three decades, punctuated by perhaps one or two more hot wars, but Islam will prevail.

Broader Issues for Science, Technology, and Ethics

Among other things, the rapid rise of fascism illustrates the severe problem of cultural disorder created by radical and rapid scientific and technological change in the early-twentieth century and the associated difficulty of moving from essentially premodern traditional societies to modern rationalistic, scientific, and technological societies with mass democratic systems.

By nature fascism is clearly opposed to those aspects of modernity linked with decadence, particularly cultural-pluralism, liberalism, and materialism. There are obvious examples of premodern thought within fascism—for instance the Blood and Soil movement, ideals in both Germany and Italy of regeneration of the peasantry and the restoration of the ancient bond between Germans and Italians and the land. Yet fascism is by no means entirely antimodern, as Gentile suggested:

> . . . as a descendant of early twentieth-century modernist nationalism, fascism does not identify with anti-modernism, but in its own way . . . it had a certain passion for modernity not inconsistent with its harking back to the traditions of the past . . . The fascists saw themselves as the modern "Romans" . . . compatible with the myth of the future and with fascism's ambition of revising modernity in order to leave its mark on the new civilization in the age of the masses. (Gentile 1993, p. 24–25)

At one level fascism clearly represented a rejection of liberal scientific positivism. But equally, as Roger Griffin (1994) argues, it contained a readiness to employ the latest scientific and technological techniques to destroy liberalism and communism and achieve its irrationalist and dystopian ends.

Many varieties of fascism also tried to replace orthodox religion with a perverted secularized and spiritualized modernism, based in part on developing and deploying the dazzling potential gains of modern science and technology and offering the chimera of an economics of plenty—a technological heaven on earth. Indeed Gentile has depicted Italian Fascism as the first and most highly developed form of modern mass political religion—offering a new ideology to fill the void left by the decline of traditional religion in Italy. Earlier cults and myths of Italian ultranationalism forged the basis of a civic religion that was then colonized and adapted by the Fascist party. As such, Italian Fascism was a vital catalyst for contemporary Italian mass politics (Gentile 1996).

Fascism clearly demonstrates the considerable negative as well as liberating functions of modern science and technology, with the state entirely taking over its promotion, direction, and end use for the deeply unethical purposes of brutal imperialist wars and, in the case of Nazi Germany, systematic mass genocide. It is, perhaps, useful to speculate on what latter-day Nazis would do with current cloning techniques and biotechnology, or with the latest weapons of mass destruction—chemical, biological and nuclear based. And with regard to the miracles of modern mass communications: the frightening image of tall men in stylish black Nazi uniforms waiting at Heathrow, or JFK, talking animatedly into their exclusive SS-issue mobile phones and opening their sleek black SS laptops in a wireless-zone, to contact the web and read their encrypted emails, comes all too readily to mind.

DAVID BAKER

SEE ALSO *Arendt, Hannah; Authoritarianism; Critical Social Theory; Socialism; Totalitarianism.*

BIBLIOGRAPHY

De Grand, Alexander. (1995). *Fascist Italy and Nazi Germany: The Fascist Style of Rule.* Cambridge, UK: Cambridge University Press.

Eatwell, Roger. (1992). "Towards a New Model of Generic Fascism." *Journal of Theoretical Politics* 4(2): 161–194.

Eatwell, Roger. (1996). "On Defining the Fascist Minimum: The Centrality of Ideology." *Journal of Political Ideologies* 1(3): 303–319.

Gentile, Emilio. (1993). "Impending Modernity: Fascism and the Ambivalent Image of the United States. *Journal of Contemporary History* 28(1): 7–29.

Gentile, Emilio. (1996). *The Sacralization of Politics in Fascist Italy*. Cambridge, MA: Harvard University Press.

Griffin, Roger. (1993). *The Nature of Fascism*. London: Routledge.

Griffin, Roger. (1994). *Modernity under the New Order: The Fascist Project for Managing the Future*. Oxford: Thamesman Publications. Part of the series *Modernity and Postmodernity: Mapping the Terrain*.

Griffin, Roger. (2002). "The Primacy of Culture: The Current Growth (or Manufacture) of Consensus within Fascist Studies." *Journal of Contemporary History* vol. 37(1): 21–43.

Herf, Jeffrey. (1984). *Reactionary Modernism: Technology, Culture, and Politics in Weimar and the Third Reich*. Cambridge, UK: Cambridge University Press.

Heidegger, Martin. (1977). "Only a God Can Save Us Now," trans. D. Schendler. *Graduate Faculty Philosophy Journal* 6(1): 5–27. Interview originally published in *Der Spiegel*.

Heidegger, Martin. (1985). "The Self-Assertion of the German University," trans. Karsten Harries. *Review of Metaphysics* 38(March): 470–480.

Kershaw, Ian. (2004). "Hitler and the Uniqueness of Nazism." *Journal of Contemporary History* 39(2): 239–254.

Laqueur, Walter. (1996). *Fascism: Past, Present, and Future*. New York: Oxford University Press.

Linz, Juan J. (2000).*Totalitarian and Authoritarian Regimes*. Boulder, CO: Lynne Rienner.

Mosse, George L. (1979). "Towards a General Theory of Fascism." In *Interpretations of Fascism*, ed. George L. Mosse. London: Sage.

Mosse, George L. (1999). *The Fascist Revolution: Toward a General Theory of Fascism*. New York: H. Fertig.

Mouffe, Chantal, ed. (1999). *The Challenge of Carl Schmitt*. London: Verso.

Payne, Stanley G. (1980). *Fascism: Comparison and Definition*. Madison: University of Wisconsin Press.

Payne, Stanley G. (1995). *A History of Fascism, 1914–1945*. Madison: University of Wisconsin Press.

Paxton, Robert. (1998). "Five Faces of Fascism." *Journal of Modern History* 70(1): 1–23.

Prowe, Diethelm. (1994). "Classic Fascism and the New Radical Right in Western Europe: Comparisons and Contrasts." *Contemporary European History* 3(3): 289–313.

Renneberg, Monika, and Mark Walker, eds. (1994). *Science, Technology, and National Socialism*. Cambridge, UK: Cambridge University Press.

Zimmerman, Michael E. (2001). "The Ontological Decline of the West" In *A Companion to Heidegger's ''Introduction to Metaphysics,''* ed. R. Polt and G. Fried. New Haven: Yale University Press.

INTERNET RESOURCES

Mussolini, Benito. (1932). "The Doctrine of Fascism." Complete text available from http://www.worldfuturefund.org/wffmaster/Reading/Germany/mussolini.htm.

Wistrich, Robert S. (2001). "The New Islamic Fascism." Israel Science and Technology Homepage. Available from http://www.science.co.il/Arab-Israeli-conflict/Articles/Wistrich-2001-11-16.asp.

FAUST

The story of Faust has been widely used in literature and popular discussions to reflect on the ethics of science and technology. The Faust myth first appeared in 1587 when it was published by an unknown German Protestant in a popular chapbook. In 1592, the book was translated into English under the title *The Historie of the Damnable Life and Deserved Death of Doctor John Faustus*. There have been several famous interpretations of the myth since the original publication, including works by Christopher Marlowe (1564–1593), Gotthold Ephraim Lessing (1729–1781), Johann Wolfgang von Goethe (1749–1832), and Thomas Mann (1875–1955). All of the interpretations are united by the central theme of one man's insatiable quest for knowledge and its implications for his world and his own soul.

Historical Roots

Dr. Johann Georg Faust (c. 1480–1540) is the historic figure on which the myth has been built. An astrologer and alchemist, Dr. Faust was born in Knittlingen, Württemberg (southwest Germany); studied at Wittenberg, Erfurt, and Ingolstadt universities; and later became a lecturer. Often accused of practicing black magic, Dr. Faust was repeatedly banished from villages. An elusive and mysterious figure, he reportedly admitted of pledging himself to the devil with his own blood. Dr. Faust was put to death in Staufen, Breisgau.

The original German publication was titled *Historia von D. Johann Fausten dem weitbeschreyten Zauberer und Schwartzkünstler* (History of Dr. Johan Faust, the notorious black-magician and necromancer). In this book, details of Faust's life are connected with speculative ideas about black magic and pacts with the devil. The first part of the book describes Faust's childhood and his studies in Wittenberg, which ends in a pact with the devil, because he wanted "*alle Gründ am Himmel und Erden erforschen*" (to probe all causes in heaven and on earth) and "*die Elementa speculieren*" (to speculate on the elements). This cannot be achieved through mere scholarship, but only with the aid of demonic powers. The second part describes Faust's travels—thanks to the power of the devil—through Earth, Heaven, and Hell. It also relates how he finally beholds paradise. The third part is composed of various tales, magic, and conjuring tricks. In the last part, an old man tries in vain to convert Faust's soul, but Faust renews his pact with the devil. In front of his students, Faust conjures Helena, the beautiful daughter of Zeus. He marries her, and they have a son, Faustus Justus. The book concludes with Faust's agonizing death and his descent into Hell in accordance with the rules of his satanic pact. Helena and their son disappear after his death.

This original tale is a moral and theological warning to live a God-fearing, modest life. Importantly, Faust's pact with the devil was not made out of a desire for material wealth, as was the case in most of the similar myths from that time, but rather from a desire for knowledge. Faust thus personifies the scientific, inquisitive intellect that is opposed to both the Catholic tradition founded upon papal authority and the humility and consciousness of sin found in the followers of Martin Luther (1483–1546).

From Marlow to Goethe

Marlowe was captivated by the English translation of Faust's story and used it as the basis for his play, *The Tragical History of Doctor Faustus*. Two versions of his play exist, one dated to 1604 and the other to 1616. It is believed to be the first dramatic interpretation of the Faust tale, and it follows the original story closely in terms of the proportions of comedy and tragedy. Marlowe's Faust is a complex character and a renaissance person who is driven by an overwhelming intellectual curiosity. Always striving for power and seeking beauty, Faust signs a pact with Mephistopheles (the devil) because the sciences of his time could bring him neither godlike knowledge nor superhuman talents and power. The punishment for this hubristic bargain is eternal damnation.

Marlowe's play became one of the most successful dramas of the Elizabethan epoch. An adaptation for the puppet theater was brought to Germany by traveling artists and became an indirect inspiration for Goethe's drama *Faust*, because he watched the puppet play as a boy. A German translation of Marlowe's drama was published in Germany at the beginning of the nineteenth century. Upon reading it, Goethe reportedly remarked, "How greatly it is all planned!"

Goethe's *Faust* is possibly the most important drama in the German language, and many quotes have been adapted into colloquial usage and proverbial sayings. Goethe's tragedy has two parts, the first was published in 1808 and the second in 1832. Goethe's Faust character is distinguished from earlier variants by his rich inner complexity. The drama raises questions across the spectrum of human knowledge from philosophy and theology to anthropology and history to ethics and aesthetics.

The play opens with a wager between God and Mephistopheles. God gives permission to the devil to lure the soul of Faust, a scholar and alchemist, and maintains that Faust would be saved despite his reliance on reason and sorcery rather than faith. Later, Faust complains that "*Wir nichts wissen können!*" (we cannot know anything!). All science stays in the dark, because it lacks a secure and certain foundation. This is why Faust devotes himself to magic: "*Daß ich erkenne was die Welt / Im Innersten zusammenhält*" (That I may know what the world / holds at its very core.)

Faust is not interested merely in power, pleasure, and knowledge, but longs to take part in the divine secrets of life. He conjures up an Earth-Spirit, but it refuses to help him slake his insatiable thirst for knowledge. Faust becomes depressed and wants to kill himself. But it is Easter and the church bells tell of the resurrection. He is overcome by childhood memories: "*Die Botschaft hör' ich wohl, / allein mir fehlt der Glaube*" (I hear the message clearly, / but I alone lack the faith). He does not commit suicide, but his inner tensions heighten. He is both sick of life and unbearably hungry to know and experience its deepest offerings. He hunts ravenously for knowledge but he also yearns to satisfy his bodily desires for action. In this situation, Mephistopheles makes an appearance and offers to fulfill Faust's every desire—for the price of his soul.

In both parts of the drama, innocent people become victims of Faust's pact with the devil. In the first part, the victims are the girl Margarete (nicknamed Gretchen), her mother, and her brother. With the help of Mephistopheles, Faust seduces Margarete, but the narcotic he gives to her mother has a lethal effect. Margarete's brother attempts to take revenge for his mother and the lost honor of his sister in a duel with Faust, but he falls by Mephistopheles's intervention. Gretchen gives birth to Faust's child, kills it, and ends up in jail.

In the second part, Faust's megalomaniac enterprise demands human sacrifices. He wishes to wrest land from the sea in Greece, so he begins the engineering construction on a system of dykes—thus becoming an archetype not just of one pursuing scientific knowledge, but also of someone intent on technological power. The henchmen of Mephistopheles burn down the home of an old couple who had cared for him as a young man, which was the only thing that the enormously wealthy yet discontented Faust did not own. The fire kills the old couple. Faust as an engineer does not foresee the unintentional consequences of his work but finally accepts them approvingly.

Goethe's *Faust* is a tale of reckless striving for boundless love, knowledge, and power. In the end, this culminates in the blind and maniacal pursuit of an engineering project that breeds outrage, destruction, and doom. Nonetheless, Faust's soul ascends to heaven with the angels singing: "Whoever strives in ceaseless toil / Him we may grant redemption." And it seems that the moral is that as long as we struggle toward greatness, God will grant salvation, even if we stray into excesses and sin.

ADAM BRIGGLE
VOLKER FRIEDRICH

SEE ALSO *Frankenstein; Playng God; Prometheus; Science, Technology, and Literature.*

BIBLIOGRAPHY

Anonymous. (1587). *Historia von D. Johann Fausten: dem weitbeschreyten Zauberer unnd Schwartzkünstler*. Frankfurt am Main.

FEDERAL AVIATION ADMINISTRATION

SEE *Aviation Regulatory Agencies.*

FEDERATION OF AMERICAN SCIENTISTS

Founded in 1945 by scientists involved in the Manhattan Project to create the atom bomb, the Federation of American Scientists (FAS) is a nonprofit organization of more than 2,000 scientists, engineers, and other citizens dedicated to the responsible use of science and technology. Originally known as the Federation of Atomic Scientists, FAS continues to focus much of its efforts on nuclear arms control and security, but it also addresses issues involving information technologies, science policy, and the environment. To achieve its goals of informed debate and the application of science and engineering to national problems, FAS utilizes several strategies including research, advocacy, outreach, and grassroots organizing.

Membership and Finances

The composition of FAS, originally dominated by physicists, has slowly diversified. A 2002 in-house survey found that nearly thirty percent of the respondents identified themselves as physicists. The next largest fields represented were medicine (18%), biology (15%), engineering (15%), and chemistry (13%). Members receive *Secrecy News*, an informal electronic publication on government secrecy, security, and intelligence policies.

The FAS budget for fiscal year 2004 was $3 million, 70 percent of which directly funded projects, while the remaining 30 percent covered overhead expenses. Approximately two-thirds of the budget was derived from private foundation contributions and one-third from government grants. Membership dues in 2004 amounted to $125,000.

Origins and History

After World War II a minority of U.S. scientists (roughly 3,000) formed the loose "scientists' movement" that sought not just to create new technologies that had an impact on social and political change, but "tried to direct that change toward a particular end" (Smith 1965, p. 528). FAS was the most important element of this movement in the early post-war years. Roughly ninety percent of the Manhattan Project scientists supported the FAS mission. Ernest O. Lawrence, however, discouraged participation by scientists in organizations devoted to non-scientific ends. FAS, originally dubbed the "scientists lobby," emerged in the same spirit as the *Bulletin of the Atomic Scientists* (also founded in 1945 by members of the Manhattan Project) and the 1955 Russell-Einstein Manifesto, which led to the first Pugwash Conference on Science in World Affairs. In all these cases, scientists gathered to appraise the perils of science and technology, prevent their misuse, and advance solutions in the name of peace and prosperity.

Three topics dominated the early FAS agenda: the need for domestic and international control of atomic energy, the need to educate the public on the promises and perils of atomic energy, and the harmful effects of secrecy on international trust and scientific growth. One of the biggest battles waged by the early FAS members and other concerned scientists was over civilian versus military control of nuclear energy. Many scientists distrusted the military, and envisioned limitless, clean energy if only the proper civilian controls could be established.

FAS did play at least a minor role in the international monitoring and control of atomic energy and weapons. Although it is difficult to assess FAS impact on the process, the formation of the U.S. Atomic Energy Commission in 1946, a civilian entity that regulated nuclear energy and controlled national research, was a major success in the battle for civilian control of atomic energy (Hewlett and Anderson 1972). In general, however, FAS members always faced limits on what their technical data and scientific knowledge could contribute to international and domestic nuclear politics.

A period of disenchantment and diminished influence ensued after the early post-war years. Members defended the integrity of science and civil liberties of scientists vigorously, while their demands for a positive role in policy making waned. Although not a member of FAS, the judgment of J. Robert Oppenheimer as a security risk in 1953 further weakened the political clout of scientists by attacking their image of trustworthiness and independence. After the McCarthy era, members adopted more modest expectations about the contributions of scientists to public life. The increased incorporation of scientists into government also forced FAS to adjust its role.

By 1969, FAS had reached its lowest ebb, with an annual budget of roughly $7,000 and a mostly volunteer staff. The greatly defunct organization was rejuvenated with the appointment of Jeremy J. Stone as president in 1970. For the next five years, FAS was heavily influenced by Stone, because he was the only staff member. He began revitalizing and promoting FAS with his monthly newsletters. Membership grew rapidly over the next two decades (including a 450 percent increase between 1970 and 1974) and by the 1990s FAS was able to support a staff of roughly a dozen (Stone 1999). From its inception, FAS had been composed of local associations or chapters, which occasionally met but primarily worked independently of one another. In the 1950s, there were approximately thirty chapters, but by 1970 only two remained—one of which, the Boston chapter, called itself the Union of Concerned Scientists (Stone 1999). Stone disbanded the chapter system in 1970 and the two remaining chapters became independent organizations. In 1974, FAS established a permanent headquarters in Washington, DC, something it had not had since the late 1940s.

By the mid 1980s, FAS relied more heavily on journalists, professional staff, and policy analysts than famous scientists. FAS has maintained a sizable influence despite the increasingly crowded security-oriented public interest community and science lobby movement. Its mission has also steadily expanded to include other areas of science and technology. In 2000 Henry Kelly became the new president and further bolstered FAS under the overarching goals of strengthening science in policy and using science to benefit society.

Assessment

In its early years (1945–1948), FAS played an important role in efforts to maintain civilian control of atomic energy. Alice Kimball Smith (1965) argues that "By guarding the rights of a particular profession in a dangerous period in the 1950s the FAS contributed to the general cause of civil liberties" (p. 531). It has also served as an effective watchdog over the relations of science and public policy. This has afforded some protection for scientists and science against attacks and, by providing a forum for self-criticism, has prevented scientists from being dangerously seduced by their own successes (Smith 1965). Its website is a comprehensive source of information pertaining to global military technologies, intelligence, terrorism, and other areas of science and society. It is a valuable educational and research tool that enhances military and government transparency.

FAS publishes an "Occasional Paper Series" to inform and stimulate debate on current science and security policy issues. The second paper in the series (Kelly et al. 2004) takes up the state of science policy advice in the United States, and argues that the infrastructure for providing science and technology advice to Congress and the President is in a state of crisis. It asserts that sound policy needs sound science advice. However, this claim raises the question of where scientists stop acting as advisers (that is, providing balanced, "objective" information) and start acting as advocates (promoting a course of action that serve the scientific community but may not align with common interests).

Since its inception, this has been the central question about FAS and other professional science and engineering organizations concerned to play an active role in shaping how science is used in politics and how policies affect the practice of science. Should scientists have a privileged voice in public decision making? What is their proper role in the value-laden, political questions raised by science and technology? These are the more subtle questions about the dual role of scientist and citizen underlying the FAS mission to focus the energies of scientists and engineers on issues of critical national importance.

ADAM BRIGGLE

SEE ALSO *American Association for the Advancement of Science; Nongovernmental Organizations; Pugwash Conferences; Union of Concerned Scientists.*

BIBLIOGRAPHY

Hewlett, Richard G., and Oscar E. Anderson. (1972). *A History of the United States Atomic Energy Commission*. Vol. 1: *The New World, 1939/1946*. University Park: Pennsylvania State University Press.

Smith, Alice Kimball. (1965). *A Peril and a Hope: The Scientists' Movement in America: 1945–47*. Chicago: The University of Chicago Press. Chronicles in detail the early years of scientists' efforts to affect public policies regarding atomic energy and weapons. Provides an extensive early history of FAS as part of the overall tension between science and government bureaucracy.

Stone, Jeremy, J. (1999). *Every Man Should Try: Adventures of a Public Interest Activist*. New York: Public Affairs. An autobiography that contains information on the rejuvenation of FAS beginning in 1970.

INTERNET RESOURCE

Kelly, Henry; Ivan Oelrich; Steven Aftergood; and Benn H. Tannenbaum. (2004). *Flying Blind: The Rise, Fall, and Possible Resurrection of Science Policy Advice in the United States*. Federation of American Scientists Occasional Paper Two, December. Available from http://www.fas.org/main/content.jsp?formAction=297&contentId=346.

FEMINIST ETHICS

Feminist ethics has developed in response to feminist attention to androcentric and sexist limitations of traditional Western ethics.

Broadly speaking, the perspectives advanced by feminist ethics may have implications for the understanding of professional ethics in science and engineering, and in such science and technology related areas of applied ethics as biomedical, environmental, or computer ethics. In the sciences and technologies themselves, feminist ethics may have more direct impact on the theoretical structures of some disciplines (such as anthropology and psychology) than others (such as physics and chemistry).

Feminist critiques have focused on three interrelated concerns. First, that women's moral capacities frequently have been seen as less developed than those of men. Second, that accounts of moral capacities have privileged traits historically identified as masculine, such as reason, autonomy, and independence, over traits identified as feminine, such as caring, community, and interconnection, and that moral theories have similarly emphasized reason, principles, and impartiality over emotion, situatedness, and relationships—again reinforcing the primacy of the culturally masculine. Third, that the majority of moral theorizing has focused on the public realm, with primary attention to men's interests, and has neglected moral concerns arising in the private realm, as well as often overlooking women's rights and interests in the public realm.

The Virtues of Women

Attending to the gendering of ethics has a long history. The tenet that women's virtues differed from those of men was canonized in Aristotelian philosophy. Based on the commonly held belief in women's relative physical weakness and rational inadequacies in comparison to men, Aristotle (384–322 B.C.E.) argued in *The Nichomachean Ethics* that the virtues of women would be different than those of free men. Whereas free men were charged with developing such virtues as courage, temperance, honesty, and justice, women's virtues were viewed as those that would best suit their domestic role and rational capacities, namely, industry and self-command.

The question of women's specific virtues or moral abilities was an often-debated tenet in the history of philosophy. Whereas many non-feminist philosophers continued to insist upon women's inferior moral abilities, many philosophers whose works can be seen as concerned with women's rights questioned both the alleged difference in moral virtues and the imputed inferiority. Mary Wollstonecraft (1759–1797) and John Stuart Mill (1806–1873), for example, argued that there were no fundamental differences between women's and men's morality. But many others argued that although there was a difference in the virtues of women and men, this difference did not imply that women's moral capacities were inferior to those of men. A few such theorists, however, such as Elizabeth Cady Stanton (1815–1902) reversed the traditional position by arguing that women's morality was both different than and superior to that of men.

Few contemporary philosophers hold the type of gender essentialism that was historically the basis for viewing morality as gendered; however, an attention to gendered differences in moral reasoning and habits once again became popular with the work of psychologist Carol Gilligan. In her widely read *In a Different Voice: Psychological Theory and Women's Development* (1982), Gilligan critiqued the developmental psychologist Lawrence Kohlberg's widely-used model of moral development as privileging masculine approaches to moral reasoning, and, in particular, the privileging of universal principles such as justice, and ignoring more typically feminine concerns with relationships, caring, and responsibilities that are richly situated and not amenable to formulation through universal rules. Gilligan argued that the empirical finding that women typically did not develop to the higher stages of Kohlberg's scale of moral development (often only achieving the third stage of his six-stage process, whereas men often reached stages four and five) was a reflection not of women's moral inadequacy but of a biased methodology.

Some have interpreted Gilligan's work as supporting the view that women's morality is different in kind than that of men, but the most significant impact of her work has been to turn scholarly attention to an analysis of moral frameworks that include attention to care, community, and relationships: analyses previously inhibited by accounts of moral capacities that privileged traits historically identified as masculine.

An Ethics of Care

Gilligan's emphasis on an ethics rooted in relationships was the catalyst for a profound rethinking of ethics within feminist philosophy. The ethics of care is seen by many as either an alternative to or a complement to principle-based universalistic ethical theories. Unlike universal rules, which require that behavior be impartial and the same for everyone in like circumstances, an ethics of care is a richly situated ethics that sees each caring relationship as unique. Rather than the rational and emotional detachment predicated by deontological or utilitarian moral theories, care ethicists argue that ethical practice includes the emotions as well as reason.

A feminist ethics of care has been developed by a number of theorists, including Virginia Held, Eva Feder Kittay, Nel Noddings, Sara Ruddick, and Joan Tronto. Care ethicists do not all share the same definition of care, but there are areas of agreement among them. A caring relationship is seen as one in which an individual is both attentive to the specific needs and interests of another, as well as acts to advance them. Hence care involves both knowledge and motivation. It is also seen as an interactive relationship in which the one caring must be attentive to the responses of the one cared for, and modifies his or her efforts to care based on how the other responds to the caring actions. Care ethicists have noted that many human relationships are not between equals but rather between individuals in very different positions—parent/child, doctor/patient, teacher/student. Based on this, care ethicists have argued that moral theories would be best constructed not from contract models that often assume relatively equally positioned individuals, but rather from models that recognize the range of relationships possible between what Noddings calls the "one-caring" and the "cared-for" (1984).

One relationship feminist care ethicists often turn to is that of parenting and, more specifically, mothering. Ruddick focused on "maternal practice" as a form of thinking that although traditionally overlooked by moral theorists provides an excellent model of relationships that strive to foster the goals of preservation, growth, and social acceptability (1989). Ruddick argues that the virtue of "attentive love" involves both reason and emotion and is key to good maternal practice. Ruddick does not limit what she calls maternal practice to women or even to parents, but rather argues that maternal practice should extend to the public world and argues that the skills of maternal thinking will enable society to move towards a politics of peaceful cooperation.

Kittay extends such insights to consider the situation of long-term care, including care of those who are too young, or too ill or impaired to take care of themselves (1999). She argues for the need for what she calls a globally pertinent ethics of long-term care. Kittay, like other care theorists, argues that much of traditional ethical theorizing, as well as liberal political theory with its distinction between public and private, gains legitimacy only through a deep denial of the inevitability of human dependency. Society's conception of justice and much of social policy is structured around the myth of the able-bodied, independent individual. Acknowledging the centrality and ever-changing nature of dependency to human life then demands a reassessment of issues of equity and justice that takes both dependency and the complex natures of care relationships seriously.

Critics of feminist ethics of care worry that care relationships have been "gendered" feminine in such a way that the traits privileged in caring relationships are and will continue to be seen as less valued than the traits of independent agents, and will result in women continuing to be seen as "naturally" more fit for such labors and thereby trapped in low-paid service occupations. Clearly a transformation of ethics that takes seriously the centrality of relationships must go hand-in-hand with social reorganization that recognizes and supports the value of caring labor.

Attention to Women's Concerns

Held has argued that dominant moral theories and the specific issues that have been at the heart of contemporary western ethical analyses have privileged men's experiences and have focused far more on the public realm than the private. Through their attention to the concerns of women, feminist ethicists have introduced new issues to ethics and social theory such as affirmative action, sexual harassment, and comparable worth, and have brought new insights to more traditional issues—for example, discussions of reproductive rights and technologies, and the institutions of marriage, sexuality, and love, as well as caring labor.

Feminist philosophers have also argued that attention to gender cannot be done in isolation from other axes of oppression such as sexuality, race, ability, or class. The work of feminist philosophers such as Linda Martín Alcoff, Claudia Card, Nancy Fraser, Marilyn Frye, Sarah Lucia Hoagland, Eva Feder Kittay, María Lugones, Anita Silvers, Elizabeth Spelman, Iris Marion Young, and Naomi Zack reveal the importance of analyses that identify the structure and consequences of the interaction between different forms of discrimination or subordination.

Sensitivity to women's concerns has had special influence in science and engineering education, where women have historically been underrepresented. It has led to reforms in the educational practices and in the structures of professional practice. In the area of professional ethics, for instance, feminist ethicists have argued for more emphasis on trust behavior development over moral rule following and have emphasized care and communities over rights and individuals. In some special areas of applied ethics related to science and technology, feminist ethics has even produced distinctive perspectives—as in the contribution of ecofeminism to environmental ethics and cyberfeminism to computer ethics.

NANCY TUANA

SEE ALSO *Consequentialism; Deontology; Ethics of Care; Sex and Gender; Virtue Ethics.*

BIBLIOGRAPHY

Baier, Annette C. (1991). *A Progress of Sentiments: Reflections on Hume's Treatise*. Cambridge, MA: Harvard University Press.

Card, Claudia. (1995). *Lesbian Choices*. New York: Columbia University Press.

Fraser, Nancy. (1989). *Unruly Practices: Power, Discourse, and Gender in Contemporary Social Theory*. Minneapolis: University of Minnesota Press.

Frye, Marilyn. (1983). *The Politics of Reality: Essays in Feminist Theory*. Trumansburg, NY: Crossing Press.

Gilligan, Carol. (1982). *In a Different Voice: Psychological Theory and Women's Development*. Cambridge, MA: Harvard University Press.

Held, Virginia. (1993). *Feminist Morality: Transforming Culture, Society, and Politics*. Chicago: University of Chicago Press.

Hoagland, Sarah Lucia. (1988). *Lesbian Ethics: Toward New Value*. Palo Alto, CA: Institute of Lesbian Studies.

Kittay, Eva Feder. (1999). *Love's Labor: Essays on Women, Equality, and Dependency*. New York: Routledge.

Lugones, María. (2003). *Pilgrimages = Peregrinajes: Theorizing Coalition Against Multiple Oppressions*. Lanham, MD: Rowman and Littlefield.

Noddings, Nel. (1984). *Caring: A Feminine Approach to Ethics and Moral Education*. Berkeley: University of California Press.

Nussbaum, Martha C. (1999). *Sex and Social Justice*. New York: Oxford University Press.

Ruddick, Sara. (1989). *Maternal Thinking: Towards a Politics of Peace*. Boston: Beacon Press.

Tong, Rosemarie. (1993). *Feminine and Feminist Ethics*. Belmont, CA: Wadsworth.

Tronto, Joan C. (1993). *Moral Boundaries: A Political Argument for an Ethic of Care*. Routledge.

Young, Iris Marion. (1990). *Justice and the Politics of Difference*. Princeton, NJ: Princeton University Press.

FEMINIST PERSPECTIVES

The term *feminism* encompasses various social movements, from the late-nineteenth-century women's rights movement to the mid-twentieth-century women's movement in Europe and the United States, as well as referring to theories that identify and critique injustices against women such as Mary Wollstonecraft's *A Vindication of the Rights of Woman* (1792) or Harriet Taylor Mill's *Enfranchisement of Women* (1868). A core connotation of "feminism" is thus a commitment to revealing and eliminating sexist oppression.

In the early twenty-first century, the label "feminist ethics" is used to signify a method or focus of attention for ethical theory and practice. Many scholars have marked the genesis of contemporary feminist philosophy and ethics with Simone de Beauvoir's *The Second Sex*

(1993 [1953]), which provides one of the first sustained analyses of the lived experience of "becoming woman." Beauvoir opened her classic text with a critique of theories contending that there are basic biological differences between women and men that explain women's secondary status in society. She concluded that "one is not born a woman: one becomes one" (p. 249), that is, that women and femininity are "produced" through complex disciplinary practices such as marriage, motherhood, and sexuality. In this way, Beauvoir's work foreshadowed contemporary work in the area of feminist science and technology studies.

Women in Science

Feminist investigations of science and technology emerged in the 1970s, but their origins can be traced to concerns over the low numbers of women in science. Feminists argued that it is a moral imperative to determine the causes of women's underrepresentation in the sciences and to remove those that unjustly block their participation. Because feminists soon realized that sexism also intersects with other axes of oppression, this move to understand the causes of women's underrepresentation in the sciences was followed by efforts to include similar studies of the impact of racism, and more recently of abilism (discrimination against persons with disabilities).

While the numbers of women have been improving in the biological and life sciences since the 1970s, the numbers of women receiving degrees in engineering, physics, and computer science continue to raise concerns. A study conducted by the U.S. National Science Foundation (NSF) found that while women received 57 percent of the doctoral degrees awarded in non-science and engineering fields in the United States in 2001, only 19 percent of the doctoral degrees in computer sciences and 17 percent of the doctoral degrees in engineering were earned by women (NSF 2004). The American Institute of Physics also reported that only 12 percent of the doctoral degrees in physics in 1997 were awarded to women. In addition both studies found that women scientists who worked in the academy were more likely to hold positions at the lower ranks in less prestigious institutions.

Given that overt barriers to women training in science had virtually disappeared by the 1950s, yet the number of women in science remained low, feminists began to explore features of science itself that might account for this disparity. Some of the more liberal approaches argued that the sole cause of the problem was that girls and women were not being encouraged to enter science. This approach led to proposals for science education reform designed to improve the education of girls and young women in science and mathematics. The American Association for the Advancement of Science's *Science for all Americans* (1989) and the National Research Council's *National Science Education Standards* (1996) are two examples.

Many feminist scholars nevertheless argued that solving the problem of science for women would take steps more far-reaching than simply reforming the education system. They began to examine the ways in which sexist and androcentric biases had marked the very topics that were of interest to scientists and had permeated research design as well as the interpretation of research findings. From this perspective, feminists began to propose a transformation of the themes and practices of science itself.

Gender Bias in Science

As feminists began to attend to the role of gender in science they identified a number of examples, particularly in the biological and medical sciences, of scientific practice that was either androcentric, that is, focused on male interests or male lives, or sexist, that is, manifested a bias that women and/or their roles are inferior to those of males.

One classic example of gender bias in science emerged out of feminist investigations of theories of human evolution. Feminists argued that theories of evolution, in providing accounts of the origin of the family and of the sexes and their roles, turned on widely accepted biases about sexual difference. "Man, the hunter" theories of human evolution were analyzed and critiqued not only for focusing primarily on the activities of males but also for the assumption that only male activities were significant to evolution. Hunting behavior alone was posited as the rudimentary beginnings of social and political organization, and only males were presumed to be hunters. Language, intellect, interests, emotions, tool use, and basic social life were portrayed as evolutionary products of the success of the hunting adaptation of males. In this evolutionary account, females were portrayed as following natural dictates in caring for hearth and home, and only male activities were depicted as skilled or socially oriented.

Feminist primatologists, among them Linda Marie Fedigan (1982), Sarah Blaffer Hrdy (1981), Nancy Tanner (1976), and Adrienne Zihlman (1978), not only exposed the gender bias of "man, the hunter" theories, their research led to an alternative account of evolution now accepted as more accurate. By questioning the assumption that women's actions were instinctual and thus of little evolutionary importance, these scientists began to examine the impact of women's activities, in particular the evolutionary significance of food gathering. From this focus, an alternative account of evolution emerged that posited food-gathering activities, now of both women and men, as responsible for increased cooperation among individuals, which resulted in enhanced social skills as well as the development of both language and tools (Haraway 1989).

Examples of androcentrism or sexism in science are numerous and frequently shown to result in poor science and, in many cases, ethically problematic beliefs or practices. The following list provides just a few examples identified by feminists: the exclusion of women in clinical drug trials, attributions of gendered cognitive differences in which female differences are posited to be deviations from the norm, the imposition on women of a male model of the sexual response cycle on women, and the lack of attention to male contraceptive technologies.

Objectivity and Situated Knowledges

Feminist perspectives on gender bias in science and technology led to an appreciation of the link between ethics and epistemology. Feminists such as Donna Haraway, Sandra Harding, and Helen E. Longino argued that nonfeminist accounts of scientific objectivity were inadequate because they provided no method for identifying values and interests that are unquestioningly embraced by the scientific community and that impact theoretical assumptions or the design of research projects. Careful analysis of the history of science documented systematic assumptions about women's biological, intellectual, and moral inferiority that were not the idiosyncratically held opinions of individual scientists but widely held beliefs imbedded in social, political, and economic institutions, as well as scientific theories and practices (Schiebinger 1989, Tuana 1993). Given this, no account or practice of scientific objectivity that does not control for community-wide biases and values could be sufficient.

Feminist science and technology theorists thus argue for a "strengthened objectivity" by developing methods for uncovering the values and interests that constitute scientific projects, particularly those common to communities of scientists, and developing a method for accessing the impact of those values and interests (Harding 1991). In developing such an account, feminists gave up the dream of a "view from nowhere" account of objectivity with its axiom that all knowledge, and in particular scientific knowledge, can be obtained only using methods that completely strip away all subjective components such as values and interests. Feminists, rather, argue that all knowledge is situated, that is, emerges from particular social, economic, or political locations. Strengthened objectivity requires attention to particularity and to partiality, with the goal not to strip all bias from knowledge, but to assess the impacts of "beginning knowledge from different locations." On this account human knowledge is inherently social and engaged. The goal, then, of any quest for objectivity is to examine how values and interests can either limit or enlarge one's knowledge practices.

As just one of many examples analyzed by feminists, consider the emphasis on recombinant DNA technologies that has been proposed since the late twentieth century as a unifying principle for molecular biology (Lodish et al. 2003). Feminists have argued that rather than the lauded neutrality and objectivity, this position reflects numerous values and interests. Recombinant DNA technologies emphasize the centrality of DNA as a "master molecule" that controls life, and ignore or view as less important the organism's environment or the organism's history. In this way, such an allegedly "neutral" technology actively frames a sharp division between genetic and nongenetic factors, trivializes the role of environments, and reinforces biological determinism. Feminists have argued that efforts to cement molecular genetics as the foundation of the science of biology leads to a perception of life, including behavior and social structures, as "gene products."

This situated knowledge practice of contemporary molecular biology is clearly linked to the emergence of "big science" and its support by venture capital. Funding for the Human Genome Project has emphasized a hierarchical, centralized organization of scientific research. And venture capital, following the promise of marketable discoveries in biomedical research, has similarly fueled the growth of such science.

Insofar as molecular genetics becomes the focus of biology, it embeds ideologies concerning the functions and significances of genes and environments that carry with them a renewed emphasis on genetic factors in disease. For example, although the vast majority of all cancers, including breast cancer, are attributable to environmental factors, there is an increasing emphasis in scientific research and medical practice on genetic factors, a move that has been sharply criticized by feminists (Eisenstein 2001). Another concern of feminists and race theorists is that this "geneticization" of human health has also led to a renewed interest in biological difference between groups, which is reinscribing a biological basis to racial classifications (Haraway 1997).

These shifts in research focus can have dramatic effects on resource allocations. Occupational hazards and environmental carcinogens have been clearly implicated in cancer rates, and the effects of environmental racism on the health of minorities have been well documented. Yet funding for research into or cleanup of modifiable environmental factors is shifting to research on genetic inheritance.

Given feminist perspectives on the interaction between biology and environment in the constitution of sex (as well as gender) and sexual identity, this reemergence of biological determinism is in conflict with feminist values and interests. Strengthened objectivity calls attention to the different values and interests guiding research and asks for examination of their roles in contributing to more effective and liberatory practices of science and technology as well as an investigation of how practices of science and technology affect values and interests.

Feminist Technology Studies

Such attention to the values and interests guiding scientific practice also influenced feminists working in the field of technology studies. Feminists came to understand that historians of technology had been accepting gender stereotypes such as "man, the producer" and "woman, the consumer," which had biased the field. In the words of Judith A. McGaw (1989), theorists working in technology studies had "looked *through* masculine ideology at the past rather than looking *at* masculine ideology in the past" (p. 177). Following Harding's call for a strengthened objectivity, feminist investigations of the history of technology recovered the histories of women who both produced and employed a technology, that is, women architects, engineers, and inventors, as well as women workers and their experiences of technological change.

But an attention to sexist or androcentric ideology revealed other types of biases in the field. Technology studies often focused on only certain types of inventions and specific kinds of work as worthy of study. The work of women in textiles and food production, for example, was either ignored or labeled "consumption." Ruth Schwartz Cowan (1983) argued that technology studies had overlooked the fact that female experiences of technology and technological change were often markedly different than male experiences. Studies such as those of McGaw, for example, demonstrated that the mechanization of industrialization often differentially affected men and women, keeping women in the lowest paying jobs where their skills were denied and they had no opportunity for advancement. Feminists also argued that attention to women's most common relationships to technology, namely through use, maintenance, and redesign, revealed an overemphasis in technology studies on the design of technology rather than its use. In critiquing the dichotomy commonly embraced in technology studies between production and consumption, feminists revealed how gender formation and technological development are co-constitutive, meaning that gendered norms are encoded into technological design and use, and that gender roles themselves emerge out of interactions with technologies (See, for example, Wajcman 1991 and 2004, and Rothschild 1983).

Medical Technologies

There is no more obvious arena for mapping the interactive emergence of gender and technology than in the science of medicine. Indeed this interaction can be found at its most literal instantiation, along with all the attendant ethical dilemmas, in the case of the intersexual child (that is, a child born with genitalia and/or secondary sexual characteristics of indeterminate sex, or which combine features of both sexes). In *Sexing the Body* (2000), Anne Fausto-Sterling argues that the U.S. and European medical practice of "fixing" intersexual individuals by assigning a specific sex and offering surgical and other medical

Such practices rest, of course, upon a series of technological advances including advances in plastic surgery originally developed to return to "normal" those bodies that had been deformed by war, accident, birth defects, or illness. But because they also rest upon a series of values, these practices provide a window into the ways in which beliefs about sex and gender affect medicine and also raise a complex series of ethical concerns. Whereas many in the medical community view infant genital surgery as being designed to fix or "cure" an abnormality, which they believe would then allow the individual to lead a "normal" and healthy life, many feminists and Lesbian, Gay, Bisexual, Transexual scholars have argued that such surgery is performed to achieve a social result, namely to make sure all bodies conform to a two-sex system. They also contest the belief that such surgery is necessary for either physiological or psychological health, citing the many cases of intersexuals whose lives were not negatively impacted by this physiological difference. While the medical community views early genital surgery as a medical imperative, critics note that such surgery is frequently a "failure," often requiring numerous additional surgeries, extensive scarring, and a decrease or elimination of sexual pleasure (Fausto-Sterling 2000). Ethical issues abound in this area of medical practice from questions of autonomy (Who decides what is best for an intersexual child?), to issues concerning sexual identity and current societal regulations concerning same-sex relations (Does an intersexual individual who has both a vagina and a penis "count" as a woman or a man in the prevailing two-sex legal economy?).

Ethical issues also permeate the new reproductive technologies, another focus of feminist analysis. Feminists have addressed the risks of various types of reproductive technologies as well as the fact that such technologies are available only to certain women, identifying the way that class issues as well as sexuality and marital status have been limiting factors in the availability of such technologies. Issues of "normalcy" are also central to feminist analyses of reproductive technologies. Many feminists have, for example, critiqued the ways in which prenatal testing intersects with societal biases concerning disability, noting that whereas prenatal testing and selective abortion for the purposes of sex selection are decried in many countries, this practice is widely accepted for fetuses with disabilities such as Down syndrome. Feminists have also investigated how new reproductive technologies are reshaping what is seen as "natural" and affecting the ways women and men experience their bodies. As women and men "bank" their eggs and sperm, as postmenopausal women become pregnant through technological interventions, as lesbian couples give birth to their own biological children, the nature/culture divide shifts and alters.

Global Issues

Feminist investigations of the impact of Western science on women in non-Western societies reveal the Eurocentric and undemocratic nature of Western science. Western scientific "voyages of discovery" were often part of colonialist efforts to mine other cultures for resources, both human and material, and maintain the forms of social control necessary to do so. Feminist and postcolonial science studies have documented how European expansion has contributed to the destruction or devaluation of the scientific practices of the colonized cultures, leading to the false belief in the superiority of Western science, indeed to the false but pervasive belief that Western science is "generic" and not itself "local," that is, not situated in particular economic and social practices (See, for example, Adas 1989).

Feminist scholars have also mapped the continuing de-development of other cultures and their scientific and technological practices through so-called development policies such as the "green revolution" and the more recent impact of biotechnology in agriculture. Feminists have examined who benefits and who is made worse through such practices, paying close attention to the profit margins of those chemicals companies, such as Novartis, AgrEvo, and Dupont, that sell the fertilizers, pesticides, and genetically engineered seeds of this revolution. Although economic impact is a key factor in such analyses, feminists pay close attention to the impact on diversity—both human diversity as well as biodiversity. Vandana Shiva (1997) has argued that the marginalization of women and the destruction of biodiversity through monocultures go hand in hand because women provide the majority of the agricultural labor in many Third World countries. Shiva examines how the biodiversity-based technologies of Third World societies have been viewed as backward and have been systematically displaced by monocultures biased toward commercial interests.

Feminists and postcolonialist science and technology theorists have argued for a democratized science/technology practice that acknowledges the importance of biological as well as cultural diversity as a way to undo the harms of colonialist science practices, including many of the current capitalist-generated practices. While this vision of science and technology emerged from feminist-inspired investigations, it is a moral vision of the intricate interactions between humans and the more than human world, between natures and cultures, and between organisms and environments that should inspire everyone.

NANCY TUANA

SEE ALSO *Assisted Reproduction Technology; Abortion; Homosexuality Debate; Juana Iñez de la Cruz; Race; Sex and Gender.*

BIBLIOGRAPHY

Adas, Michael. (1989). *Machines as the Measure of Men: Science, Technology, and Ideologies of Western Dominance*. Ithaca: Cornell University Press.

American Association for the Advancement of Science. (1989). *Science for All Americans: A Project 2061 Report on Literacy Goals in Science, Mathematics, and Technology*. Washington, DC: Author.

Beauvoir, Simone de. (1952). *The Second Sex*. New York: Bantham.

Birke, Lynda, and Ruth Hubbard. (1995). *Reinventing Biology: Respect for Life and the Creation of Knowledge*. Bloomington: Indiana University Press.

Cowan, Ruth Schwartz. (1983). *More Work for Mother: The Ironies of Household Technology from the Open Hearth to the Microwave*. New York: Basic.

Creager, Angela N. H.; Elizabeth A. Lunbeck; and Londa Schiebinger, eds. (2001). *Feminism in Twentieth-Century Science, Technology, and Medicine*. Chicago: University of Chicago Press.

Eisenstein, Zillah. (2001). *Manmade Breast Cancers*. Ithaca, NY: Cornell University Press.

Fausto-Sterling, Anne. (2000). *Sexing the Body: Gender Politics and the Construction of Sexuality*. New York: Basic.

Fedigan, Linda Marie. (1982). *Primate Paradigms: Sex Roles and Social Bonds*. Montreal: Eden Press.

Haraway, Donna. (1989). *Primate Visions: Gender, Race, and Nature in the World of Modern Science*. New York: Routledge.

Haraway, Donna. (1997). *Modest_Witness@Second_Millennium.FemaleMan©_Meets_ OncoMouse™: Feminism and Technoscience*. New York: Routledge.

Harding, Sandra. (1991). *Whose Science? Whose Knowledge? Thinking from Women's Lives*. Ithaca, NY: Cornell University Press.

Harding, Sandra. (1998). *Is Science Multicultural? Postcolonialisms, Feminisms, and Epistemologies*. Bloomington: Indiana University Press.

Hrdy, Sarah Blaffer. (1981). *The Woman that Never Evolved*. Cambridge: Harvard University Press.

Ivie, Rachel, and Katie Stowe. (2000). *Women in Physics, 2000*. Melville, NY: American Institute of Physics.

Lodish, Harvey, et al. (2003). *Molecular Cell Biology*, 5th edition. New York: W.H. Freeman.

Longino, Helen E. (1990). *Science as Social Knowledge: Values and Objectivity in Scientific Inquiry*. Princeton, NJ: Princeton University Press.

McGaw, Judith A. (1987). *Most Wonderful Machine: Mechanization and Social Change in Berkshire Paper Making, 1801–1885*. Princeton, NJ: Princeton University Press.

McGaw, Judith A. (1989). "No Passive Victims, No Separate Spheres: A Feminist Perspective on Technology's History." In *In Context: History and the History of Technology—Essays in Honor of Melvin Kranzberg*, ed. Stephen H. Cutcliffe and Robert C. Post. Bethlehem, PA: Lehigh University Press.

National Research Council. (1996). *National Science Education Standards*. Washington, DC: National Academy Press.

National Science Foundation. Division of Science Resources Statistics. (2004). *Women, Minorities, and Persons with Disabilities in Science and Engineering, 2004*. Arlington, VA: Author.

Rothschild, Joan, ed.. (1983). *Machina Ex Dea: Feminist Perspectives on Technology*. New York: Pergamon Press.

Schiebinger, Londa L. (1989). *The Mind Has No Sex? Women in the Origins of Modern Science*. Cambridge, MA: Harvard University Press.

Shiva, Vandana. (1997). *Biopiracy: The Plunder of Nature and Knowledge*. Boston: South End Press.

Tanner, Nancy. (1976). *On Becoming Human*. Cambridge, UK: Cambridge University Press.

Taylor Mill, Harriet. (1868). *Enfranchisement of Women*. St. Louis: Missouri Woman's Suffrage Association.

Tuana, Nancy. (1993). *The Less Noble Sex: Scientific, Religious, and Philosophical Conceptions of Woman's Nature*. Bloomington: Indiana University Press.

Wajcman, Judy. (1991). *Feminism Confronts Technology*. University Park, PA: Penn State University Press.

Wajcman, Judy. (2004). *TechnoFeminism*. Cambridge, UK, Malden, MA: Polity Press.

Westra, Laura, and Bill E. Lawson. (2001). *Faces of Environmental Racism: Confronting Issues of Global Justice*, 2nd edition. Lanham, MD: Rowman and Littlefield.

Wollstonecraft, Mary. (1792). *A Vindication of the Rights of Woman*. London: Joseph Johnson.

Zihlman, Adrienne. (1978). "Women and Evolution." *Signs* 4(1): 4–20.

FETAL RESEARCH

Fetal research encompasses a broad array of research activities and potential clinical applications. It is ethically controversial because, although it may yield beneficial results, it involves the human organism at a stage of development where its moral status is contested and informed consent is not possible.

Distinctions and Benefits

One key distinction centers on the stage of development of the human organism when the research is conducted, from pre-implantation to late fetal stages. The general sources of fetal material include tissue from dead fetuses; pre-viable or nonviable fetuses in utero prior to an elective abortion; nonviable living fetuses ex utero; or embryos, either in vitro or pre-implantation. Another distinction is that between *investigational* research that cannot benefit the subject fetus and *therapeutic* research that might benefit the fetus subject or is likely to benefit future fetuses. *Clinical* applications including transplantation using fetal material such as tissues, cells, or organs represent another form of fetal research. Moreover, among the many non-clinical uses of human embryos are the development of contraceptives and abortifacients and the study of abnormal cell growth and chromosomal abnormalities.

Moral Issues

One of the most controversial types of fetal research involves embryonic stem cells. Stem cells are primitive cells that have the capacity to divide for indefinite periods in culture and give rise to specialized cells. Most attention is focused on pluripotent cells, those capable of giving rise to most tissues of an organism but not all types necessary for fetal development. The source of these cells can be adult humans, modified stem cells from other species, or most promising (and controversial), cells from aborted fetuses or human embryos (either "spare" embryos from in vitro fertilization or embryos created specifically for research purposes). Some of the potential benefits of stem cell research being discussed are growing new organs, reversing paralysis and other neural/spinal damage, reversing the effects of neuro-degenerating diseases such as Alzheimer's, repairing heart damage, and treating diabetes, cancer, and other diseases.

Potential benefits of other types of fetal research include both knowledge and therapeutic applications. Among the many non-clinical uses of fetal and embryo research are: (1) investigation of abnormal cell growth including various cancers; (2) studying the development of chromosomal abnormalities and other birth defects; (3) understanding implantation problems and miscarriages; and (4) increased knowledge of cancer and aids.

Historical Background

Fetal research first appeared on the national policy agenda in the early 1970s after widely publicized exposés on several gruesome experiments conducted on still-living fetuses. In response, the U.S. Congress passed the 1974 National Research Act (Public Law 93–345) establishing the National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, whose first charge was to investigate the scientific, legal, and ethical aspects of fetal research. In 1976, regulations for the federal funding of such research were promulgated (45 CFR 46.201–211). Under the regulations, certain types of fetal research are fundable, with constraints based on parental consent and the principle of minimizing risk to the pregnant woman and the fetus.

In 1985, Congress passed a law (42 U.S.C. 289) forbidding federal conduct or funding of research on viable ex utero fetuses with an exception for therapeutic research or research that poses no added risk of suffering, injury, or death to the fetus and leads to important knowledge unobtainable by other means. Federal regulations on fetal research, then, appear to be quite clear in allowing funding within boundaries. However, in two key areas—embryo research and fetal tissue transplantation research—there in effect was a moratorium on federal funding between 1980 and 1995, which, according to the Institute of Medicine, severely hampered knowledge in medically assisted reproduction because the reliance on private funding shifted emphasis from essential basic research to rapid and often risky clinical applications. In addition, many states have laws regulating or even prohibiting certain types of fetal research, often either part of or attached to abortion statutes (for details see NCSL 2003).

At the center of the controversy over fetal research is disagreement over the moral and legal status of the fetus. Questions also center on who may consent for the use of fetal materials, under what circumstances the abortion procedure can be modified to meet the needs of the research, and what type of compensation, if any, for fetal tissues should be allowed. As a result of these issues, fetal research has been elevated to the public agenda and has become a highly volatile moral and political issue (Vawter, Kearney, and Gervais 1990).

Ongoing Debate

There is an ongoing debate over whether the use of fetal tissue from elective abortion encourages or legitimizes abortion. On the one hand, opponents argue that research using aborted fetuses gives abortion greater legitimacy and contend that use of embryos and fetuses for research exploits them and reduces them to biological commodities (Brown 2003). Moreover, because the fetus is unable to consent, there is concern over what type of consent and by whom is sufficient, and how to balance research needs with interests of the pregnant woman. On the other hand, supporters argue that research using human fetal and embryonic materials is critical for progress in many areas of medicine (Fletcher 1993).

As already suggested, perhaps the most controversial area of fetal research involves the use of fetal cells for transplantation to adult patients to treat a wide range of disorders (Stein and Glasier 1995). Such tissue can come from spontaneous abortions, induced abortions on unintended pregnancies, induced abortions on fetuses conceived specifically this purpose, or from embryos produced in vitro. A dependence on spontaneously aborted fetuses for research is impractical because of the limited number available and the inability to control the timing. The major supply of fetal tissue, therefore, is likely to come from induced abortions, but this raises vehement objections on moral grounds by groups opposed to abortion (Brown 2003).

Privatization and Related Issues

In light of the extent to which stem cell research might revolutionize health care, there is a huge commercial stake in fetal/embryo research. Already, marketing and advertising has started in the area of umbilical cord stem cell preservation and this is certain to be followed by broader efforts to market the fruits of this research. Moreover, once the benefits start to materialize, demand for cell lines will intensify, thus putting pressures on potential suppliers. Both of the two options, production of designated research embryos or increasing the supply of spare embryos, bring risks to women and raise questions concerning the consent process and proprietary rights over what promise to be very lucrative human materials.

There is also concern that increased pressures for these scarce resources could lead to exploitation of poor women paid to conceive solely to provide fetal material or an international market for multi-national drug companies.

Moreover, the continually expanding field of potential uses of fetal tissues, complicated by the difficulty of ensuring cooperation from abortion clinics and obstetricians in making fetal tissue available, has raised concerns for maintaining an adequate supply of fetal tissue. The availability of RU-486 and other abortifacients might actually diminish the supply of usable fetal tissue at a time when demand is increasing.

Assessment

Clearly some important areas of fetal research have been explicitly constrained on moral rather than scientific grounds. The presence of abortion politics continues to exert strong influence on research funded by the government across a wide range of substantive areas. In the process, some argue that long-term scientific goals are being compromised by immediate, pragmatic political objectives. The spirited debate over stem cell research in the 2004 election and the decision of California voters to invest $3 billion demonstrates that these issues will not dissipate. Given the sensitivity of human embryo and fetal research and its interdependence with abortion, this should not be surprising. Fetal research raises moral red flags for many persons and thus will remain a political as well as moral issue.

ROBERT H. BLANK

SEE ALSO *Abortion; Embryonic Stem Cells; Genethics; Genetic Counseling; Human Subjects Research; In Vitro Fertilization and Genetic Screening; Playing God; Research Ethics.*

BIBLIOGRAPHY

Fletcher, John C. (1993). "Human Fetal and Embryo Research: Lysenkoism in Reverse—How and Why?" In *Emerging Issues in Biomedical Policy*, Vol. 2, ed. Robert H. Blank and Andrea L. Bonnicksen. New York: Columbia University Press.

Stein, Donald G., and Marylou M. Glasier. (1995). "Some Practical and Theoretical Issues Concerning Fetal Brain Tissue Grafts as Therapy for Brain Dysfunction." *Behavioral and Brain Sciences* 18: 36–45.

Vawter, Dorothy E.; Warren Kearny; Karen G. Gervais, et al. (1990). *The Use of Human Fetal Tissue: Scientific, Ethical, and Policy Concerns*. Minneapolis: Center for Biomedical Ethics.

INTERNET RESOURCES

Brown, Judie. (2003). "Recycling Babies: The Practice of Fetal Tissue Research." American Life League, Inc. Available from http://www.all.org/issues/eg99y.htm.

National Conference of State Legislatures (NCSL). (2003). "State Embryonic and Fetal Research Laws." Available from http://www.ncsl.org/programs/health/genetics/embfet.htm.

FILMS

SEE *Movies*.

FIRE

From the prehistorical era, fire has generated the energy that allowed human beings to warm themselves and their surroundings, illuminate the darkness, prepare food, and create artifacts with both utilitarian and aesthetic value. More recently, fire has powered transportation and manufacturing and served as an object of and means for research.

These dual aspects of fire are represented in its deeply symbolic character. From the earliest periods fire has served as a symbol for moral and intellectual achievement. Many religions use fire in ceremonies, as in candles and funeral pyres. Fire is also common in celebrations, such as birthday candles and fireworks.

Although fire is indispensable to human beings and civilization, it also can kill and destroy or be used as a means for intentional destruction and warfare. The great library at Alexandria was destroyed by fire in 47 B.C.E. and the Chicago fire of October 1871 forced the city to rebuild itself. The World War II firebombings of Dresden and Tokyo were more destructive than the atomic bombings of Hiroshima and Nagasaki.

The Science of Fire

Chemically, fire is an exothermic reaction involving the rapid oxidation of fuel. For example, the burning of red oak could be approximated as follows:

$$CH_{1.7}O_{0.72}N_{0.001} + 1.065O_2 \rightarrow CO_2 + 0.85H_2O + 0.0005N_2$$

This reaction liberates approximately 12.7 megajoules of energy for each kilogram of red oak burned. (One joule of energy is equal to one watt of power generated for one second; a megajoule represents one million joules.) This liberated energy raises the temperature of the reaction products and emits thermal radiation. Most fires occur in a normal air atmosphere, which is approximately 21 percent oxygen and 78 percent nitrogen. Thus, the burning of red oak in air is written more correctly as follows:

$$CH_{1.7}O_{0.72}N_{0.001} + 1.065(O_2 + 3.76N_2) \rightarrow CO_2 + 0.85H_2O + 4.0049N_2$$

Because the nitrogen in the air plays no role in the reaction, the temperatures of flames in air are lower than the temperatures in pure oxygen; some of the energy that is liberated by the fire heats the ambient nitrogen.

Fires can be characterized as two different types of flaming: premixed and diffusion. Premixed flaming occurs when fuel and air are mixed before combustion; a diffusion flame exists when burning occurs as fuel and air are being mixed. Both types can be illustrated with a standard laboratory Bunsen burner. Typically, when a Bunsen burner is used, a blue flame is desired. That flame is premixed because air is entrained into the fuel stream through openings in the burner before the flame zone is established. However, if the openings where air is entrained into the burner are closed, the flame loses its regular shape and changes color from blue to yellow. This is a diffusion flame, where the gas feeding the burner must mix with the surrounding air in the area of flaming.

In general, all fires involve the combustion of gaseous fuel. If the fuel is a gas, such as the fuel that feeds a Bunsen burner, it only needs to mix with air for burning to occur. If the fuel is a liquid, it must be heated sufficiently to release vapors. The temperature at which a liquid fuel releases sufficient vapors for combustion to occur is called its *flashpoint*, and it occurs at a temperature lower than the boiling point of the liquid.

Solid fuels similarly must be heated to a temperature at which sufficient vapors are released to support combustion; however, solid fuels do not necessarily vaporize as liquids do. Some solid fuels melt and then subsequently vaporize before combustion. Others, such as wood, do not melt before releasing combustible vapors. Upon heating, these solids decompose into simpler compounds that are distinct from the original material in a process called *pyrolization*. The temperature at which a solid fuel releases sufficient vapors for combustion is called its *ignition temperature*.

Ignition of a fire requires the introduction of energy. For a gaseous fuel or a liquid fuel that is at a temperature above its flashpoint, a spark or small flame may be sufficient to provide that energy. For solid fuels or liquid fuels that are at a temperature below their flashpoint, the fuel first must be heated to a temperature at or above its flashpoint or ignition temperature.

Once a fuel is ignited, the heat liberated form the fire can transfer back to the fuel, causing the fire to sustain itself or grow. However, if the energy feedback to the fuel is not sufficient, the fire will decay and eventually go out. This can be illustrated by looking at logs in a fireplace. If there is only one wood log in a fireplace, so much of the energy liberated by burning the log is lost to the environment that the fire will go out. However, if more logs are added, some of the energy that would have been lost is transferred to the other logs, and the fire will be sustained.

Fire and Technology

Humans are the only creatures that have the ability to control and harness fire. Fire has been indispensable to technological progress. It is no accident that Prometheus is said to have stolen fire from the gods to make it possible for human beings to live. Early humanity learned how to start fires that could serve very simple uses. As humanity evolved, the heat generated by fire was used for more complex tasks, such as hardening clay and molding metals. Later, the energy liberated by fires created steam to power moving equipment.

As the understanding of fire increased, so did the efficiency with which it was used to generate energy.

Instead of using fires to heat water to create steam, fires could be ignited under controlled conditions in cylinders, allowing the potential energy in the fuel to be converted more directly to kinetic energy. It is through these types of processes that fire can be used to power generators that create electricity or to create mechanical energy to power airplanes and boats directly.

However, just as fire can serve benign purposes, it can be used in more destructive tasks. Fire applied to people or their environments either intentionally or unintentionally can cause death, injury, and the loss of property. Entire cities have been lost to fire; although the rate of death, injury, and destruction caused by fire has decreased steadily, fire continues to take a serious toll. It is likely this dichotomy of purpose that prompted fire as a symbol of attractive self-destruction, as when the moth flies into the flame.

The Ethics of Fire

The technological advances that have been made possible by the ability to harness fire also have created risks to society. As the Industrial Revolution created an environment in which manufacturing facilities were placed closely together, the flammability of the items inside those facilities, coupled with the closeness of buildings, allowed for fires that could destroy entire cities. This caused society to look for ways to protect people and the community from the hazards of fire.

As a result of fires that caused the loss of whole cities, people began to look for means of limiting the effects of a fire to a single building. This was accomplished by controlling the materials from which buildings were constructed, the spacing of buildings, and the types of openings, such as windows, installed in buildings.

As people learned ways to limit the impact of a fire to a single building, the goal of fire safety changed to limiting that impact to a single portion of a building. As methods of protection against fire improved, the maximum tolerable effects of fire became smaller.

Society has devised a number of ways to prevent fire that can be divided into two broad areas: prevention of fire ignition and management of fire impact. By controlling the methods of creating and distributing energy, it is possible to make it less likely that a fire will be ignited. Examples of means to prevent fire ignition include the electrical protections that typically are required in a home or business: the use of minimum wire sizes, electrical insulation on wires, and the use of fuses or circuit breakers.

Management of fire impact can involve means of managing a fire once it begins or ways to manage the things that are intended to be protected from fire. Fires can be managed by controlling the fire combustion process, suppressing fires, and controlling fires by means of the types of construction used. Examples of these means include controlling the type of fuel present, the use of fire suppression systems such as automatic sprinkler systems, and the use of building materials that resist the spread of fires, such as fire walls and doors.

In light of the fact that almost all human pursuits create fire risk, society has an obligation to ensure that the risks that are created are controlled. Developing better means of fire protection requires the development of a better understanding of fire and of the way fire affects buildings, people, and property. To this end there is a branch of science that is dedicated to the study of fire. Fire science involves scientific study of how fires start, how they grow, how they can be extinguished or suppressed, and the amount of heat and chemical compounds that are created when fires occur. Fire scientists also create models, or methods of simulating, fires. Fire models range in complexity from sophisticated computer programs to relatively simple equations that can be solved with a calculator.

Similarly, there is a branch of engineering that is dedicated to the application of scientific principles to protect people, property, and the environment. Fire protection engineers apply the scientific understanding of fire to reduce the risks of fire to reduce the likelihood of unwanted fires and manage the impact to society when unwanted fires occur.

MORGAN J. HURLEY

SEE ALSO *Air; Earth; Environmental Ethics; Water.*

BIBLIOGRAPHY

Bachelard, Gaston. (1964 [1938]). *The Psychoanalysis of Fire*, trans. Alan C. M. Ross. Boston: Beacon.

Drysdale, Dougal. (2002). "Chemistry of Physics and Fire." In *Fire Protection Handbook,* ed. by Arthur E. Cote. Quincy, MA: National Fire Protection Association.

Lyons, John. (1995). *Fire*. New York: Scientific American Books. Provides an overview of the hazards that fire pose to society, the science of fire, and the methods that are used to combat unwanted fire.

National Fire Protection Association Publication 550. (2002). *Guide to the Fire Safety Concepts Tree*. Quincy, MA: National Fire Protection Association. The fire safety concepts tree provides a method of communicating fire safety concepts to people who do not have specialized knowledge of fire protection.

Pyne, Stephen J. (2001). *Fire: A Brief History*. Seattle: University of Washington Press.

Tewarson, Archibald. (2002). "Generation of Heat and Chemical Compounds in Fires." In *SFPE Handbook of Fire Protection Engineering*. Quincy, MA: National Fire Protection Association.

FOOD AND DRUG ADMINISTRATION

SEE *Food and Drug Agencies*.

FOOD AND DRUG AGENCIES

Because foods and drugs are intimately involved with the quality of life, their purity and safety have been of deep concern to many citizens and the governmental agencies dedicated to human welfare. Throughout the world the purpose of food and drug agencies is to certify that foods are safe and drugs effective. Consequently these agencies have as one of their chief goals the prevention of adulteration—debasing foods or drugs by diluting them with less valuable ingredients or adding substances to make the food or drug appear to be what it is not. Adulteration has ethical consequences; for example, the dilution of a cancer drug may hasten rather than hinder death. Corrupt companies can use scientific knowledge and chemical techniques to thwart detection of their adulterated products, forcing food and drug agencies to develop advanced techniques to ferret out fraudulent drugs and thereby protect the public from harm. Science and technology are thus inextricably involved in the ethics of food and drug agencies and industries.

Early History

During the Latin Middle Ages writers of herbals and medical treatises expressed ethical qualms about adulteration and proposed remedies. These writers found that scarcity of supply played a role in fraudulent practices. In 1202 King John instituted the first English food law, which prohibited the admixture of inferior ingredients in publicly sold bread. In Germany and France rulers passed statutes that fined brewers for doctoring beer and wine. Arabs of medieval Islam appointed police officers to test the genuineness of foods and drugs in markets. Medicinal compounds had to be prepared before a supervisor, who was the guarantor of the drug's purity.

With the European voyages of discovery in the fifteenth and sixteenth centuries, new foods and herbal drugs became part of an expanding global marketplace. To preserve foods on long journeys, producers and transporters used chemicals to retard spoilage and color foods. These practices led to abuses, and some European governments passed laws to prevent and punish harmful or deceptive practices. In the seventeenth century Robert Boyle, a British physicist and chemist, invented a device for determining specific gravities, which gave pharmacists a new way to detect drug adulteration. With the increasing sophistication of scientific knowledge in the eighteenth century, technical books by Adolph Gottlob Richter, Jean-Baptiste-Augustin Vanden Sande, and others appeared on adulteration and its detection and eradication. Although these authors used the new knowledge of chemistry and highly developed apparatus of the Scientific Revolution, they also analyzed the ethics underlying nefarious practices by merchants, pharmacists, and physicians. They suggested such remedies as better education and more effective laws to correct the injuries being done to customers and patients.

Food and Drug Agencies

As the first country to combat food and drug fraud through a comprehensive set of laws, Great Britain became the model for many other nations. Beginning in the eighteenth and early nineteenth centuries with laws on the adulteration of tea, wine, and beer, the British were able to protect the integrity of these and other important commodities and, through revenue officers, enhance state income. New technologies such as the microscope helped scientists detect the adulteration of coffee with chicory, but scandals associated with injurious foods and drugs forced legislators, in a series of new laws, to shift from noninjurious adulteration to the illegal addition of substances to foods and drugs that caused physical harm.

In colonial America the earliest food adulteration laws closely followed British examples, but in the late eighteenth century the first U.S. food law clearly targeted those persons, corrupted by greed, who sold unwholesome food in Massachusetts. Once convicted, such persons could be fined, imprisoned, or pilloried. The first U.S. federal drug law was passed in 1848, and it prohibited the importation of adulterated drugs. In 1862 President Abraham Lincoln signed legislation creating the U.S. Department of Agriculture (USDA), which included a Division of Chemistry (renamed the Bureau of Chemistry in 1901). This agency, which was a precursor of the Food and Drug Administration (FDA), employed chemists to identify adulterants in foods. During the rapid growth in population and industry after the Civil War (1861–1865), interstate traffic in foods and drugs also increased, as did tragedies associated with the addition of harmful dyes and preservatives to food and drink. An outraged public clamored for remedies, and between 1880 and 1906 more than a hundred bills were introduced in the U.S. Congress, but not one passed both houses.

The person largely responsible for breaking this deadlock was Harvey Wiley (1844–1930), chief chemist at the USDA from 1883 to 1912 and the "Father of the Pure Food and Drug Law." Convinced that many food and drug businesses were placing profits ahead of public health, Wiley hired idealistic young chemists, who were nicknamed the "Poison Squad," to study how chemical additives in foods affected health. Reports of their results aroused public concern, but "Wiley's Law" would never have been realized were it not for Upton Sinclair (1878–1968), whose novel *The Jungle* (1906) dramatized the repulsive practices in the Chicago meatpacking industry. The Pure Food and Drug Act of 1906 prohibited the "manufacture, sale, or transportation of adulterated or misbranded or poisonous or deleterious foods, drugs, medicines, and liquors." The Bureau of Chemistry administered the law, and Wiley and his successors developed an organization that won many victories for pure foods and drugs in the courts.

During the three decades after passage of the new law, weaknesses in its provisions appeared, because unscrupulous manufacturers were able to use advances in scientific knowledge and techniques to circumvent the statute. Muckraking journalists charged the food, drug, and cosmetics manufacturers with using 100 million Americans as "guinea pigs," and they provided examples of cosmetics that blinded women and drugs that caused children to suffer agonizing deaths (Kallet and Schlink 1933). Although administrative modifications were made (the Agricultural Appropriation Act of 1930 changed the agency name to the Food and Drug Administration), it was not until 1938 that Congress passed the Federal Food, Drug, and Cosmetic Act, which required manufacturers to provide scientific proof, through tests on animals and humans, that all their products were safe *before* they were put onto the market.

To isolate the FDA from advocacy groups, it was transferred from the USDA to the Federal Security Agency in 1940. World War II expanded the FDA workload, and during and after the war the number, variety, and power of new drugs increased dramatically. Food and drug companies grew in size and influence, which precipitated both abuses and legislative remedies. During the 1950s and 1960s, the 1938 act was periodically amended, and after the FDA became part of the Department of Health, Education, and Welfare in 1953, it used these new laws to give control of new drugs to doctors and FDA officials. The Delaney Clause (1958), which prohibited the use of substances in food if they caused cancer in laboratory animals, led to the controversial ban on saccharin, an artificial sweetener and weak carcinogen (this clause was replaced, in 1996, with the less stringent standard that "no harm will result from pesticide residues on raw and processed foods").

In the late 1950s, because of the widespread use of the sedative thalidomide by pregnant women in Europe, thousands of deformed infants were born, which eventually led to stronger drug laws in many countries. This drug was not widely available in America because of the valiant efforts of Frances Kelsey, an FDA examiner, whose suspicions about thalidomide led to her repeated rejections of applications to market it in the United States. Congress responded to the thalidomide tragedy by passing the Kefauver-Harris Amendment in 1962. This law changed the ways in which drugs were created, rested, developed, prescribed, and sold. The burden was now on the companies sponsoring a new drug to show that it was safe and effective. The FDA also issued new regulations that made the drug review process extremely stringiest, leading to criticisms that drug approval became glacially slow, because FDA officials, fearful of another thalidomide-like calamity, required study after study.

Criticizing the FDA—and Ethics

During the last four decades of the twentieth century the FDA came under attack by industry executives, congressional subcommittees, and public action groups. These FDA critics proposed that 200 million Americans were now being used as guinea pigs, because they were ingesting drugs and food additives that were even more deadly than those of the 1930s (Fuller 1972). Congress responded with a series of laws that, for example, strengthened FDA authority to regulate medical devices and commercial baby foods. These changes did not prevent the generic drug scandals of the 1980s, and in the 1990s the FDA continued to be an agency struggling to regain its credibility as the guardian of national health.

As with similar agencies in other countries, the FDA is charged with protecting public health, and in doing so it is often entangled in controversial ethical issues made more complex by advances in science and technology. For example, the FDA is responsible for regulating investigational new drugs (INDs). These drugs, not yet approved for sale, must be scientifically tested on animals, because an adverse effect on an animal often correlates with a similar effect on humans. Animal rights advocates have objected to this phase of IND development as unethical, whereas other groups have objected to the next three phases of IND testing, because humans are involved. In Phase I, small groups of healthy volunteers are given the IND to help researchers study its effectiveness, dosage, and metabolism. In Phase II, one to 200 patients with the drug-targeted disease are monitored for drug safety, efficacy, and side effects. In Phase III, even larger numbers of patients take the drug to refine optimum dosages, and placebos are given to some patients to make sure that IND effects are not due to chance or a developer's optimism.

Critics have raised doubts about FDA procedures on INDs. For example, in the 1970s, the General Accounting Office (GAO) studied ten of the more than 6,000 drugs then classified as INDs, concluding that in eight cases the FDA failed to halt human tests after learning that the new drugs were unsafe. Furthermore, the GAO found that drug companies delayed reporting adverse drug effects to the FDA. Other critics have attacked the FDA for approving too many drugs too quickly, thereby increasing risks, whereas still others blamed the FDA for approving drugs too slowly, thus depriving people of beneficial treatments.

Because of physicians' professional involvement with nutrition, prescription and nonprescription drugs, and medical technologies, they have a vested interest in food and drug companies as well as the FDA. This interest can raise ethical conflicts. According to some studies, physicians are protective of their independence and the integrity of the doctor–patient relationship, and many doctors are wary of governmental intrusions into how they practice medicine. Some critics have nevertheless pointed out the dangers of the close relationship that has developed between many doctors and drug companies.

Congressional subcommittees have questioned the ethics and legality of certain drug company activities. For example, in 1988 generic drugs became the focus of interest when investigators discovered that three generic drug companies were receiving accelerated approval of their drug applications in exchange for payoffs to FDA employees. By the time this scandal was over, federal courts had convicted ten companies and forty-two people of corruption. This scandal also revealed a potentially corrupting collusion between FDA workers and pharmaceutical companies, because FDA employees often leave their government jobs for highly paid positions at the companies they have formerly regulated.

Other controversies associated with science, technology, and ethics have involved artificial hearts, genetically engineered foods, and pediatric drugs. In these and other cases some ethicists claim that the law of the marketplace has contaminated the ethic that has generally guided scientists. For instance, they believe that profits rather than a genuine concern for humans and the environment have guided research on genetically modified plants and animals. Because many newborns have died after receiving drugs unsuited to their undeveloped organs, ethicists have pleaded with pharmaceutical companies and the FDA to do more research on proper drug doses for infants and children. Other ethicists have been troubled by the predominant use of white males in many drug studies, to the exclusion of women and minorities, whose genetic make-up and susceptibility to certain diseases are different from white males.

Assessment of FDA Influence and Future Prospects

Food and drug industries are among the largest and most lucrative in the world, and the governmental agencies that have evolved to regulate them have also become massive and complex. Because of the accelerating growth of science and technology, some predict that these industries and agencies will continue to expand, but others have warned that pharmaceutical companies are not creating new drugs at a rate necessary to maintain their viability in the marketplace. Although global funding for drug research doubled in the last decade of the twentieth century, the number of new drugs declined by 50 percent. The reasons for this decline are controversial. Some blame an industrial emphasis on "blockbuster drugs" that generate huge profits. But others blame the gargantuan costs required to develop new drugs. At the end of the twentieth century it typically took fifteen years and $900 million to develop a new drug, but only a very small percentage of these drugs actually become commercial successes. Still other critics have proposed replacing governmental food and drug agencies with free-market certification agencies, arguing that economic incentives are more conductive to effective results than bureaucratic incentives. Furthermore, simple drug solutions to such complex diseases as cancer and Alzheimer's have proven to be illusory.

Optimists believe that new technologies will be able to lessen these skyrocketing costs. For example, some have predicted that the sequencing of the human genome will revolutionize drug creation, but so far the mass of new data has confused rather than clarified future prospects. Scientists have used rational drug design, combinatorial chemistry, and high-throughput screening to accelerate the development of new drugs, but pessimists point out that, although the quantity of potential new drugs has increased, their quality has not. These critics also emphasize a fundamental ethical conflict between commercial interests and human needs for life-enhancing foods and lifesaving drugs.

As the need for safe, high-quality foods and drugs has grown, possible solutions to the problems posed by pessimists have been offered. Some believe that the reason so many useless drugs are generated is poor understanding of basic life processes. These analysts hope that, with more research in molecular and cell biology, the information needed to create precisely targeted drugs will become available. Others believe that computers will be able to predict how certain "new molecular entities" will bond to target compounds in human cells, thus fulfilling Paul Ehrlich's dream of "magic bullets." Still others believe that the solutions will be found in the plants populating the rain forests of the world. For a growing number of scientists, the future of healthful foods and safe and effective drugs lies in combining all of these solutions together, but with a realization that new foods and drugs must be created, developed, and marketed in ways that are compatible with the most profound ethical ideals of the human family.

ROBERT J. PARADOWSKI

SEE ALSO *DDT; Food Science and Technology; Organic Foods; Regulation; Science, Technology, and Law.*

BIBLIOGRAPHY

Abraham, John. (1995). *Science, Politics, and the Pharmaceutical Industry*. New York: St. Martin's Press. The author, an English sociologist, argues that corporate bias creates political problems, causing patients to take ineffective or unsafe drugs.

Burkholz, Herbert. (1994). *The FDA Follies*. New York: Basic. Analyzes in lurid detail how the FDA failed in its mission to protect the health of Americans during the Ronald Reagan and George Bush administrations.

Fuller, John G. (1972). *200,000,000 Guinea Pigs: New Dangers in Everyday Foods, Drugs, and Cosmetics*. New York: Putnam. A sequel to *100,000,000 Guinea Pigs* in which the author claims that, forty years later, the American public is being exposed to new and more dangerous poisons in their food, drugs, and cosmetics.

Grabowski, Henry G., and John M. Vernon. (1983). *The Regulation of Pharmaceuticals*. Washington, DC: American Enterprise Institute for Public Policy Research. The authors argue that the FDA does not deal with new drugs neutrally, because there exists an imbalance of benefits and risks among manufacturers, patients, and FDA officials.

Hilts, Philip J. (2003). *Protecting America's Health: The FDA, Business, and One Hundred Years of Regulation*. New York: Knopf. A general history of the FDA, its founding, development, and involvement in many controversies.

Hinich, Melvin J., and Richard Staelin. (1980). *Consumer Protection Legislation and the U.S. Food Industry*. New York: Pergamon Press. After an introductory history of federal regulation of the food industry, the authors analyze the regulatory mechanisms of such agencies as the FDA and USDA.

Jackson, Charles O. (1970). *Food and Drug Legislation in the New Deal*. Princeton, NJ: Princeton University Press. A political and historical analysis of the complex struggle leading to the Food, Drug, and Cosmetic Act of 1938.

Kallet, Arthur, and F. J. Schlink. (1933). *100,000,000 Guinea Pigs: Dangers in Everyday Foods, Drugs, and Cosmetics*. New York: Grosset & Dunlap. The authors inform readers of the dangers of many foods, drugs, and cosmetics, and also make suggestions about how ordinary people can defend themselves against these dangers.

Lamb, Ruth deForest. (1936). *American Chamber of Horrors: The Truth about Food and Drugs*. New York: Grosset & Dunlap. Despite the provisions of the Copeland Food and Drugs Bill, Americans continued to suffer from dangerous foods, drugs, and cosmetics, according to this author, who pointed to the need for further legislation.

Marsa, Linda. (1997). *Prescription for Profits: How the Pharmaceutical Industry Bankrolled the Unholy Marriage between Science and Business*. New York: Scribner. A history of the rise and fall of the American pharmaceutical industry from the Second World War through the 1980s, showing how the lure of large profits corrupted what was once a "golden age" of medical research.

Nestle, Marion. (2003). *Safe Food: Bacteria, Biotechnology, and Bioterrorism*. Berkeley and Los Angeles: University of California Press. The author argues that safe foods intimately involves politics, since billions of dollars and the safety of hundreds of millions of people are at stake.

Patrick, William. (1988). *The Food and Drug Administration*. New York: Chelsea House. The author analyzes how science, technology, and politics interacted in helping the British cope with serious problems of drug adulteration.

Stieb, Ernst W. (1966). *Drug Adulteration: Detection and Control in Nineteenth-Century Britain*. Madison: University of Wisconsin Press.

Temin, Peter. (1980). *Taking Your Medicine: Drug Regulation in the United States*. Cambridge, MA: Harvard University Press. Both a narrative of drug regulation and an analysis of how federal regulators came to distrust the ability of doctors and consumers to choose drugs for themselves.

Turner, James S. (1970). *The Chemical Feast: The Ralph Nader Study Group Report on Food Protection and the Food and Drug Administration*. New York: Grossman. A critique of the FDA for acting to benefit the gigantic American food industry at the expense of consumers.

Young, James Harvey. (1989). *Pure Food: Securing the Federal Food and Drugs Act of 1906*. Princeton, NJ: Princeton University Press. A historical study of how pure food advocates, chemists, and politicians cooperated to make the Pure Food and Drug Law into a reality.

FOOD SCIENCE AND TECHNOLOGY

Among the concerns of food science and technology are postharvest changes in substances that nourish human beings. Food science examines everything that can happen to food between harvest and consumption. Food technology is used to develop and manage the processes by which food is transformed from raw harvest to edible goods purchased by individual consumers. Almost all foods are modified before consumption. Only some fruits, nuts, vegetables, meats, milk, and eggs may be eaten raw. About three-quarters of all the calories consumed by humans worldwide are derived from rice, wheat, and corn (maize)—truly the staff of life in almost all societies—all of which must be processed to make their delivery of nutrients feasible.

Food science and technology draw on chemistry, microbiology, engineering, physiology, toxicology, nutrition, dietetics, economics, marketing, and law; therefore, food science and food technology are inherently interdisciplinary subjects rather than narrow disciplines. Because of the importance of food, this topic also raises a host of ethical issues, including professional responsibility, equity of availability, determination of levels of safety in regard to public health, risk to workers' rights, and informed consent among consumers.

Background

Along with the making of shelter and clothing, the securing and preparing of food constitute one of the oldest technical activities, being coeval with the emergence of *Homo sapiens*. Because of its importance, from the beginning of human society food appears to have been associated with a number of ethical judgments in the form of rituals and taboos. Gender differences in regard to food procurement evolved for natural reasons: Males were the hunters, and females were the gatherers and subsequently the crop cultivators. Anthropologists also focus on cultural aspects such as food as a means of asserting identity or group membership; the reciprocal effects of class or caste systems on foodways; communal eating and food as a means of bonding and hospitality; ritual aspects of food, for example, at funerals and weddings; and food taboos and food eaten for religious reasons—these so-called ceremonial foods include bread, wine, and oil, the first manufactured foodstuffs.

Two major changes allowed human populations to shift from nomadic hunting and gathering, which they had engaged in for hundreds of thousands of years, to living in settled communities. The first was the domestication of animals, probably beginning with that of the Asiatic wolf as an aid in hunting, around 13,000 years ago after the end of the last ice age. More significant was the keeping of lactating animals such as goats and sheep to guarantee a regular supply of milk, meat, and nonfood products. By approximately 10,000 years ago sheep had been domesticated in the area that is now Iraq, as were goats. Pigs were domesticated a thousand years later, and it took another thousand years before the wild aurochs had been transformed into cattle in the Balkan area.

The second achievement was the recognition of the relationship between plants and their seeds. This allowed a previously nomadic clan to settle in an appropriate landscape. With the receding ice, fields of wild grain or grasses with edible seeds appeared, and eventually women began to plant seeds in cleared areas.

Those two achievements were the key elements in what has come to be known as the Agricultural or Neolithic Revolution, which occurred during the New Stone Age, a period that began 11,000 years ago in southern Asia and 9,000 years ago in the Tigris and Euphrates river valleys, from where the new techniques began to spread. The agricultural revolution provided more and better food, promoting improved human fertility and longevity, and therefore increased human population numbers.

Differentiating between life-sustaining and harmful foods is probably an instinctive human behavior. People are drawn to carbohydrate-rich foods, which are generally sweet, and usually are repelled by alkaloidal products, which contain bitter toxic chemicals. An important discovery was that heat, such as that provided in cooking by fire or hot water, can alter the characteristics of food. The transformation of food materials by heat to make them consistently and predictably edible, flavorful, and spoilage-resistant developed into a practice that preceded techniques for deliberately changing inorganic materials, as in the making of pottery from clay some 30,000 years ago and then the use of metallurgy about 6,000 years ago, both of which contributed to cookery.

According to Harold McGee (1990), chemistry began with the "food chemistry" of ancestral cooks. The molecules those cooks transformed and manipulated were food molecules. Each time contemporary people prepare food for eating, whether in a large food-processing plant or in a kitchen, they replicate the origins of an art practiced since the harnessing of fire 125,000 years ago.

It was not until the Enlightenment and well into the Industrial Revolution that food became a focus of scientific study. It was the modern period as well that witnessed the related developments in public health, medical nutrition, and mechanization in food processing, especially for mass production. The adaptation of mass production technologies to agricultural production and food processing radically transformed human-food relations. Those processes made it possible for smaller numbers of food workers to support larger numbers of food consumers, thus promoting urbanization on an unprecedented scale. That urbanization led to new technologies of preservation, transportation, and marketing; inspired scientific studies of nutrition (because in many instances the new technologies altered the balances in traditional diets); and raised ethical issues about the treatment of food processing workers as well as equity in access and distribution (which previously had been subject to the negotiations characteristic of traditional cultures).

Nevertheless, the basic objectives of assuring a satisfactory supply of food did not change. Those objectives only become more visible, controllable, and subject to management. Indeed, only new insights and improved techniques can assure a continuing stream of food products for the growing human population.

The Perennial Vital Objectives

All functioning modern societies attempt to provide people with foods that are readily available, abundant, affordable, appealing, appetizing, nutritious, and safe. Agriculture (including fisheries), along with food science and food technology, is essential in meeting those goals. Since prehistoric times the objectives related to feeding a clan or a larger community have been optimization of harvest yields, prevention of losses, achievement of edibility, and protection of food integrity factors such as flavor, texture, color, and nutrition.

The food system—the path from soil to mouth or from farm to fork—is a precarious one. Numerous technologies are involved in the modern effort to bring food to consumers. Much can go wrong, and much depends on climate and other natural forces. However, human ingenuity, a multitude of tools, and technological interventions are the critical factors in seizing life-sustaining products from nature. Then all foods must be protected during the transfer from their production habitats to their final destination. The notion of a carefree dependence on the abundance of nature is far removed from reality.

Each food product on the shelves of grocery stores can be traced through its passage from harvest (including slaughtering and fishing) to channels of transportation and then to storage, packaging, and distribution until it is purchased for preparation in a consumer's kitchen or an efficient mass-feeding facility. About half of all dollars spent on food consumption in the United States at the beginning of the twenty-first century was expended in eating away from home.

Other animals compete with humans for the products of nature. The biblical scourges of locusts are a familiar example, but it is mainly invisible competitors that take the most. Bacteria, molds, yeasts, and even viruses consistently make foods unavailable, inedible, or the cause of disease. Only a few microorganisms have been put to positive use, mainly in fermentation. Because eradication is impossible, pest control is a major activity and expenditure for farmers and food processors and even for the food service industry and some householders. This war against microscopic competitors is waged most effectively with chemical weapons and must be affordable and properly done.

Current agricultural pesticides are largely products of the 1950s. As with all technological interventions, it soon was realized that there was a side effect in that pesticide residues on and in foods could be harmful to human health and to the environment. A typical quandary is the war against food pests. This battle involves powerful weaponry to assure an abundance of crops and may do damage to people as a side effect.

In addition to rodent, insect, and microbiological losses numerous chemical changes occur in foods that have unpleasant results. Soured milk, bitter rice, rancid fatty food, and other unpalatable edibles are thrown away. Not even animals are fed with them because their owners suspect the presence of toxic substances. The losses to the "food system" and to society are obvious. Equally obvious is the fact that such losses, along with food deterioration overall, can be avoided to a large extent through the judicious application of food technologies. That constitutes the major preoccupation of modern food processors and handlers, the custodians who take possession of food after harvesting and deliver it to end users in the expected qualities and quantities.

Food losses and food waste are enormous, although no accurate data exist. Ironically, in places where food crops are usually scarce, often because of a lack of technological intervention but also as a result of natural disasters, personal wastage is rare. In the developed parts of the world, where technology assures an abundance of food, there is usually gross disregard for optimal personal food utilization. Examples include tray waste in institutional facilities and careless housekeeping practices.

Food protection spans the spectrum from seeds to the moment of consumption. The initial responsibility lies with food producers. Agricultural research began in the nineteenth century. It has always been devoted mainly to production studies that have culminated in the use of chemical, mechanical, computer, and more recently bioengineering technologies. Each technology has had opponents, has sparked heavy discussion, and has been improved as a result. One insight has become clear: Without science and appropriately applied technologies improvement of the human condition would be slow, difficult, and painful.

Food Processing

From cutting to gamma-irradiation, the subject of food processing involves dozens of operations. Only a few can be mentioned in this brief overview. At the heart of food technology are several processing operations that are used to modify foods primarily to preserve them for later consumption. Water removal is one way to preserve a food: Raisins last longer than grapes, cheese and sausages can be stored for long periods, fruits can be converted to fermented beverages, and grains can be made into beer. In all these cases, the original food disappears but the nutritive value is preserved.

Another method of preservation is the use of chemicals, such as acids, that are antagonistic to spoilage microorganisms. During the 1990s about 5,000 people died every year in the United States from bacterial food poisoning. The human toll from poisoned food was almost unbelievably high until the advent of food technology, along with hygienic measures and medical advances. Vinegar, yogurt, and pickled foods are examples of acid-preserved foods.

The pickling of vegetables has a long history, especially in China, and has relied primarily on the use of salt (sodium chloride). The history of salt, which is considered the first "food" of commerce, is interwoven with that of food preservation (Kurlansky 2002). A high sugar content also preserves food, as in the case of candied fruit and confectionery products. The inspiration must have come from honey, the original natural preserved food.

Modern food markets provide evidence that almost everything people eat is modified before consumption. The rationale of most processing is to protect a food until it is consumed, and an understanding of food chemistry and microbiology is essential in that endeavor.

The simplest way to defeat microorganisms is to remove the water that is vital to them. Most foods that are not dried properly spoil very quickly, but substances antagonistic to microorganisms can be added directly or indirectly, as in lactic and alcoholic fermentations. The result is not only protection but also better nutrient availability and palatability. Lactic acid fermentation utilizes the destructive and digestive ability of certain microorganisms for human advantage, as in the cases of fermented cabbage and yogurt. The production of vinegar, beer, and wine provides examples of acetic and alcoholic fermentation. Other preservatives are microbial inhibitors such as spices, herbs, and salts.

Inhibition of oxidation is achieved mainly by means of the addition of antioxidants. Foods that are rancid or have lost flavor or color are considered spoiled. The mechanism is driven largely by enzymes native to foods but also by oxygen in the air. Consequently, air exclusion is a preservative technique. The first efforts at producing and sealing sterilized food were not made until the late 1700s, and plastic wraps and packaging under nitrogen were not used until the mid-1900s.

Canning is the most noteworthy achievement in food technology. It was invented by Nicolas Appert, who in 1790 in Paris preserved heated foods in bottles. Twenty years later the food-canning industry was born when the first "tin" cans were produced in England. Only with the 1864 work of Louis Pasteur on bacteria and asepsis did it become possible to understand the principles behind this food preservation technology. It was not until 1928 that Charles Olin Ball worked out the mathematical formula that made the thermal processing of foods possible. All heat sterilizing procedures in food and pharmaceutical industries in the early twenty-first century rely on Ball's work.

Legal and Ethical Issues

In 1939 in the United States the Institute of Food Technologists (IFT) was created. Similar professional associations now exist in most major countries. This represented the beginning of the coordination of all research activities and industrial development work involving foods. By 1960 several university food science departments had emerged. In the early 2000s there are nearly fifty in North America, and the IFT, headquartered in Chicago, has almost 30,000 members. This professional association publishes a number of journals and organizes well-attended annual meetings and expositions. Its mission is to establish and promote standards of professional excellence at local as well as international levels. The IFT fosters communication, contributes to public policy, and helps individuals achieve career goals. Along with its counterparts in other countries, it embraces objectives such as combating hunger, enhancing the quality of foods, and stimulating progress in the food technology industries.

IFT lists six core values in its current strategic plan:

- Act with integrity
- Foster inventive and adaptive leadership
- Demonstrate responsible stewardship
- Focus on members
- Value diversity
- Chanmpion sound science in the interest of public well-being

IFT's counterpart in the UK, the Institute of Food Science and Technology, has a somewhat more explicit code relating to ethics. Its 10 professional conduct guidelines are entitled:

- Wholesomeness of food
- Relations with the media
- Confidentiality of information
- Conflicts involving professional ethics
- Duties towards subordinates
- Scientific issues and food promotion
- Responsibilities towards students
- Responsibilities towards the environment
- Members' business interests
- Responsibility to the profession

A number of activist groups have emerged with an interest in food technology. Greenpeace International is probably the best-funded and declares to "exist because this fragile earth deserves a voice, it needs solutions, it needs change. It needs action."

The Food Ethics Council was established in 1998 in England as a charitable trust. It has reported on such ethical issues ranging from drug use in farm animals to intellectual property in agriculture research.

It was inevitable that governments would take an interest in the food supply. Modern American food law began with the Food and Drug Act of 1906, also called the Pure Food Law. In 1938 it was redone as the Food, Drug, and Cosmetic Act, with amendments. The U.S. Food and Drug Administration (FDA) enforces this law through an elaborate set of regulations. Other agencies share this responsibility, including the U.S. Department of Agriculture, the Federal Trade Commission, and the Bureau of Alcohol, Tobacco, Firearms, and Explosives.

Food regulatory work often is subject to criticism. The public can get involved in the rulemaking process, but it is mainly consumer advocates along with trade associations and only occasionally individuals that participate.

At one time mainly unprocessed and raw foods were consumed, but then cookery, pasteurization, and sterilization created the category of mildly processed foods. Milling, brewing, refining, dairy processing, and many other food operations that frequently relied on the use of so-called food additives and blending with other ingredients provided what often is termed highly processed or reformulated foods.

The newest category in this area is synthetic food, which can be thought of as engineered edible systems. An imitation orange drink powder that could be reconstituted with water at home or during space flight was the first example, appearing in the 1970s. Except for the sugar in it there is no agricultural ingredient, and the sugar could be replaced with a synthetic sweetener to make it a diet beverage or a food for diabetic persons.

It can be said that a gradual merging of the food and pharmaceutical industries is under way. The word *nutraceutical* was coined in the 1990s, and with it came many foods and food components, including beneficial bacteria, that are claimed to have health-providing properties beyond those of traditional essential nutrients such as vitamins, amino acids, and certain minerals. Opportunities to defraud the public with scientifically unproven benefits are tempting; the subject of nutritional claims is debated hotly and is only in the early stages of governmental supervision.

Since biblical times human societies and their leaders have been interested in regulating trade and safeguarding foods. Food protection has economic and public health implications: People must be protected from cheaters and poisons. Because misrepresentation and adulteration can be inadvertent as well as deliberate, a legal and regulatory framework was needed to address these concepts and allow modern societies to function smoothly and safely.

The English Assize of Bread and Beer (*assissa panis et cerevisiae*) of 1266 attempted to control the quantity (weights and volumes) of food sold by merchants, not its quality. That law established strict penalties whose basic principles would be adopted by settlers in North America hundreds of years later. Adulteration was rampant, and the tools to detect it were lacking. In 1820 Frederick Accum, a German chemist and pharmacist living in London, published his *Treatise on the Adulteration of Food and Culinary Poisons*. Microscopy was an emerging technology that became the first analytical tool to verify food adulteration, mainly in the detection of rodent hairs and feces, insect fragments, and foreign objects such as dirt and unwanted plant matter. Chemical analysis has become a more powerful tool since that time, and the food laws of many nations stipulate the employment of food analysts and analytical methods. It is now possible to detect the presence of objectionable environmental chemical contaminants in trace amounts that are not significant in physiological terms, that is, amounts considered inconsequential.

Just as the law does not concern itself with trifles, the law of Paracelsus states that a small amount of a toxin is not worth considering because it has no effect. Parcelsus taught that "the dose makes the poison," and it can be demonstrated that a grain of salt has no effect on a living organism but that a cupful is deadly. Similarly, too much of a good thing may be harmful, as evidenced by the contemporary overconsumption of calories, especially in affluent societies. Sixty-five percent of Americans were considered obese at the start of the twenty-first century, and obesity is becoming the number one human health hazard. Discussion has begun about where to lay the blame for this phenomenon. Some have pointed to the "fast-food" industry as the primary culprit, ignoring free will, discipline, and responsibility.

The concept of American fast food also touches on ethical issues and may have spawned the "slow food" movement that arose in Italy in the late 1990s, presumably to resist the replacement of culinary traditions and the disappearance of local food varieties; however, it also might have been the product of anti-Americanism, anticapitalism, and antiglobalization. All over the world, especially in developing areas, the introduction of "Western food" constitutes a threat to indigenous food crops and processing operations that have been practiced by women for centuries. The enrichment of a local diet is welcome from a nutritional standpoint, but it also is believed to undermine the potential for self-sufficiency and the value of indigenous knowledge. Entomophagy is widely accepted and always has been: Some five hundred insect species serve as food sources worldwide. The subject of underutilized species has been dealt with by the many organizations, and as a result new foods have been "unearthed." The fungal protein quorn, manufactured in the United Kingdom and sold as a meat substitute, is an example. Other potentials are seen in leaf protein concentrate, processed plankton or cellulose, and recycled waste products.

The Future

The newest trend in the food field is genetic engineering. Apart from drug manufacturing it is applied mainly in production agriculture and involves recombinant DNA and cell fusion techniques. The driving force behind this food biotechnology is the creation of higher yields from plants and animals. Critics argue that the driving force here is not a humanitarian spirit but corporate greed. Related objectives of the new biotechnology are foods with improved nutritional properties, such as the Swiss-originated vitamin A-enriched rice that is claimed to combat childhood blindness in Asian areas and the production of crops with better utilization/processing potential, including better flavor. Many of these products are already on the market. However, there has been vigorous political and even religious debate over these genetically modified (GM) crops and foods, even over GM drugs such as insulin.

New enzymes derived from GM microorganisms are being used in food processing. Indeed, knowledge about genetic maps and the amino acid sequences of proteins makes it possible to tailor-make food ingredients with specific desirable functions and properties. Among the 150 microbial enzymes in use for food production more than 40 are produced from GM microorganisms. It is surprising to many people that practically every item on an American restaurant menu has been subject to genetic modification. Since the introduction of GM foods in the 1980s a quiet revolution in the food supply has been under way. Worldwide, 46 percent of soybean acreage and 7 percent of corn fields were sowed with transgenic crops in 2001. No transgenic animals are used in food, mainly because of ethical barriers.

Disagreement about the safety of GM foods is rooted in the differences between American and European regulatory principles: regulation of the nature of the product in the United States versus regulation of the manner in which a product is produced in Europe. One consequence of the debate was the refusal in 2002 by the Zambian government to receive food aid from the United States because it involved GM food.

All new technologies seem to be accompanied by early resistance. GM crops have been embraced in the developing parts of the world, as was discussed during the Twelfth World Congress of Food Science and Technology in 2003. Food scientists are bracing themselves as the era of GM foods is unfolding. One challenge is to develop analytical methods that will differentiate between a GM species and a conventional one. The current debate seems to indicate that consumers wish to have a choice in selecting one or the other, and regulators may be charged by policymakers to monitor the trade in and consumption of these foods.

Food technology has improved the lot of humankind, but the work is far from over. Better tools will be designed, and it will be necessary to engage in transfers of food technology and institute governance, education, and transportation infrastructures so that no needy individual is left behind.

MANFRED KROGER

SEE ALSO *Agricultural Ethics; Biotech Ethics; DDT; Food and Drug Agencies; Green Revolution; Genetically Modified Foods; Nutrition and Science; Organic Foods.*

BIBLIOGRAPHY

Davidson, Alan. (1999). *The Oxford Companion to Food.* Oxford: Oxford University Press. Considered to be the opus magnum from one of the world's great authorities on the history and use of food. It has 2,560 A-Z entries on 892 pages including 40 feature articles on staple foods.

Encyclopaedia of Food Science, Technology and Nutrition. (1993). London: Academic Press. About 1,000 entries written by international experts. The eight volumes contain 5,364 pages; agricultural aspects are not covered.

Kass, Leon R. (1994). *The Hungry Soul—Eating and the Perfecting of Our Nature.* New York: Free Press. An exploration of the natural and cultural act of eating; how homo sapiens has humanized eating, even though it is an urgent and basic animal necessity.

Kurlansky, Mark. (2002). *Salt—A World History.* Toronto: Alfred A. Knopf Canada. The long and intriguing history of the "only rock we eat" is also a very important part of humankind.

McGee, Harold. (1990). *The Curious Cook: More Kitchen Science and Lore.* San Francisco: North Point Press. An investigation into culinary problems and dogma, telling in plain English what science has discovered about the food we eat.

Pyke, Magnus. (1970). *Food Science and Technology,* 3rd edition. London: John Murray. Throughout his career the author has drawn attention to the importance of food technology and nutrition via a dozen books and numerous radio broadcasts and public lectures.

Toussaint-Samat, Maguelonne. (1992). *A History of Food,* trans. Anthea Bell. Cambridge, MA: Blackwell. A comprehensive 801-page reference history of foodstuffs, the story of cuisine, and the social history of eating, from the origins of mankind to the modern-day technological era.

Trager, James. (1996). *The Food Chronology.* London: Aurum Press. A sweeping and entertaining 783-page overview of the cultural development of food and food availability throughout human history.

Wiley Encyclopedia of Food Science and Technology, 2nd edition. (2000). New York: Wiley. The four volumes contain articles by 368 contributors around the world with information useful to food engineers, chemists, biologists, ingredient suppliers, and other professionals.

FORD, HENRY

The American automobile manufacturer Henry Ford (1863–1947) is, along with Thomas Edison and the Wright Brothers, one of those who best symbolized the use of technology to transform human life in the early twentieth century. Ford himself recognized the social orientation of his efforts. As he explained in his 1922 autobiography, he believed that successful manufacturing was rooted in public service rather than in money making. He was equally clear about his own public service goal: "To lift farm drudgery off flesh and blood and lay it on steel and motors has been my most constant ambition." Somewhat unexpectedly, however, his focus shifted when he discovered "that people were more interested in something that would travel on the road than in something that would do the work on the farms".

Ford was born on a farm in Wayne County, Michigan, on July 30 and died in Dearborn, Michigan, on April 7. As a boy he experienced the agrarian way of life that once had dominated the American economy but that during his lifetime, in part as a result of his efforts, would be replaced by manufacturing. Among the relevant features of his youth were his education in rural schools (1871–1879), the early death of his mother (1876), and his fascination with machinery. That interest led to an apprenticeship in nearby Detroit (1879–1882) and a traveling job servicing steam traction engines. After his marriage in 1888 Ford's father gave him a forty-acre farm, but rather than take up farming, Henry Ford and his wife moved to Detroit, where he became an engineer for the Edison Illuminating Company.

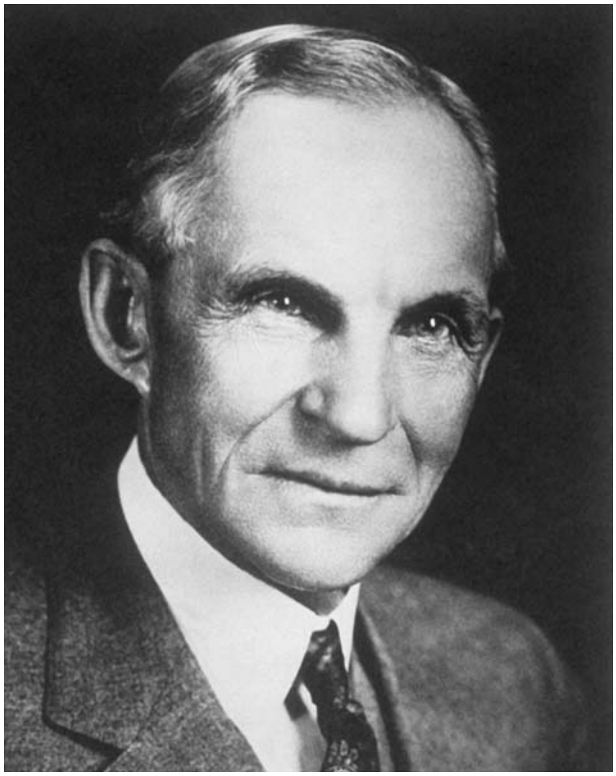
Automobile Manufacturing

By the early 1890s, when Ford turned his attention to using internal combustion engines to power road vehicles, the effort to develop automobiles had been under way for several decades. By that time American manufacturers had incorporated the general principles of machine production, interchangeable parts, and cost-based management, along with other practices of the factory system and large-scale business. Thus, Ford began neither the specific process of creating automobiles nor the overall process of industrialization. However, he would achieve lasting fame as well as notoriety by helping bring both processes to full maturity.

Ford's historic achievement was twofold. First, he rethought the basic idea of the automobile (making him more an innovator than an inventor), by aiming not for a large luxury vehicle but for one that was light and sturdy enough for unimproved rural roads and inexpensive enough for the average family. Second, he, along with the mechanics and engineers he employed, redesigned the manufacturing process to allow for the mass production of a product of unprecedented complexity.

The main features of this frequently told story include the completion of Ford's first experimental car (1896), his early interest in building race cars (driven by Barney Oldfield), the formation of the Ford Motor Company (1903), the introduction of the Model N (1906), and the successful challenge of the Seldon patent (1911), which ruled that George B. Seldon, a Rochester lawyer who was issued a patent in 1896 for the horseless carriage, was not entitled to a royalty for each car manufactured. However, looming over everything else was the Model T. First sold in 1908 for $825, the Model T remained in production until 1927, by which time 15 million had been made and the price had dropped to $290.

To lower costs and increase output, the company adopted the practices of progressive assembly at its Highland Park plant. The capstone of that effort was the continuously moving assembly line for attaching the various components to the chassis, which was put in place during the winter of 1913–1914. Although not a direct application of scientific management, Ford's system bore similarities to it, including the dramatically higher pay rate of "the Five Dollar Day" (1914). During and after World War I the company went on to construct the River Rouge plant, where production of the Model T achieved a high degree of vertical integration.



Henry Ford, 1863–1947. After founding the Ford Motor Company, the American industrialist developed a system of mass production based on the assembly line and the conveyor belt which produced a low-priced car within reach of middle-class Americans. *(AP/Wide World Photos.)*

This system was widely admired, copied, detested, and critiqued. Its place in the modern psyche can be seen in widely different cultural products, such as Charlie Chaplin's performance in the film *Modern Times* (1936) and the convention for numbering years that Aldous Huxley devised in *Brave New World* (1932): "A.F." for "After Ford."

Achievements and Criticism

Those achievements must be attributed to many people in addition to Henry Ford. Nevertheless, Ford personally led the enterprise. Before World War I the result was a highly favorable public image. However, "the Five Dollar Day" was accompanied by the systematic investigation by the Ford Motor Company of individual workers outside the plant, and after World War I that arrangement was replaced for the most part by a more traditional approach involving company spies and threats of violence. Meanwhile, with wealth and power also came the expression of personal idiosyncrasies. A newspaper Ford owned, for example, propounded anti-Semitic views that later struck a resonant chord in Nazi Germany.

From the vantage point of the present, however, probably the most significant of Ford's shortcomings was his failure to give up personal control of the company he had founded. He consolidated that control after World War I and held on to it until almost the time of his death. One result was continued production of the Model T until the company had saturated its market, making more difficult the conversion to other models (the Model A in 1928 and the V-8 engine in 1932). Limitations also can be seen in other products the company attempted to produce: submarine chasers during World War I and farm tractors and trimotor commercial aircraft in the interwar years. Even when the products were well conceived, problems arose with production or marketing; those problems could be traced back in part to Ford's personal control of the company.

Although the Ford Motor Company was his primary achievement, Henry Ford created other organizations of lasting importance, including the Ford Foundation and The Henry Ford (formerly the Henry Ford Museum and Greenfield Village) in Dearborn, Michigan.

THOMAS D. CORNELL

SEE ALSO *Automobiles; Edison, Thomas; Taylor, Frederick W.*

BIBLIOGRAPHY

Ford, Henry, with Samuel Crowther. (1922). *My Life and Work*. Garden City, NY: Doubleday. The first of several co-authored books that presented Ford's views and life story to the public.

Hounshell, David A. (1984). *From the American System to Mass Production, 1800–1932: The Development of Manufacturing Technology in the United States*. Baltimore and London: Johns Hopkins University Press. Places Ford's technological achievement in the context of the larger trend toward mass production.

Meyer, Stephen III. (1981). *The Five Dollar Day: Labor Management and Social Control in the Ford Motor Company, 1908–1921*. Albany: State University of New York Press. Explores the practices of Ford's company as a social system of production.

Nevins, Allan, and Frank Ernest Hill. (1954). *Ford: The Times, the Man, the Company*. New York: Charles Scribner's Sons.

Nevins, Allan, and Frank Ernest Hill. (1957). *Ford: Expansion and Challenge, 1915–1933*. New York: Charles Scribner's Sons.

Nevins, Allan, and Frank Ernest Hill. (1963). *Ford: Decline and Rebirth, 1933–1962*. New York: Charles Scribner's Sons. These three books by Nevins and Hill remain the most detailed treatment of Ford and the company he founded.

Wik, Reynold M. (1972). *Henry Ford and Grass-Roots America*. Ann Arbor: University of Michigan Press. Explores Ford's impact on popular culture.

FORD PINTO CASE

Events in the 1970s related to the Ford Pinto automobile illustrate some of the ethical issues related to technology and safety. In an effort to produce a stylish but affordable subcompact automobile with a low operating cost, Ford Motor Company management made a questionable decision regarding the positioning of and protection for the fuel tank. A safer gas tank and tank location were technologically feasible, but consumer affordability and style took precedence over safety. Ford engineers were constrained by design and cost limitations, and the case therefore illustrates how engineering decisions are often made in the context of marketing strategies. For example, the car was designed to have a short rear-end, perhaps in imitation of the extremely popular Ford Mustang. This limited the engineers' alternatives for fuel tank safety and placement. The tank was placed behind the rear axle instead of over-the-axle, a safer location that had been used in the Ford Capri. Critics charged that this decision was a result of the reduction in trunk space caused by the over-the-axle placement. Another example of a limitation on the engineers was that management apparently mandated that the car cost no more than $2000 and weigh no more than 2000 pounds. If these limitations were really stipulated, then the engineers would have been constrained in many areas related to safety. Given these design and cost limitations, is it fair to hold the engineers morally responsible for the preventable pinto fire injuries and deaths? Other issues illustrated by the Pinto events relate to the definition of *safety*, the appropriate responsibilities and professional obligations of engineers, the interactions between different parts of organizations, ethical management decision-making, and effective government safety policies.

For example, "safety" can be understood to mean "acceptable risk of harm," but how much risk is acceptable in a subcompact automobile? Additionally, did the engineers have a professional obligation to reject the Pinto design elements and management directives that seriously compromised safety? Should Ford management

People examining close-ups of a Ford Pinto wagon in the basement of a courthouse. The wagon was used as evidence in a murder trial resulting from a fatal accident in which the gas tank exploded upon collision. *(Art Shay/Getty Images.)*

have had the final word on the Pinto design or should the engineers have had a "veto" related to safety? If management really placed marketing considerations above safety, was that objective ethical and are members of management morally responsible for the preventable Pinto fire deaths? Finally, was the National Highway Traffic Safety Administration ineffective or unethical because the Ford Pintos always complied with all the government standards?

Ford produced the Pinto automobile from 1971 to 1980. Initially the car sold well, but a defect in early models made Pintos prone to leaking fuel and catching on fire after relatively low-speed, rear-end collisions. The Pinto's gasoline tank was located behind the rear axle. A rear-end collision of about twenty-eight miles per hour or more would crush the car's rear end, driving the fuel tank against the differential housing and causing it to split and the filler pipe to break loose. Sometimes the spilled fuel and sparks from the crash caused fires that produced fatalities or serious burns. Many such victims or their relatives filed civil suits against Ford Motor. This litigation generated damaging publicity for Ford and for the Pinto, and it increased public concern over fuel system integrity in general. In 1976 the National Highway Traffic Safety Administration (NHTSA) implemented a rear-impact safety regulation. The 1977 Pintos were in compliance with this standard, but earlier Pintos were not required to be in compliance and did not meet the standard. Responding to publicity about the Pinto's poor safety record, the NHTSA crash-tested some early Pintos and in 1978 announced that a safety defect existed in the fuel systems of 1971–1976 Pintos. With an NHTSA public hearing scheduled, Ford recalled the 1971–1976 Pintos to upgrade fuel system integrity.

The improvements to the 1977 and subsequent model-year Pintos and the recall of the earlier ones should have solved Ford's Pinto fuel system problems. In September 1978, however, an Indiana grand jury indicted Ford on three felony counts of reckless homicide. This indictment was related to an accident in which, after a van rear-ended a Pinto in an allegedly low-speed collision, three young women burned to death. In contrast to the previous Pinto cases, this one was a criminal trial, not a civil suit. Ford was found not guilty on all the charges because the corporation's lawyers persuaded the jury that the crash was not, in fact, a low-speed one, and hence the deaths did not result from

Ford's having kept a lethal vehicle in production in spite of an obvious fatal flaw. Ford stopped producing the Pinto after 1980, having sold about 3 million of the vehicles.

DOUGLAS BIRSCH

SEE ALSO *Automobiles; Engineering Ethics.*

BIBLIOGRAPHY

Birsch, Douglas, and John Fielder. (1994). *The Ford Pinto Case*. Albany: State University of New York Press. Includes the basic documents needed to understand the case and articles that discuss the ethical issues related to it.

Cullen, Francis; William Maakesstad; and Gray Cavender. (1987). *Corporate Crime under Attack: The Ford Pinto Trial and Beyond.* Cincinnati, OH: Anderson Publishing. Contains a section on corporate crime and the movement to control it and another part on the Indiana criminal trial of ford motor company related to three pinto fire fatalities.

Strobel, Lee Patrick. (1980). *Reckless Homicide? Ford's Pinto Trial.* South Bend, IN: And Books. Discusses the Indiana criminal trial in which Ford Motor Company was found not guilty on three counts of reckless homicide.

FORENSIC SCIENCE

The word forensic is derived from the Latin word *forensic*—a reference to Roman court forums in which evidence of wrongdoing was presented. Modern use of the term forensics refers to scientific principles and processes that are applied in the analysis of evidence for legal purposes. Alternatively known as *criminalistics*, forensics involves using sophisticated techniques and tools to identify, collect, analyze, preserve, and present evidence of crimes or civil wrongdoing in legal proceedings, as well as to verify identification of deceased individuals. The essential goal of forensics analysis is to verify connections between two or more physical items, for example, the blood of a homicide victim to that found on clothes worn by a suspect. Forensics involves analysis of many other types of evidentiary items such as prescription and illicit/illegal drugs, metals, glass, plastics, fuels, paints, tire/shoe prints, tool/tool marks, and latent substances such as synthetic fibers, human hair, and animal fur, among others.

Modern forensics began with nineteenth-century efforts of Alphonse Bertillon (1853–1914), director of the Bureau of Criminal Identification of the Paris (France) Police Department, to classify and identify criminals on the basis of their physical characteristics. In 1888 Francis Galton proposed a fingerprint classification method after which fingerprinting was first used for criminal identification by Scotland Yard investigators in 1901, and by New York City detectives in 1902. By 1930 the Federal Bureau of Investigation (FBI) of the U.S. Department of Justice had established a national fingerprint classification system, and in 1946 the FBI created its Identification Division that relied extensively on burgeoning fingerprint records for suspect identification in criminal cases. Since then the FBI lab has helped solve thousands of criminal cases using many forensics analysis methods, and is among the largest and most technologically capable forensic laboratories in the world.

Types of Forensics Evidence and Analysis

There are many types of forensic methods, each of which corresponds to the kind of evidence analyzed. For example, ballistics is the study of firearms, ammunition, bombs/explosives, bullets, and other projectiles. Forensic anthropology attempts to reconstruct the likeness of decomposed or dismembered bodies based on skeletal remains and other factors. Forensic odontology matches bite marks with teeth or dental records; and forensic entomologists study corpses infested with insects to determine the approximate time of death and other information. Forensic psychology and psychiatry seek to profile criminals, and also apply social work and mental health counseling practices to investigative situations. Forensic toxicology involves analysis of intoxicants, drugs, and poisons. Forensic taphonomy pertains to the examination of dead and decaying human, animal, and plant remains.

The most modern, prominent, and scientifically promising form of forensics is DNA analysis profiling which involves comparison of deoxyribonucleic acid found in human body tissue or fluids such as blood, perspiration, urine, semen, or vaginal secretions. In addition, biometrics analysis is used in forensics to verify identification of people by comparing biological traits such as finger/palm prints and iris or retina cell patterns. Other forms of forensics involve toxicology (the study of poisons and their harmful effects), computer forensics, voiceprint identification, and polygraph examinations (lie detector testing). In addition to determining the sources of criminal evidence and matching these to known sources, forensics also involves crime scene reconstruction—examining evidence to determine the nature of activities and physical dynamics of interactions among perpetrators and crime victims, series of events, directions of travel, angles and relative forces of impact, pre/post impact trajectories, and primary versus secondary causes of harm, and more.

Fundamental and Ethical Challenges in Forensics

Primary challenges in forensics pertaining to the overall validity, reliability, and credibility of evidence presented in court cases involves:

1. protecting evidence from harm before, during, and after its collection at crime scenes and in laboratories and evidence storage facilities;
2. accurately analyzing evidence and truthfully presenting findings in legal proceedings to help explain how crimes occurred and the possible guilt or innocence of individuals accused of crimes;
3. developing and maintaining expertise of forensics professionals through training;
4. acquiring, certifying, and maintaining laboratory equipment;
5. providing managerial oversight to ensure accurate analyses and truthful reporting of findings in legal proceedings;
6. truthfully testifying about analytical methods, findings, and credentials of examiners;
7. achieving laboratory accreditation by one or more nationally recognized professional membership associations.

Criticism of and concern about forensics analysis has involved all the challenges listed above. In addition, so-called *voodoo science* or *junk science* refers to the reality that all forms of forensics analysis require professional judgment in determining whether evidence collected at crime scenes matches known-source samples to the exclusion of all other possibilities. In many types of forensics analysis there is no scientific basis for employing statistical probability modeling to accurately estimate the chances that one or more evidentiary items are *not* a perfect match. Fingerprint analysis, for example, although long accepted by courts as a type of scientific evidence is actually a technical art predicated on the belief that no two people have exactly the same print patterns and that professionals conducting tests sought exculpatory evidence in addition to match points. This fundamental problem extends to other types of forensics analysis, and when combined with numerous legal cases in which forensics experts lied about their analytical findings and/or professional credentials, has resulted in considerable controversy about the reliability of evidence collection and forensics analysis procedures, and the trustworthiness of testimony in legal proceedings about forensic analysis/laboratory findings.

In *Daubert v. Merrell Dow Pharmaceuticals, Inc.* (1993), the U.S. Supreme Court scrutinized the field of forensics and established new legal standards regarding the admissibility of scientific evidence and expert witness testimony provided by forensics professionals. Standardized DNA evidence gathering and analysis championed by the National Institute of Justice of the U.S. Department of Justice, and acceptance of this form of truly scientific evidence by federal, state, and local level criminal justice systems, is important to the future of forensics, as are quality control standards such as those established by the American Society of Crime Lab Directors/Laboratory Accreditation Board. Ultimately the usefulness and reliability of forensics evidence in legal proceedings will depend on ethical (and potentially government regulated) use of forensics technologies in the public sector and in privately owned or operated laboratories.

SAMUEL C. MCQUADE, III

BIBLIOGRAPHY

Bevel, Tom. (1997). *Bloodstain Pattern Analysis: With an Introduction to Crime Scene Reconstruction*. Boca Raton, FL: CRC Press.

Cole, Simon A. (2001). *Suspect Identities: A History of Criminal Identification and Fingerprinting*. Cambridge, MA: Harvard University Press.

Daubert v. *Merrell Dow Pharmaceuticals, Inc.*, 509 US 579 (1993).

Fisher, David. (1995). *Hard Evidence: How Detectives Inside the FBI's Sci-Crime Lab Have Helped Solve America's Toughest Cases*. New York: Simon & Schuster.

Galton, Francis. (1888). "Personal Identification and Description." *Nature* 201–202.

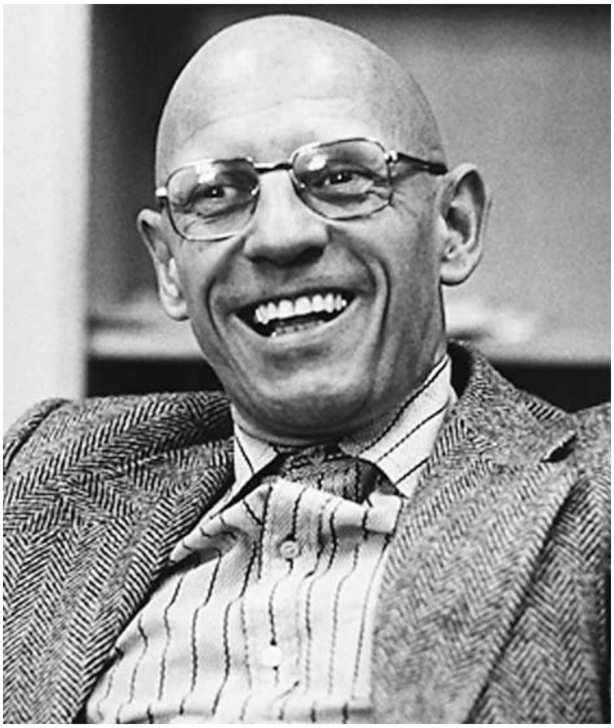
James, Stuart H., and Jon J. Nordby, eds. (2003). *Forensic Science: An Introduction to Scientific and Investigative Techniques*. Boca Raton: CRC Press.

National Research Council. (1992). *DNA Technology on Forensic Science*. Washington, DC: National Academy Press.

Schmalleger, Frank. (2005). "The Future of Criminal Justice." In *Criminal Justice Today: An Introductory Text For The Twenty-First Century*, 8th edition. Upper Saddle River, NJ: Pearson/Prentice Hall.

FOUCAULT, MICHEL

Michel Foucault (1926–1984), who was born in Poitiers, France on October 15 and died in Paris of AIDS on June 25, was a controversial philosopher whose interdisciplinary work has important if indirect implications for



Michel Foucault, 1926–1984. The French philosopher, critic, and historian was an original and creative thinker who made contributions to historiography and to understanding the forces that make history. *(© Corbis-Bettmann. Reproduced by permission.)*

science, technology, and ethics. His research often changed directions—archaeology and genealogy as ideas, history of the present, problematization, and modes of subjectification were prominent. In his final years he viewed these directions as theoretical tools to examine three perennially related but distinct relations: to truth, to power, and to self. Foucault was sufficiently intrigued by various sciences and technologies to devote much of his work (and personal involvement) to analyzing and questioning how they increasingly engage formative and dangerous aspects of human life.

Four themes with ethical implications highlight this intrigue. They are space, vision, biopolitics, and art of the self. Among humans space is seldom only a natural given. People instead design, build and defend, or violate a variety of spaces. Some illuminate ideals (utopias), many are ordinary (common domains), while others are designed for extraordinary times or unfamiliar figures (heterotopias). Asylums, hospitals, schools, and military camps are built to distinguish rituals and events (treating the mentally ill or sick, transforming adolescents or enlistees) that specifically aim to change our body, conduct, and self-understanding. Foucault studied how these spaces emerged, but also questioned their effect on human freedom, individuality, and justice.

Related to the technology of space are innovative kinds of vision. Obviously instruments such as the microscope introduce surprising ways to diagnose the body. Institutions repeatedly introduced strategies for observing the human body. Employing these different visions has two effects. First it renders individual subjects silent, because they are observed at a distance while their own words are discounted. Second this distance ushers in an allegedly more scientific understanding of human beings.

These effects are strikingly presented in the 1975 landmark book, *Discipline and Punish*. The book opens by juxtaposing an elaborate torture spectacle in 1757 Britain with a prison scene in 1838 France. A sign of moral progress in modern Europe? Not entirely. While English philosopher Jeremy Bentham's (1748–1832) design of an ideal prison, the Panopticon (literally, *all seeing*) was itself a practical failure, it paved the way for a radical shift from punishing the criminal to focusing on potentially deviant or abnormal persons—anyone, in principle. The result is a disciplinary society, one bent on surveillance and control. With typical rhetorical flair, Foucault asked, "Is it surprising that prisons resemble factories, schools, barracks, hospitals, which all resemble prisons?" (Foucault 1977, p. 228) Foucault acknowledged, however, that his portraits of modern society were occasionally hyperbolic.

The formation of new kinds of knowledge and their cultural effects has extensive political repercussions and culminates in what Foucault called *biopolitics*. This term refers to a political rationality in which specific knowledges and administrative technologies are used by a government to understand and regulate not only individuals but also groups or populations. Hence the ongoing links between, say, longevity and social security, health and insurance, risky behavior and family assistance, or poverty and education programs. Ian Hacking, an insightful extender of Foucault's approach, describes these relations as having looping effects, loosely but evidently intertwined in terms of a development of an expertise and its gradual influence on how human beings subsequently understand (accepting or resisting) new ideas about themselves.

During work on *The History of Sexuality* (1978–1984), Foucault began focusing on technologies of the self. Here technology is not so much about instruments or tools, but it is more a craft or care for oneself insofar as one uses available knowledge and experiences (such as diet, love, physiology, dream analysis, and structure of home life) to practice a moral life. While his scholarly attention surprisingly turned to texts of the early Greeks and Christians, Foucault cautioned against emulating them. Address the possibilities, he argued, rather than succumb to one's own blind spots.

Foucault was reluctant to spell out a theory of normative ethics. Not only was such an endeavor impossible for modern thought (see *Order of Things*, p. 328), he believed intellectuals should be wary of imposing solutions for those involved in specific struggles. In this light Paul Rabinow nevertheless identifies a four-fold of Foucault's ethics as comprising a will to truth, stylization of one's self, critical thought, and a telos or purpose that involves a dissembling of the self. Be prepared, in other words, that leading an ethical life amid scientific and technological changes will not confirm your identity, but transform you.

The work of Michel Foucault is daring in its range and depth. Although he builds on the approaches of phenomenology, Marxism, and existentialism, he takes the twentieth century European intellectual tradition into a new historical critical phase. As different strains of scientific discovery and technological innovations continue to emerge, his conceptual tools demand that one ask: How is it true? Where is its power? How might it change individuals and their relations to others?

ALEXANDER E. HOOKE

SEE ALSO *Regulation; Monitoring and Surveillance; Science, Technology, and Literature; Space.*

BIBLIOGRAPHY

Burchell, Graham, Colin Gordon, and Peter Miller, eds. (1991). *The Foucault Effect: Studies in Governmentality*. Chicago: University of Chicago Press.

Connolly, William. (1999). *Why I Am Not A Secularist* Minneapolis: University of Minnesota Press. Uses Foucault's style of analyzing discourses to examine controversies of contemporary politics. Connolly undercuts familiar oppositions—such as religion versus secularism, liberalism versus conservatism—to present new options in political pluralism.

Donzelot, Jacques. (1979). *The Policing of Families*, trans. Robert Hurley. New York: Pantheon.

Dumm, Thomas (2002). *Michel Foucault and the Politics of Freedom*. Lanham, MD: Rowman and Littlefield.

Eribon, Didier. (1991). *Michel Foucault*, trans. Betsy Wing. Cambridge, MA: Harvard University Press. The most thorough and balanced treatment of Foucault's personal life and intellectual development. Recounts philosophical and political climate of his life, interviews numerous associates and friends, and carefully describes his books and projects.

Foucault, Michel. (1965). *Madness and Civilization: A History of Madness in the Age of Reason*, trans. Richard Howard. New York: Vintage Books.

Foucault, Michel. (1970). *The Order of Things: An Archaeology of the Human Sciences*. New York: Vintage Books.

Foucault, Michel. (1977). *Discipline and Punish: The Birth of the Prison*, trans. Alan Sheridan. New York: Vintage Books.

Foucault, Michel. (1978–1984). *The History of Sexuality*, trans. Robert Hurley. 3 vols. New York: Pantheon.

Foucault, Michel. (1997). *Essential Works: Volume I—Ethics: Subjectivity and Truth*, ed. Paul Rabinow. New York: The New Press.

Fraser, Nancy, and Mary Gordon. (1997). "Genealogy of *Dependency* in Tracing a Keyword of the U.S. Welfare State." In *Justice Interruptus*, by Nancy Fraser. New York: Routledge. Insightful and concise application of Foucault's genealogy. Fraser and Gordon discuss how changes in the definitions of dependency correlate with cultural shifts (from benign to negative) on the value and status of being dependent.

Hacking, Ian. (1995). *Rewriting the Soul: Multiple Personality and the Sciences of Memory*. Princeton, NJ: Princeton University Press. Investigates the emergence or discovery of contemporary pathologies in light of popular perceptions, scientific analysis, and the growing prominence of psychology.

Hacking, Ian. (1999). *The Social Construction of What?* Cambridge, MA: Harvard University Press. Sometimes playful but always enlightening discussion of how specific ideas and discourses arise and the disputes they foster among various political and scientific representatives, particularly those who claim to ground their views either in natural kinds or social construction.

Martin, Luther; Huck Gutman; and Patrick Hutton, eds. (1988). *Technologies of the Self: A Seminar With Michel Foucault*. Amherst: University of Massachusetts Press. Collaborative project among scholars during Foucault's visit to University of Vermont. Historians, religious scholars, and philosophers develop their own themes sparked by Foucault's work. He has an essay and an interview with the hosts.

FRANKENSTEIN

Frankenstein, or The Modern Prometheus (1818) by Mary Shelley provides the most potent, characteristic, and uniquely modern myth of science gone fatally awry. The common association of the name Frankenstein, thanks to many popular movies, is with the ugly, lumbering, murderous monster whom the book never names. In his many film versions, this lurching omen reflects the eras of his creation, from the dazed, scorned and feared working-class creature played by Boris Karloff in James Whale's depression-era *Frankenstein* (1931) to the slyly silent and sexually potent creature played by Peter Boyle in the me decade's *Young Frankenstein* (1974). But while

Boris Karloff as Frankenstein's monster in the 1931 film verison of *Frankenstein*. Karloff's portrayal of the creature is perhaps the most well-known. *(© Bettmann/Corbis.)*

movies have spread the image of *Doctor* Frankenstein and associated his name with the manlike monster he created, the novel carefully never names his creation which is, in fact, a doppelganger, a dramatic double of the obsessive undergraduate who made him.

The Modern Prometheus

The ancient myth of Prometheus took two forms: Prometheus *pyrphoros* (fire-bringer) and Prometheus *plasticator* (shaper). In the first the god steals divine fire, emblematic of the combined good and bad potentials of all technologies, for humans; in the second he shapes humans from clay and breathes life into them. In both Zeus makes Prometheus suffer endlessly for his disobedience. In the modern myth, Frankenstein shapes his creation from *charnel matter* and reanimates it (rather than *creating life*) with electricity, an occurrence, as Shelley writes in her preface, "supposed by Dr. [Erasmus] Darwin, and some of the physiological writers of Germany, as not of impossible occurrence." The bounds that Frankenstein transgresses are those of obedience to community. He makes himself a monster in two senses. The price is death not only for himself but for his family and potentially all humanity.

As Gothic novels of the supernatural became stale, authors added a twist, revealing at the end some realistic explanation for the fantastic occurrences. By moving that explanation to the beginning of *Frankenstein,* Shelley created the genre that has explored human fears of science ever since: science fiction.

Structure and Narrative of the Novel

This early science fiction is composed of letters from an explorer, Robert Walton, to his sister back in England. He cannot send the letters because his ship is mired in the arctic where he seeks to confirm the ancient Hyperborea myth of a land of warmth beyond the far north, but he writes nonetheless. On a passing floe he discovers the debilitated Victor Frankenstein whom he rescues. During Victor's recuperation, Robert remarks that "I begin to love him as a brother" (1969, p. 27). In some sense, Robert and Victor, too, are doppelgangers.

The book is a series of nested narratives. The outermost, Robert's own, contains Victor's story that tells of his pursuit of greatness and withdrawal into feverish, isolated work. He finally succeeds, but one look at his stirring creation shows him instantly that the creature is evil. He would kill it, but it flees. The reader comes to learn that the creature is the strongest, smartest, most articulate character in the book, a fit embodiment of science. He confronts Victor on a glacier (the ice imagery mirroring the situation of Robert and Victor, all three males surrounded by frozen fertility) and pleads for paternal help, requesting a bride so that he, universally shunned for his ugly exterior, can find community. Victor reports the creature's narrative which includes his plea and his reported story of Felix (happiness) and Safie (wisdom), Christian-Muslim lovers who are promised help against prejudice and the opportunity to marry by Safie's father, but are betrayed by him. The creature learns the lovers' tale overhearing them in a cottage through a knothole in the wall of the outer shed he has been occupying while altruistically providing firewood for the blind old man who lives there. With the couple on the scene, the creature learns to read just by watching their sharing aloud three books: Milton's *Paradise Lost,* which concerns disobedience and provides *Frankenstein's* epigraph, fallen Adam's plea to God ("Did I request thee, Maker, from my clay / To mould Me man? Did I solicit thee / From darkness to promote me?) (Book X, lines 743–745); *Plutarch's Lives,* a classic collection of exemplary biographies; and *The Sorrows of Young Werther,* Goethe's famous tale of unrequited love ending in death. The creature, initially the most virtuous character in the book, is driven away when the blind cottager's guests see him. Readers believe him when he says to Victor that "My vices are the children of a forced solitude that I abhor; and my virtues will necessarily arise when I live in communion with an equal" (line 1470). At the heart of *Frankenstein's* nested narratives is the betrayal by Safie's father. The rupture of community echoes throughout the book.

When Victor first absents himself to work, his father sends a letter that says, quite rightly, "I regard any interruption in your correspondence as a proof that your other duties are equally neglected" (p. 55). Victor destroys his creature's unfinished bride in sight of the monster, who then begins murdering Victor's family to force him to start again. Instead they chase each other north. While Victor never writes, Robert always writes. Robert heeds his frightened crew and turns back from his quest, saving all their lives. Victor dies, and the monster (from the Latin for *warning*) carries him further north for a funeral pyre, knowing that with his *father* dead, his hopes for any family have died, too.

Science Unbound

At the heart of *Frankenstein* is the tension between the power science confers on individuals and the just restraints of community. Frankenstein, both creator and creature, stands not for science in general but for the acquisition of scientific power foolishly pursued without the wisdom of the world. As such, Frankenstein has represented, in the films of the Great Depression, the isolation of the privileged from the suffering of the common person. When the educated *Doctor* or *Baron* in his hilltop castle, his title varying from film to film, disdained the peasants swirling up toward him with their angry torches, his doppelganger monster was inarticulate because, the movies imply, the overly powerful never heed the consequences of their power.

That image has entered the very language of the early 2000s. Genetically modified farm crops are bashed as *Frankenfoods* and contemplated human cloning for spare parts is called a *Frankenstein nightmare*. Shelley has a character say early on, "One man's life or death were but a small price to pay for the acquirement of the knowledge which I sought" (1969, p. 28). That sounds like Victor, but it is Robert, the seeker who learns the limits of seeking. *Frankenstein* is the early twenty-first century's greatest cautionary tale.

ERIC S. RABKIN

SEE ALSO *Autonomous Technology; Brave New World; Playing God; Science Fiction; Science, Technology, and Literature; Shelley, Mary Wollstonecraft.*

BIBLIOGRAPHY

Schoene-Harwood, Berthold, ed. (2000). *Mary Shelley, Frankenstein*. Columbia University Press Critical Guides. New York: Columbia University Press.

Shelley, Mary. (1969 [1818; 1831]). *Frankenstein, or the Modern Prometheus*, ed. M. K. Joseph. The World's Classics series. New York: Oxford University Press.

Shelley, Mary. (2000). *Frankenstein: Complete, Authoritative Text with Biographical, Historical, and Cultural Contexts, Critical History, and Essays from Contemporary Critical Perspectives*, ed. Johanna M. Smith. Boston: Bedford/St. Martin's.

FRAUD AND MISCONDUCT IN SCIENCE

SEE *Misconduct in Science.*

FREE AND INFORMED CONSENT

SEE *Informed Consent.*

FREEDOM

The concept of freedom or liberty is complex, with political, ethical, and psychological dimensions. In the context of modern science, technology, and ethics, freedom exhibits all of the ambiguity of human experience. The promise of modern science and technology is that the increases in knowledge and the power they afford will expand human freedom in an unqualified sense. But in opposition to this original and continuing justification are questions about the extent to which science and technology may also limit or qualify freedom. Moreover, the professional ethical requirement for the free and informed consent of human participants in scientific research situates the complexities of freedom in the heart of science itself. The issue of "free and informed consent" is a key locus for the discussion of freedom in science and technology.

Human Freedom versus Deterministic Science

The philosophical concept of freedom may be seen in opposition to that of determinism. The determinist holds that there is no freedom. For a hard determinist, all events in nature are strictly determined. As such, the idea of freedom is incompatible with that of the causal determination of all natural events. What is sometimes called soft determinism or compatibilism modifies the hard position by maintaining that freedom is compatible with the determination of natural events. A compatibilist holds that all events in nature are causally determined but that human beings can initiate new series of events and have responsibility for the outcomes of their actions. Thus, moral ideas of praise and blame make sense if people are able to act according to some causality arising from their will or for reasons of their own choosing.

Finally, it should be noted that with the development of quantum mechanics some thinkers allow for indeterminacy at the atomic level. This may allow for a notion of freedom in the sense that an action is not caused, but it may not be able to account for personal responsibility if the action is not determined in some way by the person.

Whether or not human beings are in fact free, most people think and act as if they are. Such acts of freedom have been conceptualized in two basic ways: negative and positive.

Negative Freedom

Negative freedom may be taken as an absence of obstacles to the fulfillment of one's desires or wishes. The view of the English philosopher Thomas Hobbes (1588–1679) is representative of this approach. This form of freedom depends upon the existence of favorable external circumstances for the attainment of a human goal. It can thus be considered a freedom of self-realization. One peculiar implication of this approach is that a person who wishes to be in a prison cell may be said to be free. Nor does it require that there be alternatives from which to choose. If there is only one course of action available, but that is what an individual wishes, then such a person may be said to be free. It also seems to allow for animals to be described as free. A further point is that the obstacles to human desires include physical and social ones. Thus, if persons are physically constrained or constrained by fear, they may not be said to be free to act. If, on the contrary, they are coerced to act in a certain way, they are not considered to be free nor responsible for their actions.

According to this conception, modern science and technology may be construed as eliminating any number of obstacles that have historically restrained human action. Therefore, those taking engineering approaches to science and technology tend to see modern technical methods as enhancing human freedom. With modern methods of communication and travel, for example, time and space seem to shrink in their significance. Many elderly people of the late twentieth and early twenty-first centuries have been able to act without the encumbrances of the maladies of old age that have plagued human beings for millennia. This form of freedom is a freedom from such things as disease, hunger, and fear.

Modern technologies, however, may also be seen as introducing new obstacles to human action. The automobile provides for transportation over great distances, but millions of cars on the roads produce traffic jams that obstruct a person's desire to move. The roadways also block a person's desire to walk if the destination is across a multilane highway. The very complexity of modern technological societies may represent an obstacle to human action. With all of the information that is available through the various media, many persons feel overwhelmed by information overload. Greater knowledge is thought to increase one's freedom to act, but it becomes difficult to act rationally in such an environment. Indeed, the self may become fragmented as it interacts with the technological environment.

This seems to be an outcome that is contrary to the self-realization that is characteristic of the notion of negative freedom. A further problem with the notion of negative freedom is that modern science and technology may be used to manipulate human desires, and so in a sense persons are coerced to act. Thus, propaganda techniques are used to mold consumer desires. Indeed, it has become possible to manipulate human desires pharmacologically. This possibility has been the theme of dystopias such as Aldous Huxley's *Brave New World* (1932). Huxley imagined a society in which a drug called "soma" could be taken that would make a person content in any environment. Anthony Burgess's *A Clockwork Orange* (1962) depicted a cruder reconditioning of human desires. Many thinkers in the humanistic tradition would not consider human beings to be free if there are no obstacles to the fulfillment of a person's desires, but the desires one has result from technical manipulation. It is appropriate from this perspective that B. F. Skinner should have written *Beyond Freedom and Dignity* (1971). The practical application of his behaviorism would make human freedom into an illusion because behaviorism holds that all human behaviors are molded by the environment. The control of nature, as C. S. Lewis (1898–1963) pointed out *The Abolition of Man,* easily leads to the control of some human beings by others.

Positive Freedom

The positive notion of freedom requires that individuals be able not only to act on their desires but also to choose from among the many desires they have to act upon. Such a view of freedom constitutes a theory of self-perfection. According to this conception, some desires may be more worthy than others given a standard of human life that is considered good. Only persons who have acquired virtue or a self-consciousness of their humanity may be said to be free. Contrary to the common view that people have greater freedom to act if they have more choices, in this case ideas of virtue or moral duty may lead individuals to restrict their pursuit of certain desires. Rather than simply doing what one wants, one does what one thinks one ought to do.

Moreover, one may have a desire for freedom itself that requires the subordination of one's physical inclinations. This is an example of second order desire, that is, the desire for certain kinds of desires. Here, freedom is an end to be pursued in itself rather than a means to the pursuit of other ends. A peculiar aspect of the positive notion of freedom is that it seems to require a degree of self-denial, at least the denial of the drives of the lower self for the sake of higher drives or interests. It may be that this is necessary for the fulfillment of the higher self. A certain independence of the self from the social and physical environment is also necessary for the pursuit of this form of freedom. As such, positive freedom does not depend upon external circumstances.

The positive notion of freedom is especially significant in ethical reflections on the impact of science and technology on the quality of human existence. The concern here is whether human existence is degraded by the rationalization of the world associated with modern science and technology. If all of human existence, including human beings themselves, is subject to rational control, then there may be no room for the dignity of persons; in such a scenario, persons will have been reduced to objects of manipulation and control. If technical methods are applied to political action, for example, this tends to transform what has traditionally been considered the "art of the possible" into a matter of technical necessity. Technical rationality is a rationality directed to the efficient determination of means to achieving some end. This form of rationality tends to become the dominant form of rationality in a highly developed technological society in which the only worthy ends that are recognized are those that can be pursued by the technical means available.

Positive freedom, however, seems to require a broader form of rationality that takes into consideration the choice of humanly worthy ends. In the debate concerning human cloning, for example, the President's Council on Bioethics placed special emphasis on "human dignity" by calling one of its reports, *Human Cloning and Human Dignity* (2002). Furthermore, Francis Fukuyama (2003) has described a posthuman future resulting from the genetic manipulation of human beings. If modern science and technology lead to the evolution of a posthuman era, of what value is human freedom?

Dialectical Freedom

Beyond the negative and positive accounts of freedom is a dialectical one, with roots in the work of Georg Wilhelm Friedrich Hegel (1770–1831) and Karl Marx (1818–1883), among others. According to this account, human freedom is to be understood precisely as an opposition to some obstacle. As such, freedom depends on the existence of some resistance against which we struggle. If humanity were to succeed in eliminating all obstacles to the fulfillment of its wishes as per the view of negative freedom, it would also eliminate human freedom. The dialectical approach to freedom recognizes that the obstacles human beings confront take both physical and social forms. As one obstacle is overcome, however, new ones arise, so that human freedom can be seen as developing over time as humans confront new obstacles.

From a dialectical perspective, freedom must be coordinated with the environment in which humans exercise their freedom. The first and historically most fundamental form of freedom in this scenario occurred when human beings struggled against nature. Nature provided both the means of pursuing human desires through the use of tools as well as obstacles to their use. This form of freedom was superseded by a stage in which human beings developed social institutions, which can be seen as "second nature." Social institutions provided protection from the forces of nature but also introduced new human-made obstacles. After the development of this new environment, the desire for freedom had to be directed against social institutions. The dialectical character of this view of freedom can be seen in that the liberty gained with respect to one environment gives rise to new necessities that must be overcome by creating a new form of freedom. In turn, the new form of freedom is also relevant to a new milieu.

The sociologist Karl Mannheim distinguishes a third stage, that of planning. In this stage, the totality of social institutions and other techniques are organized into a systematic whole. For Mannheim, democratic planning is the last stage in the development of human freedom, whereby human beings take conscious control over the social process. Jacques Ellul (1976) depicted this third stage as the stage of technique, which involves a new technological determination of the human person by the systematic application of techniques to human beings. He thus called for a struggle against the technological environment, especially in its ideological aspect.

The Ethics of Freedom in the Scientific and Technological World

In all of its forms—negative, positive, and dialectical—freedom is closely associated with notions of moral autonomy and political democracy. The ideals of moral autonomy and democratic politics depend on persons and citizens not being wholly determined by external forces, able to pursue personal perfection and the public good, in dialectical engagement with others and the world around them. In the contemporary technoscientific milieu, the others and the world exhibit strongly scientific and technological characteristics.

One area in which this is particularly pronounced is in research on human subjects. Especially since World War II both the scientific community and society at large have increasingly stipulated that scientific research on human subjects be limited by requiring free and informed consent of any such subjects. Participants in scientific research must not be constrained to participate either by force (as in Nazi Germany) or by ignorance (as in the Tuskegee Syphilis Study [1932–1972] in the United States); they must be able to see their participation as positive aspects of their own lives; and they will inevitably struggle against the obstacles of disease and perhaps their own lack of understanding in the process. The commitment to such freedom, which respects limitations in science, even when it also limits scientific progress, makes science more human.

In the larger technoscientific world there are further reflections of such efforts to respect freedom in the emergence of individual and collective ethical responses to the artificial environment produced by modern science and technology and the cultural aspirations to use science and technology to transform the world. Thus, Hans Jonas (1984) has called for an ethic of responsibility that posits an ethical imperative to maintain the existence of human beings. This marks a sharp contrast with those who have called for a posthuman age. Further examples include Ellul (1976), who developed an ethic of non-power to counter the technical impulse to augment human power. And, more recently, Bill McKibben has sought limits to the effort to perfect human beings in his 2003 book, *Enough*. All of these observers are concerned with establishing some humanly significant limits to the technological remaking of the world. They recognize that within a dialectical account of freedom, while the reality of human freedom depends upon the overcoming of limits, it also depends upon the recognition of limits. If the technological project has become an attempt to eliminate all limits, it may very well eliminate freedom as well.

DARYL J. WENNEMANN

SEE ALSO *Alienation; Autonomous Technology; Critical Social Theory; Determinism; Dignity; Ellul, Jacques; Free Will; Hegel, Georg Wilhelm Friedrich; Jonas, Hans; Kant, Immanuel; Marx, Karl; Posthumanism; Security; Rand, Ayn; Thoreau, Henry David; Tocqueville, Alexis de; Weil, Simone.*

BIBLIOGRAPHY

Adler, Mortimer J. (1973). *The Idea of Freedom*. 2 vols. Westport, CT: Greenwood.

Berlin, Isaiah. (2002). *Liberty: Incorporating Four Essays on Liberty*, rev. edition, ed. Henry Hardy. Oxford: Oxford University Press. A modern classic of liberalism, Berlin's four essays defended the notion of negative freedom as necessary for maintaining a liberal society.

Borgmann, Albert. (1984). *Technology and the Character of Contemporary Life*. Chicago: University of Chicago Press.

Burgess, Anthony. (1962). *A Clockwork Orange*. New York: Norton.

Campbell, Neil. (2003). *Freedom, Determinism, and Responsibility: Readings in Metaphysics*. Upper Saddle River, NJ: Prentice Hall.

Dennett, Daniel C. (2003). *Freedom Evolves*. New York: Viking.

Ekstrom, Laura Waddell, ed. (2001). *Agency and Responsibility: Essays on the Metaphysics of Freedom*. Boulder, CO: Westview.

Ellul, Jacques. (1976). *The Ethics of Freedom*, trans. and ed. Geoffrey W. Bromiley. Grand Rapids, MI: Eerdmans.

Fukuyama, Francis. (2003). *Our Posthuman Future: Consequences of the Biotechnology Revolution*. New York: Farrar, Straus and Giroux.

Hayek, Friedrich A. (1960). *The Constitution of Liberty*. Chicago: University of Chicago Press. A defense of freedom as an absence of arbitrary coercion.

Hayles, N. Katherine. (1999). *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics.* Chicago: University of Chicago Press.

Hobbes, Thomas. (1994). *Leviathan: With Selected Variants from the Latin Edition of 1668,* ed. Edwin Curley. Indianapolis, IN: Hackett.

Huxley, Aldous. (1932). *Brave New World.* Garden City, NY: Doubleday, Doran.

Jonas, Hans. (1984). *The Imperative of Responsibility: In Search of an Ethics for the Technological Age,* trans. Hans Jonas, with the collaboration of David Herr. Chicago: University of Chicago Press.

Kane, Robert. (1996). *The Significance of Free Will.* New York: Oxford University Press.

Kane, Robert, ed. (2002). *Free Will.* Malden, MA: Blackwell.

Lewis, C. S. *The Abolition of Man.* New York: Macmillan, 1947.

Malinowski, Bronisław. (1976 [1944]). *Freedom and Civilization.* Westport, CT: Greenwood.

Mannheim, Karl. (1940). *Man and Society in an Age of Reconstruction.* New York: Harcourt, Brace & World, Inc.

McKibben, Bill. (2003). *Enough: Staying Human in an Engineered Age.* New York: Times Books.

Mill, John Stuart. (1998). *On Liberty, and Other Essays,* ed. John Gray. Oxford: Oxford University Press. An immensely influential study of the limits of individual liberty and the power of the state.

O'Connor, Timothy, ed. (1995). *Agents, Causes, and Events: Essays on Indeterminism and Free Will.* New York: Oxford University Press.

President's Council on Bioethics. (2002). *Human Cloning and Human Dignity: An Ethical Inquiry.* Washington, DC: Author.

Rutsky, R. L. (1999). *High Technē: Art and Technology from the Machine Aesthetic to the Posthuman.* Minneapolis: University of Minnesota Press.

Skinner, B. F. (1971). *Beyond Freedom and Dignity.* New York: Knopf.

Watson, Gary, ed. (2003). *Free Will,* 2nd edition. Oxford: Oxford University Press.

FREE SOFTWARE

Proponents of *free* software distinguish *free speech* from *free beer,* and argue that their conception of free software is intended to evoke the former idea. That is, software is a form of speech used by programmers to express technical ideas in very specific language. Free software does not necessarily mean that the price is zero. The *free software* movement is an explicit attempt to encode in technology specific ethical values about how the world should work. The term *free software* was coined by Richard Stallman, and following his lead, free software programmers have written licenses and computer programs that they believe help create liberty.

Freedom to Use, Change, and Expand the Work of Another

In order for programmers' speech to be heard, it must be transmitted to others. Programmers' work is written in *source code,* usually a text file, which is then interpreted or compiled by other programs in order to perform some computation (for example, to calculate a statistical result or to display a web page). A central idea in the free software movement is that programmers' work, their source code, should be made available in its original form to anyone who is interested in it. A related movement refers to this as *open source.* Although in practice open source and free software often refer to the same programs, their emphases are different. Free software focuses on the goal to promote freedom, while open source focuses on the goal to make the source code available to everyone.

In order to guarantee this availability, programmers distribute free software under licenses that prohibit users from denying others the freedoms they have received. Thus free software may be used and shared by anyone who accepts the terms of the license. The most common free software license is the General Public License (GPL). The GPL offers the following:

- The freedom to run the program, for any purpose.
- The freedom to study how the program works, and adapt it to one's needs. Access to the source code is a precondition for this.
- The freedom to redistribute copies so users can help others.
- The freedom to improve the program, and release one's improvements to the public, so the whole community benefits. Access to the source code is a precondition for this.

To use free software licensed under the GPL, one must accept the license terms. If one refuses these freedoms (for example, because one wishes to keep a particular code secret), the right to use free software is forfeited. That is, if a programmer wants to use code from free software in a new application, the new application must carry the same freedoms as the original code. In order to share or distribute free software, one must pass along these same freedoms to the people to whom the software is distributed.

The Origins of the Free Software Movement

Academic computing from the 1950s through the early 1980s had been mostly unconstrained by concerns about copyright. Scientists shared source code with each other, freely commenting and critiquing each others' work. In the early 1980s, markets opened for the commercial development and sale of software, and among the first moves of the new private-sector ventures was to limit the distribution of the original source code. The limitation seemed sensible at the time—why pay programmers to produce something that customers or competitors could take for free?

Some programmers were critical of the new trend to "close the source," or restrict access to source code. The first criticisms were technical: if programmers find a bug in closed-source software, they cannot simply fix the bug, as they had previously been accustomed to doing. Broader critiques soon followed as programmers realized that in this new work environment, they could not easily share code with colleagues in other organizations. It became more difficult to share ideas and experiences.

In January, 1984, Richard Stallman crystallized the discontent with the foundation of the GNU ("Gnu's not Unix," a recursive pun) Project. In his initial announcement, he said that he and his collaborators would write an entire Unix clone from scratch with entirely free software which would be available to anyone who wanted it. The GNU Project succeeded in developing nearly all the parts of an operating system. However, the GNU Project lacked a kernel, the central part of the operating system that manages memory and connections to hardware. Using many of the GNU tools, a Finnish graduate student named Linus Torvalds released *Linux* in 1991, a kernel that provided exactly this component. Over the next five years, the GNU tools and the Linux kernel made free software a practical platform for general purpose computing.

Free software development proceeded rapidly. In the early 1990s, several other free Unixes emerged from a legal battle between free software programmers (mostly in Berkeley, California) and AT&T. The Berkeley programmers replaced nearly all of AT&T's original Unix code. There are a number of descendants of this process, called the "Berkeley Software Distribution" (BSD). In 1995, other programmers re-wrote the original Netscape HTTP web server and named it the Apache HTTP server (the name is a pun: "a patchy server"). At the time of this writing, Apache powers approximately two-thirds of the web servers on the Internet.

By the late 1990s, different positions in the free software community emerged about the relative priority of different goals. Some people felt that the most important aspects of free software was the promotion of a vigorous intellectual community and growth into new areas, especially by convincing businesses to produce free software. In this perspective, the term "free software" was deemed inappropriate because it discouraged potential allies in the corporate world from adopting it. To avoid the perceived anti-business implication of "free," in 1998 this group re-labeled the community "open source." Since then, the term "open source" has grown significantly more quickly than the term "free software." In practice, the terms refer to mostly the same programs, and even to the same licenses, but signify important differences in the license-holder's focus.

Free Software in Practice

Numerous free software programs have been published. There are free operating systems (including GNU/Linux and various versions of BSD), graphical windowing environments (gnome, KDE), Internet browsers (mozilla, konqueror), office software (OpenOffice, gnumeric), a web server (apache), computer languages (C, perl, PHP, python), and scientific software (the R statistical language, grace—a plotting package), to mention only a few of the tens of thousands of free software programs available. It is possible to do almost any computing, on the desktop or on the server, exclusively by using free software, including interoperating with colleagues using proprietary systems (such as those offered by Microsoft or Apple).

Free Software and Scientific Ethics

Many of the technical and ethical values expressed in the free software movement parallel broader values in the scientific and technical community. In particular, free software programmers prize open technical debate in which all the participants have access to the material in question for testing, benchmarking, critique, and for the creation of derivative works.

As described earlier, free software is distributed in a human-readable form called source code, the original form in which programmers write software. By studying the source code, programmers can evaluate the quality of the solution: Does it work? Is it efficient? Is it elegantly written? In this way, free software is transparent and encourages vigorous peer review. Indeed communities of free software programmers usually exist on publicly available Internet mailing lists, newsgroups, and

Internet sites The only requirement for participating in the review process is the skill to be a programmer.

The Ability and Responsibility to Share

Another central idea in free software is that every user is encouraged to share the software with other users. By sharing, programmers build on each other's ideas and accomplishments, and this serves to advance knowledge, another central scientific value. The idea that software *should* be shared is linked to the sense that tinkering with technology is intrinsically valuable, and that the ability to *open the hood* is the first step toward innovation.

However, as implied by the references to freedom, free software programmers explicitly intend their work to advance the cause of human liberty, and so sharing software has several benefits beyond peer review and encouraging exploration. For example, sharing software helps to decentralize control over the access to information technology. With the rise of technology as the mechanism by which most communication is effected, the practice of free speech depends on free access to the means of speech. Decentralizing control of communications software is one way to help to keep virtual space open to everybody.

Sharing free software also helps lower the cash cost of software, which enables more people to be able to use technology to express their ideas. In the world of free software, this means more people can be free.

Free software uses open data standards. Because the internal working of the software is available for any programmer to tinker with, it becomes relatively much easier for other programmers to figure out how to read and write the files used by a particular program. If a free software program's developers decide to change a data format, or if the developers abandon the program (such as when firms go out of business), the users themselves may choose to continue work on the software. Because the source code is available, the users always have the option of becoming developers, if necessary.

Protecting Privacy and Control

Perhaps the most fundamental aspect of free software is that users control their own computers. Users face two challenges to control of their machines. First some governments attempt to monitor or censor their citizens' use of email, the Internet, or other digital communications media. A second challenge is that some media companies (music, movies, electronic books, digital television) would like to monitor who consumes their products, as well as prevent legal or illegal copying of the content. Accomplishing these goals requires placing monitoring software in the users' computers, and it requires removing the capacity to copy the content from the user. With free software, it is difficult and potentially impossible for users to lose control of their computers in these ways. With a computer running free software, the user can (at least in theory) review all the software on the machine to assure that none of it is spying on him. Similarly if free software can present content to the user, then it can also make copies of that content.

There are a number of differences between free and nonfree software that are debated by software experts. For example, free operating systems have been nearly entirely free of the viruses and worms that plague the world of proprietary software. This may be because free operating systems are more resistant to worms and viruses, or because the virus and worm writers are attracted to more popular consumer computing platforms. Free operating systems have been relatively less frequently cracked by direct attacks, but as with viruses, it is not clear if the free systems are more secure or if attackers are more drawn to proprietary systems. The proponents of the proprietary systems often claim that free systems have no guarantee of functionality or support; proponents of free systems reply that the mere existence of a company charging money for software is no guarantee of support. Finally some charge that free software lacks *user friendliness*.

Programmers write free software because they enjoy pursuing technical challenges, and because they want the respect of their colleagues (Raymond 2001). In short, free software programmers are motivated by the same personal goals that motivate most scientists. The close fit between free software and scientific endeavors is therefore unsurprising. To a scientist or engineer, free software enables a powerful array of tools, of places where one can open the hood and tweak behavior to precise specifications; in a high-performance application, these capacities may outweigh the relatively greater complexity of free software relative to proprietary software. Combined with the richness of the Unix toolset and databases, numerical routines, and statistical software, free software can be the ideal scientific computing environment.

PATRICK BALL

SEE ALSO *Autonomy; Digital Divide; Information Society; Internet; Hardware and Software.*

BIBLIOGRAPHY

Raymond, Eric S. (2001). *The Cathedral and the Bazaar: Musings on Linux and Open Source by an Accidental Revolutionary*. Cambridge, MA: O'Reilly. This book expresses many of the core ideas that motivate many programmers to publish open source/free software.

Torvalds, Linus, and David Diamond. (2001). *Just for Fun: The Story of an Accidental Revolutionary*. New York: HarperCollins. Torvald's memoir of why he wrote the Linux kernel is an engaging example of how programmers write code to satisfy their personal curiosity and then to gain the respect of their peers.

Wayner, Peter. (2000). *Free for All: How Linux and the Free Software Movement Undercut the High-Tech Titans*. New York: Harper Business. Wayner's lively story covers the broad history of the free Unixes—linux, NetBSD, FreeBSD, and later, OpenBSD.

Williams, Sam. (2002). *Free as in Freedom: Richard Stallman's Crusade for Free Software*. Sebastopol, Calif.: O'Reilly. Stallman's biography traces his extraordinary personal life and the growth of the community which has given rise to the ideas and the technology.

INTERNET RESOURCES

Free Software Foundation. Available from http://www.fsf.org. Information on the development of the free software movement. See especially the GNU "General Public License," available from http://www.gnu.org/licenses/licenses.html#GPL.

"Hacker History and Culture." Eric S. Raymond's home page. Available from http://www.catb.org/~esr/faqs.

"Homesteading the Noosphere." Eric S. Raymond's home page. Available from http://www.catb.org/~esr/writings/cathedral-bazaar/homesteading/index.html

SourceForge.net. Available from www.sourceforge.net. Many of the most dynamic free software projects are hosted here.

KernelTrap.org. Available from http:// www.kerneltrap.org. A highly-technical site with interviews with developers from across the community of the free Unixes, and a place to browse Linux kernel mailing list, with commentary by the site's owners.

Open Source. Available from http://www.opensource.org/. A review of the myriad of open source and free software licenses, with critiques.

Python. Available from http://www.python.org/. Access to software, mailing lists, documentation, tutorials, and everything python.

Trusted Computing. Available from the Internet site of British cryptographer Ross Anderson, http://www.cl.cam.ac.uk/~rja14/tcpa-faq.html.

FREE WILL

To have free will means that in some nontrivial sense persons are able to make choices that are not determined by causes other than themselves, so that each person may be regarded as the unique author of his or her own thoughts and actions. The term *nontrivial* indicates more than the absence of external and future determinants. A snowflake is free to fall until it hits the ground, but this freedom seems trivial. Free will implies the absence of internal or prior determinations.

Notions of free will involve two closely related ideas. Moral freedom is the idea that human being are morally responsible for their actions, and so may legitimately be praised or blamed, rewarded or punished. Metaphysical freedom amounts to the more radical claim that human choosing involves a break in the chain of physical causation. The human being is thus an indeterministic system, producing outcomes that are not wholly caused by previous physical states. Modern controversies over the meaning and possibility of free will tend to pit science against morality. Free will in some sense is thought to be necessary for human dignity, but both versions of free will appear to be at odds with the causality investigated by modern science.

Historical Background

Human free will was not a problem in classical philosophy, for at least two reasons. According to Plato (c. 428–c. 348 B.C.E.), for instance, human freedom is not a given but something to be achieved through education. Most human beings are described as slaves, of their passions if not of other humans. Moreover, for Aristotle (384–322 B.C.E.) nature itself was not seen as a rigid set of causal relations; those things that are by *phusis*, or nature, have their own source of motion and rest, that is, are self-moving. Thus the achievement of human freedom is not opposed to nature but its perfection.

Augustine's *De libero arbitrio* (On free will) is the first extended analysis of the concept. For Augustine (354–430), the early Christian church father, the problem arises not from an opposition between human will and physical causation but between human will and God as the cause of everything. If God is all powerful and all knowing, including predestining humans for salvation and knowing the future, how can humans have free will? The Christian theological solution to this problem is simply to argue that God created humans with free will.

In the modern period, however, it is argued that all human beings are equally free (the democratic proposition) and that nature is a deterministic system of causal relations (the scientific proposition). The ethical implication of these two propositions is that humans should use science to control nature for human benefit (the technological proposition). There nevertheless remains a problem of how to reconcile free will and scientific determinism, in theory if not in practice.

Common Sense and Moral Freedom

Moral freedom is grounded in a commonsense interpretation of choosing (sometimes called folk wisdom). I am persistently conscious of alternatives—rare or medium rare? More importantly, I am subject to temptation—I should not break my promise, but just now I really want to. The impression that I could do either allows for a sense of moral responsibility. If you respect my rights, I ought to respect yours; if I do not, I deserve to be punished. This sense of responsibility in turn becomes the ground of all moral authority. Because I am as capable of it as anyone else, I can be ruled only with my consent. In this way, moral freedom supports the idea of individual dignity that underlies both liberty and democracy.

This folk wisdom view of free will has been vigorously challenged within the modern social sciences. Human beings are subject to any number of influences beyond any individual's control: culturally sanctioned values and taboos, character as formed over a lifetime of interactions, genetic inheritance, and more. When one thinks one is choosing, perhaps one is only expressing these social and biological forces. From this perspective, free will is an illusion. The real authors of one's choices are the various forces of social and natural history.

But it is unclear whether these challenges amount to much. Everyone recognizes powerful outside influences on their will. But our very consciousness of alternatives suggests that these influences never quite add up to a choice. A person is required to complete the action. It may be enough to recognize social forces do not act, people do. Each person stands as a unique pivot point in history, interpreting rather than merely communicating biological and social inputs. This may be an adequate ground for human dignity.

Metaphysical Freedom and Determinism

Unlike moral freedom, which largely abstracts from physical causes, the concept of metaphysical freedom focuses on causation all the way down. A person is metaphysically free only if the sum total of physical forces acting on her, including for example the momentum of every molecule in her brain, is insufficient to determine her choice. This would be to say that human choosing is not in all respects a physically caused event. At first glance modern science would seem to preclude such an account of free will. Much of science presupposes a physically deterministic universe in which the state of a system at one time rigidly determines its state at any future time. The view that the universe as a whole constitutes such a system is known generally as determinism.

Yet modern science is no longer uniformly deterministic. Quantum physics, in some interpretations, allows that very small events may be physically uncaused. But it is not clear that this does anything to save metaphysical freedom. Quantum events may have no appreciable consequences on the scale of human perception and action, or if they do this would still represent the influence of material constituents on the brain and could not explain how the person as a coherent self makes choices.

Given that metaphysical freedom involves more radical claims than moral freedom, the obvious question is whether the latter depends on the former. Call metaphysical freedom F1 and moral freedom F2. There are then three general positions. Determinists hold that F1 is required for F2, but that F1 does not exist. Thus there can be no free will in either sense. Libertarians accept the dependence of F2 on F1, but argue that F1 is possible. They then try to show how physical indeterminacy can support human choosing.

Finally, compatibilists argue that there can be F2 without F1. In fact, some have argued that F2 requires determinism. It is only because actions are rigidly determined by what a person is that we can praise that person for the actions; otherwise they would be regarded as mere luck. But this is unconvincing. We recognize that a horse's performance on the track results from its breeding and training, but we do not praise the horse for this. We praise an owner because the owner was free to make poorer choices. Compatibilism may save this sort of freedom only as a necessary illusion. We assume we are free precisely because we have no choice in the matter.

Reconciliations

All three positions rest on the assumption that determinism is the primary obstacle to moral freedom because freedom is conceived as whatever wiggle room does or does not exist between the boundaries set by causation. This is probably a mistake for two reasons. First, determinism relies on a concept of rigid causation that is neither required by theory nor possible in practice. While it simplifies our models of many phenomena to assume a perfect determination of events by antecedent states, there is no reason to believe that this perfection is real. And real or not, we can measure anything only to within some degree of precision. Past that point, things can be as messy as they please.

Secondly, the fundamental requirement of moral freedom is that my individual self is the cause of my own thoughts and deeds. To be more precise, I am genuinely free if my conscious choosing is among the causes that determine my choice. Otherwise I am indeed a puppet of forces beyond my control. But determinism is not, in itself, inconsistent with this, because it involves no theory of consciousness. It cannot rule out a role for awareness in the chain of causation. Conversely, libertarians have a hard time explaining how noncaused events can contribute to conscious choosing. If my puppet strings are being pulled by very small particles, it matters little whether those particles themselves are determined or indeterministic. Either way something besides me is in charge.

The real challenge to free will comes not from determinism but from two closely related views of consciousness. Both are examples of reductionism in so far as they attempt to explain an apparently complex thing, in this case the brain, by reference to its simpler material constituents. The epiphenomenalist claims that the conscious mind is an effect of physical events but is in no sense a cause of those events. No conscious state can be responsible for another, so there is no sense trying to think anything through. More radical still, eliminative materialists argue that consciousness does not exist at all. Like a ghost or a mirage, it is a delusion, though who is being deluded is something of a mystery. Moral freedom can scarcely survive any of these claims.

But perhaps it does not have to, because both seem to rest on an untenable dualism. They treat consciousness as something separate from the brain as a whole. A more mature view is possible. Just as sight is not produced by the eyes but is rather the activity of the eyes, nerves, and neurons, so consciousness is precisely an activity of the body and brain working in concert. The mind is a complex whole that functions to gather and store information and translate it into thoughts and actions. Its material constituents, determined or not, participate in this work only by virtue of their integration into the larger whole. It is this larger whole, perhaps, this congress of neurons, that is the seat of government. Consciousness is what happens when congress is in session.

Free will, like vision or flight, may be regarded as a product of mammalian evolution. Evolution can be understood only in the context of real time. The present is the finished product of a now vanished past. The future is, both in theory and practice, open and unpredictable. Trial and error is the engine of evolution, and free will may be understood as a small-scale model of that engine. Human beings adapt with astounding speed to unforeseen circumstances. Moreover they have constructed moral cultures and political regimes to preserve their successes. Liberal democracy using science for technological benefit is among the most effective of these precisely because it recognizes human beings for what they are. Both determinism and reductionism may have outlived their usefulness as models of the human mind.

Paradoxically, the democratic use of scientific technology may also propose more of a practical than a theoretical threat to free will. Advanced biomedical technologies for the control of human behavior and genetic nature can be interpreted as willful actions that can destroy the will. Recognition of such a possibility might then appeal to the phenomenon of free will as a good to be protected and thus as a moral limit or boundary on technoscientific action.

KENNETH C. BLANCHARD JR.

SEE ALSO *Complexity and Chaos; Determinism; Freedom.*

BIBLIOGRAPHY

Dennett, Daniel C. (2003). *Freedom Evolves.* New York: Viking. Dennett is among the most famous of contemporary compatibilists. He relies on a thoroughly Darwinian account of the human mind in order to build a philosophical account of consciousness and choice. Many critics argue that his version of free will is not genuine and that he is in fact a strict determinist.

Double, Richard. (1991). *The Non-reality of Free Will.* New York: Oxford University Press. Presents a rigorous argument against free will from the standpoint of contemporary analytical philosophy.

Hume, David. 1999 (1748). *An Inquiry concerning Human Understanding,* ed. Charles W. Hendel. Oxford: Oxford University Press. Hume is a famous early modern critic of the notion of free will. Like Dennett, he claims, in effect, to be a compatibilist, but most see his argument as determinist.

Kane, Robert. (1996). *The Significance of Free Will.* Oxford: Oxford University Press. Kane, a libertarian, is a frequent foil for Daniel Dennett. Kane argues that metaphysical freedom is both necessary for moral freedom and that it is possible.

FRENCH PERSPECTIVES

French intellectual culture, from its Enlightenment heritage, is deeply imbued with a positivist approach to human problems. Modern science and technology are simply assumed to be the proper expressions of human reason. Under such assumptions it would be meaningless to consider the possibility that either science or technology could be intrinsically problematic or that it would be appropriate to try to identify proper limits to their development. Instead, for more than a century the main philosophical debate raised by scientific and technological progress dealt with conflicting political responses to extrinsic problems, such as the uses of technology to exploit the working class.

In France, moreover, academic life is highly centralized and, as a result of their selection and training, professional intellectuals tend to live in a world situated between the Ecole Normale Supérieure and the Sorbonne. Such a context favors the reproduction of existing problems and debates, so that questioning of the intrinsic character of science or technology was at most a minor issue in the history of science. Those few thinkers who took seriously science or technology as issues in themselves remained isolated, their work largely ignored, with students who were interested in such topics systematically discouraged from appropriate programs of study. In consequence, questions of science, technology, and ethics in France during most of the twentieth century were not so much part of a tradition of critical reflection as they were associated with a series of individuals who, in somewhat eccentric manner, undertook to investigate them.

From Henri Bergson to Emmanuel Mounier

The response of Henri Bergson (1859–1941), the leading French philosopher of the first third of the twentieth century, to the disastrous experience of World War I is indicative of the basic attitude during this period. Educated at the Ecole Normale Supérieure, after teaching philosophy at a series of lycées, Bergson became a professor at the College de France, where his lectures attracted not only students and academics but even the general public and tourists. His most original reflections on creativity and time having been completed before the war, afterward Bergson served as a diplomat and worked in support of the League of Nations. His *Les deux sources de la morale et de la religion* (The two sources of morality and religion, 1932) argues a chastened but continuing commitment to the Enlightenment tradition.

Les deux sources acknowledges that there is something frenzied and uncontrolled (*frénétique et emporté*) in the race for material progress. Yet Bergson's perception of the problems raised by the scientific technology that is at the foundations of such progress is surprisingly narrow and shortsighted. He seems mostly sorry about "the search for comfort and luxury which seems to have become humankind's primary concern" (p. 322), although he quickly adds that there is no cause for worry, because humanity has always progressed by oscillating from one extreme attitude to its opposite—from a mysticism oriented toward self-control and self-possession to a materialistic mechanism aspiring to the control and possession of things. This is why "we should engage with no restraint in one direction in order to find out what the result will be: When it will no longer be possible to persist, we shall swing back with all our acquisitions, in the direction we had neglected or abandoned" (p. 321).

The dialectic of progress thus exhibits a kind of fatality that, in due time, can be expected to provide humankind, whose material body has grown dramatically, with a "supplement of soul" (p. 335). Bergson is confident that democracy will enable mechanism to satisfy everyone's true needs. Moreover, he expects that science will liberate the *elan vital* (vital impulse) from its materiality and spiritualize existence: "the material obstacle has almost tumbled down" (p. 337). Material progress fosters spiritual progress and thereby fulfills "the essential function of the universe, which is a machine for making gods" (p. 343). Understandably, a mind that entertains such lofty vistas will not be very sensitive to the concrete problems of everyday life, even those that would lead directly to a new and even more terrible war.

After World War II, French intellectuals were absorbed in the ideological and political debate for or against Marxism and communism. On the margins, such literary and religious thinkers as the Russian émigré Nicholas Berdyaev (1874–1948) and the novelists Georges Bernanos (1888–1948) and Jean Giono (1895–1970) raised pointed criticisms—as exemplified, for example, in the 1947 proceedings from a Geneva conference, *Progrès technique et progrès moral.* Against the threat of such views, Bergson's optimism was reaffirmed and turned into a technological messianism by the French personalist philosopher and founder of the journal *Esprit,* Emmanuel Mounier (1905–1950). His essay *Be Not Afraid* (1948) is a compendium of the irenic technophilia that predominated in French intellectual life until the late 1970s.

In response to the crisis of conscience that Hiroshima caused for some, Mounier dedicated himself to an unconditional justification of technology. For him, the criticisms made of "machinism" are founded on a theoretical error about the relationships between technology and society. The exponents of this view "claim to criticize the essential character of the machine, but in the main they attack the structure of capitalist society which has twisted the first services of the machine to its own ends" (pp. 31–32). Mounier thus summarizes in a nutshell the spirit of the time.

Whether spiritualists or materialists, rationalists or existentialists, most French philosophers were to adopt the Marxist doctrine that states "there is no problem of the machine as such." To the ethically scandalous problems of exploitation, economic inequality, and poor material living standards there are appropriate political responses. Concern for the environment was not yet a serious issue. Thus there was no philosophical problem of technology as such, and the leading French philosophers of the day completely ignored technology or even science as a theme calling for explicit critical assessment. Despite the fact that the work of Martin Heidegger (1889–1976) has been influential in France since the 1930s, there is little to nothing on technology in the work of Jean-Paul Sartre (1905–1980), Maurice Merleau-Ponty (1908–1961), or Albert Camus (1913–1960).

Bernard Charbonneau and Jacques Ellul

Although he does not mention them, Mounier's argument is almost certainly directed in part against the critical position of a small group of "Gascon personalists" led by Bernard Charbonneau (1910–1996) and Jacques Ellul (1912–1994). Born and educated in Bordeaux, under the shadow of World War I, the first truly industrialized war, Charbonneau passed his *agrégation* in both history and geography, but chose not to follow the standard academic career. Instead, he elected employment at a small teachers' college in order to be able to live a rural life in the Pyrenees.

Charbonneau's central intuition is that modern technoscientific development creates what he calls "the great mutation." Early on, Charbonneau became convinced that since the war humankind was experiencing an utterly new phase in its history, one that displays two basic characteristics. First, the Great War (World War I), as a total war, subordinated reality to the logic of industrial and technological imperatives, which require the mobilization of the whole population, resources (industry, agriculture, forests), and space itself. Indeed, the war achieved as well a mobilization of the inner life of the people who, on both sides, were not just affected by the war, but consented to it, thus justifying the anonymous process that would destroy them. The Great War was the first experience of what Charbonneau describes as "a total social phenomenon," insisting that it does not have to be totalitarian in order to be total.

Second, this great mutation is characterized by auto-acceleration. Human power takes hold of the entire planet at an ever-accelerating pace. This acceleration is a quasi-autonomous process. It is not a collective project, because most of its effects have not been chosen, and there is no pilot, because it simply rushes forward independent of any direct guidance. Technoscientific and industrial development fosters more and more rapid change throughout the world, across all aspects of life, without any respect for cultural meaning or purpose. The result is a radical disruption of society and nature, a state of permanent change.

Charbonneau was convinced that contemporary conflicting ideologies (nationalism, fascism, communism, liberalism) were outdated and provided no purchase on this great mutation, and that the uncontrolled development of industry, technology, and science was the problem and the not the solution. In his major books, written during the 1940s but published much later, Charbonneau insists that the issues of technoscientific development, of totalitarianism, and of ecological disruption are interrelated. In *L'Etat* (1987), he describes how the technological and industrial dynamism of liberal society has created the conditions of a total and technocratic organization of social and individual life. In *Le jardin de Babylone* (1969), he describes how the expansion of human power and of the techno-industrial order into a planetary scale deprives human beings of a harmonious relationship with nature and threatens not only ecological balance but also human freedom. In *Le système et le chaos* (1990), Charbonneau warns that the disorganizing impact of technological, scientific, and industrial development on nature and on society calls for a total organization of social life that will compromise human liberty.

Ellul was likewise born and educated in Bordeaux; together he and Charbonneau developed a version of personalism that promoted small, decentralized, and environmentally focused groups rather than centralized Parisian leadership. Unlike Charbonneau, Ellul elected a more academic career, and following his *agrégation* in Roman Law, became professor of the history of law at the University of Bordeaux.

Ellul is often characterized as a pessimistic Calvinist, urging the rejection of modern technology as an evil runaway power. But although Christian, he is neither Calvinist nor pessimistic; he firmly believes that it is possible to control and direct technological change, and indeed that technological choices are necessary and urgent. This is precisely the great political challenge that humankind must accept, otherwise politics is nothing but vain agitation. But the mastery of technological change is a difficult task, and in order to have any chance of success it is necessary to have a clear vision of the obstacles.

Ellul's analysis of the central role of technology in contemporary society is developed in three books. In *The Technological Society* (1954), he insists that the discussion of the role of machines is no longer relevant, because modern technology is not a mere accumulation of tools and machines; it is a global phenomenon which by means of propaganda, social planning and business management, and the organization of leisure subsumes all areas of individual and social life to the systematic search for efficiency. As a result there is a fundamental ambiguity of technological development, which, on the one hand, emancipates people from natural constraints and, on the other, submits them to a system of abstract and coherent functional constraints that in their own way determine social life. Technological progress fosters a technological society, more and more organized and integrated on the basis of impersonal logics.

In *The Technological System* (1977), Ellul argues that technology is now the environment in which human beings live and to which they must adapt. This technological environment is increasingly exhibiting a systemic cohesion. It is an interconnected network of technological ensembles; it organizes itself and evolves according to a process of "self-augmentation" dictated by its internal needs. This is why it is so resistant to attempts at reorganization from the perspective of non-technological values, whether ethical, political, or aesthetic. This technological system exhibits its own totalizing dynamic and tends to provide the main framework of social life. Nevertheless, Ellul adds that in spite of its capacity for auto-unification, this system is not and cannot be entirely coherent, because irrationalities and dysfunctions occur each time it is in contact with a different environment, natural, human, or social.

In *The Technological Bluff* (1988), Ellul argues that the development of the technological system parallels a cultural inability to address the problems created by technology, and that the suffusion of contemporary *mentalities* by a technicist worldview is one of the major obstacles to the mastery of technology. This is why policies aimed at controlling technological change require, in order to be effective, a change in both collective mentality and individual action. In *Changer la révolution* (1982), Ellul offers some guidelines for this new ethics of political action, which he terms an "ethics of non-power."

Jean Brun's Existentialist Interpretation

Another major contribution to the understanding of technology from an intellectual who lived and worked outside of Parisian institutions is Jean Brun (1919–1994). Like Ellul, Brun was a committed Protestant Christian who taught in the provinces at the University of Dijon. To the analysis of technology he brought an education in Greek and Roman philosophy that enabled him to once again challenge received views.

In *Le rêve et la machine* (1992), which synthesizes his major ideas, Brun maintains that the common understanding of technology as an application of rational and objective knowledge for effectively altering the world in order to satisfy human needs is dramatically one-sided and inadequate for appreciating contemporary problems of science and technology. The formal rationality of technoscientific endeavors is deceiving; it prevents people from recognizing the informal, imaginative, and often unconscious dimensions of technoscientific behavior.

Brun argues that technology is both a force of life and a force of death. On the one hand, without technology of some kind, human life would scarcely be possible. On the other, technology fosters destructive delirium, mechanized hysteria, and the planning of crazy projects. Human use of technology and the way humans develop it is often unreasonable, and its impact on nature and on human beings can be quite violent. For Brun there is a deep connection between technology and irrationality, and the obstacles to its rational uses must be appreciated.

According to Brun, technology manifests two goals: satisfying human *needs* for a better life (motives of pragmatic utility) and responding to *desires* to alter the human condition (existential motives). The study of ancient myths and ancient philosophy convinced Brun that technology is not merely an instrument useful for satisfying human needs, but also a means for empowering human desire for surpassing the ontological foundations of existence, for transmuting and overcoming the human condition. Human beings suffer and have always suffered from their finitude, from the alienation of consciousness, from physical and spiritual limitations, grounded in the necessity of living in space and time.

For Brun, the history of machines has been shaped and fueled by humanity's obstinate attempts to develop technologies of communication and transportation that attempt to break through such limitations. Beneath such obstinacy lies a hidden but fundamental despair within human consciousness regarding its separate and temporal mode of existence. Human technologies are often endowed with the power of discovering doors that open an existential labyrinth. In this respect human techniques are the offspring of human dreams as much as they are the application of positive knowledge. For Brun, "machines are both daughters and mothers of fantasies that we should call metaphysical ... [T]he utilitarian function of the machine is only its diurnal face; we must unveil its nocturnal face" (1992, p. 14).

This unveiling, which he also calls a demystification of technology, is a necessary precondition for any rational control and wise use of science and technology, as it is because humans project onto their technologies their desires for an ontological liberation that they remain fascinated by and addicted to their technologies. For the same reason, people often remain indifferent to technology's negative side effects and tend to transform the means into an end. Along with movies such as *The Fly* (1986) or *eXistenZ* (1999) by the Canadian filmmaker David Cronenberg, Brun argues for examining the ways utilitarian functions of technology are easily contaminated by its symbolic and existential functions.

The Mechanology of Gilbert Simondon

Another and quite different alternative to Enlightenment or positivist approaches to modern technology as applied science is found in the work of Gilbert Simondon (1924–1989), who proposed a general theory of the evolution of technological realities. Simondon was educated as a psychologist and philosopher at the Ecole Normale Supérieure in Paris and worked for the major part of his career in Poitiers and Paris. Because of a longtime interest in the character of machines, he studied what came to be called human factors engineering or ergonomics, which led him to attempt to understand their development somewhat independent of economic or other human interests.

In order to better clarify the human problems raised by machinism, Simondon chose the difficult path of laying the foundations of a kind of natural history of technological evolution. To this end he developed a conceptual framework for understanding the autonomy of technology and its radical alterity or otherness. As with Charbonneau, Ellul, and Brun, for him the category of instrumentality is inadequate for understanding the essential character of the technical order.

In *Du mode d'existence des objets techniques* (1958), Simondon argues that technical objects are not mere embodiments of abstract ideas, that they have their own mode of being or, as he says, of *existing*. Machines and technical objects evolve, and this evolution tends to exhibit a fundamental unity (structure). By analyzing the history of a few artifacts (motors, turbine, lamps, etc.), Simondon demonstrates how engineering practice follows the principle of functional unity, between the parts of the machine and between the machine and the exigencies of the surrounding world. "The technological being evolves by convergence and adaptation to itself. It unifies itself interiorly according to a principle of internal resonance" (p. 20).

Using as an example the evolution of the internal combustion engine, Simondon shows that each element assures the maximum possible of functions rather than attempt to realize a principle in its abstraction. Therefore, it is toward an interdependence of all the parts of the engine that its evolution converges, and it is this that leads to its progressive concretization through an organic-like integration of its diverse technical elements. According to Simondon, "The technological object exists then as a specific type that is found at the end of a convergent series. This series goes from the abstract to the concrete mode. It tends toward a state that would make the technological being a system entirely coherent with itself, entirely unified" (p. 23).

On this analytical basis Simondon develops a general theory of technology which, in the early twenty-first century, provides an intellectual framework for understanding the autonomy of technical objects and of technical systems: They develop according to a relational and reticular logic, obeying inner functional necessities that have little to do with human psychological, economical, social, and political goals. Although human beings produce technology, there is in technology something that is essentially resistant to human projects and values.

Simondon thinks that the solution to problems raised by the technicization of the world cannot be solved by politics, which relies on a poor understanding of the technical order and its dynamism. But for Simondon this is no reason for despair, and most of his subsequent intellectual endeavors aim at bridging the gap between the two cultures: the technoscientific operative one and the humanistic symbolic one. It is worth noting, in this respect, that although the second post-World War II generation of French philosophers such as Michel Foucault (1926–1984) and Jacques Derrida (b. 1930) were as silent about science and technology as their predecessors, some postmodernist authors such as Gilles Deleuze (1925–1995) have been attracted to Simondon. It may also be suggested that even those who do not share Simondon's rather optimistic and technophilic spirit may find in his thought substance for the pursuit of an authentic post-technological culture.

Supplementary Dimensions

The works of these four philosophers and the issues they wished to address were not, during their own time, well received in the French academic world. It is remarkable, for instance, that despite the 1974 French commitment to the development of nuclear power, this led to none of the kinds of public or intellectual debates typical of nuclear power developments in such countries as the United States or Great Britain. Nor has the increased technical powers of the professions of medicine or engineering engendered the kinds of discussions of professional ethics typical, especially, of the United States. Yet in the 1980s things did begin to change. One of these changes was the influence from the English-speaking world of the applied ethics movement, especially the field of bioethics.

In 1983, for instance, French President François Mitterrand created the Comité Consultatif National d'Ethique (CCNE), which consists of forty members, including representatives from different philosophical and religious schools of thought, public figures, and various scientific research institutions. Unlike similar or related commissions in other countries, the CCNE is not designed to be impartial but to elicit different points of view. Also unlike Enquette commissions in Germany or Royal Commissions in Commonwealth countries, the CCNE in not limited to specific topics but is an ongoing body. In 1994, in part as an outgrowth of its opinions, the French National Assembly passed legislation dealing with organ donation, medically assisted reproduction, and prenatal diagnosis.

Another associated activity emphasizing bioethics is the Science Generation Web site, which is cosponsored by the Institute de France, the Aventis Foundation, the Royal Swedish Academy of Engineering Sciences, the Federation of Scientific and Technical Associations, the European Council of Applied Sciences and Engineering, and the European Commission. This Internet site thus serves as a model of interdisciplinary and government-private partnership. But precisely because of their high profiles, neither the CCNE nor Science Generation represents serious critical assessment. Although both manifest an emerging concern for science, technology, and ethics issues, both focus much more on reflecting the opinions of technoscientific experts or the general public.

Another indication of the emerging French interest in science, technology, and ethics has been the stepping out of scholars more consistently devoted to these topics than has previously been the case. One example was an exchange between mathematician and historian of science Michel Serres and science studies ethnographer Bruno Latour (1990), in which the two explore how technoscientific power entails in itself ethical challenges. Still another was the creation in 1992 of the Société pour la Philosophie de la Technique (SPT), which provides an arena where competing philosophic approaches toward technology can be discussed in a constructive way.

Among the contributors to SPT discussions one may take special note of the following: Jean-Jacques Salomon (Conservatoire National des Arts et Métiers), in analyses of relations between science and politics, has raised the issue of democratic control not only of technology but also of scientific research. Dominique Janicaud (Université de Nice), with his theory of *potentialization*, has examined how progress in some types of rationality has created a potential for new forms of dehumanizing irrationalities. Gilbert Hottois (Université Libre de Bruxelles), a Belgian philosopher, has argued the inherently *an-ethicity* and autonomy of technological change, while arguing from the example of bioethics for the possibility an *accompagnement symbolique* for science and technology. And Franck Tinland (Université Paul Valéry, Montpellier) insists from an anthropological point of view on the long term autonomy of technological change and the resulting ethical problems that humankind is now facing.

DANIEL CÉRÉZUELLE

SEE ALSO *Bergson, Henri; Comte; Auguste; Descarte, René Durkheim, Émile; Ellul, Jacques; Enlightenment Social Theory; Existentialism; Foucault, Michel; Levinas, Emmanuel; Lyotard, Jean-François; Paschal, Blaise; Phenomenology; Progress; Rousseau, Jean-Jacques; Verne, Jules.*

BIBLIOGRAPHY

Bergson, Henri. (1932). *Les deux sources de la morale et de la religion* The two sources of morality and religion]. Paris: Félix Alcan.

Brun, Jean. (1992). *Le rêve et la machine* [The dream and the machine]. Paris: Table Ronde.

Charbonneau, Bernard. (1969). *Le jardin de Babylone* [The garden of Babylon]. Paris: Gallimard.

Charbonneau, Bernard. (1987). *L'Etat* [The state]. Paris: Economica.

Charbonneau, Bernard. (1990). *Le systéme et le chaos* [The system and chaos]. Paris: Economica.

Ellul, Jacques. (1964 [1954]). *The Technological Society*, trans. John Wilkinson. New York: Knopf.

Ellul, Jacques. (1967). *The Political Illusion*, trans. Konrad Kellen. New York: Knopf.

Ellul, Jacques. (1980 [1977]). *The Technological System,* trans. Joachim Neugroschel. New York: Continuum.

Ellul, Jacques. (1982). *Changer la révolution: L'inéluctable prolétariat* [To transform the revolution: The unavoidable proletariat]. Paris: Seuil.

Ellul, Jacques. (1990 [1988]). *The Technological Bluff,* trans. Geoffrey W. Bromiley. Grand Rapids, MI: Eerdmans.

Hottois, Gilbert. (1984). *Le signe et la technique* [Symbol and technique]. Paris: Aubier.

Hottois, Gilbert. (1999). *Essais de philosophie bioéthique et biopolitique* [Essays on philosophical bioethics and biopolitics]. Paris: Vrin.

Janicaud, Dominique. (1994). *Powers of the Rational: Science, Technology, and the Future of Thought,* trans. Peg Birmingham and Elizabeth Birmingham. Bloomington: Indiana University Press.

Mounier, Emmanuel. (1951). *Be Not Afraid: Studies in Personalist Sociology,* trans. Cynthia Rowland. London: Rockliff.

Recontres internationales de Geneve. (1948). *Progrès technique et progrès moral* [Technical progress and moral progress]. Neuchatel: La Baconnière.

Salomon, Jean-Jacques. (1973). *Science and Politics,* trans. Noël Lindsay. Cambridge, MA: MIT Press.

Salomon, Jean-Jacques. (1999). *Survivre a la science* [Surviving science]. Paris: Aubier-Montaigne.

Serres, Michel, and Bruno Latour. (1995). *Conversations on Science, Culture, and Time,* trans. Roxanne Lapidus. Ann Arbor: University of Michigan Press.

Simondon, Gilbert. (1958). *Du mode d'existence des objets techniques* [On the mode of the existence of technical objects]. Paris: Aubier.

Tinland, Franck. (1977). *La diférence anthropologique* [The anthropological difference]. Paris: Aubier-Montaigne.

Tinland, Franck. (1997). *L'homme alétoire* [Human otherness]. Paris: Presses Universitaires de France, 1997.

Toulouse, Gérard. (1998). *Regards sur l'ethique des sciences* [Considering the ethics of the sciences]. Paris: Hachette-Littératures. Presents the views of an influential physicist.

Toulouse, Gérard. (2003). *Les scientifiques et les droits de l'Homme* [Scientists and human rights]. Paris: Maison des sciences de l'homme.

FREUD, SIGMUND

The psychologist Sigmund Freud (1856–1939), who was born in Freiberg (now Príbor in the Czech Republic) on May 6 of Jewish parents and educated as a medical doctor in Vienna, founded the field of depth psychology (which he called psychoanalysis) and became one of the most influential thinkers of the late nineteenth and early twentieth centuries. His studies of the structure of the human psyche, the contents of the unconscious mind, the meaning and interpretation of dreams, repression, anxiety, and the role of the libido in the personality gave rise to many schools of psychological theory and therapy.

Ambivalence toward Science and Technology

Throughout this life Freud maintained a deep-seated belief in the value of scientific inquiry and a deep antipathy toward religion. In *New Introductory Lectures on Psycho-Analysis* (1952 [1932]), Freud stated

> Of the three forces which can dispute the position of science, religion alone is a really serious enemy. Art is almost always harmless and beneficent, it does not seek to be anything else but an illusion. . . . Philosophy is not opposed to science; it behaves itself as if it were a science, and to a certain extent makes use of the same methods. . . . Our best hope for the future is that the intellect—the scientific spirit, reason—should in time establish a dictatorship over the human mind. . . . Whatever, like the ban laid upon thought by religion, opposes such a development is a danger for the future of mankind. (p. 875)

However, Freud seemed ambivalent about the vast achievements of science and technology. On the one hand, he fully endorsed the desirability of human domination of nature. In perhaps his best-known work, *Civilization and Its Discontents* (1961 [1929]), Freud observes: "During the last few generations mankind has made an extraordinary advance in the natural sciences and in their technical application and has established his control over nature in a way never before imagined" (p. 39).

On the other hand, this domination has not brought with it a commensurate increase in human contentment. Human beings, Freud writes in *Civilization and Its Discontents,* "seem to have observed that this newly-won power over space and time, this subjugation of the forces of nature, which is the fulfillment of a longing that goes back thousands of years, has not increased the amount of pleasurable satisfaction which they may expect from life and has not made them feel happier" (p. 39).

Freud's greater worry, however, was the potential for destructive misuse of humankind's new powers. In *The Future of an Illusion* (1961 [1927]) Freud confesses his deep anxiety in a single sentence: "Human creations are easily destroyed, and science and technology, which have built them up, can also be used for their annihilation" (p. 7). This dark theme is taken up again in *Civilization* *and Its Discontents*, where he states that humans "have gained control over the forces of nature to such an extent that with their help they would have no difficulty in exterminating one another to the last man. They know this, and hence comes a large part of their current unrest, their unhappiness and their mood of anxiety" (p. 112).

Freud's psychoanalytical studies suggested to him that human beings overestimate themselves. In the middle of the calamity of World War I Freud wrote in *Thoughts for the Times on War and Death* (1952 [1915]):

> From the foregoing observations, we may already derive this consolation—that our mortification and our grievous disillusionment regarding the uncivilized behavior of our world-compatriots in this war are shown to be unjustified. They were based on an illusion to which we had abandoned ourselves. In reality our fellow-citizens have not sunk so low as we feared, because they had never risen so high as we believed. (p. 760)

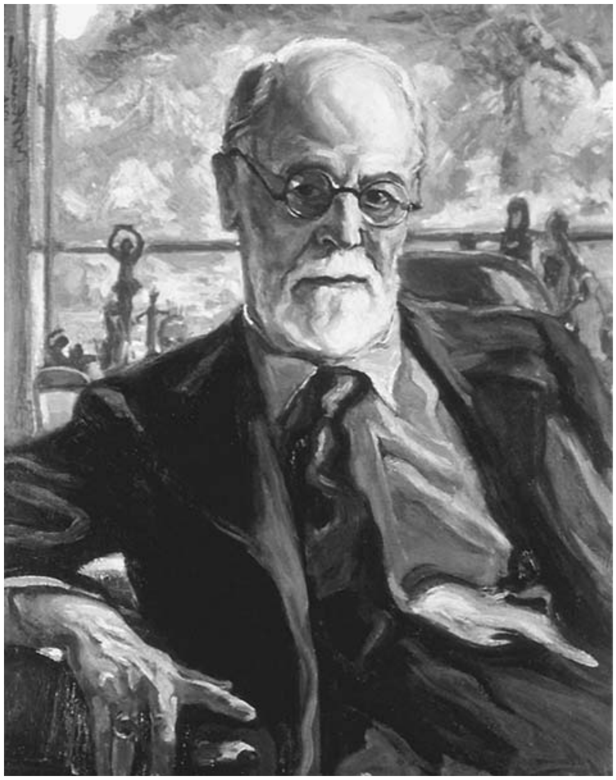
Ethics

Ethics does not constitute an important theme in Freud's major works. In *Civilization and Its Discontents* he suggested that ethics represents an attempt to accommodate the demands of a culture. The pleasure-seeking drive of the id is opposed by social restrictions in the form of the super-ego, and the ego is forced to mediate between these two poles: "Ethics is thus to be regarded as a therapeutic attempt—as an endeavor to achieve, by means of a command of the super-ego, something which has not so far been achieved by means of any other cultural activities" (p. 108)

Freud offers candid, less psychologically-oriented remarks on ethics in letters to a friend, the Swiss pastor Oskar Pfister. Writing in 1918, Freud admits a lack of interest in issues of "good" and "evil" because he has found "little that is 'good' about human beings on the whole. In my experience, most of them are trash, no matter whether they publicly subscribe to this or that ethical doctrine or to none at all. . . . If we are to talk of ethics, I subscribe to a high ideal from which most of the human beings I come across depart most lamentably" (pp. 61–62).

In a letter written a decade later Freud characterized ethics as a "kind of highway code for traffic among mankind" (p. 123). His last brief comment on ethics appears in a 1929 letter in which he states that: "ethics are not based on an external world order but on the inescapable exigencies of human cohabitation" (p. 129).

Freud's theories of the mind have been criticized, modified, extended, and even rejected by some schools of thought. Feminist writers, for example, have criticized Freud's essay on the psychology of women as deeply embedded in the gender stereotypes of his time. Yet even this critical stance must be measured against the strong presence of women in the field of psychoanalysis from its inception; Freud's own daughter Anna extended her father's work into the psychopathology of children.



Sigmund Freud, 1856–1939. The work of Freud, the Austrian founder of psychoanalysis, marked the beginning of a modern, dynamic psychology by providing the first systematic explanation of the inner mental forces determining human behavior. *(The Library of Congress.)*

More than six decades after his death, Freud continues to exert a powerful influence on how people view themselves as individuals and as a culture.

WILLIAM SHIELDS

SEE ALSO *Jung, Carl Gustav; Psychology.*

BIBLIOGRAPHY

Freud, Sigmund. (1952 [1915]). *Thoughts for the Times on War and Death,* trans. E. Colburn Mayne. *Great Books of the Western World,* Volume 54. Chicago: Encyclopedia Britannica. Gloomy essay written in 1915 amidst the onset of World War I.

Freud, Sigmund. (1961 [1927]). *The Future of an Illusion,* trans. James Strachey. New York: Norton and Company. Freud's main assault on religion as the enemy of science.

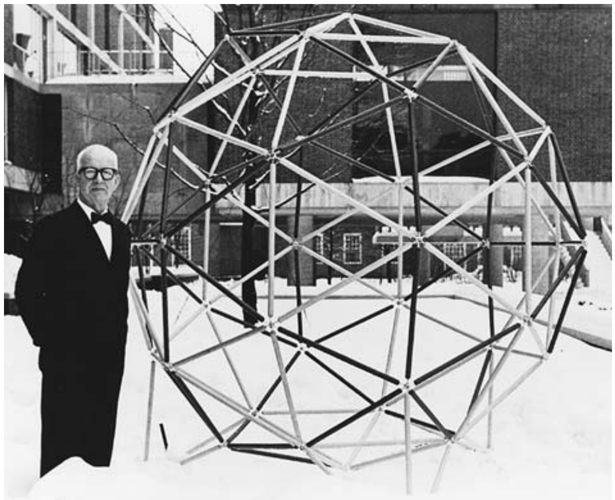
Freud, Sigmund. (1961 [1929]). *Civilization and Its Discontents*, trans. James Strachey. New York: Norton and Company. Searching inquiry into the causes of human unhappiness viewed from the psychoanalytic viewpoint.

Freud, Sigmund. (1952 [1932]). *New Introductory Lectures on Psycho-Analysis*, trans. W. J. H. Sprott. *Great Books of the Western World*, Volume 54. Chicago: Encyclopedia Britannica. Freud's 1932 revision of his 1915–1917 lectures; essentially the final form of his psychoanalytic theories.

Freud, Sigmund. (1963). *Psychoanalysis and Faith: The Letters of Sigmund Freud and Oskar Pfister*, ed. Heinrich Meng and Ernst L. Freud; trans. Eric Mosbacher. New York: Basic Books. Candid thoughts expressed to a friend, casual but interspersed with sharp observations and criticisms.

Ricoeur, Paul. (1970). *Freud and Philosophy: An Essay on Interpretation*. New Haven, CT: Yale University Press. Penetrating analytic guide to Freud's thought.

Roazen, Paul. (1968). *Freud: Political and Social Thought*. New York: Knopf. Freud's thought applied to politics and social theory.



R. Buckminster Fuller, 1895–1983. The American architect and engineer was in a broad sense a product designer who understood architecture as well as the engineering sciences in relation to mass production and in association with the idea of total environment. *(AP/Wide World Photos.)*

FULLER, R. BUCKMINSTER

A major contributor to scientific engineering and environmental studies, Richard Buckminster (Bucky) Fuller (1895–1983) was born on July 12 in Milton, Massachusetts, and died July 1 in Los Angeles, California. His epitaph, "TRIMTAB," sums up the worldview of the man who coined the term "spaceship earth." *Trim tab* is an aviator's term that refers to adjusting the wing's surface in order to change direction slightly. "TRIMTAB" refers to Fuller's belief that no one could actually steer the entire spaceship earth, but one could adjust the course slightly and stabilize it in times of turbulence.

Fuller entered Harvard in 1914, only to be expelled twice for "irresponsibility and lack of interest." From this inauspicious educational beginning, Fuller went on to receive forty-four honorary degrees, lecture at more than five hundred universities around the world, author twenty-four books as well as hundreds of articles, travel around the world more than forty times, and hold twenty-six patents.

Fuller was an environmentalist long before the word was popular. In 1927, Fuller designed Dymaxion House, a metal structure hung from a central mast with outer walls of glass. The unique house was heated and cooled by natural means, created its own power, included prefabrication, had rotating closets, was self-vacuuming, and was storm- and earthquake-proof. He built an example of the Dymaxion House in 1946 in Wichita, Kansas. In naming this contribution, Fuller demonstrated he was also a master of creating neologisms. *Dymaxion* is a combination of "dynamic," "maximum," and "ion." These three properties characterize his design strategy applied to many different problems.

For the 1933 World's Fair in Chicago, Fuller designed and built the Dymaxion Car. It had three wheels, was twenty feet long, carried eleven passengers, got thirty miles to a gallon of gasoline, and obtained a speed of 120 miles per hour. The car could make a u-turn within its own length.

In 1936, Fuller turned his attention to poor sanitation and the high cost of bathrooms. The five-square-foot Dymaxion Bathroom was his solution. The prefabricated bathroom consisted of four sections of either sheet metal or molded plastic. All of the necessary pipes, wires, and appliances were built in so that the entire unit merely required being hooked up. Both the sink and bath/shower allowed easy access by children and seniors.

In 1940, recognizing the need for military housing, Fuller designed and built the Dymaxion Deployment Unit (DDU). The DDU was a circular structure twenty feet in diameter made of corrugated galvanized steel, lined with wallboard on the inside and insulated with fiberglass. The house was naturally air-conditioned. Superheated air rising from the outer steel walls created a vacuum under the house that sucked cool air down the ventilator.

Fuller's Dymaxion Airocean World Map shows the continents on a flat surface without any visible distortion. On this map, the earth appears to be approximately one island surrounded by water. In the March 1, 1943, issue, *Life* magazine published Fuller's world map. That issue sold 3 million copies, the largest circulation of the magazine to that date.

In 1945, the Dymaxion Dwelling Machine house was designed and built. This was a vast improvement on the DDU house. The intention was to create a prefabricated house at low cost whose disassembled parts could be shipped anywhere in the world to meet the housing needs that were emerging at the end of World War II. The house was featured in *Fortune* magazine and generated thousands of unsolicited orders. These orders were never filled because of ethical differences between Fuller and financiers.

In 1948 Fuller created the most well known of his designs, the geodesic dome. A geodesic dome was selected for the United States Pavilion at the 1967 Montreal Exposition, where it still stands.

Buckminster Fuller was an early thinker about the entire earth. His *Operating Manual for Spaceship Earth* (1978) helped to focus world attention on one earth and the growing need to work together for survival. In poetic works such as *No More Secondhand God* (1963), Fuller also imbued technology with religious significance and called on human beings to accept responsibility for their god-like powers. He argued that human beings had to either create utopia or destroy themselves. *Synergetics* and *Synergistics 2* (1975 and 1979) is Fuller's mathematical masterpiece concerning the geometry of nature and the universe.

A truly remarkable man, Fuller's contributions all focused on what he referred to as a "Comprehensive Anticipatory Design Science." In this view, the science is directed to anticipating human problems and solving them by providing more and more support for everyone, with less and less resources. Yet Fuller often expressed himself in a vocabulary that critics sometimes found eccentric if not opaque.

HENRY H. WALBESSER

SEE ALSO *Earth; Earth Systems Engineering and Management; Efficiency; Engineering Ethics; Environmentalism.*

BIBLIOGRAPHY

Fuller, Buckminster. (1938). *Nine Chains to the Moon*. New York: J. B. Lippencott. Fuller's solution to the space trajectory to the moon.

Fuller, Buckminster. (1962). *Education Automation*. Carbondale: Southern Illinois Press. Thoughts about educationally effective and environmentally safe applications of automation.

Fuller, Buckminster. (1963). *No More Secondhand God*. Carbondale: Southern Illinois University Press. Fuller's view of how technology and the spiritual are related.

Fuller, Buckminster. (1970 [1928]). *4-D Timelock*. Corrales, NM: The Lama Foundation. Fuller's view of the space-time continuum.

Fuller, Buckminster. (1973). *Operating Manual for Spaceship Earth*. New York: Penguin. A view of earth as a contained spaceship with finite and non-renewable natural resources.

Fuller, Buckminster. (1975). *Synergetics: Explorations in the Geometry of Thinking*. New York: Macmillan. The geometry of nature is presented in this volume and the second volume.

Fuller, Buckminster. (1979). *Synergetics 2: Further Explorations in the Geometry of Thinking*. New York: Macmillan.

Fuller, Buckminster. (1981). *Critical Path*. New York: St. Martin's Press. An economic analysis solving problems within the model of using less to obtain more.

Fuller, Buckminster. (1983). *Grunch of Giants*. New York: St. Martin's Press. An extension of critical path with applications of Fuller's geometry of nature.

Fuller, Buckminster. (1983). *Inventions—The Patented Works of R. Buckminster Fuller*. New York: St. Martin's Press. A compendium of Fuller's inventions.

Fuller, Buckminster. (1992). *Cosmography*. New York: Macmillan. Published posthumously. An extension of Fuller's views of the universe and the earth as one of its elements.

FUTURE GENERATIONS

Responsibility to future generations appears at first to be an uncomplicated concept, and its widespread appearance in public pronouncements and political rhetoric testifies to its apparently widespread endorsement by public opinion. Moreover, advances in science and technology have directly increased the urgency and relevance of this concept as the present generation becomes ever more aware of its capacity to impact (with industrial chemicals, environmental exploitation, and climate change), destroy (with nuclear and biological weapons), and alter (with genetic engineering) the life conditions of the generations that will follow.

However clear and urgent the concept of responsibility to the future might seem upon casual reflection, as philosophers examine that concept with their typical meticulous analytic scrutiny, numerous puzzles, paradoxes, and quandaries emerge. Questions concerning the ontological, epistemological, and moral status of future persons (stipulated here as having non-concurrent lives with the current generation) are crucial. Most fundamentally, future persons, *qua future*, do not exist *now*, although the burdens of responsibility fall upon the living. Thus the question arises as to the attribution of such moral categories as *rights of* and *duties to* non-actual beings. Moreover, one cannot know future people as *individuals*. Instead, *posterity* is an abstract category containing unnumbered and undifferentiated members. And yet, much moral theory is based upon the principle of "respect for autonomous *individuals*." Additionally, one's relationship with future persons is unidirectional and non-reciprocal. Future persons will be unable to reward or punish the current generation, as the case may be, for the provision for their lives. Finally, because living people are ignorant of the life conditions of future persons, they cannot determine just what might *benefit* future persons—that is, what will or will not be "goods" to them. Clearly, by assigning moral significance to those not yet born, one introduces problems that are unique in moral philosophy.

Four Special Problems

One problem is that of Radical Contingency (or "The Future Persons Paradox"). Attempts in the present to improve the living conditions in the future result in different individuals existing in the future. Accordingly, in the present one cannot improve the lives of any particular future individuals (because any such attempt results in different individuals). Thomas Schwartz, who posed this paradox in 1978, concluded that present generations have no obligations to the future, other than to insure that their lives are, on balance, "worth living" (Schwartz 1978).

A rebuttal position would be to accept the paradox but to conclude that the responsibility to the future is to promote policies that will result in optimum conditions for *alternative populations*. In other words, Policy A is to be preferred to Policy B, if the lives resulting from Policy A are preferable to the lives resulting from Policy B, even though no *particular* future lives are improved thereby (Partridge 1998).

A second problem regards the duties to and rights of future persons. Do future persons have rights to clean air and water, wild areas, a tolerable climate, biodiversity, and energy resources? The question has significant policy implications regarding, for example, the use or conservation of natural resources, the depositing of nuclear wastes, or the reduction in the use of fossil fuels to minimize global warming. Rights claims have stronger moral force than mere *duties of beneficence* that are not correlated with the rights of the beneficiaries. Accordingly, by acknowledging the rights of future persons, those in the present generations may be morally obliged to accept greater sacrifices.

While many philosophers acknowledge duties to future generations, most who have written on the issue would deny that future persons have rights in the present, for the simple reason that potential persons, because they do not exist and cannot make claims, cannot be said to have rights (deGeorge 1979; Beckerman and Pasek 2001).

A contrary view contends that the denial of the rights of future persons involves an oversimplification of the concept of rights. There are, in fact, several categories of rights. While it is true that future persons, being non-actual, do not now have *active rights* to initiate or forbear activities on their own initiative, they do have *passive rights* not to be deprived of opportunities and not to be harmed. Unlike active rights, passive rights entail no initiative on the part of the rights-holder (future persons) but instead place a burden of responsibility on the correlative duty-bearer (the present generation) (Partridge 1990).

A third problem involves possible people and eventual people. Does a responsibility to future generations entail a duty of procreation—a duty to *create* future people (*possibles*)? Or is it confined to a duty to individuals who will, in any case, exist in the future (*eventuals*)? Clearly, the question has important implications for population policy. If current generations have a duty to bring possibles into existence, then the morally optimal future population will be much larger than if the duty of present persons is confined to eventual people. The issue also entails some deep ontological puzzles. For example, if a person is very pleased to be alive, would that person have been "harmed" if he or she had not been born? If so, then who is the "victim"? By stipulation, there is none. If no victim, then wherein is the harm? And yet, it is generally regarded as irresponsible to conceive a child who is certain to lead a brief and miserable life (e.g., a victim of Tay Sachs disease). Herein lies a paradox that is much discussed by moral philosophers (Warren 1981; Parfit 1984).

Finally, there is the problem of average utility versus total utility. When the utilitarian proposes to "maximize utility" (variously defined), does this mean *average* or *total* utility? With reference to a given (e.g., the current) population, there is no difference: raise the total and the average raises, and *vice versa*. However, the difference arises with the issue of population policy: That is, how many persons should be brought into existence in the future? Full commitment to either average or total utility leads to counter-intuitive conclusions. According to the average utility principle, Adam and Eve alone, before the fall, lived in a better world than a hypothetically later world of thousands or millions of individuals who, though quite happy on average, were slightly less so than the original couple. On the other hand, the total utility principle requires fertile couples to produce children whose lives will be on balance slightly happier than unhappy—an obligation that applies even in an overcrowded world. The average versus total utility dilemma leads to a question that lies at the very foundation of utilitarian philosophy: are those living in the present obliged to create people for happiness (total utility), or should they create happiness for people (average utility)? (Sikora and Barry 1978).

Policy Guidelines

Once one has accepted a moral foundation for a responsibility to future generations, the question remains: How might this moral obligation best be fulfilled?

The question is complicated by current necessary ignorance of the essential needs, of the cultural "goods," and of the technological conditions of future generations. Past generations, out of a sense of responsibility to those of the present, might have uselessly preserved a continuing supply of whale oil (not knowing about petroleum) and taken no heed to preserving semi-conducting substances. How would current generations, similarly, avoid wasting effort and treasure by preserving "goods" that would prove to be of no value to their successors?

One begins by taking inventory of some firm assumptions of the condition and needs of future generations. These assumptions would include:

(a) that they will be humans, with well-known biotic requirements;
(b) therefore, that they will need to be sustained by a functioning ecosystem;
(c) those future persons to whom one has obligations will be *moral agents*, and thus bound by such familiar moral categories as *rights*, *responsibilities*, and the *demands of justice;* and
(d) that they will require stable social institutions and a body of knowledge and skills that will allow them to meet and overcome cultural and natural crises that may occur during their lifetimes.

These considerations entail the following three essential policy guidelines:

- *First do no harm.* Because of current generations' ignorance regarding future cultures and technologies, and considering also the above list of basic needs, it is much easier to identify future harms than future benefits. Accordingly, one should favor policies that mitigate evils over those that promote good. The pains and tribulations of future persons, like those of the currently living, can often be clearly attributed to disruptions in the fundamental biotic, ecosystemic, psychological, and institutional conditions listed above, while their pleasures and satisfactions will come from a future evolution of culture, taste, and technology that one cannot even imagine.
- The *critical Lockean proviso.* John Locke's proviso that one leave "as much and as good" for one's successors, while applicable to the preservation of just institutions and sustainable ecosystems, cannot apply to non-renewable resources. If, for example, current generations were to share fossil fuels equally with all future generations (hypothetically setting aside an ignorance of their numbers), their share might reduce to cup of oil and a lump of coal—in any case, this resource would be useless, and the current industrial civilization would collapse (deGeorge 1979). Instead, the obligation to the future is to supply not fossil fuels but what fossil fuels provide, namely energy. Thus this obligation entails aggressive research and investment in a successor source of energy, presumably renewable. The critical Lockean proviso also entails a utilization of "interest-bearing" renewable resources, such as sustainable forestry, fisheries, and agriculture, and this in turn validates the need to preserve natural ecosystems.
- *Preserve the options.* This rule is clearly entailed by the previous two. While one cannot predict the technological solutions to future resource scarcity, the currently living owe future generations a full range of options and opportunities for research and development of these technologies. This in turn entails a continuing investment in scientific and technical education and research. Happily, such an investment benefits the current generation and that of its immediate successors, as well as the remote future (Partridge 1994).

Historical Background

The issue of the duty to posterity, though recurrent in the history of philosophy, has only recently attracted close scrutiny. Of the approximately one million doctoral dissertations listed in *Dissertation Abstracts* in 2004, the first to contain the either the terms "future generations" or "posterity" in its title was completed in 1976. Of the nearly two hundred entries in *The Philosophers Index* listed under "future generations" and "posterity," all but three have been published since the first Earth Day, April 22, 1970.

An explanation of this sudden appearance of interest in the topic of the responsibility to future generations may be found in an analysis of the concept of *responsibility*. Two criteria that appear to be essential to the concept are *knowledge* of the consequences of an act, and *capacity* to select among alternative anticipated consequences. Accordingly, the issue of responsibility to future generations has arisen with the extraordinary advances in science (knowledge) and technology (capacity).

During the first half of the twentieth century, the very idea that human activities might seriously and permanently affect the global atmosphere and oceans, or the gene pool of the human species and others, seemed preposterous. Now the sciences have disabused humankind of such assurances: technology has produced chemicals and radioactive substances unknown to nature, and evidence proliferates of permanent anthropogenic effects upon the seas, atmosphere, and the global ecosystem. Furthermore, such consequences of industrial civilization as ozone depletion, global warming, the contamination of aquifers, and the deposition of radioactive waste, although the byproducts of benefits to the present generation, exact postponed costs to remote generations. With science providing knowledge of these possible hazards for the future, and technology providing the capacity to deal with them, current generations have the responsibility to act with caution and moral insight, so that they might proceed toward a secure and prosperous future.

ERNEST PARTRIDGE

SEE ALSO *Consequentialism; Deontology; Jonas, Hans; Posthumanism; Responsibility.*

BIBLIOGRAPHY

Beckerman, Wilfred, and Joanna Pasek. (2001). *Justice, Posterity, and the Environment*. Oxford, UK: Oxford University Press. An optimistic view of future prospects by an economist and a philosopher, who deny rights-claims of future generations upon present persons. The authors perceive no great burden of obligation to the future.

deGeorge, Richard. (1979). "The Environment, Rights and Future Generations." *Ethics and Problems of the 21st Century*, ed. Kenneth Goodpaster and Kenneth Sayre. Notre Dame, IN: University of Notre Dame Press. A denial of the rights of future generations combined with an affirmation of a "duty of non-malevolence" toward the future. Argues that current obligations to the future are severely constrained by ignorance of future conditions or the capacity to affect these conditions.

Parfit, Derek. (1984). *Reasons and Persons*. Oxford, UK: Clarendon Press. Through skillful and insightful uses of "thought experiments," Parfit reveals deep paradoxes and puzzles regarding future persons—imaginable, possible, and eventual. These analyses have profound implications for population policy and procreation decisions.

Partridge, Ernest. (1990). "On the Rights of Future Generations." In *Upstream/Downstream: Issues in Environmental Ethics*, ed. Donald Scherer. Philadelphia: Temple University Press. A qualified defense of the present rights-claims of future generations. Concedes that future persons do not currently have "active rights" (to act or to forbear action). However, they have "passive rights" to resources, knowledge, and just institutions that entail moral duties that apply to present persons.

Partridge, Ernest. (1994). "Posterity and the 'Strains of Commitment.'" In *Creating a New History for Future Generations*, ed. Tae-Chang Kim and James Dator. Kyoto, Japan: Institute for the Integrated Study of Future Generations. Explores the psychological capacity of present persons to make moral provision to the future. Lists several policy implications of this capacity.

Partridge, Ernest. (1998). "Should We Seek a Better Future?" *Ethics and the Environment* 3(1): 81–96. A reply to Thomas Schwartz's radical denial of obligation to future generations (see below). Concedes Schwartz's argument that there are no duties to individual persons in the future, but that nonetheless, present persons have a duty to enhance the life prospects of the class of eventual future persons.

Schwartz, Thomas. (1978). "Obligations to Posterity." In *Obligations to Future Generations*, ed. Richard Sikora and Brian Barry. Philadelphia, PA: Temple University Press. An original, influential, and logically compelling presentation of "the future persons paradox": namely, the conclusion that because significant policy decisions cause different individuals to come into existence, no obligations are owed to particular individuals in not-distant future (i.e., approximately six generations).

Sikora, Richard, and Brian Barry, eds. (1978). *Obligations to Future Generations*. Philadelphia, PA: Temple University Press, 1978. An important early collection of essays on the issue of responsibility to future generations. Discusses many issues, most prominently the utilitarian problems of average versus total utility and population policy.

Warren, Mary Anne. (1981). "Do potential people have rights?" In *Responsibilities To Future Generations*, ed. Ernest Partridge. Buffalo, NY: Prometheus Books. Examines "the person-affecting principle"—that the morality of an act is to be evaluated in terms of its benefit or harm to persons. Thus stated, the "principle" seems axiomatic and indisputable. But when applied to "possible" future persons, and to the decision of present persons to procreate, profound ethical and even ontological questions arise. (See also Parfit, above.)

G

GAIA

First articulated by the British chemist James Lovelock in the 1970s, the Gaia hypothesis (named for the Greek goddess who personified the earth) proposes that the biosphere, atmosphere, oceans, and surface rocks make up a single, self-regulating, homeostatic system (Lovelock 1979). Key observations that Lovelock used in support of Gaia include the long-term stability of chemical disequilibria in the atmosphere and oceans despite both high fluxes of many chemicals within the earth system, and the fact that these persistent (in some cases for billions of years) yet nonequilibrium conditions are particularly well-suited for life as it has evolved. To Lovelock, the implication of these and related observations is that the biosphere must actively modulate the chemical make-up, temperature, pH, and other attributes of the earth system in order to maintain conditions under which life can flourish. In particular, the composition of the atmosphere must be regulated by the biosphere to maintain near-optimal concentrations of chemicals such as hydrogen, oxygen, and nitrogen.

Lovelock and his followers have promoted Gaia as an integrative framework for the study of the earth system. It raises scientific questions and demands experiments that would not be recognized under the traditional disciplinary and reductionist regimens dominant in the earth and environmental sciences. Gaia is thus not only an attempt to specify a unifying framework for the operation of the entire earth system, but also an explicit critique of the existing organization of knowledge inquiry.

Gaia has had little effect on research agendas, however, and the number of working scientists willing to be associated with the hypothesis is small—perhaps less than a dozen. Critique of the hypothesis focuses on three lines of argument. Gaia is said to be tautological because it asserts that life exists under exactly those conditions that are suitable for life. It is said to be teleological because it implies that the earth system must have evolved according to a design concept. And it is said to be trivial because, even so, Gaia adds little to existing knowledge about feedbacks among physical, chemical, and biological processes (Kirchner 2002). In response it is argued that Gaia is an emergent phenomenon that cannot be understood through traditional, disciplinary, and reductionist cause-and-effect reasoning. Lynn Margulis, a forceful advocate of Gaia, suggests: "The Gaian viewpoint is not popular because so many scientists, wishing to continue business as usual, are loath to venture outside of their respective disciplines. At least a generation or so may be required before an understanding of the Gaia hypothesis leads to appropriate research" (Margulis and West 1997, p. 223).

But it remains to be seen if the type of interdisciplinary synthesis that Gaia demands is even possible. Interdisciplinarity founders not just on the administrative boundaries between disciplines, but also on the differences in subject, method, time and spatial scales, types of data, definition of problems, and criteria of proof among various disciplines. These differences cannot easily be transcended or reconciled. This disunity of science is not entirely capricious, but in part reflects the richness and diversity of nature. How actually to move from reductionism and disciplines to Gaian synthesis remains far from clear.

Indeed while the need for interdisciplinarity is accepted by many scientists, strategies in the early twenty-first century—exemplified by the construction of highly complex, mathematical models aimed at simulating the coupled ocean-ice-atmosphere system—are still essentially reductionist in nature, building a story from first principles and supporting bodies of observational data. Gaia's claim is that such approaches can no more yield a comprehensive understanding of the earth system than a mapping of synapses can reveal the workings of an individual's consciousness.

Thus at least at this point in the evolution of science and society, Gaia's greatest impact may be largely metaphorical. On one level this metaphor may continue to challenge science to engage nature more synthetically, just as the Cartesian metaphor of nature as a clockwork helped to advance the cause of reductionist science. But on a broader, societal level Gaia has already been embraced as a cautionary symbol of the earth's complexity, interconnectedness, and inscrutability. Wrote Václav Havel, "Our destiny is not dependent merely on what we do for ourselves but also on what we do for Gaia as a whole. If we endanger her, she will dispense with us in the interests of a higher value—that is, life itself" (Havel 1998, p. 171).

DANIEL SAREWITZ

SEE ALSO *Earth; Earth Systems Engineering and Management; Ecology; Environmental Ethics; Environmentalism.*

BIBLIOGRAPHY

Havel, Vaclav. (1998). "The Philadelphia Liberty Medal." In *The Art of the Impossible*. New York: Fromm International.

Kirchner, James W. (2002). "The Gaia Hypothesis: Fact, Theory, and Wishful Thinking." *Climatic Change* 52: 391–408. A spirited scientific (as opposed to espistemological) critique of the Gaia hypothesis.

Lovelock, James E. (1979). *Gaia: A New Look at Life on Earth*. Oxford: Oxford University Press. The most complete treatment of the hypothesis, by its creator.

Margulis, Lynn, and Oona West. (1997). "Gaia and the Colonization of Mars." In *Slanted Truths: Essays on Gaia, Symbiosis and Evolution*, ed. Lynn Margulis and Dorian Sagan. New York: Copernicus.

GALENIC MEDICINE

Galenic medicine (also called humoralism or Galenism) derives its name from the Greek physician and philosopher Galen (129–c.216C.E..). Galen's prolific writings were rooted in the Hippocratic corpus as well as the philosophical doctrines of Plato, Aristotle, and the Stoics. Medicine was identified with Galenism for 1,300 years, and was institutionalized in the European universities of the eleventh century after Arabic translations of Galen's writings were retranslated into Latin. Though Galenism was eclipsed in Europe by the rise of modern medicine, it still survives as *Unani* (Greek) medicine in some parts of India and Pakistan.

The foundation of modern medicine rests on the divorce of medicine from philosophy, two disciplines wedded in Galenism. Both philosophy and medicine were practical arts that sought to answer the Socratic question: How should a person live the good life? (Hadot 2002). The good life demanded a striving toward excellence (*arête*), in the gymnasium no less than in the symposium. In medicine, health was the excellence expressed by the proper blending of the humors (*krasis*). In philosophy, virtue required knowing what was moderate or intermediate between excess and deficiency. As such, bodily health was analogous to moral virtue and the physician like the philosopher was a guide to living according to the mean (*mesotes*)(Tracy 1969).

The Galenic physician could only assist nature (*physis*) to restore the proper balance in the patient because it was inherently good. Nature thus constituted both the source and the limit of the physician's art. In order to gain insight into the workings of nature, the Galenic physician incorporated the three parts of philosophy (natural philosophy, logic, and ethics) into diagnosis, prognosis, and therapy. How deeply the physician was steeped in the study of philosophy also distinguished true medicine from quackery (Galen 1997).

The study of natural philosophy allowed the physician insight into both human nature and the nature of the universe. The Galenic body was fluid because it was composed of humors—blood, black bile, yellow bile, and phlegm—which were formed by the same elements that constituted the cosmos (fire, water, air, and earth). Disease resulted from the imbalance (*dyskrasia*) of the humors or the predominance of one or another quality (hot, cold, wet and dry) Humors and their qualities linked humankind to the macrocosm and established a correspondence or proportion between them.

Logic was necessary to make sound judgments about conditions of illness and health. The good physician was urged to train and sharpen the senses, which included not only the five external senses but also the common sense (*koine aesthesis*) through which the givens of the senses were synthesized and delivered to the intellect (Nutton 1993). Hence both reason and sense experience were essential for the discovery and confirmation of the true nature of things. Logic also led to the search for causes within a teleological cosmology that demanded the inference of the invisible from the visible; the hidden causes from the manifest signs.

Ethics was the domain of human action and conduct. In Galenism, the patient, the physician, and their mutual relation were subjected to an elaborate *askesis* aimed at cultivating certain dispositions and habits (*hexis*) to restore the balance of body and soul (Edelstein 1967). Galenic therapeutics throughout the Middle Ages placed a strong emphasis on *dieta,* the art and craft of moral and somatic virtues. Health required the good ordering of the *naturals* (elements, humors, parts of the body, and faculties) and the regulation of the *non-naturals* (rest, motion, food and drink, evacuation, passions, and errors of the soul). The virtuous character of the physician hastened the healing powers of nature by forging a relationship of trust and friendship (Entralgo 1967).

The union of philosophy and medicine in Galenism was founded on the norms of a teleological nature. The medical art was practiced within the bounds of the natural order that tended toward health and virtue as the right proportion of the humors and the passions. The replacement of Galenism with scientific medicine occurred in the seventeenth century when nature lost its *telos* and was construed as an inert mechanism to be manipulated at will. In Galenism, the foundation in teleological nature made the medical art inherently ethical. By contrast, medical ethics in the twenty-first century is the mere application of established rules to a professional field.

SAMAR FARAGE

SEE ALSO *Acupuncture; Complementary and Alternative Medicine; Health and Disease.*

BIBLIOGRAPHY

Edelstein, Ludwig. (1967). "The Ethics of the Greek Physician." In *Ancient Medicine: Collected Papers of Ludwig Edelstein,* ed. Lilian Temkin and Oswei Temkin. Baltimore, MD: Johns Hopkins University Press.

Entralgo, Lain P. (1967). *Doctor and Patient.* New York: McGraw Hill. Explores the ethics of the doctor-patient relationship from ancient Greece to the present.

Galen. (1997). "The Best Doctor is Also a Philosopher." In *Galen: Selected Works,* trans. Peter N. Singer. New York: Oxford University Press. Galen's text that discusses the nature of the relation between philosophy and medicine.

Hadot, Pierre. (2002). *What is Ancient Philosophy?,* trans. Michael Chase. Cambridge, MA: Harvard University Press. Excellent investigation of ancient philosophy as a way of life and the changes brought about by Christianity and the Middle Ages.

Nutton, Vivian. (1993). "Galen at the Bedside: Methods of a Medical Detective." In *Medicine and the Five Senses,* ed. Roy Porter and William F. Bynum. New York: Cambridge University Press. Nutton shows the intimate relation between experience and reason in Galenic medicine.

Tracy, Theodore. (1969). *Physiological Theory and the Doctrine of the Mean in Plato and Aristotle.* Chicago: Loyola University Press. Exploration of the Greek founding of moral virtues and physical excellences in the notion of the mean.

GALILEI, GALILEO

Mathematician, astronomer, and natural philosopher, Galileo Galilei (1564–1642), who was born the same year as William Shakespeare in Pisa, Italy, on February 15, contributed fundamentally to the scientific revolution of the sixteenth and seventeenth centuries in which Ptolemaic geocentric cosmology and Aristotelian were successfully challenged by Copernican heliocentric cosmology and a new science of motion. Galileo's participation in the astronomical revolution included the best-known cases of his technological innovation and ethical/religious conflict, namely, his application of the telescope as an astronomical instrument and his engagement with the Roman Catholic Church over matters of biblical interpretation and the Copernican hypothesis. He died on January 8 in Arcetri near Florence where he was living under house arrest that had been imposed following his conflict with the church.

Natural Philosopher and Inventor

Galileo's career as a natural philosopher involved an ongoing study of natural motion, especially inertial motion and that of falling bodies, projectiles, and pendulums. His work helped lay the foundation for the new science of classical mechanics, which found its early modern culmination in the genius of Isaac Newton (1642–1727). In addition to the telescope, which he first turned toward the heavens in 1609, evidence suggests that Galileo contributed to the technological development, improvement, and scientific application of no fewer than eight other scientific instruments. These included the *pulsilogium,* a device that applied a

Galileo Galilei, 1564–1642. The Italian scientist is renowned for his epoch-making contributions to astronomy, physics, and scientific philosophy. *(The Library of Congress.)*

pendulum to measure the human pulse, in 1583; a hydrostatic balance which he developed for his experiments on floating bodies, in 1586; the *thermoscope,* an early thermometer, in 1593; a geometrical and military compass, in 1597; a natural magnet called a loadstone used to further the new science of magnetism, in 1601; the microscope, in 1610; the *giovilabio,* which was an obscure tool developed to compute the distances and periods of revolution of Jupiter's moons, which Galileo had discovered with his telescope in 1612; and finally, a number of *vibration-counters,* some derived from his study of pendulums, which he applied to the mechanisms of clocks by 1637.

That the majority of Galileo's technical instruments were measuring devices is indicative of his philosophical commitment to a quantitative science. Well-know for his aphorism that mathematics is the language in which the book of Nature has been written, Galileo sought mathematical regularities in his scientific description and placed a premium on the collection of quantitatively accurate data. Indeed it was Galileo's unswerving commitment to an ideal of scientific knowledge grounded in rigorous measurement and observation that fostered his commitment to Copernicanism, which led to his famous struggle with authorities of the Roman Catholic Church.

Galileo did not invent the telescope. He learned in 1609, however, that a Dutch lens grinder had secured a patent the previous year for a device that magnified distant objects by combining two lenses. On the strength of this news, Galileo crafted his own telescope and turned the tool, which had originally been conceived for terrestrial purposes, toward the heavens. He reported his observations, which included details of lunar topography, descriptions of previously unobserved stars and constellations, and an account of Jupiter's four principal moons, the following year in his best-selling book, *The Starry Messenger* (1610). By this time Galileo was fully convinced of the truth of Copernican (sun-centered) theory. Hence as his book popularized astronomy, it introduced Copernicanism to the common people. This move did not help his reputation among contemporary natural philosophers.

Argument with the Church

Galileo's Copernicanism placed him in opposition to common sense as well as to reigning scientific and theological opinions. During Galileo's lifetime conclusive scientific evidence sufficient to establish the Copernican system as true was not yet available. Galileo believed his theory of the tides provided the needed empirical proof, but he was mistaken. This error made him overconfident. He was originally attracted to Copernicanism by its mathematical elegance and aesthetic superiority, not because he possessed irrefutable evidence. Galileo's principal opponents, Aristotelian natural philosophers (that is, the scientific community), did not believe that such evidence would ever be found. Moreover many of these opponents disliked Galileo for reasons unrelated to the Copernicanism. Galileo had inherited from his father a feisty spirit and taste for intellectual combat. He had engaged anti-Copernican natural philosophers on other scientific questions related to such matters as floating bodies, sunspots, and a new supernova. In each case he had distanced himself from the established scientific authorities and embittered his opponents, many of whom wished to see Galileo silenced, by the Church if necessary.

The Catholic Church, in the absence of conclusive scientific evidence for Copernicanism, followed the lead of natural philosophers in rejecting it. Moreover this seemed to be in accord with a straightforward reading of relevant Biblical texts (Gen. 1; Eccles. 1:4–5; Josh. 10:12; Ps 19:4–6; Ps 93: 1; Ps 104: 5, 19), the interpretation of which rested with church authorities. As a loyal Catholic, Galileo was interested in persuading church leaders to reject geocentrism and thereby be saved from future embarrassment. To do so, however, would require scientific evidence he could not provide. Just as importantly, it would also require expert theological skill in interpreting those biblical texts that seemed to refute Copernicanism. Although a layman, Galileo attempted to provide such advice on biblical interpretation. His "Letter to the Grand Duchess Christina" (1615) was offered as guidance "concerning the use of Biblical quotations in matters of science." It ranks among the classic statements on the relation of the Bible to science. In it Galileo argued that because God is the author of both the book of nature (i.e. the physical world) and the book of revelation (the Bible), it is not possible for genuine conflict between science and scripture. When there appeared to be such a conflict regarding matters of the physical world, the advice of Cardinal Baronius (1538–1607) should be recalled, namely, "That the intention of the Holy Ghost is to teach us how one goes to heaven, not how the heaven goes" (Drake 1957, p. 186). Because, argued Galileo, the Bible is a religious and moral text, not a scientific text, passages that seemed to treat subjects of scientific inquiry should be interpreted with deference to scientific opinion.

Although Galileo had made a compelling argument, two factors counted against him. First the weight of scientific opinion did not yet favor Copernicanism. Second he was a layman presuming to instruct on principles of biblical interpretation. This was an especially dangerous thing to do in the early seventeenth century in the wake of the Protestant Reformation and the Council of Trent (1545–1563). Predictably and defensibly the Catholic Church acted with prudence by upholding both contemporary scientific judgment and received biblical interpretation. Thus in 1616 the Theological Consultors of the Holy Office (advisors to the Pope) declared the Copernican theory foolish and heretical. This opinion was not uniquely Catholic either: Both Martin Luther and John Calvin disapproved of Copernicanism. After the publication of his *Dialogue Concerning the Two Chief World Systems: Ptolemaic and Copernican* (1632), Galileo was judged by church authorities to be *vehemently suspected of heresy* and sentenced to house arrest. It is interesting and important to note, however, that despite the opposition of so many church leaders to Galileo's Copernicanism, the Church never formally condemned the Copernican theory *ex cathedra*. That is, it never formally made rejection of terrestrial motion a matter of ecclesiastical dogma. Galileo had been punished for transgressing a theological boundary by engaging in biblical interpretation as a layman, even though the question was of scientific relevance. Here a key ethical/philosophical dimension of the affair turned on the question of whether or not Copernicanism was a matter of religious faith. Galileo did not believe that it properly was. Church authorities disagreed. Viewed in such a light, the Galileo affair, ultimately, stands as a religious debate between Roman Catholics about biblical interpretation.

Galileo's achievement as a scientist rests not only on the fact that history has vindicated his Copernicanism. His achievements in the fields of dynamics, technical instrumentation, optics, astronomy, and philosophy of science combine to place him among the greatest of scientific minds. His engagement with the Catholic Church was a complicated affair that testifies to the vigor of his scientific ability and to his Christian faith. Although it has often been presented as a clash between modern science and religion, the Galileo affair is not best understood in this way, because all players were committed churchmen. Rather the affair evidences the complicated religious and ethical dimensions that surface when human beings seek to construct a coherent worldview that also does justice to deeply held convictions about matters both scientific and religious.

MARK A. KALTHOFF

SEE ALSO *Scientific Revolution; Space Exploration.*

BIBLIOGRAPHY

Blackwell, Richard J. (1991). *Galileo, Bellarmine, and the Bible*. Notre Dame, IN: University of Notre Dame Press.

DeSantillana, Giorgio. (1955). *The Crime of Galileo*. Chicago: University of Chicago Press.

Drake, Stillman. (1957). *Discoveries and Opinions of Galileo*. New York: Doubleday Anchor Books. This volume remains the standard English translation of Galileo's *Starry Messenger*, his letter to the Grand Duchess Christina, and other early works.

Galilei, Galileo. (1997). *Galileo on the World Systems: A New Abridged Translation and Guide*, trans. Maurice A. Finocchiaro. Berkeley: University of California Press. An accessible abridged English translation of Galileo's dialogue with a valuable introduction and notes for the modern student.

Howell, Kenneth J. (2002). *God's Two Books: Copernican Cosmology and Biblical Interpretation in Early Modern Science*. Notre Dame, IN: University of Notre Dame Press.

Jaki, Stanley L. (2001). *Galileo Lessons*. Pinckney, MI: Real View Books.

Koyré, Alexandre. (1978). *Galileo Studies,* trans. John Mepham. Atlantic Highlands, NJ: Humanities Press.

Langford, Jerome J. (1992). *Galileo, Science and the Church,* 3rd edition. Ann Arbor: University of Michigan Press. This is the best brief introductory volume on the subject of Galileo's encounter with the catholic church.

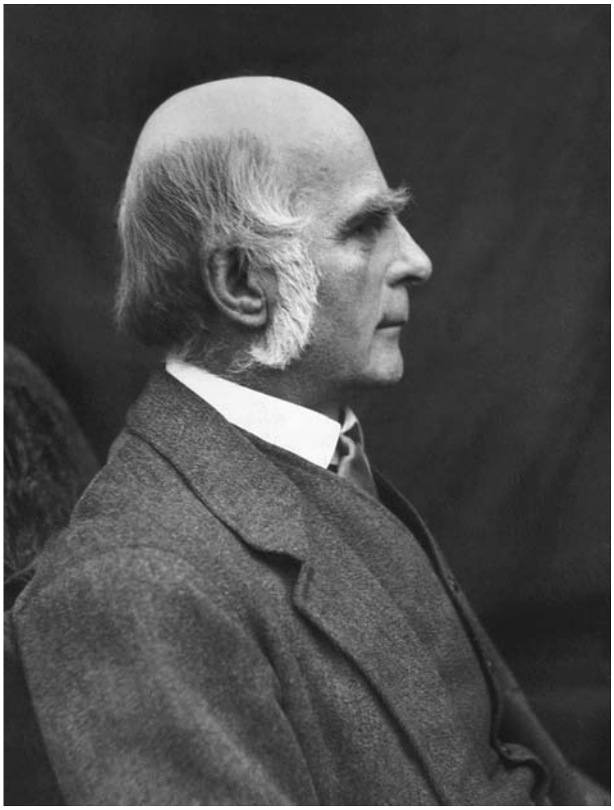
Lindberg, David C., and Ronald L. Numbers. (1986). *God and Nature: Historical Essays on the Encounter between Christianity and Science*. Chicago: University of Chicago Press. This classic anthology of scholarly articles includes two important chapters on Copernicanism and Galileo.

Machamer, Peter, ed. (1998). *The Cambridge Companion to Galileo*. New York: Cambridge University Press.

McMullin, Ernan, ed. (1967). *Galileo: Man of Science*. New York: Basic Books.

Shea, William R., and Mariano Artigas. (2003). *Galileo in Rome: The Rise and Fall of a Troublesome Genius*. Oxford, UK: Oxford University Press.

GALTON, FRANCIS



Francis Galton, 1822-1911. The English scientist, biometrician, and explorer founded the science of eugenics and introduced the theory of the anticyclone in meteorology. *(© Corbis-Bettmann.)*

Francis Galton (1822–1911), the scientist who created and promoted eugenics, the notion that a fitter human race might be created through selective breeding, was born near Birmingham, England, on February 16, and died in Haslemere, Surrey, England, on January 17. Originally oriented toward a medical career, Galton switched to Cambridge University to study mathematics, graduating with an ordinary degree. But his Cambridge experience was crucial to Galton's future career, during which he attempted to introduce quantitative analysis into whatever problem on which he happened to be working. His quantitative interests led Galton to discover the important statistical concepts of regression and correlation. He applied these in his anthropometric studies whose ultimate goal was to contribute to the improvement of humanity through eugenics, a term coined by Galton, that has profound ethical implications.

Galton's decision to abandon medicine was strongly influenced by his cousin, Charles Darwin (1809–1882), thirteen years his senior. They were grandsons by different marriages of Erasmus Darwin (1731–1802), a physician, scientist, poet, and inventor.

Like Darwin, Galton began his career as an explorer. Several years after graduating from Cambridge, he financed his own expedition and traveled through northern Namibia, a region of Africa not previously visited by Europeans. Galton took careful measurements of latitudes, longitudes, and altitudes, published his results in the *Journal of the Royal Geographical Society* in 1852, and was awarded a gold medal by the Society the same year. He also wrote a nontechnical book about his journey, *Tropical South Africa* (1853), but is best remembered for *The Art of Travel* (1855), an immensely popular guidebook for amateur and professional alike who ventured into the bush. The book went through many editions, grew in size, and Phoenix Press reissued the fifth edition in 2001. Subsequently Galton was active in the Royal Geographical Society for many years commenting frequently at Society meetings. During this part of his career he also became interested in meteorology. This led to his discovery of the anticyclone, a weather feature characteristic of a high-pressure system.

The second part of Galton's career commenced when he read Darwin's *On the Origin of Species* (1859). Galton concluded that it should be possible to improve the human race through selective breeding just as was true for domestic animals and cultivated plants. In 1865 he published a two-part article entitled "Hereditary Talent and Character" in a popular periodical called *MacMillan's Magazine*. The *MacMillan's* article was a precursor for Galton's book *Hereditary Genius* (1869). In both the article and the book Galton attempted to show that what he called *talent and character* were inherited. The book contained sections on judges and statesmen among others. Galton's thesis was that if he picked an eminent judge, for instance, that judge's immediate male relatives (e.g., father and son) were more likely to be eminent than those whose relationship was more distant (e.g., grandfather and grandson). Women were excluded from the analysis. Galton believed that analysis supported his thesis while recognizing, as others argued, that environment (for example, the father might obtain a good position for the son) might also be responsible for the correlation.

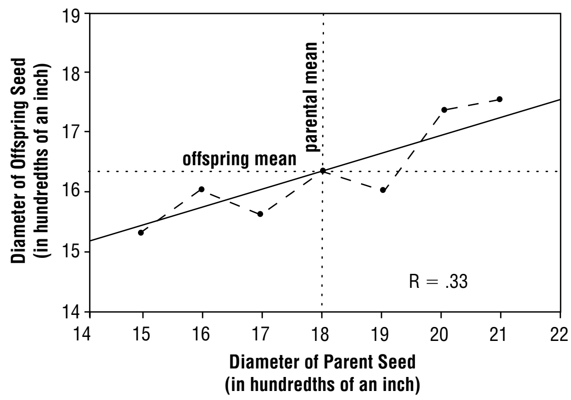
Galton was intensely interested in the analysis of quantitative data. By the time he had written *Hereditary Genius* he had become aware of the normal distribution and its application. In the book he used the bell curve to calculate a hypothetical distribution of the estimated 15 million males in the United Kingdom according to their natural abilities. Later Galton described two important new statistical concepts: regression and correlation. In experiments with sweet peas he found that seed diameter was normally distributed, but the diameter of seeds of progeny of large seeded and small seeded plants tended to be closer to the mean of the population as a whole than they did to the parental seed from which they had come. He dubbed this property regression to the mean. Regression to the mean has been documented over and over again since (for instance, in the case of different classes of mutual funds such as ones specializing in growth versus international stocks).

Galton also found he could draw a straight line on a graph comparing the diameters of parental and progeny seeds (Figure 1). This was the first regression line and from it he computed the first regression coefficient. Later he obtained comparable numerical data for humans (e.g., height) in the anthropometric laboratory organized at the International Health Exhibition of 1884 held in South Kensington, London. After the exhibition ended the laboratory reopened in the Science Galleries of the South Kensington Museum. Because Galton collected data on both parents and children, he once more demonstrated regression to the mean (e.g., for height).

FIGURE 1

Inheritance in Size of Sweet Pea Seeds

THE FIRST "REGRESSION LINE"



SOURCE: Galton, Francis. (1877). Royal Institution lecture, London. In Gillham (2001b).

While plotting forearm length against height he discovered another important statistical concept, correlation (i.e., tall men have long forearms). He reported the first correlation coefficient, countless numbers of which have been calculated since. Galton also became interested in fingerprints and their classification and used his anthropometric laboratory to collect scores of fingerprints. His work was central to the development of fingerprinting as a forensic technique.

Galton collected many of these important observations together in his book *Natural Inheritance* (1889). He began to acquire disciples. One of these, Karl Pearson (1857–1936), a superb mathematician, was able to develop statistical theory and go far beyond Galton in its formulation.

The Legacy of Eugenics

All the while Galton had been promoting eugenics. The notion that fitter people could be bred through selection began to gain great momentum in the first decade of the twentieth century. Positive eugenics envisioned the selective reproduction of those regarded as fit, while negative eugenics discouraged or prevented the reproduction of those deemed unfit. Sadly negative eugenics prevailed. In the United States eugenic sterilization laws were passed in many states leading to the involuntary sterilization of thousands of people who were thought to be mentally deficient or *feebleminded*. Developments in the United States were followed with interest elsewhere, especially in Germany. When the Nazis came to power they passed an involuntary sterilization law that resulted in the sterilization of hundreds of thousands of individuals. After World War II eugenic sterilization gradually came to an end. Although eugenics is Galton's unfortunate legacy, he also leaves important accomplishments such as statistics and the development of fingerprinting technology.

NICHOLAS WRIGHT GILLHAM

SEE ALSO *Darwin, Charles; Eugenics.*

BIBLIOGRAPHY

Gillham, Nicholas W. (2001a). "Sir Francis Galton and the Birth of Eugenics." *Annual Review of Genetics* 35: 83–101.

Gillham, Nicholas W. (2001b). *A Life of Sir Francis Galton: From African Exploration to the Birth of Eugenics*. New York: Oxford University Press.

Kevles, Daniel. (1995). *In the Name of Eugenics*. Cambridge, MA: Harvard University Press.

Kühl, Stefan. (1994). *The Nazi Connection*. New York: Oxford University Press.

Paul, Diane B. (1995). *Controlling Human Heredity:1865 to the Present*. Atlantic Highlands, NJ: Humanities Press.

Reilly, Philip R. (1991). *The Surgical Solution: A History of Involuntary Sterilization in the United States*. Baltimore, MD: Johns Hopkins University Press.

GAMES

SEE *Video Games.*

GAME THEORY

Game theory is the analysis of choices made by individuals, institutions, or governments, which are termed players; the results of one player's choice depend on the choices made by the others. Anticipations by players about how others may respond or may anticipate their actions thus influence choices of actions. An important attempt to use game theory involved the formation of nuclear deterrence strategy by the United States during the Cold War (1945–1990). However, game theory has many more general implications that go beyond those involving intentional choice.

Despite the fact that game theory matured only toward the end of the twentieth century, it has become a central tool in some of the behavioral sciences and doubtless will extend its influence into all disciplines that attempt to explain the behavior of living organisms. Indeed, game theory provides a language that transcends and potentially unites the various disciplines that deal with human behavior. Moreover, it provides an experimental methodology that allows for the rigorous construction and testing of strategic interaction because it forces an experimenter to be explicit in defining the actions available to the subjects, the payoffs, and the distribution of information among the subjects.

An Illuminating Example

A fox is chasing a rabbit through a wooded area. Foxes are faster than rabbits, and so if the rabbit runs in a straight line, it will be caught and eaten. The rabbit therefore periodically veers left or right, gaining ground on the fox. If the rabbit changes course too rapidly, its average forward movement will be so slow that it will be caught, but if it changes course too slowly, the fox will be so close that a small misstep by the rabbit will lead to its immediate demise. Therefore, the rabbit must choose the average rate of veering to optimize its probability of escaping.

In game theory it is said that the rabbit has *actions*: R_t = "Veer Right after t seconds" and L_t = "Veer Left after t seconds." The rabbit also wants to randomize its choice of Veer Right and Veer Left, because if the fox discovers a pattern in the rabbit's movement, it may be able to anticipate the rabbit's next move, thereby gaining ground on it. The proper mix of Veer Left and Veer right is doubtless 50 percent Left and 50 percent Right, for the fox potentially could exploit an imbalance in either direction.

However, suppose that there is an open field some distance to the east of the wood and that foxes run much faster than rabbits do in an open field. Then the fox might run constantly a little to the west of the rabbit, forcing the rabbit to turn east more often than it turns west. The rabbit in turn may risk being caught by veering west more frequently than it would otherwise, trying to keep away from the open field. It can be seen that both the rabbit and the fox choose actions to maximize the probability of winning, with each anticipating the effect of its actions on the other. This is the type of situation studied in game theory.

How important is game theory? It is central to understanding life in all its varied forms. This may sound excessive, but one must step back from this interaction between a rabbit and a fox to ask more basic questions. For example, why are rabbits bilaterally symmetrical about the axis along which their movement is most rapid and energy-efficient (left leg and right leg symmetrically placed and equally strong, left eye and right eye symmetrically placed and of equal size and discriminating capacity, and single external body parts such as the nose and tail arrayed along the axis of movement)? The answer is that if rabbits had strength biased to the right, it would be easier for them to jump left than jump right, and that would give an advantage to their natural predators, the foxes. Foxes are bilaterally symmetrical for similar reasons. Game theory thus explains important facts about life that otherwise appear arbitrary and incomprehensible.

This simple game theoretic argument explains a major fact about the organization of life. Animals that run to escape predators or capture prey have body forms that are bilaterally symmetrical about a vertical axis along the direction of their most rapid motion. This applies to most animals and fish but not to plants, which do not run and are radially symmetrical, or to squid, octopuses, and other sea creatures whose primary motion is up and down.

To avoid the conclusion that game theory deals only with conflict, one can consider an example that is called the Cooperation Game. A group of ten hunters in a village spread out in the jungle every day to look for large game. They hunt individually, climbing tall trees and waiting quietly and attentively for long hours until the prey appears. At the end of the day the hunters share the day's kill equally. Of course, each hunter could spend the day sleeping in a tree. Suppose that by working each hunter adds an average of 3,000 calories to the total kill, of which his share is 300, but expends 500 calories of energy hunting as opposed to sleeping. A selfish hunter thus will sleep rather than hunt, saving 200 calories but costing the other group members 2,700 calories. This is a game in which there are n players and each player (i.e., each hunter) has two actions: Work or Shirk. If m hunters Work, the Shirkers' payoff is $3{,}000m/n$ each, whereas the Workers' payoff is $3{,}000m/n - 500$.

A *best response* of a player in a game can be defined as a strategy (in this case an action) that maximizes that player's payoff in light of the strategies of the other players. It is easy to see that a self-interested player's best response in this game is to Shirk no matter what the other players do. A *Nash equilibrium* of a game is defined as a choice of strategies made by the players such that each is a best response to the other players' choices. It is clear that in the Cooperation Game there is only one Nash equilibrium, in which everyone shirks ($m = 0$) and no one eats.

Suppose another rule is added to the game. If a hunter is caught shirking, he is punished by being prohibited from hunting and sharing the kill for two days. Further, suppose the probability of being caught shirking is 0.50. To see that having everyone hunt is now a Nash equilibrium, one must decide whether a single hunter in a group of ten could do better by shirking and risking getting caught. The hunter saves 200 calories by shirking, but half the time he is caught and then loses two days' payoff, which is 5,400 calories. Thus, that hunter loses an average of 2,500 calories a day by shirking, and so his best response to hunt with the others. The conclusion is that with this new punishing mechanism full cooperation by each hunter becomes a Nash equilibrium.

History and Analytics of Game Theory

Game theory presupposes rational choice theory because it assumes that players have rational preferences in regard to the game's outcomes. It also presupposes rational decision theory because choice under conditions of uncertainty is the rule in most game situations. Because rational choice theory and decision theory were codified only in the late twentieth century, it is not surprising that game theory is still an incomplete and rather underdeveloped science. Before about 1950 games were assumed to be zero-sum; that means that what one player loses, the other player wins. The rabbit-fox game described earlier is zero-sum, but the hunter game is not because with the proper strategies all the hunters gain by cooperating.

With the zero-sum assumption cooperation never leas to a gain, and this would undercut some of the major contributions of game theory to the understanding of cooperation in biology and economics. Moreover, the three mathematicians who developed game theory—Ernst Zermelo (1871–1953), Stefan Banach (1892–1945), and John von Neumann (1903–1957)—assumed that each player will choose a strategy that minimizes the maximum gain for an opponent. This so-called *minimax* analysis cannot be extended to more general strategic contexts.

Modern game theory was born in 1950 after the publication of a paper by the young Princeton mathematician John F. Nash, Jr. (b. 1928; winner of a Nobel Prize in economics in 1994), who introduced the novel idea of a game equilibrium as a set of mutual best responses. The central term in modern game theory, the Nash equilibrium, acknowledges his work. Several conceptual problems had to be cleared up before game theory could attain a central position in the behavioral sciences. In 1965 Reinhard Selten (b. 1930; winner of a Nobel Prize in economics in 1994) developed the concept of *equilibrium refinement*, which showed why certain Nash equilibria are likely to be of empirical relevance and others are not. In 1967 and 1968 John Harsanyi (1920–2000; winner of a Nobel Prize in economics in 1994) showed how to apply game theory when the players have incomplete knowledge of the other players and the payoffs.

Until the 1980s it was believed by many people that game theory could be applied only to highly intelligent, so-called rational players because an analysis of the best responses is intellectually demanding. However, in 1972 the biologist John Maynard Smith (1920–2004) applied game theoretic notions to explaining animal conflict, a process that culminated in his publication of *Evolution and the Theory of Games* (1982). The innovation here is the idea that evolution can provide an alternative to high-level mental reasoning. For instance, rabbits veer optimally when chased by foxes not because each rabbit logically compares and empirically tests the alternatives but because running behavior is encoded in a rabbit's genes and those genes which render the rabbit most capable of eluding the fox are favored by natural selection in successive generations of rabbits. Inefficient genes simply become fox food.

The Ultimatum Game and Altruistic Preferences

An example of such research is the *ultimatum game*, in which under conditions of complete anonymity two players separately are shown a sum of money, say, $10. One of the players, called the proposer, is instructed to offer any number of dollars from $1 to $10 to the second player, who is called the responder. The proposer can make only one offer, and the game is never repeated with the same players facing each other. The responder can accept or reject this offer. If the responder accepts the offer, the money is shared accordingly. If the responder rejects the offer, both players receive nothing.

If the responder cares only about her own payoff in the game (it is said that she is *self-regarding* in this case) and the proposer knows or supposes this, the proposer will make the responder the minimum offer of $1, the responder will accept, and the game will be over. However, when the game actually is played, the self-regarding outcome almost never is attained or even approximated. In fact, as many replications of this experiment have documented, under varying conditions and with varying amounts of money, proposers routinely offer responders very substantial amounts (50 percent of the total generally is the modal offer) and responders frequently reject offers below 30 percent (Camerer 2003).

Are these results culturally dependent? Do they have a strong genetic component, or do all "successful" cultures transmit similar values of reciprocity to individuals? Alvin Roth (Roth, Prasnikar, Okuno-Fujiwara, and Zamir 1991) conducted ultimatum games in four different countries (the United States, Yugoslavia, Japan, and Israel) and found that although the level of offers differed slightly in different countries, the probability of an offer being rejected did not. This indicates that both proposers and responders have the same notion of what is considered fair in that society and that proposers adjust their offers to reflect that common notion. The differences in the levels of offers across countries were relatively small.

This ultimatum game result, along with that of many other similar games, suggests that many human subjects are strong reciprocators. Strong reciprocators come to strategic interactions with a propensity to cooperate (*altruistic cooperation*), respond to cooperative behavior by maintaining or increasing their level of cooperation, and responds to noncooperative behavior by punishing the "offenders" even at a cost to themselves and even when they cannot reasonably expect future personal gains to flow from the imposition of such punishment (this is called *altruistic punishment*).

Behavior in the ultimatum game thus conforms to the strong reciprocity model: Fair behavior in the ultimatum game among college students is a fifty-fifty split. Responders reject offers under 40 percent as a form of altruistic punishment of a norm-violating proposer. Proposers offer 50 percent because they are altruistic cooperators or 40 percent because they fear rejection. To support this interpretation it can be noted that if the offers in an ultimatum game are generated by a computer rather than by the proposer and if the respondents know this, low offers very rarely are rejected (Blount 1995). Moreover, in a variant of the game in which a responder's rejection leads to the responder getting nothing but allows the proposer to keep the share she suggested for herself, responders infrequently reject offers and proposers make considerably smaller offers.

The strong reciprocator is not a representative of one of the types of human nature found in traditional political philosophy. A strong reciprocator thus is neither the selfless altruist of utopian theory in the tradition of Jean-Jacques Rousseau (1712–1778) or that of Karl Marx (1818–1883) nor the selfish hedonist found in traditional economics and described by the economist Adam Smith (1723–1790) in *The Wealth of Nations*

(1776). Such a person is a conditional cooperator whose penchant for reciprocity can be elicited in circumstances in which pure selfishness would dictate a different action. Indeed, the strong reciprocator is more akin to the empathetic individual found in Adam Smith's other important work, *The Theory of the Moral Sentiments* (1759) except that Smith there emphasizes the sweet side of human nature, playing down the willingness to punish transgressions that is uncovered routinely in behavioral games.

FIGURES 1–3

Figure 1: The Even-Odd Game

	Two	One
Two	1, −1	−1, 1
One	−1, 1	1, −1

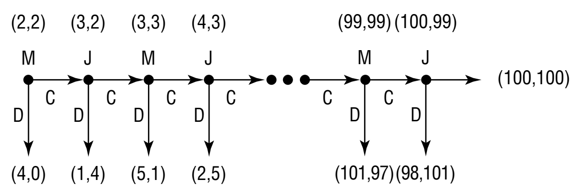
SOURCE: Courtesy of Herbert Gintis.

Figure 2: The Battle of the Sexes

	Gambling	Ballet
Gambling	2, 1	0, 0
Ballet	0, 0	1, 2

SOURCE: Courtesy of Herbert Gintis.

Figure 3: The Centipede Game



SOURCE: Courtesy of Herbert Gintis.

Social Dilemmas

Another important behavioral game that sheds light on human nature and increases people's understanding of human social interaction is the *social dilemma*. A social dilemma is a group interaction in which all the players benefit if they all cooperate but each individual has an incentive to shirk and benefit from the cooperation of others.

An experimental representation of a social dilemma is the so-called *public goods game*. A typical public goods game consists of a number of rounds, say, ten. In each round each subject is grouped with several other subjects, say, three others. Each subject is given a certain amount of money, say, $20. Each subject, unseen by the others, then places a fraction of his or her money in a common account and puts the remainder in his or her private account. The experimenter then tells the subjects how much was contributed to the common account adds to the money in the common account enough so that, when divided among the four players, the private account of each subject can be increased by a fraction, say, 40 percent, of the players' original contribution to in the common account. Thus, if a subject contributes his or her whole $20 to the common account, the experimenter adds an additional $12, so each of the four group members will receive ($20 + $12)/4 = $8 at the end of the round. In effect, by putting the whole endowment into the common account, a player loses $12 and the other three group members gain in total $24 (= $8 × 3).

A self-regarding player will contribute nothing to the common account. However, only a fraction of subjects conform to the self-regarding model. The subjects begin by contributing on average about half of their endowments to the public account. The level of contributions decays over the course of the ten rounds until in the final rounds most players behave in a self-regarding manner. This is exactly what is predicted by the strong reciprocity model. Because they are altruistic contributors, strong reciprocators start out by contributing to the common pool, but in response to the norm violation on the part of the self-regarding types they begin to refrain from contributing.

How can it be known that the decay of cooperation in the public goods game is due to cooperators punishing free riders by refusing to contribute? Subjects often report this behavior retrospectively. More compelling, however, is the fact that when subjects are given a more constructive way of punishing defectors, they use it in a manner that helps sustain cooperation. For instance, Ernst Fehr and Simon Gächter (2000) set up an experimental situation in which the possibility of punishment for personal gain was removed completely. They used six- and ten-round public goods games with groups of four and with costly punishment allowed at the end of each round, employing three different methods of assigning members to groups.

They found that when costly punishment is permitted, cooperation does not deteriorate; indeed, if the same players stay together for the whole session, despite strict anonymity cooperation increases almost to full cooperation even on the final round. In effect, even though the groups had some selfish players, there was a sufficiently large fraction of strong reciprocators to ensure that it was not in the interest of the selfish to act selfishly.

The Epistemological Foundations of Game Theory

One can characterize the choice situation facing an agent in terms of its level of complexity. The least complex situation occurs when an agent must choose from a set of fixed alternatives. Analytically complete axiomatic models of choice in this situation are well developed and empirically successful. Of intermediate complexity is a situation in which an agent must choose from a set of alternatives, each of which is a *probability distribution* over determinate outcomes. Analytically complete axiomatic models of choice in this situation are also well developed and empirically successful, although some important anomalies in human behavior have been noted in regard to decision theory. The most complex situation is the one described by game theory: An agent's choices affect not only that agent but other agents as well, the other agents also are engaged in making choices that affect themselves and others, and all agents take into account the strategic nature of their interactions. One of the most widely known attempts to illustrate such a game theoretic situation is the Prisoner's Dilemma.

It would be gratifying to have a fully successful analytical model of strategic interaction applicable to the highly complex level, but despite the efforts of theoreticians since the second half of the twentieth century, none exists. Ignoring the Prisoner's Dilemma for now, one can consider three simple games that dramatize the problems in developing such a theory, which then can be used to outline some important contributions to the epistemological underpinnings of game theory.

EVEN-ODD GAME. The first is the simple Even-Odd game. This game has two players, each of whom can show either one finger (One) or two fingers (Two). The two players show their fingers simultaneously, with player 1 winning if his choice matches that of the other player (i.e., if One-One or Two-Two occurs) and player 2 winning if her choice does not match it (i.e., if One-Two or Two-One occurs). Figure 1 shows the normal form of this game (the normal form specifies the moves that each player can make and the payoffs for each player as a function of the moves of both players).

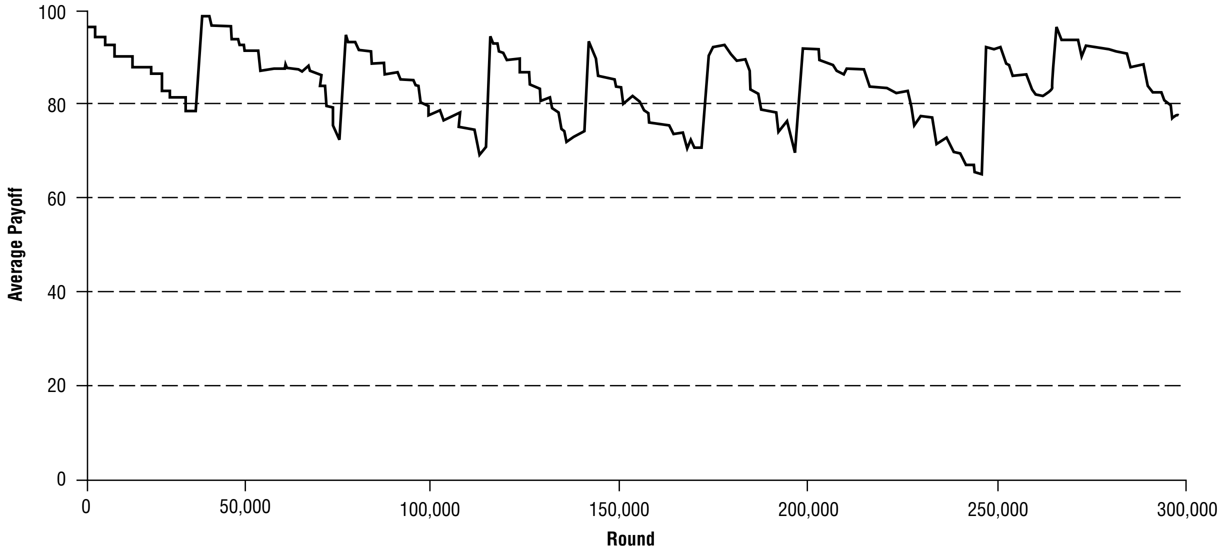
This game obviously has no Nash equilibria in the "pure" strategies: One and Two. However it does have a unique Nash equilibrium in which each player plays One with probability 1/2 and plays Two with probability 1/2. Doubtless many people remember this solution from schoolyard days, when they learned to "mix up" their choices so that an opponent could not discover their next move. The problem is that this game is played just once (it is a *one-shot* game). Hence, if a player's opponent randomizes as suggested by the Nash equilibrium, it does not matter what the first player does: The expected payoff is zero whether the first player chooses One, Two, or a probability distribution over One and Two. However, the same is true for the opponent. Therefore, there is no reason for either player to randomize, yet that is the solution suggested by game theory.

An important step toward dealing with this problem is to note that each player chooses a best response not to the actual strategy of the other players but to his or her own conjecture about what the other players will do. Robert Aumann and Adam Brandenburger (1995) prove the following theorem for a two-player game. Suppose ϕ_1 is player 1's conjecture concerning player 2's strategy and ϕ_2 is player 2's conjecture concerning player 1's strategy. If both players know each other's conjectures and each knows that the other is rational (i.e., chooses a best response to his or her conjecture), (ϕ_2,ϕ_1) is a Nash equilibrium.

BATTLE OF THE SEXES. This is a fine solution for Odd or Even, which has only one Nash equilibrium. However, one must consider another famous game, the Battle of the Sexes, which is depicted in Figure 2. In this game Rowena and Colin love each other and get one point by being together. However, Rowena loves the ballet and Colin loves gambling. Each gets a point for attending his or her favorite event. Thus, if both go to the opera, Rowena gets 2 and Colin gets 1, whereas if they both go gambling, Colin gets 2 and Rowena gets 1. Moreover, when they are not together, it is assume that they are so unhappy that each gets zero. It is easy to find two Nash equilibria: Both go gambling, and both go to the opera. It turns out that there is also a third Nash equilibrium in which each party goes to his or her favorite place with probability 2/3 and to the other's favorite

FIGURE 4

Average Payoff in Dynamic Centipede Game



SOURCE: Courtesy of Herbert Gintis.

place with probability 1/3. This is called a *mixed strategy equilibrium*.

To see that One gambling with probability 2/3 and Two gambling with probability 1/3 is a Nash equilibrium, one should note that the expected payoff to One from gambling equals $2 \times 1/3 + 0 \times 2/3 = 2/3$, whereas the expected payoff to One from ballet equals $0 \times 1/3 + 1 \times 2/3 = 2/3$. Because these probabilities are equal, One can do no better than his probability 2/3 gambling, probability 1/3 ballet strategy, and a similar argument holds for Two.

In the case of Battle of the Sexes it is unreasonable to posit that each player knows the other's conjecture because there is no way of explaining how this mutual knowledge would have come about. Indeed, it is not even plausible to suppose that the players have conjectures concerning what the other will do unless there is more to the social situation than has been explained. Moreover, the players still have no incentive to play according to their partners' conjectures (Binmore 1988).

The problem becomes even more implausible when there are more than two players. In this case Aumann and Brandenburger (1995) show that if all players assign the same probability distribution to player types, it is known mutually that all players are rational (i.e., choose best responses), and the players' conjectures are commonly known, these conjectures form a Nash equilibrium. One says that a fact is commonly known if all players know the fact, all know that the others know it, all know that all know that the others know it, and so on (Lewis 1969).

CENTIPEDE GAME. There are simple games in which the very notion of rationality and the adequacy of the concept of the Nash equilibrium are brought into question. Consider, for instance, the Centipede Game. The players, Mutt and Jeff, start out with \$2 each, and they alternate rounds. On the first round Mutt can defect (D) by stealing \$2 from Jeff, and the game is over. Otherwise Mutt cooperates (C) by not stealing and receives an additional \$1. Then Jeff can defect (D) and steal \$2 from Mutt, and the game is over, or he can cooperate (C) and receive an additional \$1. This continues until one player or the other defects or until each player has \$100. The game tree is illustrated in Figure 3.

This game has only one Nash equilibrium outcome, in which Mutt defects on the first round. To see this, let round k be the first round in which either player defects in a Nash equilibrium. If $k > 1$, the other player's best response is to defect on round $k - 1$. Of course, common sense indicates that this is not the way real players would act in this situation, and empirical evidence corroborates this (McKelvey and Palfrey 1992). People in this game will cooperate up to round 90 and beyond before considering defecting.

It would be difficult to fault players for not being rational in this case because they do much better playing the way they do rather than the way dictated by the Nash equilibrium concept. The concept of rationality is problematized for the following reason: If Jeff believes Mutt is rational, Jeff will defect in round 2. This is why Mutt defects in round 1. But suppose Mutt cooperates in round 1. Then Jeff will recognize that his assumption concerning Mutt must be false. Jeff probably will say to himself, "I don't know what strategy Mutt is using, but since he cooperated once, perhaps if I cooperate now, Mutt will cooperate a second time." Thus, Jeff will tend to cooperate in round 2. Now Mutt, who is very smart, can foresee what Jeff will be thinking and hence will cooperate even if he is rational. One can conclude that agents who use best responses will not play the Nash equilibrium in this game. It is easy to see the problem by referring to the analysis of Aumann and Brandenburger (1995): The two players do not know each other's conjectures.

Evolutionary Game Theory

To this point the focus has been on so-called classical game theory, which depicts the strategic interaction among a number of *rational agents*. The interaction is socially disembodied, with the agents having neither history nor substance outside this particular interaction. All socially relevant aspects of the actors must be captured by their beliefs and conjectures, which are totally disembodied and unmotivated. A similar degree of social minimality has given rise to powerful models of decision making when strategic interaction is absent, as in rational choice theory and decision theory. However, this does not extend to game theory, in which a more socially embedded approach is needed to derive plausible results.

The most promising alternative foundation for strategic interaction is known as *evolutionary game theory* (Maynard Smith 1982, Samuelson 1997, Gintis 2000). The central actors in evolutionary game theory are not players but strategies. Suppose a group of agents periodically plays a certain classical game G. One assumes a large population of agents, each of whom adopts a particular strategy in playing G. One does not assume that the strategies represented in the population are in any way optimal, although one does assume that there is enough random variation and mutation across time that all pure strategies are represented.

In each period agents from the population are assigned randomly to play G. Their scores are tallied, and the change in the population over time is governed by an evolutionary dynamic in the sense that agents whose strategies are very successful tend to be copied by agents whose strategies are less successful. Thus, the population ecology of strategies moves over time in accordance with the notion of survival of the fittest. This is called a *replicator dynamic* (Hofbauer and Sigmund 1998, Gintis 2000).

The fundamental theorem of evolutionary game theory is that every equilibrium point of an evolutionary dynamic is a Nash equilibrium. This provides a justification for the concept of the Nash equilibrium without the need for the epistemological assumptions of classical game theory. Moreover, evolutionary game theory shows that many Nash equilibria of classical game theory are not evolutionarily stable and thus cannot explain observable social behavior.

A case in point is the Centipede Game described earlier in this entry. The author of this entry has created a computer program to simulate the evolution of behavior in the Centipede Game (this is called an *agent-based simulation*). The author created a population of 200 agents, each supplied with a strategy *sk* of the following form: "cooperate until round k, then defect." Initially, these strategies are assigned randomly to the agents, and they play 300,000 rounds, with a mutation rate of 0.001 (a mutant assumes a random strategy *sk* where $1 \leq k \leq 101$). The results are shown in Figure 4.

It can be seen that cooperation quickly increases until after only a few rounds the average payoff is more than 95. Then cooperation erodes, as might be expected, until the average payoff dips below 80. At that point a pair of agents who choose strategies near $k = 100$ do very well, and those strategies grow at the expense of the strategies that involve defection on rounds near $k = 80$. Cooperation shoots back up to nearly perfect. The cycle repeats for 300,000 rounds and shows no signs of changing its basic character.

Even though the only Nash equilibrium of the stage game uses strategy s_1, it can be seen that the evolutionary dynamic never remotely approaches this equilibrium. This is the case because the Nash equilibrium involves such poor payoffs that even a small number of mutant players can invade a population of all-defectors, and the system quickly ramps up to almost full cooperation (changing the mutation rate does not alter this result). Thus, evolutionary game theory shows that the behavior observed when people play the Centipede Game is easy to model in a dynamic framework.

Game Theory and Ethics

Game theory has been applied to ethical theory by John Harsanyi (1992). Harsanyi (1920–2000; winner of a Nobel Prize in economics in 1994) develops a theory of justice very close to that of the philosopher John Rawls (1921–2002) and shows that it can be derived from basic game theoretic reasoning. Other important contributions to the game theoretic analysis of ethics include those of Brian Skyrms (1996) and Ken Binmore (1998).

Perhaps the first indication that game theory would be important to ethical theory was the famous tit-for-tat computer competition run by Robert Axelrod (Axelrod and Hamilton 1981). Axelrod asked what a successful strategy in the repeated Prisoner's Dilemma might look like. In that game the dominant strategy is to defect. However, if the game is repeated several times, players may be able to use the threat of defecting in the future to induce their partners to cooperate in the present.

Axelrod recruited fourteen game theorists from economics, mathematics, and the behavioral and computer sciences to submit computerized strategies for playing 200 rounds of the Prisoner's Dilemma. Those strategies were paired with each other in a round robin tournament with the result that the absolutely simplest strategy won. This strategy was *tit-for-tat*, supplied by Anatol Rapoport, a mathematician at the University of Toronto. Tit-for-tat cooperates on the first move and then does whatever its partner did on the previous move. Tit-for-tat is thus a simple reciprocity enforcer, cooperating when its partner cooperates and defecting when its partner defects.

After publishing these results (Axelrod and Hamilton 1981) Axelrod decided to stage a second tournament. More than sixty researchers from six countries submitted new programs, many of which were aimed explicitly at defeating tit-for-tat. Nevertheless, tit-for-tat again won handily.

This result relates to ethical theory because it shows the success of a strategy that is *nice* (never defect first), *punishing* (always retaliate against a defector), and *forgiving* (always revert to cooperating if your partner cooperates). These responses, of course, represent three important ethical principles. A fourth common ethical principle—*always turn the other cheek*—certainly would not fare well in this encounter, as it would be beaten by any program that could detect "wimps" (those who do not punish) and defect consistently in playing against them.

It is clear that the ethical principles behind the strong reciprocity associated with social dilemmas represent a higher development of tit-for-tat. Whereas tit-for-tat applies only to dyadic relationships, strong reciprocity applies to *n*-player social dilemmas.

HERBERT GINTIS

SEE ALSO *Artificial Morality; Choice Behavior; Decision Theory; Rational Choice theory.*

BIBLIOGRAPHY

Aumann, Robert, and Adam Brandenburger. (1995). "Epistemic Conditions for Nash Equilibrium." *Econometrica* 65(5): 1161–1180.

Axelrod, Robert, and William D. Hamilton. (1981). "The Evolution of Cooperation." *Science* 211: 1390–1396.

Binmore, Ken. (1988). "Modelling Rational Players: II." *Economics and Philosophy* 4: 9–55.

Binmore, Ken. (1998). *Game Theory and the Social Contract: Just Playing.* Cambridge, MA: MIT Press.

Blount, Sally. (1995). "When Social Outcomes Aren't Fair: The Effect of Causal Attributions on Preferences." *Organizational Behavior & Human Decision Processes* 63(2): 131–144.

Camerer, Colin. (2003). *Behavioral Game Theory: Experiments in Strategic Interaction.* Princeton, NJ: Princeton University Press.

Fehr, Ernst, and Simon Gächter. (2000). "Cooperation and Punishment." *American Economic Review* 90(4): 980–994.

Gintis, Herbert. (2000). *Game Theory Evolving.* Princeton, NJ: Princeton University Press.

Harsanyi, John C. (1992). "Game and Decision Theoretic Models in Ethics, Vol. I." In *Handbook of Game Theory with Economic Applications*, eds. Robert J. Aumann and Sergiu Hart. Amsterdam and New York: Elsevier Science.

Hofbauer, Josef, and Karl Sigmund. (1998). *Evolutionary Games and Population Dynamics.* Cambridge, UK: Cambridge University Press.

Lewis, David. (1969). *Conventions: A Philosophical Study.* Cambridge, MA: Harvard University Press.

Maynard Smith, John. (1982). *Evolution and the Theory of Games.* Cambridge, UK: Cambridge University Press.

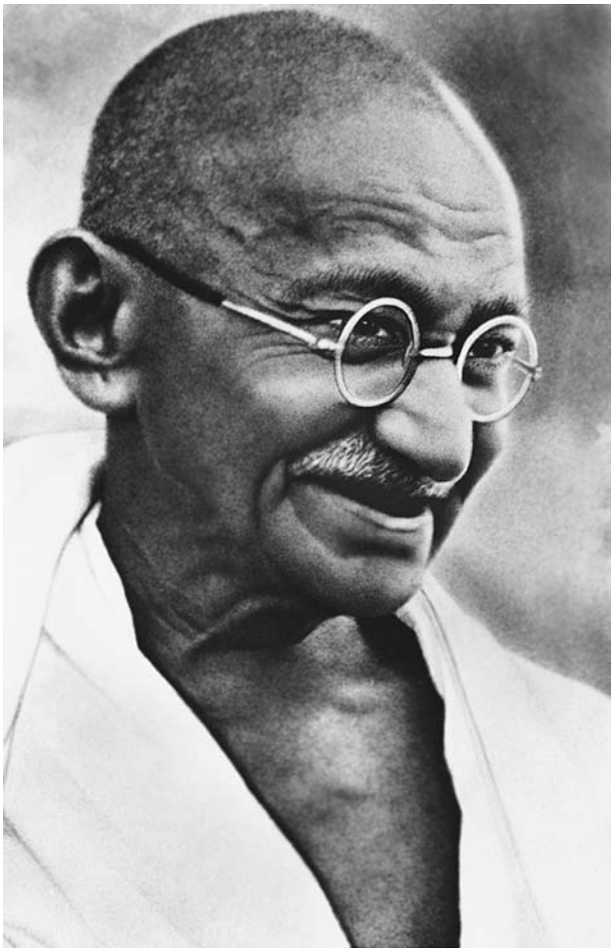
McKelvey, Richard D., and Thomas R. Palfrey. (1992). "An Experimental Study of the Centipede Game." *Econometrica* 60: 803–836.

Roth, Alvin E.; Vesna Prasnikar; Masahiro Okuno-Fujiwara; and Shmuel Zamir. (1991). "Bargaining and Market Behavior in Jerusalem, Ljubljana, Pittsburgh, and Tokyo: An Experimental Study." *American Economic Review* 81(5): 1068–1095.

Samuelson, Larry. (1997). *Evolutionary Games and Equilibrium Selection.* Cambridge, MA: MIT Press.

Skyrms, Brian. (1996). *Evolution of the Social Contract.* Cambridge, UK: Cambridge University Press.

Smith, John Maynard. (1982). *Evolution and the Theory of Games.* Cambridge, UK: Cambridge University Press.



Mohandas Gandhi, 1869–1948. Gandhi was an Indian revolutionary religious leader who used his religious power for political and social reform. Although he held no governmental office, he was the prime mover in the struggle for independence of the world's second-largest nation. *(© Corbis-Bettmann.)*

GANDHI, MOHANDAS

Mohandas Karamchand Gandhi (1869–1948) was born in Porbandar, Gujarat, India, on October 2, and led India to independence from Great Britain on August 15, 1947, by preaching and practicing nonviolent resistance. After studying jurisprudence at University College, London, Gandhi began practicing law in Durban, South Africa, in 1893. It was here that he started his political career by fighting discrimination against Indians. Following World War I he returned to India and became involved with the Indian National Congress and the movement for national independence. He was repeatedly imprisoned for his use of civil disobedience, fasting, and boycotts as methods of social reform. In addition to his nonviolent opposition to Western colonialism and capitalism, Gandhi advocated the reformation of the caste system and the harmonious coexistence of Muslims and Hindus in a unified India. His critiques of modern technoscience also influenced later theoretical developments and social movements. Gandhi was assassinated by a Hindu radical in New Delhi on January 30.

Nonviolence and Westernization

Gandhi initially defined his method of social action as *passive resistance,* but later refined and strengthened his ideals into a principle called Satyagraha. The term is derived from two Sanskrit words highlighting his central beliefs: *satya,* truth, and *agraha,* firmness—but practiced with *ahimsa,* non-injury to living things. As a method of direct social action, Satyagraha is a nonviolent insistence on truth in the political realm. Gandhi employed this principle with its offshoots, noncooperation and civil disobedience, in order to vindicate the truth by inflicting self-suffering rather than forcing his opponents to suffer. His persistence provoked anger in the British, including Winston Churchill, who called Gandhi "a malignant subversive fanatic" (Hardiman 2004, p. 238). The political success of this social reform method demonstrated the efficacy of nonviolence to the world and inspired other peace activists such as Nelson Mandela (b. 1918) and Martin Luther King Jr. (1929–1968).

Gandhi's experiments with Satyagraha made him aware of the economic, social, and political exploitation of people around the world, especially the uneducated and impoverished in South Africa and India. He believed that the root of this oppression and poverty was the culture of violence that resulted from Western materialist values, and he maintained that adopting the culture of nonviolence is the only way to attain truth, peace, and harmony. Thus Gandhi's nonviolent social reform was directly targeted against the globalization of Western values and material culture in the form of capitalism and imperialism.

He described the culture of violence in terms of the *seven social sins* of the world: wealth without work; pleasure without conscience; knowledge without character; commerce without morality; science without humanity; worship without sacrifice; and politics without principles. Gandhi's philosophy of nonviolence requires one to live life as an eternal quest for truth. It is often interpreted dogmatically or rejected as impractical, although it is founded upon the positive and near-universal values of love, respect, understanding, acceptance, and appreciation.

Gandhi believed that the westernization of India would destroy its culture and result in an unequal distribution of wealth and resources. Unlike his political heir, Jawaharlal Nehru (1889–1964), he did not believe that the systems of political organization that develop around Western science and technology could ever promote justice and human dignity. Gandhi maintained that the benefits of westernization would never trickle down to the poor because capitalist technology thrives on exploitation and creates a cycle of greed and consumption that never brings fulfillment.

Gandhi did not espouse communism, and in fact believed that capitalism could work if based on compassion rather than greed. Furthermore he understood that humans have legitimate material needs. The Western model of human development, however, sacrifices morality by overemphasizing materialism. He argued that human relationships ought to be guided by *trusteeship and constructive action*, meaning that human beings do not own their talents but hold them in trust for humanity. This fosters constructive action by helping the disenfranchised achieve greater self-confidence and self-sufficiency.

Gandhi's Reforms

Gandhi's opposition to Western values created an ideological gulf between him and other Indian political leaders. This motivated him to institute several societal reforms (he referred to them as the *constructive program*) even as the country struggled for independence, because he knew that his vision of an agrarian, self-sufficient, and traditional India would not be championed by his successors.

He developed small-scale technologies such as the *charkha*, or spinning wheel that helped liberate poor peasants from England's textile monopoly. Gandhi also helped in the effort to expand and improve basic education. Students learned reading and writing as well as best practices in agriculture. They were exposed to other cultures and religions in order to develop character and foster tolerance.

This education plan was a part of Gandhi's two part social reformation: promoting Hindu-Muslim unity and eradicating the caste system. Acutely aware of the multiethnicity of India and the tensions therein, Gandhi practiced interreligious harmony in his prayers by incorporating hymns from every major religion. His courage in the face of religious and ethnic violence inspired many Muslims to remain in a predominantly Hindu India.

Gandhi worked quietly to eradicate the caste system. He was cautious not to incite bitterness, because he feared the British would capitalize on divisions within India to strengthen their rule. Gandhi wished to change the name of *untouchables* from the derogatory *Bhangi* to the respectful *Harijan* (Children of God). With typical wisdom, he argued that by their suffering the untouchables had earned the right to be called Harijan, but other members of Hindu society will also earn that right when they atone for their sins.

Alternatives to Modern Science and Technology

When asked what he thought of Western civilization, Gandhi famously replied, "I think it would be a great idea." Thus he did not equate increasing scientific and technological sophistication with progress in civilization. In *Hind Swaraj* (1909), one of the earliest critiques of modernity as a development paradigm, Gandhi defined civilization as the ethical performance of one's duty and the attainment of mastery over passion. He also argued that "all research will be useless if it is not allied to internal research, which can link your hearts with those of the millions" (Gupta 2002 Internet site).

Nonetheless admitting there are lessons to be learned from modernity, Gandhi wrote that his "resistance to Western civilisation is really a resistance to its indiscriminate and thoughtless imitation based on the assumption that Asiatics are fit only to copy everything that comes from the West" (Hardiman 2004, p. 71). Gandhi believed that technoscience must be guided toward true human fulfillment and the alleviation of suffering. The fact that it is often used instead in the service of oppression, slavish consumerism, and war fueled Gandhi's conviction that Western values were bankrupt. In 1935, he initiated a movement called Science for People, which sought small-scale technological solutions for the problems faced by the rural poor. This indicated his vision for an alternative Indian future, which influenced especially ideas related to *alternative technology*.

For example, E. F. Schumacher's calls for a more humane economic system built upon small-scale *intermediate technology* were inspired by Gandhi. Likewise the Ghandian economists J. C. Kumarappa and D. R. Gadgil developed the concept of *appropriate technology* to counter the injustices that arise from the application of universal science in mass production processes. Although Gandhi is not explicitly mentioned, parts of Ivan Illich's *Medical Nemesis* (1975) echo Gandhi's *Hind Swaraj*. Gandhi's thought has also informed workers at development nongovernmental organizations (NGOs) such as Oxfam and ecological activists such as Ramachandra Guha and those participating in the Chipko and Narmada movements.

Faced with the pressures of economic and technoscientific globalization, Gandhi's vision of a traditional India has largely failed to materialize. It may be that the forces of westernization are too difficult to resist. As Chakravarti Rajagopalachari, a former Governor-General of independent India, wryly assessed, "The glamour of modern technology, money, and power is so seductive that no one . . . can resist it. The handful of Gandhians who still believe in his philosophy of a simple life in a simple society are mostly cranks" (Rushdie Internet site). Yet this does not diminish Gandhi's inspirational legacy or his teaching that life is more than science and technology.

ARUN GANDHI

SEE ALSO *Development Ethics; Indian Perspectives.*

BIBLIOGRAPHY

Andrews, C. F. (1930). *Mahatma Gandhi's Ideas.* Woodstock, VT: Skylight Paths.

Bondurant, Joan. (1965). *Conquest of Violence,* revised edition. Berkeley: University of California Press.

Fischer, Louis, ed. (1962). *The Essential Gandhi: His Life, Work, and Ideas: An Anthology.* New York: Random House.

Gandhi, Mahatma. (1949). *An Autobiography: The Story of My Experiments With Truth,* trans. Mahadev Desai. London: Phoenix Press.

Hardiman, David. (2004). *Gandhi in His Time and Ours: The Global Legacy of His Ideas.* New York: Columbia University Press.

Husain, Abid S. (1959). *The Way of Gandhi and Nehru.* London: Asia House Publishing.

INTERNET RESOURCES

Gupta, Vibha. (2002). "The Economics of Scarcity." Life Positive. Available from http://www.lifepositive.com/Spirit/masters/mahatma-gandhi/gandhian-economics.asp.

Rushdie, Salman. "Mohandas Gandhi." Time. Available from http://www.time.com/time/time100/leaders/profile/gandhi.html.

GATES, BILL

Born in Seattle, Washington, on October 28, 1955, William Henry Gates III, founder of the Microsoft computer empire, is, in the year 2003, the world's wealthiest person, as well as the founder of the world's largest philanthropic foundation. Superlatives and paradoxes stick to Gates. Having scored a perfect 800 on the math portion of the Standard Aptitude Test (SAT), he later dropped out of college. Praising technology for "enhancing our leisure time" (Gates 1996, p. 284), his idea of a slow week (after marrying Melinda French in 1994) was to cut his workday to twelve hours a day during the week and eight hours a day on weekends.

Bill Gates, b. 1955. The co-founder and chief executive officer of Microsoft became the wealthiest man in America and one of the most influential personalities on the ever-evolving information superhighway and computer industry. *(© Jim Lake/Corbis.)*

Paradoxes also demarcate his ethical stances, both in business and technology. In 1975 he caused a stir among libertarian computer hackers by arguing in a letter to *Computer Notes* that software programs were "intellectual property" and should be legally protected through copyrights (Lowe 1998, pp. 86–87). As a result of his efforts, copying computer programs became illegal. However over the years a host of other computer companies have complained that he freely borrows their ideas.

A fierce competitor, Gates has said that "business is a good game [with] lots of competition and a minimum of rules" (Lowe 1998, p. 156), yet has been criticized for monopolistic practices. His competitors argue that he "cuts off the oxygen of the competition" (Lowe 1998, p. xiii). In 1998 the U.S. Justice Department sued Microsoft, alleging that the company had forced computer makers to sell its Internet Explorer browser as part of the licensing agreement for its Windows 95 software. Judge Thomas Penfield Jackson declared Microsoft a monopoly a year later. While accused of hardball tactics, it is important to note that Gates votes Democratic (i.e., more rules) more often than Republican and he vows to give away 95 percent of his wealth to charity (Lowe 1998, p. 178)

An unabashed optimist about the future, Gates believes technological "doomsayers vastly underestimate the potential of technology to help us overcome problems" caused by technology (Gates 1996, p. 291). Problems he considers self-correcting with the help of technology include unemployment, overpopulation, environmental dangers, globalization, and virtual reality, as well as privacy and security issues. Quoting H. G. Wells's belief that "human history becomes more and more a race between education and catastrophe" (Gates 1996, p. 293), Gates's foundation invests billions of dollars in the areas of education and global health issues.

Two problems he is less sanguine about include terrorism and artificial intelligence. In the short run terrorism worries him because of the inability of defensive weaponry to keep pace with advances in offensive developments. In the long run he is also concerned that "computers and software could achieve true intelligence" (Gates 1996, p. 290).

But, as a gambler, Gates clearly bets education will trump catastrophe, unlike, for example, Jacques Ellul's dire predictions in his *La technique ou l'enjeu du siecle* [Technology or the Bet of the Century] (Paris: Colin, 1954). The secret to Gates's worldview is poker. Part of Microsoft's startup costs came from Gates's poker winnings at Harvard. As he says, "In poker, a player collects different pieces of information . . . and then crunches all that data together to devise a plan for his own hand. I got pretty good at this kind of information processing" (Gates 1996, p. 43). A extraordinary understatement from a superlative intellect.

JIM GROTE

SEE ALSO *Business Ethics; Computer Ethics.*

BIBLIOGRAPHY

Gates, Bill. (1996). *The Road Ahead.* New York: Penguin.

Gates, Bill. (1999). *Business @ The Speed of Thought: Using a Digital Nervous System.* New York: Warner Books.

Lesinksi, Jeanne. (2000). *Bill Gates.* Minneapolis, MN: Lerner Publications Company.

Lowe, Janet. (1998). *Bill Gates Speaks: Insight from the World's Greatest Entrepreneur.* New York: John Wiley and Sons.

INTERNET RESOURCE

Website of the Microsoft Corporation. Available from http://microsoft.com.

GENDER

SEE *Sex and Gender.*

GENE THERAPY

Gene therapies (gene transfer technology) involve one or more experimental techniques for correcting or altering genes, including defective genes associated with physiological or psychological disorders. As has historically been the case with many other novel interventions (such as those that depend on drugs or surgery), debates have arisen between those who believe there is a moral obligation to pursue gene transfer research and those who challenge them as illegitimate or unnatural. As yet there is no strong consensus regarding distinctions between what is morally unacceptable, simply permissible, or obligatory.

Technical Aspects

There are a number of approaches to gene alteration including replacing an "abnormal" gene (i.e., DNA sequence) with a "normal" gene through homologous recombination, repairing an "abnormal" gene through selective reverse mutation, and altering the regulation of a particular gene. The term "abnormal" is placed in quotation marks, indicating that there remains room for disagreement about what constitutes a normal gene, is certainly one source of disagreement about these procedures.

Typically, for mostly practical reasons, gene therapy research involves the insertion of a functional gene into a non-specific location in the genome without removal or correction of the disease-causing gene. This can be done in vitro or in vivo. In vitro techniques require cells to be removed from an organism, corrective genetic material added in culture, and the altered cells returned to the organism. The advantages of this approach are twofold. If there is a problem with the genetic manipulation, the altered cells need not be transferred to the organism; also, the risk of unintentionally affecting non-targeted tissues is reduced. Alternatively, the corrective genetic material may be delivered to the targeted cells in vivo using a vector (often a virus that has been altered) to carry the gene into the cells. Retroviruses, adenoviruses, adeno-associated viruses, and herpes simplex viruses are among the viruses altered for vector use.

There are two categories of future gene therapy: somatic cell gene therapy and germ-line gene therapy. Somatic cell therapy involves the genetic alteration of nonfunctioning or malfunctioning somatic (i.e., non-reproductive) cells. These alterations are not passed on to subsequent generations. Germ-line therapy involves the genetic alteration of the germ (i.e., reproductive) cells or the early embryo prior to the development of gonadal tissue. Any resulting genetic changes will be inherited.

Use of gene transfer technology is not limited, however, to therapeutic goals. The technology can also be used for enhancement purposes to improve the functioning of normal genes—for example, the introduction of a growth hormone gene into a person of normal stature.

Ethical Issues

From the beginning, there has been considerable debate about the ethics of future gene therapy (Parens 1995, Walters and Palmer 1997, Stock and Campbell 2000). Some insist that somatic cell gene therapy is a logical extension of available techniques for treating disease; others argue that such genetic interventions are dangerous or inappropriate. Out of this debate emerged a moral demarcation line between somatic and germ-line gene therapy, the latter being widely described as ethically unacceptable because of the risks of physical and social harms (Anderson 1989).

In the late 1980s and early 1990s, with the move to clinical trials involving somatic cell gene transfer (and the possibility of inadvertent germ-line modification), debate about the ethics of germ-line gene transfer resurfaced. Some argued that germ-line gene transfer could be an effective and efficient treatment for diseases that affect many different organs and their cell types (such as cystic fibrosis); for diseases expressed in non-removable or non-dividing cells (such as Lesch-Nyhan syndrome); and for diseases that develop in the very early embryo that could be prevented through germ-line genetic intervention (such as albinism linked to tyrosinase). Indeed, some even argued that in such cases there was a moral obligation to reduce the incidence of disease in subsequent generations using germ-line gene transfer, instead of continuing to treat each successive generation with somatic cell genetic interventions. In opposition, questions have been raised about whether such work is an appropriate use of limited research funds when other efforts might have a more general public benefit, with some also objecting to the pursuit of a kind of biological perfectionism.

Controversial History

The history of gene transfer research in humans is a checkered one, mired in controversy (NRCBL 2002, Johnston and Baylis 2004). Martin Cline of the University of California Los Angeles (UCLA) conducted the first human gene transfer clinical trial in July 1980. The unsuccessful trial involved two patients with thalassemia, one in Israel and the other in Italy. Cline did not inform the UCLA Institutional Review Board (IRB) of his research, and did not fully disclose details of the trial to the Israeli research ethics review committee (at the time, Italy did not have an ethics review system). News of the unauthorized trial became public in a *Los Angeles Times* story published in October 1980. An internal investigation by UCLA and an external investigation by the U.S. National Institutes of Health (NIH) followed, resulting in significant sanctions for Cline. It would be another decade before an officially approved human gene therapy trial would begin in the United States.

The first federally approved gene transfer into humans in the United States came in 1989. The research involved the autologous transfer of gene-marked lymphocytes into five patients with terminal melanoma. The purpose of this research was to demonstrate safety.

A year later, in 1990, the first gene transfer experiment was approved. This research began with four-year-old Ashanthi DeSilva. DeSilva suffered from an adenosine deaminase (ADA) deficiency (a rare immune defect). She was the first of two children to be injected with her own blood cells that had been altered by a retroviral vector to contain functioning ADA genes. DeSilva and the other child research participant also received a new drug, PEG-ADA (a synthetic form of the ADA enzyme).

Around the same time, a similar trial, also involving two patients with ADA deficiency, was conducted by Italian researchers. In both cases the combined interventions proved successful, although the efficacy of the genetic intervention remains unclear since the children continue to receive PEG-ADA therapy.

The pace of gene transfer research picked up after 1990. As reported on the U.S. Center for Disease Control website, gene transfer clinical trials worldwide jumped from one in 1989 and two in 1990 to sixty-six by 1995. Meanwhile, there was growing concern about the hype surrounding gene therapy. In December of 1995, an NIH-appointed ad hoc committee reported that: "[W]hile the expectations and the promise of gene therapy are great, clinical efficacy has not been definitively demonstrated at this time in any gene therapy protocol" (Orkin and Motulsky 1995). In the same report, concerns were raised about the relationship between gene transfer researchers and industry.

A major setback for gene transfer research came at the end of the 1990s with the death of a small number of research participants in different gene therapy trials. The most widely publicized death was that of Jesse Gelsinger, an eighteen-year-old patient with a rare liver condition who was enrolled in a study at the University of Pennsylvania. In September 1999, Gelsinger received an injection of adenovirus vectors designed to carry corrected ornithine transcarbamylase (OTC) genes to his liver. Four days later, he died of multiple organ failure as a result of the experimental intervention (Raper, Chirmule, Lee, et al. 2003).

A few years later, there was yet another major setback. In October 2002, researchers in France with the first apparently unequivocal success in gene transfer research announced that one of the nine boys in their gene transfer trial for X-linked severe combined immunodeficiency disease (X-SCID) had developed a leukemia-like condition. Three months later, in December 2002, a second X-SCID child in the trial was also showing signs of a leukemia-like disease (Johnston and Baylis 2004).

As of early 2005, there had been no unqualified successes in human gene transfer research. Research continues on ways to improve gene control and targeting, effectively integrate DNA into the genome, limit the risk of stimulating an immune response, and avoid the problems with viral vectors that can result in inflammation and toxicity. Only when these problems are resolved will the promise of gene transfer research begin to be realized—assuming the research is deemed morally acceptable.

FRANÇOISE BAYLIS
JASON SCOTT ROBERT

SEE ALSO *Genethics; Genetic Counseling; Genetic Research and Technology; Homosexuality Debate; Playing God.*

BIBLIOGRAPHY

Anderson, W. French. (1989). "Human Gene Therapy: Why Draw a Line." *Journal of Medicine and Philosophy* 14: 682–693.

Johnston, Josephine, and Françoise Baylis. (2004). "What Happened to Gene Therapy? A Review of Recent Events." *Clinical Researcher* 4: 11–15.

Parens, Eric. (1995). "Should We Hold the (Germ) Line?" *Journal of Law, Medicine, and Ethics* 23: 173–176.

Raper, Steven E.; Chirmule, Naredra; Lee, Frank S.; et al. (2003). "Fatal Systemic Inflammatory Response Syndrome in a Ornithine Transcarbamylase Deficient Patient Following Adenoviral Gene Transfer." *Molecular Genetics and Metabolism* 80: 148–58.

Stock, Gregory, and John Campbell, eds. (2000). *Engineering the Human Germline: An Exploration of the Science and Ethics of Altering the Genes We Pass to Our Children*. New York: Oxford University Press.

Walters, LeRoy, and Julie Gage Palmer. (1997). *The Ethics of Human Gene Therapy*. New York: Oxford University Press.

INTERNET RESOURCES

National Reference Center for Bioethics Literature (NRCBL). (2002). "Scope Note 24: Human Gene Therapy." Available from http://www.georgetown.edu/research/nrcbl/publications/scopenotes/.

Orkin, Stuart H., and Arno G. Motulsky. (1995). "Report and Recommendations of the Panel to Assess the NIH Investment in Research on Gene Therapy." National Institutes of Health, 1995. Available from www.nih.gov/news/panelrep.html.

GENETHICS

The term *genethics* first appeared in the literature with the publication of a book of the same title by David Suzuki and Peter Knudtson (1989), a volume that dealt with the moral guidelines for genetic research and engineering. In a second book of the same title, David Heyd (1992) extended the definition to the field that focuses on the mortality of creating people—that is, decisions having to do with people's existence, number, and identity. Since then, the term has spawned several other books (Bayertz 1995, Burley and Harris 2002), a number of periodicals including *GenEthics News*, and numerous web sites, many of which are no longer active.

Is Genethics Necessary?

There has been some debate over whether the introduction of the term is advisable. While Suzuki and Knudtson and others were arguing for a genethics to deal with the problems raised by the new genetics, John Maddox in a 1993 *Nature* article played down the notion that the sequencing of the genome and related developments in molecular biology created ethical problems that are intrinsically unique. For Maddox, "this new knowledge has not created novel ethical problems, only ethical simplifications" (1993, p. 97). Darryl Macer (1993), in a follow-up letter, agreed that there is no inherent value clash between genetics and human values as Suzuki and Knudtson had proposed. Macer argued that the concept of genethics "should be stopped" and that what is needed instead is "a revival and renewed discussion of ethical values as society interacts with technology, and reassurance that scientists are responsible" (1993, p. 102). Society does not need a new ethics to cope with the impact of genetic technology.

Despite these objections, the term genethics is still in use and its development has received impetus from the Human Genome Project (HGP), the multi-billion dollar public-private, international initiative to map out the entire human genome begun in the 1990s and completed in 2000. Genethics was particularly fostered through the establishment of the Ethical, Legal and Social Implications (ELSI) program, under which the U.S. Department of Energy and the National Institutes of Health devoted 3 to 5 percent of the annual HGP budget toward examining such issues in relation to the availability of genetic information flowing from HGP. Specific areas of funding included the fair use of genetic information, privacy and confidentiality, stigmatization, conceptual and philosophical implications, and clinical and reproductive issues. Through this significant investment, ELSI became the largest bioethics program in the world and spawned similar endeavors elsewhere, often under the genethics moniker.

Although in some quarters the term has become a catchword for ethical issues raised by human interventions only, it is generally used more broadly to encompass the full range of ethical issues raised by advances in the science and technology of genetics and genetic engineering. In this broader sense, genethics cuts across all areas of science and technology related to engineering of genes, from human research and applications, to genetic modification of crops and animals, to other biotechnological applications such as drugs and potential terrorist and warfare uses of this knowledge (Reiss and Straughan 1996; Burley and Harris 2002). It might also be tied to secondary consequences of genetic technology such as eugenics and the link between genes and human behavior alleged to exist in drug or alcohol addiction or violence. Because some specific applications are discussed in other entries, attention here will focus on the issues surrounding human applications, largely the product of the HGP.

Increasing Knowledge

Knowledge of human genetics has undergone an accelerating expansion in the last several decades in large part as a result of the HGP. This increased knowledge and the emerging capacity to apply it for diagnostic and therapeutic purposes promise benefits to individuals and to society as a whole, but they also carry risks. These promises and risks have attracted the interest of bioethicists and social scientists as well as leading researchers. The issues raised in genethics relate directly to the almost daily announcements of new findings in molecular biology and related scientific fields and the development innovative technological applications.

Genetic intervention is especially controversial because of rapid advances in knowledge and the shortened lead time between basic research discoveries and their application. It has been estimated that knowledge in molecular biology is doubling every year, and a cursory survey of journals and Internet sites suggest that, although the shortened lead time might be exaggerated by some observers on either side of the debate, there is a rapid diffusion of applications, giving society less and less time to access their impact. In addition to challenging basic values, human genetics for some persons raises the specter of eugenics and social control (Kevles 1985). References to a "brave new world" scenario, in which human reproduction is a sophisticated manufacturing process and a major instrument for social stability, are commonplace. The notions of designer or made-for-order babies accentuate concern over this apparent quest for the perfect child (McGee 1997). Human genetic engineering is often criticized as playing God or interfering with evolution. Not surprisingly, opposition to genetic and reproductive intervention in this context is frequently intense and pits opponents against the research community and some commercial interests.

Diagnostics and Therapy

A complicating factor is the selective nature of genetic diseases. The success of genetic screening efforts often depends on the ability to isolate high-risk groups. In targeting such groups, however, problems of stigmatization, due process, and invasion of privacy arise. For instance, the early experience with screening for sickle-cell anemia in the early 1970s led to perceived and real threats to the African-American community when they experienced discrimination based on their carrier status by employers, insurance companies, and even the Air Force Academy that denied admission to those identified as having the sickle-cell trait. As DNA tests are developed to identify individuals at heightened risk for alcoholism, personality disorders, aggressive and antisocial behavior, and so forth, the fear of eugenics is bound to reemerge, thus making any attempts to screen most controversial. In this case, however, the "eugenics" is most likely to flow from decisions by individual parents who use the techniques to maximize their children's characteristics, not a social program. Some fear that once the tests become accepted as legitimate by society, it is likely that legislatures and courts will promote professional standards of care that incorporate increasingly intrusive testing.

Following the development of techniques to diagnose genetic disorders are emerging capacities to provide gene therapy. These techniques would act to correct genetic defects by acting directly on the affected DNA and could be directed at either somatic or germline cells. This move from diagnostic to therapeutic ends accentuates sensitive issues concerning the role of government in encouraging or discouraging human genome research and applications. The huge financial investment of government in many human genome initiatives clearly demonstrates a commitment to genetic technology and eventually gene therapy. In turn, however, any developments in gene therapy will raise ethical questions concerning safety, parental responsibilities to children, societal perceptions of children, the distribution of social benefits, and definitions of what it means to be human.

Both diagnosis and therapy constitute expansions of genetic knowledge, which can pose ethical challenges both for social and personal use. Socially, there is the problem of discrimination in attitudes not only toward individuals with certain genetic diseases but also toward how individuals might handle such possible knowledge. Personally, some individuals might choose not to know, and it is not clear that this would always be as equally acceptable as knowing.

Immediate genethics issues involved with this expanding genetic knowledge center on problems of discrimination and stigmatization. Genetic information of the type now promised is self-defining and can easily stigmatize individuals, thus enabling others to discriminate against them on the basis of such information. In fact, no information is potentially more invasive of personal privacy than tests that provide precise and inclusive knowledge of a person's genetic makeup. One issue that requires urgent attention concerns access to sensitive information collected through voluntary screening programs. Because such information is potentially embarrassing and humiliating, individuals must be protected from unauthorized disclosure. Even when confidentiality is assured, maintaining the security of genetic records will be difficult, though these are mostly questions of policy not ethics.

This problem is even more difficult, however, because there are circumstances that may warrant disclosure despite risks to patient privacy. Because genetic traits may be present in other family members, one question concerns the possible rights of these family members to any information relevant to their own well-being. Under what circumstances may a genetic counselor or physician disclose genetic information that might affect another family member or even future progeny? These issues of confidentiality and privacy, of course, are heightened significantly if mandatory genetic screening programs are instituted. Given technological developments, genetic tests are soon likely to be routine health indicators, only more precise and accurate than conventional ones. This will lead employers and insurance companies to screen potential employees or those applying for insurance for an array of genetic traits. At the same time, companies might want to include such tests in health promotion or preventive medicine programs with, for instance, persons identified as having a genetic proclivity toward hypertension placed into early diagnosis programs.

When, if ever, is an individual right to genetic privacy to be sacrificed to the interests of an employer? Under what circumstances does the responsibility of a genetic counselor or physician to society outweigh responsibility to the patient? As health care costs continue to escalate, employers will find it attractive to use genetic screening to exclude individuals who might cost them large sums of money in terms of future health bills. This is particularly critical if predictive tests are developed for general health status or for susceptibility to heart disease, cancer, diabetes, or alcoholism. Insurance companies, too, have a stake in data obtained through these methods. Genetic tests could be used either to determine insurability or to establish premium rates on the basis of test results. Life insurance companies traditionally have excluded people who are poor health risks and could easily extend this through tests that place certain individuals at risk for a wide range of conditions or diseases. Likewise, health insurers know that a large proportion of health care costs are attributable to a small proportion of the population, and as tests become available to identify individuals who are genetically predisposed to ill health, this is likely to put pressure on employers to screen prospective employees.

Confidentiality questions become more problematic when DNA or gene data banks are created where thousands of samples of blood, hair, or other tissue are stored for future use. The creation of such banks for criminal investigations elicits intense controversy. The issue is even more complex because unlike traditional fingerprints or other records (medical, credit, criminal) that are currently maintained, the DNA record contains potential as well as actual information. New genetic discoveries permit new information to be decoded from old samples. As science and technology advances, samples collected for a specific use could be used for totally unrelated purposes. Given the uncertainty of just how much and what type of data may be decoded from samples in the future, it is all but impossible to provide fully informed consent. Furthermore, questions remain as to who has proper access to this storehouse of knowledge on potentially millions of individuals.

Commercialization and Allocation of Resources

Although considerable public resources are being invested in human genome initiatives by governments, genetic tests and other applications will largely be influenced by commercial interests. Huge profits are likely to be made, especially as predictive tests for common disease categories are developed. Moreover, it is likely that DNA banking will include a significant entrepreneurial component in both the testing and data development components. Some observers argue that it is critical in light of ethical concerns over record-keeping, confidentiality, and so forth, that the emerging genetic industry be monitored closely and regulated where appropriate to guard sensitive data, control for the possibilities of error, and protect the economic and personal stakes involved.

Other issues inherent in the development of the new genetics involves decisions as to how these resources will be distributed and how high a priority they should be given in funding. Although resource allocation questions have not generally been at the center of genethics, they are becoming more critical because whereas resources are finite, demands and expectations fueled by new technologies have few bounds. While it is premature to speculate about the relative costs and benefits of yet undeveloped procedures, it is logical to assume that gene therapy will be a complicated, costly procedure. Will access be equitable and coverage universal, and, if so, how will it be funded? Or, will it be yet another reproductive technology available to the affluent but largely denied to persons who lack sufficient resources?

Should these technologies be available to all persons on an equal basis? Maxwell J. Mehlman and Jeffrey R. Botkin (1998) make a persuasive case that access to the benefits of genome technologies is bound to be inequitable. The traditional market-oriented, third-party-payer system leaves out many people. The debate over whether or not the government has a responsibility to facilitate access will intensify as the scope of technological intervention possibilities broadens. What criteria should be used to determine who gets the benefits of the HGP, especially given that considerable research has been financed with public funds?

More broadly, what priority should the search for genetic knowledge and ever-expanding uses of this knowledge have vis-à-vis other strategies and health care areas? What benefits will it hold for the population as a whole, compared to other policy options? In recent decades there has been a proclivity to develop and widely diffuse expensive curative techniques without first critically assessing their overall contribution to health. Similarly, research has been rapidly transferred to the clinical setting, thus blurring the line between experimentation and therapy. In contrast, the availability of effective and inexpensive genetic tests could provide valuable information for disease prevention and health promotion by targeting individuals who are at heightened risk for diseases that could be reduced by early intervention. Therefore, to the extent it furthers preventive efforts, genetic technology could be cost-effective.

The Genethics Controversy

This brief discussion of genethics and the new scientific and technological environment of genetic knowledge and expanding capacities to apply it demonstrate the challenges facing all societies. The revolutionary nature of such developments and the far-reaching implications of how people view themselves and others, requires a reevaluation of how far human genetic intervention should proceed. Additional questions to be addressed more clearly by genethics concern the impact of each potential application of the HGP on society, on individual members, and on the way members of that society relate to each other. Here genethics has been criticized by some observers.

One criticism of genethics and genetic policymaking to date is that they have been largely reactive in scope, pointing out potential problems without assurance they will occur, but offering little in the way of anticipatory solutions in the event they do. Although national commissions or similar bodies have studied these issues and made recommendations in many countries, and the ELSI program has produced innumerable academic studies, most governments have chosen either to take an affirmative stance through funding genome research and encouraging diagnostic and therapeutic applications, or they have attempted to avoid the issues raised.

Another criticism of genethics is that it has been almost exclusively the domain of ethicists and journalists, who in some cases make little effort to communicate with the genetic science and research community and often take a combative stance on the issues (Maddox 1993). Not surprisingly, some in the genetic research community see genethics as an irritant at best and a hostile force against scientific and technological process at worst. In the process, the broader public is often sidelined. Although enlightened public debate over goals and priorities related to the issues raised here seems warranted, it can be argued that genethics has not gone beyond providing a framework for action by clarifying the ethical and moral issues surrounding the science and technology of genetics. While this might be a start, Bartha Maria Knoppers (2000) sees as discouraging the "general failure to develop and include the ethics of public interest, public health, and the notion of civic participation in genetic research for the welfare of the community or for the advancement of science" (p. s38). By focusing on the problems and issues raised by the new genetics, genethics might be overlooking a variety of potential societal benefits. The costs of avoiding admittedly risky technologies out of the fear of potential stigmatization, commodification, or other ethical problems for the individual, then, might be high if it means foreclosing benefits for individuals and society.

In summary, genethics is inextricably related to science and technology and is a product of rapid developments in molecular biology and related fields since the mid-twentieth century. Although one could widen the concept of genethics to include the study of eugenics pre–double helix, the term as applied today represents a direct response to molecular biology and the science and technology surrounding the genome, and thus it is inextricably tied to and guided by it.

ROBERT H. BLANK

SEE ALSO *Bioethics; Biotech Ethics; Fetal Research; Gene Therapy; Genetic Counseling; Genetic Research and Technology; Health and Disease; Human Genome Organization; In Vitro Fertilization and Genetic Screening; Medical Ethics; Playing God; Privacy.*

BIBLIOGRAPHY

Bayertz, Kurt. (1995). *GenEthics.* Cambridge, UK: Cambridge University Press. Attempts to clarify the ethical dimensions generated by new human reproductive and genetic advancements. Most emphasis is on the reproductive assisting technologies.

Burley, Justine, and John Harris, eds. (2002). *A Companion to Genethics.* Oxford: Blackwell. This 600-page edited volume is a comprehensive look at the philosophical, ethical, social and political dimensions of developments in human genetics.

Heyd, David. (1992). *Genethics: Moral Issues in the Creation of People.* Berkeley: University of California Press. Heyd attempts to resolve many ethical paradoxes in intergenerational justice raised by advances in medicine, genetic engineering, and demographic forecasting.

Kevles, Daniel J. (1985). *In the Name of Eugenics: Genetics and the Use of Human Heredity.* Berkeley: University of California Press. Seminal work on history of eugenics and the eugenic implications of new reproductive technologies.

Knoppers, Bartha Maria. (2000). "From Medical Ethics to 'Genethics.'" *Lancet* 356(suppl. 1): s38. Short article argues for the inclusion of the ethics of public interest, public health and the notion of civic participation in genetic research for the welfare of the community.

Macer, Darryl. (1993). "No to 'Genethics.'" *Nature* 365(6442): 102. Letter in *Nature* that argues that concept of a separate "genethics" should be stopped because the ethical issues raised by the application of genetics are not novel.

Maddox, John. (1993). "New Genetics Means No Ethics." *Nature* 364(6433): 97. Contends that the opinion that genome sequencing will create novel ethical problems is mistaken and that these techniques are unlikely to be any more troublesome than genetic manipulation of bacteria decades ago.

McGee, Glenn. (1997). *The Perfect Baby: A Pragmatic Approach to Genetics.* New York: Rowman and Littlefield. McGee denies the necessity of a "genethics," arguing that the wisdom we need can be found in the everyday experience of parents.

Mehlman, Maxwell J., and Jeffrey R. Botkin. (1998). *Access to the Genome: The Challenge to Equality.* Washington, DC: Georgetown University Press. After summarizing the Human Genome Project, the authors discuss its practical health applications and ethical and policy challenges such as banning them, equal access, genetic handicapping, and genetic lotteries.

Reiss, Michael J., and Roger Straughan. (1996). *Improving Nature? The Science and Ethics of Genetic Engineering*. New York: Cambridge University Press. Covers a broad range of ethical and theological concerns inherent in genetic engineering of microorganisms, plants, animals, and humans.

Suzuki, David, and Peter Knudtson. (1989). *Genethics: The Clash between the New Genetics and Human Values*. Cambridge, MA: Harvard University Press. The authors propose a set of genetic principles that emphasize individual rights and confidentiality with regard to genetic screening, caution in violating boundaries across species, and a ban on biological weapon development and the genetic manipulation of human germ cells.

GENETICALLY MODIFIED FOODS

The production of genetically modified foods has provoked an ethical debate about whether it is right to use technology to create new forms of plant and animal life that otherwise would not exist. However, throughout human history agricultural crops have been genetically modified. There is nothing "natural" about food crops because most of them would be unable to propagate or survive without human intervention. What have changed over the years are the technologies that have been used to bring about genetic modification.

In general, humans have used three methods to modify plants genetically.

Conventional Breeding

At one time farmers practiced selective breeding and cross-breeding, or what is termed conventional breeding. Conventional breeding is less precise and predictable and therefore arguably less safe than genetic modification or, more correctly, *transgenic* plant breeding. The process has worked well because humans practicing conventional plant breeding have been able to increase yields in agriculture and support a larger population and/or improve human nutrition. The high-yielding dwarf varieties of wheat and rice that produced the Green Revolution were the result of conventional breeding.

Until the twentieth century most plant and animal breeding was largely a matter of selection and cross-breeding. Occasionally crosses between separate species were made as a result of human action or an unexplained “natural” happening. Wheat is a product of two or three different transpecies crosses of plants with different chromosomal structures.

In the 1920s advanced pollination techniques were used to create hybrid maize, a major but accepted genetic modification that far outyielded normal or “natural” maize. However, seed saved from hybrid maize for planting reverts to its original form and yields much less than the hybrid does. This means that a farmer has to buy new seed each year, but the increased yield normally makes that effort worthwhile. Hybrid maize has become the number one food crop in Africa.

Mutagenesis

The next method in this technological continuum involved the use of nuclear radiation or chemical mutagens to bring about mutations. This method is called *mutagenesis* and has the least-predictable outcome of all forms of plant breeding, but the technology is accepted and has escaped the label *genetic modification* presumably because these techniques have been used for more than half a century. The only advantage of the powerful and sometimes lethal genetic mutagens is that they produce a great many more mutations than occur naturally, thus generating the variability that breeders need for finding and introducing new characteristics into their plants. The Food and Agriculture Organization/International Atomic Energy Agency’s Mutant Varieties Database Register (December 2000) lists over 2,252 crops in the more than seventy countries in which these mutant varieties are used. Key varieties are grown and/or eaten in virtually every country. Barley used in commercial beers around the world as well as wheats used to make pasta are products of radiation mutation breeding.

Genetic Engineering

With the discovery of the structure of DNA (deoxyribonucleic acid) in the 1950s, followed over the decades by a greater understanding of the process of inheritance, the way became clear for transgenic technology, or genetic engineering. This allowed desirable characteristics expressed by a gene or a small group of genes from any organism to be transferred to another organism. By the early 1980s the first genetically engineered pharmaceuticals were released, and they have been followed by an increasingly sophisticated array of new drugs. By the late 1980s transgenic enzymes and bacteria were involved in the production of cheese, bread, wine, beer, and vitamins that are consumed on a daily basis by numerous people.

Biotechnology is done under precisely controlled conditions in which a gene, together with a marker, is incorporated in plant tissue, which then is grown in tissue culture to produce plants. At this stage the plant is subject to initial evaluation to ensure that the gene has been transferred successfully and stably and produces the desired trait and that there are no unintended effects on plant growth or quality.

The gene transfer process is far more precise than the other accepted procedures and allows desirable plant transformations to be performed that are not possible using conventional breeding.

Benefits

Since their introduction in the mid-1990s transgenic crops engineered for herbicide tolerance, by expressing a protein that is fully digestible by humans and other animals, have brought about a decline in pesticide use, something critics of those crops have long claimed to favor. There have been enormous benefits from plants engineered to resist certain pesticides. Modern conservation tillage (or reduced-, minimum-, or no-tillage) agriculture using pesticides for weed and pest control conserves water, soil, and biodiversity better than does any current or previous form of tillage. In addition, this method saves fuel and therefore releases less carbon into the atmosphere. Conservation tillage is improving soil and soil quality. Planting with a drill, possibly disking the field, preserves soil structure and vegetative cover and the diversity of life therein, such as earthworms and other life forms that often are destroyed by deep plowing and other older forms of conventional agriculture. Conservation tillage has led to a reduction in overall pesticide use as a less toxic broad-spectrum pesticide is substituted for multiple sprayings of an array of targeted pesticides and herbicides.

Popular Fears of the Dangers of Frankenfoods

Genetic modification or engineering of crop plants has generated far more adverse reactions than did the informed guesswork that preceded it. Those products have been called *Frankenfoods,* a pejorative term for genetically modified foods that evokes the film version of Doctor Victor Frankenstein's monster from the novel by Mary Shelley (1797–1851). The fears are based on the extraordinary power of this new technology but concentrate principally on two issues: concern for human health and concern for the environment. Exhaustive tests have been carried out to determine whether genetically modified crops carry an increased risk of allergic reactions or other effects in people who eat them. There is no evidence so far that this or any other adverse reaction or nutritional problem has been caused in consumers of these crops after nearly ten years of production on more than 400 million acres of products consumed by more than 1 billion people.

Damage to the environment has been postulated to be a possible result of growing transgenic crops. Fears include the escape of genes into related wild plants, adverse effects of insect toxins (in the case of crops with the Bt gene) on desirable insects, and transfer of antibiotic resistance. Several factors lessen the likelihood of damage to the environment. Some crop plants and their wild relatives are self-pollinated, and so there is no opportunity for gene transfer to take place. Others have no wild relatives in the local flora, and so the local environment does not have suitable gene recipients. Transfer of antibiotic resistance from transgenic plants into the soil microflora is very unlikely and has not been demonstrated convincingly. Even if there were transfer, these genes already are ubiquitous in the soil microflora.

The most prominent public phobias in developed countries involve *chemicals* (a code word for industrially produced chemicals), which are all assumed to be carcinogenic; and radiation, which is assumed to cause cancer and mutations. One wonders why there has been no outcry about the use of *chemicals* and radiation in plant breeding, particularly in light of the fact that many critics of transgenics also oppose the irradiation of foods to kill microorganisms (a technique that has been used for more than forty years). Starting with a blank slate of public opinion on plant breeding, it would be far easier to frighten people about chemical and radiation breeding than about the insertion of a single gene plus a promoter and a marker. The promoter is simply a DNA sequence that allows the gene to be expressed, whereas current techniques require the use of marker genes.

Conclusion

The process and result of genetic modification have been subject to close scrutiny by some of the world's best scientists. The plants and the foods derived from them are extensively tested to assure consumers that these products are safe for the environment and for humans. In a joint report issued in July 2000 the National Academies of Brazil, China, India, Mexico, the United States, the United Kingdom, and the Third World Academy of Sciences concluded: "It is critical that the potential benefits of GM technology become available to developing countries." They also concluded that "steps must be taken to meet the urgent need for sustainable practices in world agriculture if the demands of an expanding world population are to be met without destroying the environment or natural resource base. In particular, GM technology coupled with important developments in other areas should be used to increase the production of main food staples, improve the efficiency of production, reduce the environmental impact of agriculture and provide access to food for small scale farmers" (Royal Society 2000).

THOMAS R. DEGREGORI

SEE ALSO *Agricultural Ethics; Biotech Ethics; Environmental Ethics; Food Science and Technology; International Relations; Nutrition and Science; Organic Foods*

BIBLIOGRAPHY

Centro Internacional de Mejoramiento de Maiz y Trigo. (2002). *Transgenic Maize in Mexico: Facts and Future Research Needs*. Mexico: International Maize and Wheat Improvement Center.

DeGregori, Thomas R. (2001). *Agriculture and Modern Technology*. Ames: Iowa State University Press.

Harten, A. M. van. (1998). *Mutation Breeding: Theory and Practical Applications*. New York: Cambridge University Press.

McHughen, Alan. (2000). *Pandora's Picnic Basket: The Potential and Hazards of Genetically Modified Foods*. New York: Oxford University Press.

Persley, Gabrielle J., ed. (1999). *Biotechnology for Developing-Country Agriculture: Problems and Opportunities*. Washington, DC: International Food Policy Research Institute.

Persley, Gabrielle J., and M. M. Lantin, eds. (2000). *Agricultural Biotechnology and the Poor*. Washington, DC: Consultitative Group on International Agricultural Research and the U.S. National Academy of Sciences.

Qaim, M., and D. Zilberman. (2003). "Yield Effects of Genetically Modified Crops in Developing Countries." *Science* 299(5608): 900–902.

Royal Society. (2000). *Transgenic Plants and World Agriculture: Report Prepared under the Auspices of the Royal Society of London, the U.S. National Academy of Sciences, the Brazilian Academy of Sciences, the Chinese Academy of Sciences, the Indian National Science Academy, the Mexican Academy of Sciences and the Third World Academy of Sciences*. Washington, DC: National Academy Press.

U.S. Food and Drug Administration. (2000). *Bt Corn: Less Insect Damage, Lower Mycotoxin Levels, Healthier Corn*. Washington, DC: Author, ARS News Service.

INTERNET RESOURCE

International Council for Science. (2003). *New Genetics, Food and Agriculture: Scientific Discoveries—Societal Dilemmas*. Paris: International Council for Science. ICS represents more than 100 science academies, including the U.S. National Academy of Science and the United Kingdom's Royal Society. This study draws together evidence from all leading reviews of genetically modified crops to see where the consensus is. Available from http://www.icsu.org/.

GENETIC COUNSELING

Genetic counseling is an educational service that aims to help people become informed and responsible consumers of genetic tests and to cope with the results. With nondirectiveness as a basic rule and autonomous decision making its goal, genetic counseling exemplifies a shift of the professional-client relationship from *doctor knows best* to *patient decides best*.

There is a widespread consensus in advanced scientific and technological societies that in order to guarantee a client's informed choice any genetic test, whether prenatal (by amniocentesis or chorion villus sampling) or adult (for example, for hereditary breast cancer), should be prepared for and followed by genetic counseling. Prior to testing, counselors determine a risk profile by examining a client's medical history and family tree for potential genetic risks. The risk profile determines an array of test options with their risks, potential results, and possible actions, all of which are discussed with the client. After genetic testing, a counselor explains the significance of the test result and reviews treatment options. For example, if a prenatal test result shows a fetal chromosomal aberration, the counselor describes the average development of the fetal population in which the unborn child is placed by its cytological anomaly and offers the possibility of terminating the pregnancy. Both before and after testing, the counselor emphasizes that any decision is the client's.

History

The first *hereditary counseling clinics* opened in Germany and Denmark in the 1930s, and in Britain and the United States in the 1940s. Their explicit goal was to improve the population gene pool by avoiding the birth of children probably affected by illnesses or handicaps. For geneticists of the time, all but a few sympathizing with eugenic ideas, giving *marriage advice* was an instrument for breeding a better society. After World War II, when Nazi Germany brought eugenics into public discredit, geneticists shifted their focus from public to individual prevention without losing track of its effects on the population's quality of health.

In order to differentiate individual decision making from state eugenic programs, the geneticist Sheldon Reed coined the term genetic counseling in 1947 (Reed 1947). Ahead of his time, Reed argued that clients should make their own decisions. Most of his colleagues, however, either told their clients what to do or assumed that, after having been enlightened about genetics, they would make the *right choice*. Before amniocentesis was introduced into prenatal care in the 1970s, there were not many options a geneticist could offer anyway: The counselor drew a pedigree and, on the basis of Mendel's laws and empirical data, established the recurrence risk for some disease in question. In cases where the risk was considered high, all the expert could do was advise clients to remain childless. Because people were not yet accustomed to consulting doctors about health problems that might, with some statistical probability, occur in the future, there was no great demand for this kind of expertise.

In 1975 the American Society of Human Genetics adopted a definition of genetic counseling that was purified of all traces of eugenics. The clients' informed decision superseded prevention as the primary goal of the procedure. Genetic counseling was redefined as a *communication process* (Ad-Hoc-Committee on Genetic Counseling 1975) with the aim of informing clients and leading them to a decision that would fit their goals and values. This definition was adopted internationally.

Genetic Counseling in the Early-Twenty-First Century

Demand changed dramatically when chromosomal tests of cells from amniotic fluid and the option of terminating pregnancy allowed geneticists to enter the field of prenatal care. By the end of the 1950s, researchers determined the normal number of human chromosomes and identified deviations such as Trisomie 21 (Down Syndrome). In the 1970s, amniocentesis was introduced into prenatal care and abortion laws liberalized in most Western countries.

Originally intended as special treatment for a defined fraction of pregnancies, namely those diagnosed as being *at risk*, within a few years the chromosomal checkup expanded into a routine procedure. As prenatal monitoring techniques such as ultrasound or maternal serum screening, designed to track down potential risks, became standard, increasing numbers of pregnant women were classified as at risk and in need of professional guidance. Thus the major and still increasing clientele of genetic counselors are pregnant women.

Apart from chromosomal checkups in prenatal care, genetic tests have only limited application in medical practice. Most of them test Mendelian hereditary diseases (such as cystic fibrosis or Huntington's chorea), which are relatively rare. In 1994 a test for *familial breast cancer* opened a new field of counseling activity: the offer to help people cope with test results that cast a shadow over their future. It is estimated that at most 5 to 10 percent of all breast cancer cases can be classified as hereditary. Those who possess a mutation in the BRCA-genes are told that they have a lifetime risk of about 80 percent of actually getting this particular cancer—though further research has provided evidence that these numbers are too high for a general penetrance estimate (Bregg 2002). As a result of human genome research, geneticists expect a growing number of such predictive genetic tests for widespread diseases such as different forms of cancer, coronary heart disease, or Alzheimer's disease.

Risk Communication as Social Technology

Genetic tests go beyond the scope of the traditional doctor-patient relationship because, strictly speaking, there is no medical indication for performing them. Most patients are eligible for testing because they are classified as being at risk. This means, for the most part, they are—and might remain—completely healthy. The test result does not provide a diagnosis in order to determine an appropriate treatment. Instead a positive gene test will leave them with *bad news* about their future without offering any cure. In the case of a prenatal test, the *patient* is not yet born, and the only *therapy* would be an abortion. Predictive tests, such as those for familial breast cancer, result in risk figures for a tomorrow that might never occur.

This heterogeneity between a medical diagnosis and the attribution of a risk profile is generally overlooked. Statistical probabilities express nothing but frequencies in statistical populations. But in the counseling session these numbers jell into risks and chances, indicating to clients a threat to them or to a coming child. Clients expect the counselor to say something relevant about them as individuals, while, by definition, risk measures the frequency with which something happens in the statistical universe from which the sample has been taken.

Because genetic counseling educates clients regarding genetically derived risk figures, it serves as a powerful social technology that individualizes social hazards. Members of various disability communities have criticized such testing as a way to extend prejudices toward those who have only some risk of becoming disabled rather than promoting compassion and social inclusion for those with special needs. Appealing to clients to make autonomous decisions, the counselor invites them to take responsibility for a future that can be statistically assessed but is as yet unknown, so that genetic counseling opens up a completely new possibility for victim blaming: No matter what a client decides, the client becomes responsible.

Professionalization and Ethics

Anticipating the evolving demand for professional guidance provoked by prenatal testing, a two-year masters program was started at Sarah Lawrence College in New York in 1969 to train genetic counselors as collaborators of medical geneticists in hospitals and clinics. Since then, genetic counseling as a profession has grown widely throughout North America and is largely populated by women. In 1979 the National Society of Genetic Counselors (NSGC) was founded. In 1992 NSGC launched its own journal (*Journal of Genetic Counseling*) and adopted a code of ethics (National Society of Genetic Counselors 1992). Genetic counselors have been certified by the American Board of Genetic Counseling since 1993.

In most European countries, genetic counseling is not yet fully professionalized. With the expansion of prenatal testing and, gradually, predictive genetic testing, countries such as the United Kingdom, Norway, and the Netherlands have followed the U.S. model and introduced masters programs for genetic counselors who are not medical doctors. In France and Germany, however, doctors blocked inroads into what they consider their own field of competence. In these countries, medical geneticists usually deal with special cases and predictive testing whereas prenatal diagnostics is left to obstetricians (Godard, Kääriäinen, Kristoffersson et al. 2003).

Genetic counselors insist on nondirectiveness as their basic principle. Originally a psychotherapy precept (Rogers 1951), nondirectiveness has become the cornerstone of a counseling concept that is based on patient autonomy. However there is no consensus about what this actually means in practice. The context and the conception of the encounter between genetic counselor and patient gives rise to different social and ethical conflicts, and so does the nature of the imparted information (Clarke 1994).

In general, an expert's information can cause misunderstandings fraught with consequences for the client. Technical terminology almost inevitably clashes with colloquial language. A term such as *syndrome* can evoke horrifying associations and, as a consequence, clients might expect a child to look monstrous (Chapple, Champion, and May 1997). In order to enable clients to make an informed choice, they are told about test options and their respective risks and benefits. In the case of prenatal testing, women are asked to weigh the probability of detecting a fetal chromosomal or genetic abnormality against the risk of inducing a miscarriage which is about 0.5 percent in case of amniocentesis and at least 1 percent in case of Chorion Villus Sampling. Nevertheless, those interventions are offered as a routine part of prenatal care regardless of women's age and family history, which means that on the long run there are more pregnancies lost than abnormalities detected. Scientific denotation and everyday connotations diverge grossly on the subject of risk figures. Clients inevitably personalize the numbers; they fail to grasp the statistical nature of probabilities and interpret them as personal threats (Rapp 1999, Samerski 2002). This gap between professional information and lay understanding widens with clients from different ethnic backgrounds (Rapp 1999, Browner et al. 2003).

According to their notion of autonomy, genetic counselors are bound to respect both the *right to know* and the *right not to know*. The right to be informed is generally taken for granted because knowing about probabilities, test options, and test results facilitates autonomous decision making. But genetic information may also profoundly change the client's perceptions and lifestyle, and therefore genetic counselors respect confidentiality and the *right not to know*, especially in cases of late-onset diseases (for example, Huntington's chorea) when there is no third party involved. In prenatal diagnostics, test results can only serve to provide grounds for terminating the pregnancy. Even though the moral status of abortion is controversial in most countries, it is generally legalized and socially accepted as pertaining to reproductive autonomy. The decision to abort or not after positive test results is the client's, even though the counselor's judgment might differ considerably. Yet, the options of testing and aborting put new pressures on women: Abnormal children are considered to be avoidable. A new sense of responsibility for the existence of a disabled child after having been offered a choice, fear of stigmatization, and the intimidating effect of professional diagnosis cause most women to terminate their pregnancies in case of abnormal test results. Out of respect for patient autonomy a growing number of genetic counselors would even recognize prenatal sex selection as an acceptable option (Wertz and Fletcher 1998). The call to limit prenatal selection to medically approved conditions is countered by members of the disability community who argue that just like the discrimination of women, "disability" is a social issue. The continuing efforts to track down a "gene for" homosexuality substantiate fears about a new, genetic discrimination of minorities (Schüklenk, Stein, Kerin, and Byne 1997).

There is a growing market of commercial laboratories promising to optimize health and well-being by genetic testing combined with "personalized" guidance on lifestyle, diet, and drugs. But consumer mentality is only one aspect of the seamy side of patient autonomy. The idea of *informed choice* seems to increase autonomy, but could force people to become managerial decision makers on their own behalf and on the behalf of their children. Genetic counseling burdens people with decisions on the basis of statistical probabilities, which makes them responsible for events they cannot control. Wrongful life actions, in which parents argue that the birth of their affected child was an avoidable consequence of misinformation or bad advice, reinforce the idea that misfortune can be avoided by correct information and decision making.

SILJA SAMERSKI

SEE ALSO *Fetal Research; Genethics; Homosexuality Debate; In Vitro Fertilization and Genetic Screening; Playing God.*

BIBLIOGRAPHY

Ad-Hoc-Committee on Genetic Counseling. (1975). "Genetic Counseling." *American Journal of Human Genetics* 27(2): 240–242. First internationally acknowledged definition of genetic counseling.

Bregg, Colin B. (2002). "On the Use of Familial Aggregation in Population-Based Case Probands for Calculating Penetrance." *Journal of the National Cancer Institute* 94: 1221–1226. Critically reviews the early estimates of the lifetime risk of breast cancer associated with BRCA1 and BRCA2 mutations.

Browner, Carole H.; Mabel H. Preloran; Maria Christina Casado; et al. (2003). "Genetic Counseling Gone Awry: Miscommunication between Prenatal Genetic Service Providers and Mexican-origin Clients." *Social Science and Medicine* 56: 1933–1946. Empirical study on misunderstandings by clients due to medical terminology, and nondirectiveness, among other factors.

Chapple, Alison; Peter Champion; and Carl May. (1997). "Clinical Terminology: Anxiety and Confusion Amongst Families Undergoing Genetic Counseling." *Patient Education and Counseling* 32(1–2): 81–91. Empirical study that explores clients' understanding of medical terminology, especially the fears and associations evoked by the term syndrome.

Clarke, Angus, ed. (1994). *Genetic Counseling: Practices and Principles*. London, New York: Routledge. Anthology of historical, social, and ethical aspects of genetic counseling, including its eugenic predecessors and the problem of confidentiality.

Godard, Béatrice; Kääriäinen, Helena; Kristoffersson, Ulf; et al. (2003). "Provision of Genetic Services in Europe: Current Practices and Issues." *European Journal of Human Genetics* 11(Suppl. 2): S13–S48. Examines the professional and scientific views on the social, ethical and legal issues that impact on the provision of genetic services in Europe.

National Society of Genetic Counselors. (1992). "National Society of Genetic Counselors Code of Ethics." *Journal of Genetic Counseling* 1(1): 41–43.

Rapp, Rayna. (1999). *Testing Women, Testing the Fetus: The Social Impact of Amniocentesis in America*. New York: Routledge. Study based on a decade of fieldwork on prenatal diagnostics and genetic counseling and interviews with professionals and clients.

Reed, Sheldon. (1974). "A Short History of Genetic Counseling." *Social Biology* 21(4): 332–339. Reed looks back after twenty-seven years and describes the historical background and development of his counseling concept.

Rogers, Carl R. (1951). *Client-centered Therapy*. Boston: Houghton Mifflin. Discusses the concept of nondirectiveness and client-centered psychotherapy and the reconceptualization of genetic counseling as an aid to individual decision making.

Samerski, Silja. (2002). *Die verrechnete Hoffnung: Von der selbstbestimmten Entscheidung durch genetische Beratung* [The mathematization of hope: On autonomous decision-making through genetic counseling]. Münster, Germany: Westfälisches Dampfboot. Study based on participant observation and tape recordings of genetic counseling sessions in Germany. Analyzes how information about risk figures and test options and the demand to choose transforms pregnant women into managerial decision makers.

Schüklenk, Udo; Stein, Edward; Kerin, Jacinta; and Byne William. (1997). "The Ethics of Genetic Research on Sexual Orientation." *Hastings Center Report* 27 (4): 6–13.

Wertz, Dorothy C., and John C. Fletcher. (1998). "Ethical and Social Issues in Prenatal Sex Selection: A Survey of Geneticists in 37 Nations." *Social Science and Medicine* 46(2): 255. Discusses the trend towards prenatal sex selection.

GENETIC ETHICS

SEE *Genethics*.

GENETIC RESEARCH AND TECHNOLOGY

• • •

The early twenty-first century is an era of genetics. Genetic science, genetic technologies, genetically based diseases, animal and human cloning, and genetically modified organisms are regular visitors to the news and entertainment culture. Together with the revolution in information technologies, and sometimes going hand in hand, the biotech revolution promises to transform the world. The well-known successes of molecular biology in the 1950s and 1960s have transformed biology and especially genetics. But because from the very beginning genetics has been intimately involved with human values, the revolutionary changes of this science and technology have challenged moral reflection.

A brief historical review of the development of genetics research will help place such challenges in context. For present purposes this history may conveniently be divided into three periods. The first, and longest, period was one of protogenetics, in which human values played a dominant role. The second period saw the emergence of genetics as a science and its revolutionary research successes. During this period, the science aspired to a complete independence of any specific moral interests that were not directly entailed by the pursuit of scientific knowledge itself. Finally, the third period, although still trying to promote an ideal of value neutrality, may be characterized as making some efforts to bridge science and ethics.

Protogenetics: From Premoderns to the Eighteenth Century

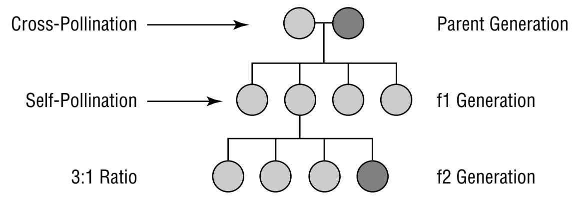
Humans have long interacted with plants and animals, seeking to improve human life through their manipulation. Thus, before there was a formal science of genetics, humans developed tacit or implicit knowledge of how to genetically alter plants and animals for human use. Human needs and values guided these manipulations and search for knowledge. Plants and animals were selectively bred for their usefulness, and microorganisms were used to make food items such as beverages, cheese, and bread.

Early farmers noted that they could improve each succeeding harvest by using seeds from only the best plants of the current crop. They noticed that plants that gave the highest yield, stayed the healthiest during periods of drought or disease, or were easiest to harvest tended to produce future generations with these same characteristics. Through several years of careful seed selection, farmers could maintain and strengthen such desirable traits.

The ancient Greeks also gave careful attention to the heredity of humans. The accounts given were largely speculative, and many aimed at the continuation of noble lineages. Plato (428–347 B.C.E.) in *The Republic*

FIGURE 1

Results of Mendel's Experiments on Inheritance in Yellow and Green Pea Plants: First and Second Generation



SOURCE: Courtesy of Immaculada de Melo-Martín.

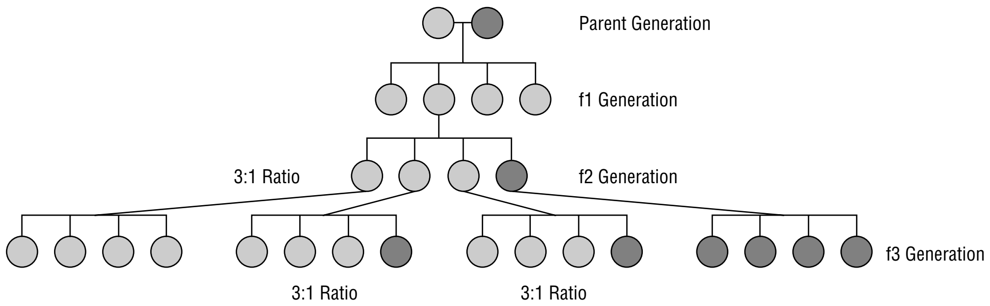
proposed strict laws governing human reproduction in order to perfect and preserve an ideal state. He presented what is known as the "noble myth," according to which rulers were fashioned from gold, those who would occupy the middle rung in the state were fashioned from silver, and the farmers and artisans were fashioned with bronze. Such an ideology would explain to people that differences between them were in their very nature and needed to be preserved by laws governing procreation.

The fourth century B.C.E. also brought the theory of pangenesis, according to which, the reproductive material included atomic parts that originated in each part of the parental body. This theory was used to explain the transmission of traits from parents to children. Hippocrates (460–377 B.C.E.) also determined that the male contribution to a child's heredity is carried in the semen and argued that because children exhibit traits from both parents, there was a similar fluid in women. Aristotle (384–322 B.C.E.) rejected pangenesis, in part because traits often reappear after generations, which the theory could not explain. He argued that an individual's development was determined by internal nature, and that semen alone determined the baby's form; the mother merely provided the material from which the baby is made.

During Roman and medieval times in Europe, little was added to human understanding of reproduction and heredity. During the seventeenth century, a new conception of natural science began to develop. This new understanding of the scientific enterprise focused on experimental designs and empirical proofs. The belief that the natural sciences were completely value free and, therefore, the best means to understand the natural world began to take root. In this context, the development of the natural sciences brought a renewed attention to human reproduction and heredity. William Har-

FIGURE 2

Results of Mendel's Experiments on Inheritance in Yellow and Green Pea Plants: Subsequent Generations



SOURCE: Courtesy of Immaculada de Melo-Martín.

vey (1578–1657) concluded that plants and animals alike reproduced in a sexual manner and defended the idea of epigenesis, that the organs of the body were assembled and differentiated as produced. Opposing epigenesis, Marcello Malpighi (1628–1694) developed the idea of preformation, according to which new organisms are fully present and preformed within either the egg or the sperm. By the middle of the seventeenth century, however, the idea of preformation was called into question by a variety of scientists. Pierre-Louis Moreau de Maupertuis (1698–1759) rejected preformationism by appealing to observations about the blending of traits. Also, the development of a theory of the cell by Kasper Friedrich Wolff (1734–1794) further supported epigenesis.

The Rise of Modern Genetics: From Mendel to Watson and Crick

The late eighteenth century and the beginning of the nineteenth century in Europe saw the advent of vaccinations, crop rotation involving leguminous crops, and animal-drawn machinery. The growth of modern science and of scientific technologies further contributed to the idea that science should be pursued for its own sake.

MENDELIAN GENETICS. Throughout this period, a number of hypotheses were proposed to explain heredity. The one that would prove most successful was developed by Austrian monk Gregor Johann Mendel (1822–1884). (The part of Austria where Mendel was born and lived is now located in the Czech Republic.) Through a variety of experiments, Mendel realized that certain traits showed up in offspring plants without any blending or mixing of the parent's characteristics. The traits were not intermediate between those of different parents. This observation was important because it contested the leading theory in biology at the time. Most of the scientists in the nineteenth century, including Charles Robert Darwin (1809–1882), believed that inherited traits blended from generation to generation.

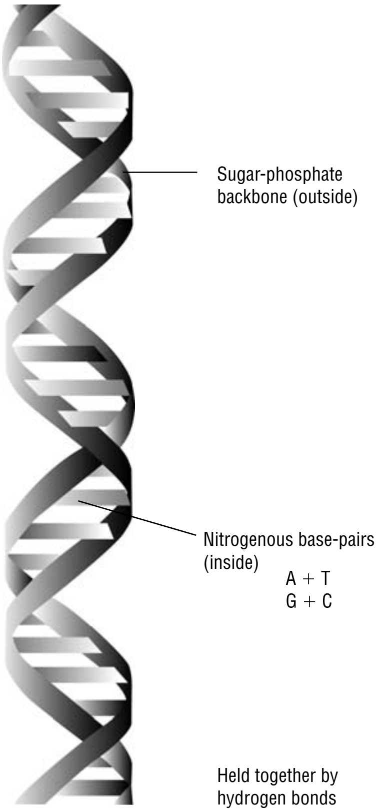
Mendel used common garden pea plants for his research because they could be grown easily in large numbers and their reproduction easily manipulated. Pea plants have both male and female reproductive organs. As a result, they can either self-pollinate or cross-pollinate with another plant. In cross-pollinating plants that produce either yellow or green peas exclusively, Mendel found that the first offspring generation (f1) always had yellow peas. However, the following generation (f2) consistently had a 3:1 ratio of yellow to green (See Figure 1).

This 3:1 ratio occurred in subsequent generations as well. Mendel thus thought that this was the key to understanding the basic mechanisms of inheritance (See Figure 2). He came to four important conclusions from these experimental results:

- that the inheritance of each trait was determined by "units" or "factors" that were passed on to descendents unchanged (now called "genes");
- that an individual inherited one such unit from each parent for each trait (the principle of segregation);
- that a trait might not show up in an individual, but could still be passed on to the next generation;
- that the inheritance of one trait from a particular parent could be independent of inheriting other traits from that same parent (the principle of independent assortment).

FIGURE 3

The DNA Double-Helix



SOURCE: Courtesy of Immaculada de Melo-Martín.

Mendel's ideas were published in 1866. However, they remained unnoticed until 1900, when Hugo Marie de Vries (1838–1945), Erich Von Tschermak-Seysenegg (1871–1962), and Karl Erich Correns (1864–1933) independently published research corroborating Mendel's mechanism of heredity.

POST-MENDEL DEVELOPMENTS. By the late 1800s, the invention of better microscopes allowed biologists to describe specific events of cell division and sexual reproduction. August Friedrich Leopold Weismann (1834–1914), who coined the term "germ-plasm," asserted that the male and female parent each contributed equally to the heredity of the offspring and that sexual reproduction generated new combinations of hereditary factors. He also argued that the chromosomes were the bearers of heredity. Edouard van Beneden (1846–1910) discovered that each species has a fixed number of chromosomes. He later discovered the formation of haploid cells during cell division of sperm and ova.

The publication of Darwin's *The Origin of Species* (1859), together with an incomplete understanding of human heredity, were used as grounds to support the idea of carefully controlling human reproduction to perfect the species. In 1883, Sir Francis Galton (1822–1911) coined the term *eugenics* to refer to the science of improving the human condition through "judicious matings." In the twentieth century, eugenics would be used to justify forced sterilization programs and immigration restrictions in the United States, and human experimentation in Nazi Germany.

After 1900, the pace of advance in genetic science and technology was rapid. During the first decade, William Bateson (1861–1926) coined the terms *genetics*, *allelomorph* (later *allele*), *homozygote*, and *heterozygote*. The cellular and chromosomal basis of heredity (*cytogenetics*) was identified by Theodor Heinrich Boveri (1862–1915) and others. And Sir Archibald Edward Garrod (1837–1936) developed the subspecialty of biochemical genetics by showing that certain human diseases were inborn errors of metabolism, inherited as Mendelian recessive characters.

During his investigations with the fruit fly Drosophila, Thomas Hunt Morgan (1866–1945) proposed that genes located on the same chromosome were linked together and could recombine by exchanging chromosome segments. Alfred Henry Sturtevant (1891–1970) drew the first genetic map, using cross-over frequencies between six sex-linked Drosophila genes to show their relative locations on the X chromosome. And in 1931, Harriet Creighton (1910–2004) and Barbara McClintock (1902–1992), and Curt Stern (1902–1981) working independently, found in cells under the microscope the first direct proof of crossing-over.

THE DISCOVERY OF DNA. In the 1940s, Oswald Theodore Avery (1877–1955), Colin Munro MacLeod (1909–1972), and Maclyn McCarty (1911–2005) offered evidence that DNA was the hereditary material. The challenge then was to determine the structure of this molecule. In 1953, James D. Watson (b. 1928) and Francis Crick (1916–2004) published in *Nature* the three-dimensional molecular structure of DNA, presenting what would be a breakthrough discovery in the biological sciences. They relied on the methods of Linus Pauling (1901–1994) for finding the helical structure in a complex protein and on unpublished x-ray crystallographic data obtained largely by Rosalind Elsie Franklin (1920–1958) and also by Maurice Wilkins (1916–2004). Watson and Crick determined that the DNA molecule was a double helix with phosphate backbones on the outside and the bases on the inside. They also determined that the strands were antiparallel and that there was a specific base pairing, adenine (A) with thymine (T), and guanine (G) with cytosine (C) (see Figure 3).

It is difficult to overstate the importance of the discovery of the structure of the DNA molecule. It has not only revolutionized the field of biology, but has become a cultural icon. The metaphor of the DNA as the "blueprint" of life has become engrained in much talk about human traits, diseases, and development. And with it, the ideology of genetic determinism, the idea that genes alone determine human traits and behaviors, has gained strength, despite the fact that practically every geneticist alive has disavowed it. Indeed, psychologist Susan Oyama has argued that genetic determinism is inherent in the way that what genes do is represented, because they have been given a privileged causal status. To describe and think about DNA in any way other than through this problematic representation of the power of DNA, is ever more difficult.

The Challenge of Genetic Knowledge and Power

The Watson-Crick model of DNA resulted in remarkable theoretical and technological achievements during the next decades. The genetic code was deciphered, the cellular components as well as the biochemical pathways involved in DNA replication, translation, and protein synthesis were carefully described, and the enzymes responsible for catalyzing these processes were isolated.

DNA RESEARCH. A striking result of these theoretical advances was the newly found ability to use a variety of techniques that would allow researchers to control and manipulate DNA. The discovery of restriction enzymes was one of the most important steps in this ability to manipulate DNA material. These enzymes are bacterial proteins that can recognize and cleave specific DNA sequences. They act as a kind of immune system, protecting the cell from the invasion of foreign DNA by acting as chemical knives or scissors. The capacity to cut DNA into distinct fragments was a revolutionary advance. For the first time, scientists could segment the DNA that composed a genome into fragments that were small enough to handle. Human chromosomes range in size from 50 million to 250 million base pairs, and thus are very difficult to work with. Additionally, methods for synthesizing DNA and for using messenger RNA to make DNA copies provided reliable means for obtaining DNA.

Moreover, they now had the opportunity to separate an organism's genes, remove its DNA, rearrange the cut pieces, or add sections from other parts of the DNA or from other organisms. The use of plasmids, extra-chromosomal genetic elements found in a variety of bacterial species, and of bacterial viruses as vectors or vehicles to introduce foreign DNA material into living cells served as a major tool in genetic engineering. Once introduced into the nucleus, the foreign DNA material is inserted, usually at a random site, into the organism's chromosomes by intracellular enzymes. In some rare occasions, however, a foreign DNA molecule carrying a mutated gene is able to replace one of the two copies of the organism's normal gene. These rare events can be used to alter or inactivate genes of interest. This process can be done with stem cells, which will eventually give rise to a new organism with a defective or missing gene, or with somatic cells in order to compensate for a nonfunctioning gene.

No less important for the ability to understand and manipulate genetic material were the development of techniques to sequence DNA, the establishment of the methodology for gene cloning, and the development of the polymerase chain reaction (PCR). With these techniques it was possible to obtain and analyze unlimited amounts of DNA and RNA within a short period of time. Additionally, PCR would prove an invaluable method to identify mutations associated with genetic disease, to detect the presence of unwanted genetic material (for example in cases of bacterial or viral infection), and to use in forensic science.

Researchers working on organisms such as worms developed technologies that allow mapping of their genomes. These mapping techniques permitted the location of the positions of known landmarks throughout the organism's chromosomes. Furthermore, as these molecular techniques improved, their application to cancer studies became more and more common, leading to the discovery of viruses that were able to transform normal cells into cancer cells, the description of oncogenes, cancer suppressor genes, and a variety of other molecules and biochemical pathways involved in the development of cancer.

HUMAN GENOME PROJECT. This new venture traces its origins back to Los Alamos national laboratory and the Manhattan Project. After the atomic bomb was developed and used in Hiroshima and Nagasaki, the U.S. Congress charged the Atomic Energy Commission and the Energy Research and Development Administration, the predecessors of the U.S. Department of Energy (DOE) with studying and evaluating genome damage and repair as well as the consequences of genetic mutations. There was a special interest in focusing the research on genetic damages caused by radiation and chemical by-products of energy production. From this research developed the plan to analyze the entire human genome.

The automation of DNA sequencing in the 1980s brought to the forefront of the scientific community the possibility of not just mapping the human genome, but also sequencing it. Thus, while gene mapping allowed researchers to determine the relative position of genes on a DNA molecule and the distance between them, sequencing let them identify one by one the order of bases along each chromosome.

It was in this context that discussions began about launching a human genome program. During a series of informal meetings, researchers and government officials attempted to assess the feasibility of different aspects of a project to map and sequence the entire three billion bases of the human genome. Although the majority of scientific opinion by the end of the 1980s was that sequencing the entire human genome was feasible, not all researchers were persuaded that such a project was a good idea. Many of them saw it as a massive work in data gathering rather than important research. Many scientists were also worried that the potential huge costs of such a project would diminish the funds dedicated to basic biological research.

In spite of the concerns, in 1990 the Human Genome Project (HGP) was formally launched as a fifteen-year plan coordinated by the U.S. Department of Energy and the National Institutes of Health. James Watson had been asked to head the project and did so until 1992. He resigned then because of his opposition to the patenting of human gene sequences. Francis Collins, who in 2005 is still the director of the National Human Genome Research Institute (NHGRI), replaced him in 1993. The main goals of the project were to identify all the genes in human DNA and to determine the sequences of its three billion chemical base pairs. Other important objectives of this international project were to improve the existent tools for data analysis and store the information obtained about the genome in databases.

The main focus was the human genome. However, important resources were also devoted to sequencing the entire genomes of other organisms, often called "model organisms" and used extensively in biological research, such as mice, fruit flies, and flatworms. The idea was that such efforts would be mutually supportive because most organisms have many similar genes with like functions. Hence, the identification of the sequence or function of a gene in a model organism had the potential to explain a homologous gene in human beings, or in one of the other model organisms.

The International Human Genome Sequencing Consortium published the first draft of the human genome in the journal *Nature* in February 2001, with about 90 percent of the sequence of the entire genome's three billion base pairs completed. Simultaneously the journal *Science* published the human sequence generated by Celera Genomics Corporation headed by Craig Venter.

Although the original expected conclusion date for the project was 2005, in April 2003, coinciding with the fiftieth anniversary of the discovery of the DNA double helix, the full sequence was published in special issues of *Nature* and *Science*. The early conclusion of the program was the result of a strong competition between the public program and the private one directed by Venter. His announcement in 1998 that his company would be able to sequence the entire human genome in just three years, forced the leaders of the public program to increase the pace, so as to not be left behind. The involvement of private capital in a project of this magnitude was a major turning point in science policy because it called into question the common belief since World War II that only the federal government had sufficient resources to fund "big science."

In December 2003, the NHGRI announced the formation of the social and behavioral research branch. This new branch has as its purpose developing approaches to translating the discoveries from the completed human genome into interventions leading to health promotion and disease prevention. The launching of this new branch is evidence of the shift of the NHGRI from genome sequencing to behavioral genetics.

ETHICAL, LEGAL, AND SOCIAL ISSUES. Because of the well-known abuses of eugenics during the beginning decades of the twentieth century in the United States and then in Nazi Germany, there was an unprecedented decision to attend to the possible consequences of the research into the human genome. Thus a significant goal of the HGP was to support research on the ethical, legal, and social issues (ELSI) that might arise from the project. Funds were dedicated to the examination of issues raised by the integration of genetic technologies and information into health care and public health activities and to explore the interaction of genetic knowledge with a variety of philosophical, theological, and ethical perspectives. Similarly, part of the ELSI budget was dedicated to supporting research exploring how racial, ethnic, and socioeconomic factors affect the use, understanding, and interpretation of genetic information; the use of genetic services; and the development of public policy.

Of course, the HGP, and the scientific and technological advances that permitted it, are extremely significant because of the theoretical knowledge it has produced on how, for example, genes work and what their contribution to health and disease is. It is difficult, however, to clearly separate theory and practice in molecular genetics given that this science is very technique intensive. In any case, the research supported by the HGP is also noteworthy because it has grounded the development of a variety of what are now common biotechnologies. Hence, genetic tests and screening for several human diseases such as Tay Sachs, sickle cell anemia, Huntington's disease, and breast cancer are now part of medical practice. Agricultural products such as corn plants genetically modified to produce selective insecticides or tomatoes engineered to prevent expression of a protein involved in the process of repining are common in food markets. Animal cloning does not make the front page anymore. Genetic therapy and pharmacogenetics are more and more often presented as the new medical miracles. And, of course, discussions of genetic enhancement and the hopeful, or frightening, possibility of designer babies are regular features of the news and entertainment media.

Given the increased presence of biotechnologies in people's lives and the significance of the genetic sciences, it is not surprising then that both the so-called theoretical research on human genetics and the practical applications of such knowledge have raised heated debates about ethical, legal, and social implications. Consider, for example, the following issues that have emerged in discussions of medical and agricultural biotechnologies.

GENETIC INFORMATION. The increasing use of genetic knowledge and genetics technologies in medical practice has been a subject of concern, though to different degrees, for both those who support such use and those who are skeptical of its benefits. One of the topics that has attracted the most attention among bioethicists working on ELSI issues is related to the availability and possible abuse of genetic information. Hence, the availability of genetic information has opened discussions about privacy and confidentiality. Questions have arisen about whether medical practitioners have an obligation to inform the family members of a patient with a genetic disease, or whether such information should be available to insurers and employers, for example. The concern for the possibility of genetic discrimination has been such that many states have proposed and passed legislation prohibiting insurers from discriminating on genetic grounds. Similarly, given past experiences with eugenics, there are good reasons to have some concern about the possible stigmatization of individuals due to their genetic makeup.

GENETIC DIAGNOSIS AND HUMAN RESPONSIBILITY. The use of genetic diagnosis for a variety of medical conditions has received no less attention. Concern about fair access to these technologies, the reliability and usefulness of the tests, the training of health care professionals, the psychological effects they might have on people, and the consequences for family relationships are common. Similarly, many of the tests being developed, and some of the ones already in use, point to genetic susceptibilities or test for complex conditions that are linked to multiple genes and gene-environment interactions. Thus, such tests provide information not of a present or even a future disease, but of an increased risk of suffering such a disease. In many cases, these tests reveal possibilities of disorders, such as Huntington's disease, for which no available treatments exist. Given these issues, concerns about regulation of these tests, whether they should be performed at all, or whether parents have a right or an obligation to test their children for late-onset diseases are certainly justifiable. Moreover, the use of genetic diagnosis techniques in reproductive decision-making can also have serious implications for reproductive rights, our view of human beings, the expectations people might impose on their offspring, and the way we might treat people with disabilities.

The emphasis on people's genetic makeup might also have implications for their ideas of human responsibility, views regarding control of behavior and health status, their notions of health and disease, and their conceptions of treating a disorder or enhancing a trait. Such emphasis also has consequences for the kind of public policies people support regarding education, health promotion, disease prevention, and environmental regulations.

AGRICULTURAL BIODIVERSITY. Discussions about agricultural biotechnologies focus not just on the effects that these technologies might have on human beings, but also the consequences for animals and the natural environment. Genetic recombination techniques are used to create genetically modified organisms (GMOs) and products. These technologies enable the alteration of the genetic makeup of living organisms such as animals, plants, or bacteria, by modifying some of their own genes or by introducing genes from other organisms. GM crops, for example, are now grown commercially or in field trials in more than forty countries and on six continents. Some of these crops, including soybeans, corn, cotton, and canola, are genetically engineered to be herbicide and insecticide-resistant. Other crops grown commercially or field-tested are a sweet potato resistant to a virus that could decimate most of the African harvest, rice with increased iron and vitamins, and a variety of plants able to survive weather extremes. Research is being conducted to create bananas that produce human vaccines against infectious diseases such as hepatitis, fish that mature more quickly, fruit and nut trees that yield years earlier, and plants that produce new plastics with distinctive properties. It is unclear at this point how many of this research lines will be successful.

Questions about whether genetically modified organisms and products are safe for humans, whether they might produce allergens or transfer antibiotic resistance, whether they are safe for the environment, whether there might be an unintended transfer of transgenes through cross-pollination, whether they might have unknown effects on other organisms or result in the loss of floral and faunal biodiversity, for instance, are at the forefront of these debates. But the use of these technologies has also raised concern about possible implications for people's conceptions of other animals and the environment, their views of agricultural production, and their relationships with natural objects. Thus, many have wondered whether the use of these techniques constitutes a violation of natural organisms' intrinsic value, whether humans are unjustifiably tampering with nature by mixing genes among species, or whether the use of animals exclusively for human purposes is immoral. Debates also have been sparked about access to these technologies and the effect that this might have on non-industrialized countries. Some have questioned whether the domination of world food production by a few companies might not be putting food production at risk, and poor farmers in poor countries at an increasing dependence on industrialized nations. Issues about the commercialization of these products through the use of patents, copyrights, and trade secrets are also relevant when analyzing the implications of these technologies. Thus, many have called attention to the accessibility of data and materials.

Assessment

It is important to point out that although the ELSI program of the HGP has certainly had a significant effect on the understanding and evaluation of the consequences of new genetic technologies, the prevalent idea that humans must pay attention exclusively to the consequences of scientific or technological advances might be a reason for concern. A focus on consequences reinforces the incorrect view that science and technology are value-neutral. Issues about scientific or technological advances are thus framed as questions related to the implementation of scientific knowledge or technological practices. Hence, under the presumption that such practices are not the problem, but the use that people make of them might be, an evaluation of the scientific practices themselves appears illegitimate. This prevents researchers from trying to analyze the values that might underlie the current focus on genes, or attempting to propose different value assumptions to guide scientific research. Moreover, the emphasis on consequences directs attention to analysis of means and away from an evaluation of ends. Thus, scientists are encouraged to evaluate whether a particular technology is good to solve certain problems, but cannot analyze the goals for which such a technique has been developed. Technical discussions of biotechnology that focus on impacts presuppose that these goals are unquestionable. Thus, attention must be paid to the fact that assessments of new technologies must require not only discussions of risks and benefits—that is, discussions of means—but also reflections about ends. Of course, these issues apply to a variety of bioethical problems and not just to ELSI work.

INMACULADA DE MELO-MARTÍN

SEE ALSO *Bioethics; Biotech Ethics; Fetal Research; Gene Therapy; Genethics; Genetic Counseling; Health and Disease; Human Genome Organization; In Vitro Fertilization and Genetic Screening; Medical Ethics; Playing God; Privacy.*

BIBLIOGRAPHY

Buchanan, Allen; Dan W. Brock; Norman Daniels; and Daniel Wikler. (2001). *From Chance to Choice: Genetics and Justice*. Cambridge, UK: Cambridge University Press.

Davis, Kevin. (2001). *Cracking the Genome: Inside the Race to Unlock Human DNA*. Baltimore: Johns Hopkins University Press.

Dunn, Leslie C. (1965). *A Short History of Genetics: The Development of Some of the Main Lines of Thought: 1864–1939*. New York: McGraw-Hill.

Kass, Leon. (2002). *Life, Liberty, and the Defense of Dignity: The Challenges for Bioethics*. San Francisco: Encounter Books.

Kevles, Daniel J., and Leroy Hood. (1992). *The Code of Codes: Scientific and Social Issues in the Human Genome Project*. Cambridge, MA: Harvard University Press.

Keller, Evelyn Fox. (2000). *The Century of the Gene*. Cambridge, MA: Harvard University Press.

Kristol, William, and Eric Cohen, eds. (2002). *The Future Is Now: America Confronts the New Genetics*. New York: Rowman and Littlefield.

Lee, Keekok. (2003). *Philosophy and Revolutions in Genetics: Deep Science and Deep Technology*. New York: Palgrave MacMillan.

Mahowald, Mary Briody. (2000). *Genes, Women, Equality*. New York: Oxford University Press.

Mayr, Ernest. (1982). *The Growth of Biological Thought: Diversity, Evolution, and Inheritance*. Cambridge, MA: Belknap Press.

Nelkin, Dorothy, and Susan Lindee. (2004). *The DNA Mystique: The Gene as Cultural Icon*, 2nd edition. Ann Arbor: University of Michigan Press.

Oyama, Susan. (1985). *Ontogeny of Information: Developmental Systems and Evolution*. Cambridge, UK: Cambridge University Press.

Sherlock, Richard, and John D. Morrey, eds. (2002). *Ethical Issues in Biotechnology*. Lanham, MD: Rowman and Littlefield.

Stubbe, Hans. (1972). *History of Genetics: From Prehistoric Times to the Rediscovery of Mendel's Laws*, trans. Trevor R. W. Waters. Cambridge, MA: MIT Press.

Tudge, Colin. (2000). *The Impact of the Gene: From Mendel's Peas to Designer Babies*. New York: Hill and Wang.

Watson, James, and Andrew Berry. (2003). *DNA: The Secret of Life*. New York: Knopf.

Watson, James, and Francis Crick. (1953). "A Structure for Deoxyribose Nucleic Acid." *Nature* 171: 737–38.

Watson, James; Michael Gilman; Jan Witkowski; and Mark Zoller. (1992). *Recombinant DNA*, 2nd edition. New York: W.H. Freeman.

Wright, Susan. (1986). "Recombinant DNA Technology and Its Social Transformation 1972–1982." *Osiris* 2: 303–60.

INTERNET RESOURCES

U.S. National Human Genome Research Institute, National Institutes of Health. Available from http://www.genome.gov.

U.S. Department of Energy, Office of Science. "Human Genome Project Information." Available from http://www.ornl.gov/sci/techresources/Human_Genome/home.shtml.

GENETICS AND BEHAVIOR

Despite longstanding hostility to the biological explanation of human behavior, there are presently three general research programs aimed at the study of genetic influences on behavior: sociobiology and evolutionary psychology, behavioral genetics, and developmental psychobiology. Evolutionary psychology and its forebear, sociobiology, aim to discover species-typical traits that are adaptations (that is, traits that are in most cases the result of natural selection): Why do humans behave aggressively? What is the evolutionary source of altruism? Behavioral genetics aims primarily to uncover and disentangle genetic contributions (as distinct from environmental contributions) to individual differences in behavior: What are the predictors of aggressive versus nonaggressive behavior? Why does one person perform well on an IQ test, and another not? Developmental psychobiology aims to elucidate developmental pathways to particular behaviors: What is the mechanism by which organisms come to behave aggressively? What are the determinants of central nervous system development?

Such sample questions are by no means exhaustive; they are meant simply to illustrate the focal differences between these three approaches to genetics and behavior (see Table 1), the latter two of which will be the focus here. That is, rather than focus on how biological evolution as a whole has affected species-specific behaviors, the emphasis will be on how genetics can account for individual differences within species and on the more detailed pathways by which DNA causally influences human behavior.

Born of Controversy

Both behavior geneticists and developmental psychobiologists aim to move beyond the nature/nurture dichotomy, according to which traits are either genetically influenced (nature) or environmentally influenced (nurture), in favor of some collaborative interaction. What nature-*and*-nurture or nature-*via*-nurture actually means in practice is not always clear, however, because most scientists continue to partition correlational and causal influence in traditional terms (Schaffner 2001, Robert 2003).

The modern roots of the nature–nurture controversy are to be found in the writings of Francis Galton (1822–1911), a cousin of Charles Darwin, in the latter half of the nineteenth century. In 1869 Galton published *Hereditary Genius*, in which he attempted to discern what makes some humans geniuses and others exceptionally stupid. Based in part on anecdotal observations of twins, along with a questionnaire he administered to a small group of twins who were believed to be more similar in their youth than at the time of testing, Galton eventually concluded that "nature prevails enormously over nurture" in explaining variance in cogni-

TABLE 1

Three Approaches to the Study of Genetic Influences on Behavior

Problem domain	Explanatory focus	Content of explanations
Sociobiology and evolutionary psychology	Species-typical social and individual behaviors (adaptations)	Evolutionary vs. cultural, stochastic, or volitional explanations of species functional behaviors
Behavioral genetics	Individual differences, heritabilities	Genetic vs. environmental explanations of variability
Developmental psychobiology	Developmental pathways to phenotypic outcomes	Causal explanations of the role of DNA, other developmental resources, and environments (in evolutionary context)

SOURCE: Courtesy of Jason Scott Robert.

tive outcome (Galton 1875, p. 576). Galton later coined the term *eugenics* as part of a program to increase the number of so-called desirables in a population and to decrease the number of so-called undesirables (Kevles 1985). The "eugenics movement" has, of course, had its own very controversial history—including the rationalization of human rights violations in the United States, Nazi Germany, and other countries.

Since its modern incarnation, then, and however well-intended, behavior genetics has been associated with the justification of class-based and racial prejudice, exemplified more recently with the argument of Arthur R. Jensen (1969) that genetic differences between "races" influence the lower intelligence (or the poorer performance on IQ tests) of blacks as compared with whites. While most behavior geneticists have disowned this and related work, in 1995 the outgoing president of the Behavior Genetics Association (BGA), Glayde Whitney, celebrated Jensen's putatively brilliant and bold 1969 work in his presidential address. Whitney's speech was widely disparaged, and the editor of the BGA journal, *Behavior Genetics*, refused to publish it.

Classical Behavior Genetics

Three key concepts in classical genetics that referred originally not so much to behavioral but to anatomical characteristics that need to be clarified are genotype, phenotypes, and allele. The genotype is simply the genetic make-up of the organism, its complement of DNA. Genes, now known to be sections of chromosomes, manifest themselves as the organism's phenotype, its outward appearance. Any one gene may also come in different or alternative forms called alleles. For example, the founder of genetics, Gregor Mendel (1822–1884), in his research with pea plants, identified that one gene controls seed color, and the two forms of this gene give either green or yellow peas. That is, one allele (for yellow pea color) will be expressed as one phenotype (yellow peas), whereas another allele (for green pea color) will be expressed as another phenotype (green peas). One question for behavior genetics is whether and to what extent there are genotypes with different alleles that control for phenotypical behavior as well as physical characteristics.

The attempt to answer this question through the practice of observing twins continues to this day—though now with considerably more sophistication and computational power. Modern behavior geneticists establish correlations between genes and behavioral outcomes on the basis of two general types of study, involving classical or quantitative genetics (family, twin, and adoption studies) and molecular genetics and genomics (linkage, association, allele sharing, quantitative trait locus mapping, and DNA microarray studies). Although it is not necessary to know the complete meaning of the technical terms here, linkage and association refer to kinds of connections between genes, alleles (as already explained) are different forms of the same gene, trait locus mapping seeks to locate genes at specific points on a chromosome, and DNA microarray studies aim to show which genes are expressed at any given time. Classical studies are used to reveal the relationship between genetic variation and variation in phenotypic outcome.

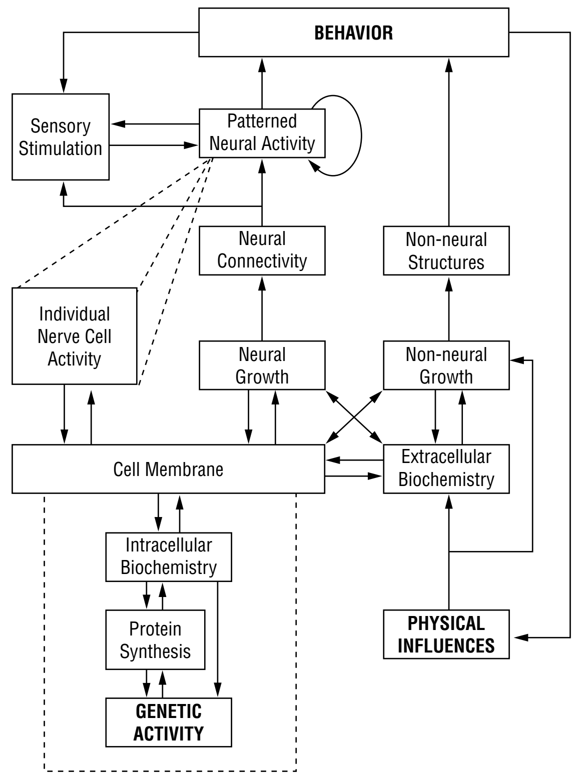
Twin studies, for instance, are premised on the notion that, on average, identical (monozygotic, or MZ) twins share almost 100 percent of their genes in common, while fraternal (dizygotic, or DZ) twins share approximately 50 percent of their genes in common. A fundamental assumption is that both kinds of twins are affected by their rearing environments in a similar way, and that their "equal environments" cannot make MZ twins any more alike than DZ twins. On the basis of this assumption, behavior geneticists argue that what makes MZ twins more alike than DZ twins is that they are more genetically similar.

In any given population, *heritability* refers to the proportion of phenotypic (or apparent, expressed) variance that can be explained by genotypic (or hidden, genetic) variation, and is quantified as between zero (no variation explained by genetic inheritance) and one (all variation explained by inheritance). In humans, the heritability of having two legs is just about zero: Because almost all humans are born with two legs, there is very little phenotypic variance to be explained. By contrast, the heritability of eye color in a random human population approaches one, inasmuch as the variation in eye color can be explained almost exclusively by genetic variance. T the heritability of height is somewhere in between. Like physical characteristics, behaviors of interest to behavior geneticists have nonzero heritability (often in the range of 0.4 to 0.6), though it is often unclear what inferences are justified on the basis of a heritability estimate (Turkheimer 1998).

Behavior geneticists distinguish between traits that are either present or absent, and those that are continuously distributed. Where presence/absence is appropriate, scientists calculate *concordance rates*. Where the trait is continuous, scientists calculate *correlation coefficients*. So if MZ twins both exhibit some noncontinuous phenotypic outcome (say, depression), they are said to be "concordant" for that trait; and where the concordance rate for MZ twins is greater than that for DZ twins, the greater concordance is attributed to genes. Where MZ and DZ concordance rates are similar, this is attributed to shared environmental influences. And where MZ twins are discordant for a trait, this is attributed to nonshared environmental influences. In many cases, genes, shared environment, and nonshared environment are invoked to partially explain phenotypic differences (Baker 2004, Parens 2004), although nonshared environmental effects remain very difficult to discern (Turkheimer 2000).

FIGURE 1

A Model of Behavioral Development



SOURCE: Adapted by Tim Fedak from Johnston and Edwards (2002), p. 28.

Molecular Behavior Genetics

Classical studies can reveal associations between genetic variance and phenotypic variance, but do not identify the particular genes that may generate a trait. In the 1980s, behavior geneticists began to take advantage of emerging molecular techniques to attempt to identify specific genes. *Linkage studies* are employed to detect genes of major effect shared by a disproportionately large number of family members manifesting a condition or trait of interest. Successful linkage studies require three conditions to have been met: that a gene of major effect is implicated; that there is only one such gene segregating in a given family; and that the mode of inheritance is known (Robert 2003). For most complex behaviors, at least one of these conditions is violated; for many complex behaviors, all three are violated.

Allelic association studies are employed to discern whether alleles or different forms of particular genes are transmitted preferentially to family members, or whether there are differences in the frequency of alleles between individuals and control populations. These studies avoid the requirement for a single gene of major effect; moreover, in the company of now-possible genome-wide scans, there is no need even to identify candidate genes or regions in order to turn up possible correlations. Further, success with these studies does not depend on knowing a specific mode of inheritance. But correlations are not causes, and allelic association studies risk turning up correlations that are causally spurious. For instance, where an allele is in linkage disequilibrium with another allele, allelic association studies will positively correlate both alleles with the phenotype, even if only one is actually involved in generating the phenotype.

Behavior geneticists are now using still more sophisticated techniques to reveal associations between genes and phenotypic outcomes. These include quantitative trait locus mapping and DNA microarray technology. Most phenotypes, especially of behaviors, are complex combinations of traits and thus governed by more than one gene. Quantitative trait locus mapping attempts to determine in quantitative terms what set of traits define a complex phenotype. DNA microarray technology, using what is variously called a biochip, DNA chip, or gene chip, allows for large-scale gene expression studies in order to identify interacting genes. Progress has nevertheless been slower than initially anticipated (e.g., Hamer 2002), and very few specific genes have been identified.

According to behavior geneticist Michael Rutter (2002), "knowing that a trait is genetically influenced . . . is of zero use on its own in understanding causal mechanisms" (p. 4). Some developmental psychobiologists take this as evidence of the sterility of behavior genetics (e.g., Gottlieb 1995). If the focus of behavior genetics is on the establishment of correlations and other associations between inherited genes and particular behavioral outcomes, the focus of developmental psychobiology is on the identification of the developmental pathways that lead to those outcomes. Often, these pathways involve heritable elements, including genes; sometimes, other levels of analysis are more apt to yield developmental insights.

Developmental Psychobiology

Behavior geneticists do not study behavior as such, but rather differences in behavior. Moreover, behavior geneticists study associations between genetic variance, environmental variance, and interactions between the two, not causal relationships between developmental factors. By contrast, developmental psychobiologists seek to unpack genetic and other influences on complex behavioral phenotypes by elucidating causal mechanisms and pathways within the developing organism.

There is a long history of research in animal behavior (ethology) and comparative psychology, including experimental studies of animal behavior. Many historians begin with the work of Konrad Lorenz (1903–1989) on innateness. Lorenz's research was not entirely well-received among "English-speaking ethologists," as he called them, particularly Daniel S. Lehrman (1919–1972). Lehrman's criticisms of Lorenz (1953) continue to inspire developmental psychobiologists (e.g., Johnston 1987, Lickliter 2000, Oyama 2000), while classical ethology has generally been dislodged by sociobiology and evolutionary psychology. (Developmental criticisms of the concept of innateness preceded the work of Lorenz; see, for instance, Kuo 1921.)

Experimental analyses of animal behavioral development have revealed aspects of development from conception through senescence, including factors, mechanisms, and causal interactions involved in central nervous system development. Coupled with results from brain science, developmental psychobiologists are shedding light on the pathways of neural, cognitive, and motor development in a wide range of animals, including those chosen as models for understanding human development. Nonetheless, developmental psychobiology has yet to yield a fully integrative account of behavioral development, in large part because of the complexity of the task.

Yet a framework for the integrative project is now in place. Timothy D. Johnston and Laura Edwards's series of increasingly specific (or "unpacked") representations of a model of the development of behavior are not intended to specify every molecular or cellular aspect of the complexity of development, but rather to provide "a useful intermediate level of detail that captures that complexity while at the same time rendering it reasonably comprehensible" and open to empirical investigation (Johnston and Edwards 2002, p. 31). Genes, neurons, and experience have indirect and reciprocal effects on the development of behavior, though their activity is mediated through multiple levels of biological, ecological, and social organization. The model is meant to focus investigative attention on developmental interactions and specific mechanisms, as depicted in Figure 1.

Any particular concrete use of this model would represent only a snapshot of a specific developmental moment. The model could also be transformed from two dimensions to three with the addition of information regarding the timing of individual influences on development, though this would obviously make it considerably less easy to represent graphically. This model of behavioral development can be used to organize existing knowledge and to make predictions about behavioral development that can be empirically investigated, yielding support for or requiring alteration of the underlying model.

In using this model of behavioral development in a research context, it is evident that scientists cannot do the kinds of studies with humans that would yield results of interest. There are limits on what is acceptable with human subjects. Accordingly, developmental psychobiologists (like all developmental researchers) must infer from animal models, a process that is both conceptually and ethically fraught (Gottlieb and Lickliter 2004). Are the behaviors observed (or created) in animal models in fact homologous (or even analogous) to human behaviors? How does a passive–aggressive rat or an alcoholic monkey behave? What can be learned about human neural development from a fruit fly? These challenges beset any attempt to understand human behavioral development on the basis of studies with nonhuman animals.

Ethical and Social Considerations

While both behavior genetics and developmental psychobiology continue to provide important insights into the development of behavior, ethical concerns persist. These range from eugenic fears about the discovery of so-called gay genes and genes predisposing to antisocial behavior, to worries about the possible genetic enhancement of human cognitive function.

Following the mapping and sequencing of the human genome, a project that was sometimes viewed in exaggerated terms, there has been a shift to functional genomics, that is, attempts to determine what genes do and how they interact. Some hope that functional genomics will tell us not just how genes produce certain proteins but also how genes produce phenotypes, including behavior. But according to one policy commentary in *Science* magazine:

> The genetics of behavior offers more opportunity for media sensationalism than any other branch of current science. Frequent news reports claim that researchers have discovered the "gene for" such traits as aggression, intelligence, criminality, homosexuality, feminine intuition, and even bad luck. Rarely is it mentioned that traits involving behavior are likely to have a more complex genetic basis. This is probably because most journalists—in common with most educated laypeople (and some biologists)—tend to have a straightforward, single-gene view of genetics. (McGuffin et al. 2001, p. 1232)

Thus there is clearly a place for the lowering of expectations with regard to behavioral genetics.

More broadly, though, simply to study genetics and behavior by any means is to study what makes humans behaviorally different from one another. For many, any advances in this domain threaten to impinge, at least conceptually, on precisely what it is that distinguishes human from nonhuman nature. While these concerns may be ill-founded, behavioral scientists must take seriously the imperative to assuage these fears by promoting socially responsible public engagement with the science.

JASON SCOTT ROBERT

SEE ALSO *Bioethics; Genethics; Genetic Research and Technology.*

BIBLIOGRAPHY

Baker, Catherine. (2004). *Behavioral Genetics: An Introduction to How Genes and Environments Interact through Development to Shape Differences in Mood, Personality, and Intelligence*. Washington, DC: American Association for the Advancement of Science.

Galton, Francis. (1869). *Hereditary Genius: An Inquiry into Its Laws and Consequences*. London: Macmillan. A classic text that initiated behavioral genetics.

Galton, Francis. (1875). "The History of Twins, as a Criterion of the Relative Powers of Nature and Nurture." *Fraser's Magazine* 12(92): 566–576. Revised version published in *Journal of the Royal Anthropological Institute*, vol. 5, pp. 391–406.

Gottlieb, Gilbert. (1995). "Some Conceptual Deficiencies in 'Developmental' Behavior Genetics." *Human Development* 38(3): 131–141.

Gottlieb, Gilbert, and Robert Lickliter. (2004). "The Various Roles of Animal Models in Understanding Human Development." *Social Development* 13(2): 311–325.

Hamer, Dean. (2002). "Rethinking Behavior Genetics." *Science* 298(5591): 71–72.

Jensen, Arthur R. (1969). "How Much Can We Boost IQ and Scholastic Achievement?" *Harvard Educational Review* 39(1): 1–123.

Johnston, Timothy D. (1987). "The Persistence of Dichotomies in the Study of Behavioral Development." *Developmental Review* 7(2): 149–182.

Johnston, Timothy D., and Laura Edwards. (2002). "Genes, Interactions, and the Development of Behavior." *Psychological Review* 109(1): 26–34.

Kevles, Daniel J. (1985). *In the Name of Eugenics*. New York: Knopf.

Kuo, Zing-Yang. (1921). "Giving Up Instincts in Psychology." *Journal of Philosophy* 18(24): 645–664.

Lehrman, Daniel S. (1953). "A Critique of Konrad Lorenz's Theory of Instinctive Behavior." *Quarterly Review of Biology* 28(4): 337–363.

Lickliter, Robert. (2000). "An Ecological Approach to Behavioral Development: Insights from Comparative Psychology." *Ecological Psychology* 12(4): 319–334.

Lorenz, Konrad. (1957). "The Nature of Instinct." In *Instinctive Behavior: The Development of a Modern Concept,* trans. and ed. Claire H. Schiller. New York: International Universities Press. Originally published, 1937.

McGuffin, Peter; Brien Riley; and Robert Plomin. (2001). "Genomics and Behavior: Toward Behavioral Genomics." *Science* 291(5507): 1232–1233.

Oyama, Susan. (2000). *The Ontogeny of Information: Developmental Systems and Evolution,* 2nd edition. Durham, NC: Duke University Press.

Parens, Erik. (2004). "Genetic Differences and Human Identities: On Why Talking about Behavioral Genetics Is Important and Difficult." *Hastings Center Report,* special supplement, 34(1): S1–S36.

Robert, Jason Scott. (2003). "Developmental Systems and Animal Behaviour." *Biology and Philosophy* 18(3): 477–489.

Rutter, Michael. (2002). "Nature, Nurture, and Development: From Evangelism through Science toward Policy and Practice." *Child Development* 73(1): 1–21.

Schaffner, Kenneth F. (2001). "Nature and Nurture." *Current Opinion in Psychiatry* 14(5): 485–490.

Turkheimer, Eric. (1998). "Heritability and Biological Explanation." *Psychological Review* 105(4): 782–791.

Turkheimer, Eric. (2000). "Three Laws of Behavior Genetics and What They Mean." *Current Directions in Psychological Science* 9(5): 160–164.

Whitney, Glayde. (1995). "Ideology and Censorship in Behavior Genetics." *Mankind Quarterly* 35(4): 327–342.

GENETIC SCREENING

SEE *Genetic Research and Technology; In Vitro Fertilization.*

GENOCIDE

The word *genocide* is relatively new, even though the act of genocide is not. Yet in part because of its twentieth-century origins, genocide is often associated with the use of modern science and technology. The extent to which this is the case is one of the contentious ethical issues associated with the term.

Origins and Controversies

Polish jurist Raphael Lemkin introduced the term genocide in 1944 to describe the widespread killing of civilians that occurred during the first half of the twentieth century. He created the term as an amalgam of the Greek *genos,* meaning race or kind, and the Latin based suffix *-cide,* indicating killing (Smith 2002, Hinton 2002). At the time genocide was not a distinct crime, but Lemkin lobbied strongly to get it recognized as such.

The result was the 1948 United Nations Convention on the Prevention and Punishment of the Crime of Genocide which 136 countries have ratified. In the convention, genocide is defined as "any of the following acts committed with intent to destroy, in whole or in part, a national, ethnical, racial or religious group, as such: (a) Killing members of the group; (b) Causing serious bodily or mental harm to members of the group; (c) Deliberately inflicting on the group conditions of life calculated to bring about its physical destruction in whole or in part; (d) Imposing measures intended to prevent births within the group; (e) Forcibly transferring children of the group to another group."

As with any legal document, the UN definition of genocide has been scrutinized by scholars and politicians. The current definition, which limits genocide to ethnic, racial, religious, and national identity, describes human characteristics that are inherent to one's person. Race, ethnicity, and to a lesser extent, nationality and religion are determined at birth. Some critics argue that these criteria are too narrow in that they exclude particular social groups, such as political affiliation. Joseph Stalin slaughtered millions in the Soviet Union for largely political reasons, yet his actions do not constitute genocide under the UN definition. Indeed the Soviet Union lobbied the United Nations to remove any reference to political groups that had existed in an earlier draft.

The UN definition also excludes other social groups such as mentally ill or mentally challenged people, of which Nazi Germany exterminated tens of thousands. Homosexuals, bourgeoisie, the educated, and city-dwellers are all social classes that have been victims of genocidal acts although their deaths do not constitute genocide under existing law. Some scholars suggest expanding the definition of genocide to include mass killings in general (Gellately and Kiernan 2003). Others argue that it is beneficial to define mass killings and genocide separately so as to understand the origins of each and learn how to prevent them (Staub 2002). According to Helen Fein, one important component of the UN definition that sets genocide apart from other heinous acts, such as terror, war, oppression or torture, is "the perpetrators' sustained and purposeful attempt to destroy a collectivity" (Hinton 2002, p. 6).

Another phrase related to genocide is *ethnic cleansing,* and sometimes people conflate the two phrases. But as Paul Mojzes explains, "while every genocide is an ethnic cleansing, not every ethnic cleansing is a genocide. If an ethnic cleansing does not genuinely threaten the existence of a group, it would not qualify as genocide" (Mojzes 2002, p. 54). Genocide is also confused with *crimes against humanity,* which describes a "widespread or systematic attack directed against any civilian population" (Rome Statute of the International Criminal Court Internet site), including murder, torture, kidnap, rape, and forced expulsion. Another related phrase is *war crimes* which describes "grave breaches of the Geneva Conventions of 12 August 1949" such as willful killing, torture, unnecessary destruction of property, and denying prisoners of war the right to a fair trial, among others (Rome Statute of the International Criminal Court Internet site). Together genocide, crimes against humanity, and war crimes all fall under the jurisdiction of the International Criminal Court.

How society defines genocide is more than academic; it is a matter of life and death for millions of people. While the international community may respond with force to stop acts of genocide, it may not respond to ethnic cleansing and probably would not respond to mass killings. Thus it is important to understand the moral and ethical consequences of how genocide and related terms are defined, and to clarify the legal basis of controlling them.

Historical Developments

Historical records are rife with accounts of mass killings and genocidal acts perpetrated against tribes, cities, clans, and races in premodern times. The Romans, after defeating Carthage in the Third Punic War, killed the inhabitants, burned the city, and "sowed the ground with salt to symbolize that it should forevermore remain barren" (Alvarez 2001, p. 28). Greeks, Mongols, Christians, Assyrians, and others all committed such acts, yet at the time such killings were an accepted component of war and conquest and not considered a crime against humanity (Rittner et al. 2002). Although acts of genocide have been perpetrated throughout the ages, it was not until the twentieth century that society began to ask whether genocide was wrong. Two reasons explain this process: the rise of science and technology, which enabled acts of genocide on a massive scale, and the growing appreciation of human rights.

The twentieth century began as a century of promise and hope with an expectation that solutions to human problems could be solved through scientific and technological progress. Sadly the century ended as the deadliest in human history. While most persons commonly think of war as the major source of death, and primarily to young men, it was actually genocide that killed more people in the twentieth century than any other human activity, and most of the victims were civilians (Smith 2002). (Others would point out, of course, that more people also survived in the twentieth century.) Some experts place the number of state-sponsored killings, which includes acts of genocide, at more than 150 million—four times higher than those killed in warfare (Fein 2002).

Science, technology, and the nation-state all contributed to the escalation and scale of genocide. First, the development of more efficient guns, bullets, and bombs enabled perpetrators to kill more people more rapidly. Gun-toting Germans easily slaughtered the Hereros of German Southwest Africa, a primitive culture, in one of the first acts of genocide in the twentieth century (1904–1905). Transportation, improved infrastructure, and bureaucracy enabled Nazi Germany to coordinate and carry out murder more effectively in its attempt to annihilate all Jews (1933–1945). Scientific and technological progress also created new methods of mass killing such as the development and proliferation of weapons of mass destruction (WMDs). Saddam Hussein was the first to use WMDs against his own people (1987–1988), killing thousands of Iraqi Kurds with poison gas. The nation-state, another product of modernity, was very successful at perpetrating genocide on scales that are almost unfathomable. An estimated 20 million civilians died under Stalin's regime in the Soviet Union (1922–1953), and millions more under Mao Zedong (1949–1959) in China and the Pol Pot (1975–1979) regime in Kampuchea. Indeed science, technology, and political institutions of modernity have combined to make genocide possible on a historically unique scale.

Despite efforts by the United Nations and international community to stop genocide, it has not been eliminated. Marginalized groups around the world are increasingly vulnerable, especially with the development of newer and more deadly WMDs. It may be possible in the not-so-distant future to design genetically engineered diseases or poisons that affect only a certain ethnic or racial group that share similar genes. Then again, genocide can also be extremely low-tech, as illustrated in the Rwandan massacres (1994) in which 800,000 Tutsis were slaughtered by machete-wielding Hutus.

ELIZABETH C. MCNIE

SEE ALSO *Holocaust; Human Rights; Race; Weapons of Mass Destruction.*

BIBLIOGRAPHY

Alvarez, Alex. (2001). *Governments, Citizens, and Genocide: A Comparative and Interdisciplinary Approach.* Bloomington: Indiana University Press.

Fein, Helen. (2002). "States of Genocide and Other States." In *Will Genocide Ever End?*, ed. Carol Rittner, John K. Roth, and James M. Smith. St. Paul, MN: Paragon House.

Gellately, Robert, and Ben Kiernan. (2003). "The Study of Mass Murder and Genocide." In *The Specter of Genocide: Mass Murder in Historical Perspective*, ed. Robert Gellately and Ben Kiernan. Cambridge, UK: Cambridge University Press. Provides a good overview on the subject of genocide.

Hinton, Alexander Laban. (2002). "The Dark Side of Modernity: Toward an Anthropology of Genocide." In *Annihilating Difference: The Anthropology of Genocide*, ed. Alexander Laban Hinton. Berkeley: University of California Press.

Mojzes, Paul. (2002). "Ethnic Cleansings." In *Will Genocide Ever End?*, ed. Carol Rittner, John K. Roth, and James M. Smith. St. Paul, MN: Paragon House. A good analysis of genocide vs. ethnic cleansing.

Rittner, Carol; John K. Roth; and James M. Smith, eds. (2002). "Chronology." In *Will Genocide Ever End?*, ed. Carol Rittner, John K. Roth, and James M. Smith. St. Paul, MN: Paragon House. A good place to begin learning about ethics and genocide.

Smith, Roger W. (2002). "As Old as History." In *Will Genocide Ever End?*, ed. Carol Rittner, John K. Roth, and James M. Smith. St. Paul, MN: Paragon House.

Staub, Earl. (2002). "Understanding Genocide." In *Will Genocide Ever End?*, ed. Carol Rittner, John K. Roth, and James M. Smith. St. Paul, MN: Paragon House.

INTERNET RESOURCES

Convention on the Prevention and Punishment of the Crime of Genocide. Office of the High Commissioner for Human Rights-United Nations Office at Geneva. Available from http://www.unhchr.ch/html/menu3/b/p_genoci.htm.

Rome Statute of the International Criminal Court. International Criminal Court. Available from http://www.un.org/law/icc/statute/99_corr/cstatute.htm.

GEOGRAPHIC INFORMATION SYSTEMS

Geographic information systems (GIS) are computer-based information systems that work with geographic or spatial data. The term GIS is also used to describe the whole discipline dealing with geographic information systems or geographic information science. A GIS can produce maps, but its unique attribute is the ability to integrate and analyze spatial data and related statistical or descriptive data. GIS has been described as "perhaps . . . the most significant event in spatial data handling since the invention of the map" (Pickles 1995, p. 49). Like maps and any information production system, from writing to scientific research, GIS involves basic ethical questions of truthfulness, equity, and power. Maps are graphical depictions of the nature and spatial relationships of objects—they are generalized, simplified representations of reality. Cartographers strive to produce value-free, objective maps, but maps are also cultural and rhetorical texts imbued with social significance (Harley 2001). The symbols and projection used, the items included and excluded, and the graphic design of maps convey information, but they are also expressions of power that are made all the more effective by being hidden behind a "mask of seemingly objective science" (Harley 2001). The same elements characterize GIS, with the addition of a mask of technology. Cartographic historians and philosophers have developed methods for analyzing the social significance of maps—similar techniques are needed to analyze the statistical and graphic output of GIS.

GIS is founded on developments in computer science, geostatistics, and geography; as well as information from cognitive science, landscape architecture and planning, and many other fields. Roger Tomlinson conceived the architecture of GIS in 1963 and the first system, used to support Canadian national land-use planning, became fully operational in 1971. The U.S. Census Bureau adopted GIS for the 1970 census and was the first to digitize street maps efficiently. As computing power, datasets, and graphical interfaces have improved, GIS has become pervasive in both the public and private sectors.

GIS is not just technology—people are also critical components. Technology may constrain the capacity of a GIS, but the user's choice of data and analytical methods influences the output. Spatial data present complex analytical challenges: very different, but equally valid, results may be obtained by using different analytical methods on the same data. There is an ethical obligation on those using GIS to explain the meaning, limitations, and uncertainty embedded in the output of a GIS. Such explanations may also limit the legal liability of the producer for any subsequent use or interpretation of the information.

Much GIS work deals with the physical infrastructure of the planet and is generally uncontroversial. When GIS is used to examine socioeconomic data, however, its impact can be contentious. Presently there are so many geographic information systems holding large amounts of data, much of it related to individuals, that it is virtually impossible for people to know who holds information about them, the accuracy of that information, and the use to which it is being put. Laws that balance personal privacy with the potential commercial and administrative benefits of comprehensive databases are still being developed.

Approximately 80 percent of government data has a spatial component, so all levels of government are heavy users of GIS. Civilian use of GIS by the U.S. government is strictly regulated. Agencies must have a reason for collecting data. They must protect the privacy of individuals, provide people with access to data pertaining to them and an opportunity to make corrections, and make databases publicly available for the cost of dissemination without copyright restrictions. The U.S. government treats its non-secure databases as a public good; most other countries, and many U.S. state and local governments, regard data as a commodity that may be restricted and sold.

In the United States, GIS use in the private sector is much less regulated than in the federal sector. Marketing companies, realtors, insurance companies, credit-rating agencies, and many other organizations use GIS to assess risk, predict markets, and monitor social changes, among other activities. The private sector holds, and can provide, much of the information on individuals and national security sites that federal agencies go to great lengths to mask. Databases are weakly protected by copyright law in the United States; the European Union provides stronger protection for data compilations.

Military and intelligence use of GIS by governments is difficult to quantify but is known to be extensive. GIS could be described as a non-destructive weapon, a tool that is used to plan and execute actions, to identify targets, to organize infrastructure, and to detect suspicious patterns in individual and group behavior. Information is a global commodity, and many countries and groups monitor and analyze activities both inside and outside their borders. There are concerns that security databases may be used to compromise individual and group liberties.

GIS is not an objective technology, it is a tool used for many ends. Society has not yet found the mechanisms to guarantee the aspirations expressed in Article 1 of the French *Loi No 78-17 du 6 Janvier 1978* which states, "Computer science must be at the service of each citizen; its development has to operate within the framework of international co-operation; it should not damage human identity, human rights, private life or individual and public liberties" (Keane 1991, p. 134).

MAEVE A. BOLAND

SEE ALSO *Computer Ethics; Global Positioning System; Information; Military Ethics; Privacy.*

BIBLIOGRAPHY

Foresman, Timothy W., ed. (1998). *The History of Geographic Information Systems: Perspectives from the Pioneers*. Upper Saddle River, NJ: Prentice Hall PTR.

Harley, J.B., edited By Paul Laxton. (2001). *The New Nature of Maps: Essays in the History of Cartography*. Baltimore, MD: The Johns Hopkins University Press.

Keane, John. (1991). *The Media and Democracy*. Cambridge, UK: Polity Press.

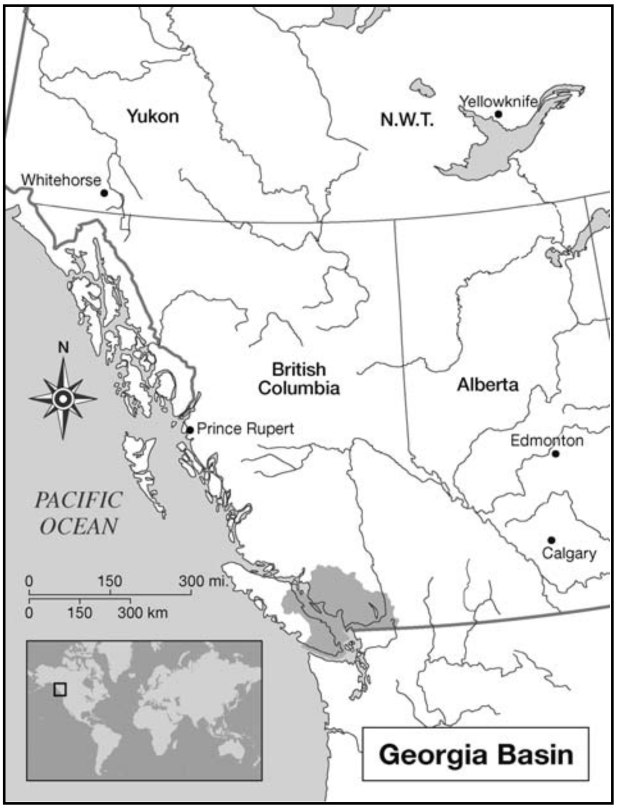
Pickles, John, ed. (1995). *Ground Truth: The Social Implications of Geographic Information Systems*. New York: The Guilford Press.

GEORGIA BASIN FUTURES PROJECT

The Georgia Basin Futures Project (GBFP) is a five-year regional participatory integrated assessment whose purpose is to combine public values, preferences. and beliefs with expert knowledge in the production of scenarios for the future of the area in western Canada known as the Georgia Basin (see map) over the next forty years. The key goals are to increase public involvement in the discourse about issues of sustainability, explore pathways to sustainability in the region, and create a database of public preferences, values, and acceptable and unacceptable trade-offs that can be analyzed to provide a picture of how participants feel about sustainability issues and evaluate the relationship between the use of computer-based simulation tools and the beliefs, values, and behaviors of the users of those tools (Tansey, Carmichael et al. 2002).

Background

The GBFP is based on a long tradition of futures studies in the environmental field. From the extensive literature associated with this tradition four concerns have been identified that have influenced the project design significantly. The first is a concern with undertaking research that integrates natural and physical science analyses of environmental systems with social science, health science, and humanities research on the human systems that interact with the environment. The second is a focus on the future and on studying the various ways people can work collectively or individually toward bringing about a more sustainable world.



The population of the Georgia Basin is 2.9 million people and the GDP is about C$65 billion.

The third is a growing recognition of the need to involve various interests, or "stakeholders," in the research process. The fourth is a concern with the appropriate temporal and spatial scale of analysis. Although issues such as climate change are inherently global in scope, research that is truly problem-centered, policy-oriented, and connected to users must establish temporal and spatial scales that are relevant for decision makers.

All these strands came together in the development of the conceptual and methodological framework of the Georgia Basin Futures Project, which was funded by the Social Sciences and Humanities Research Council of Canada (SSHRC) in early 1999 and is supported by financial and in-kind contributions from governmental, nongovernmental, and industrial partners in the Georgia Basin region.

Project Design

Research in the project is organized into six major components undertaken by a core team of twenty coinvestigators and research collaborators, three research staff members, about thirty graduate students, and several administrative staff members working in conjunction with sixteen nongovernmental organizations, government, and private sector partners in the community.

Using expert analysis of key relationships among the social, ecological, and economic systems in the Georgia Basin and relying on initial consultations with stakeholders, the project has built a number of software tools for engaging stakeholders in sustainability issues. These tools have been used in several interactive processes, including workshops and classroom applications. The effect and effectiveness of this approach to engaging different publics with interactive software tools also are being evaluated.

Model Development: The QUEST Approach

The project's approach to modeling and scenario analysis is based on three key elements:

- A backcasting approach that involves the exploration of the feasibility and consequences of trying to reach desirable futures rather than the prediction of the most likely outcomes (Robinson 2003)
- A design approach to modeling that focuses on the physical flows of matter and energy through the economic system, the economic flows of currency through the economic sectors, and the economic benefits and costs incurred as a result of environmental and socioeconomic decisions (Gault 1987)
- An interactive social science approach to use of the model that requires that the local community be actively involved in both the design and the use of the modeling tool. (Caswill and Shove 2000)

The methodological core of the project is the development and use of the GB-QUEST modeling system (Rothman, Robinson, and Biggs 2002). QUEST is a computer-based system for scenario generation and evaluation that was designed to encourage public participation in thinking about sustainability in a regional context. Through QUEST users explore different scenarios for the future in terms of their social, economic, and environmental characteristics. The goal is to acquaint users with the complex realities of decision making, specifically the uncertainties involved, the necessary trade-offs, and the role of subjective values. For the GB-QUEST modeling system the geographic range encompasses the whole of the Canadian side of the Georgia Basin. The temporal scale is forty years.

Through the adoption of the "feel" and user-friendliness of a computer game, QUEST scenarios actively involve the user in their creation and evaluation. The user-selected scenario choices include choices involving the future patterns of population, economic activity, transportation, the density of urban growth, the style of neighborhoods, agricultural development, forestry practices, and consumption. The consequences of these decisions affect human well-being, environmental quality, economic and social health, and the long-term ability to maintain all these results.

QUEST does not provide a picture of the most likely future and is not intended to reflect a detailed understanding of all the complex systems involved. Instead, it enables users to learn about the linkages between choices and possible consequences and the trade-offs society faces in deciding among available options.

Community Engagement

A critical element of the project relates to the involvement of stakeholders and community partners in the research process. The project builds on the tradition of participatory integrated assessment modeling (Kasemir et al. 2000, van Asselt and Rijkens-Klomp 2002) and has adopted an interactive social science approach that is based on an explicit recognition of the value-laden nature of scientific analysis and modeling and the resultant need to incorporate community-based partners and the interested public directly into the research activities in two ways. First, by working with partner organizations in the community, the project has incorporated public values, preferences, and concerns into the process of model design and implementation. Second, through an elaborate process of community engagement that also involves the partners, the project has included the interested public in the generation of preferred sustainability scenarios using those modeling tools.

The key method for obtaining community engagement is the use of GB-QUEST in various ways, including three regional case studies; expert workshops; classroom use; a large exhibition space at Science World, a local science museum; and Web-based interaction.

The regional case studies involve working with three local municipal or regional governments in the Georgia Basin to use GB-QUEST in workshops with government staff members and stakeholders to explore regional sustainability scenarios, with the goal of contributing to the development of policies for sustainability. These workshops are followed by workshops to explore policy implementation issues, using a conceptual model of policy development that has emerged from the health promotion field. The expert workshops involve working with partner organizations and stakeholder groups to develop desired future scenarios and explore the implementation measures that would be required to realize those scenarios.

A teaching and learning team has tested GB-QUEST in the classroom at the high school level. This group is responsible for creating a set of curriculum guides and resource packages supporting QUEST that focus on sustainability in several classes and at different grade levels.

Since the fall of 2001 a twenty-minute-long video-based version of QUEST has been playing twice per day, five days per week at Science World. Approximately 15,000 people, mostly elementary school students, have played this version of QUEST, using interactive touch pads set into the seat arms of the 200-seat theater at Science World.

Based partly on funding from another project, a Web-based version of GB-QUEST is being developed that will incorporate information visualization and landscape visualization techniques to improve playability and comprehension of the complex contents and results of QUEST scenarios. A prototype was scheduled to be operation in April 2004.

The project also is studying the effect of playing QUEST on the mental models of sustainability, preferences, and behaviors of QUEST users. The GBFP culture and cognition team is holding impact workshops in which QUEST users are interviewed intensively and observed while playing QUEST.

Strategies

An important focus of the Georgia Basin Futures Project (GBFP) is the policy measures required to implement the scenarios that GB-QUEST generates. Both the case study and the expert workshops involve analysis of implementation requirements. In addition, GBFP is creating a database of all the scenarios developed in the project. That database, though limited in quantity, will present an informative picture of the values, preferences, and preferred options of QUEST users with regard to the future of the basin. The project will analyze those scenarios in terms of their policy and implementation requirements.

Other Tools

In addition to GB-QUEST, several interactive software tools have been developed in the GBFP, including the refinement of a personal Climate Change Calculator and the Sustainability Tools and Resources website for helping community groups and individuals establish themselves and interact with other groups. In addition, the GBFP has combined forces with a research group at Natural Resources Canada to develop a prototype of a Georgia Basin Digital Library (GBDL), a Web-based digital library that will be used to integrate natural and social science information (Geographic Information System maps, images, and text) into a comprehensive and interactive information resource to support sustainability research, community-focused decision making, and public consultation activities in the Georgia Basin.

Some Preliminary Results

While the GBFP is still ongoing, some preliminary findings are beginning to emerge. An immense interested has been demonstrated by participants from the general public and local government agencies in exploring desirable futures. Timeframes of forty years are no barrier to participation but the spatial scale of a region the size of the Georgia Basin (about 5.6 million hectares) is a challenge for participants who tend to want to focus on more local issues. In virtually all cases, however, participants are interested in exploring the nature of the choices and consequences of their future scenarios.

The use of interactive tools such as GB-QUEST was found to contribute to community activities to promote sustainability at the municipal scale in several communities. It has been less successful in contributing to the specific needs of regional government policy development. These findings suggest that a preferred audience for such engagement may be individuals and groups, including politicians, who do not have expert knowledge of specific sustainability issues. Classroom pilots of quest-based curriculum indicated a possible significant role for such techniques in school curricula.

Users of GB-QUEST are strongly disposed to make choices about preferred future conditions that reflect a strong environmental ethic. There is a desire to find scenarios that express those values without compromising other goals, such as economic growth or employment. The discussions that ensue explore issues that are not typically part of public and political debates in the region, suggesting a strong latent and unmet demand for such interactive processes.

Science, Technology, Ethics, and Public Policy

The GBFP exists at the interface of science and society. It is intended to combine expert knowledge and public attitudes, preferences, and values in ways that incorporate the best understanding of complex ecological, social, and economic systems and that will be useful to stakeholder and institutions that are grappling with the practical problems of sustainability.

What distinguishes the GBFP approach is a fundamental commitment to interactivity that recognizes that the role of science in the policy process is inherently value-laden and that stakeholder input into both the development of integrated assessment tools and the development of scenarios is essential for two reasons. First, policy decisions about sustainability are inherently normative. The challenge is to combine those normative considerations with scientific understanding through the use of "boundary objects" such as QUEST and the GBDL. Second, it is clear that a major potential obstacle to achieving sustainability involves public acceptance. Politicians cannot make policy decisions that require significant change without a supportive political constituency. New means of engaging different publics in the complex public policy issues that surround sustainability are essential to build understanding of the policy trade-offs in the public and to learn what trade-offs and choices may be acceptable. In this way a process of community engagement that is appropriately designed may increase the sophistication of discussion about key choices affecting the sustainability of the region and help make explicit the points of conflict between stakeholders in the community that will affected by a decision.

An important question raised by the use of computer-based tools in the GBFP is the degree to which information technology can provide ways to engage large numbers of people in sustainability issues without trivializing the issues or misleading users about the consequences of particular choices. An important danger is the possibility of converting normative questions of deep moral and political significance into technical questions related to the choice of technology or behavior. For this reason the GBFP separates the analysis of the consequences of particular technological and behavioral choices (the realm of the scenario analysis using QUEST) from the discussion of the desirability of those outcomes and the means that may be required to realize them (a discussion that occurs outside the model). In this sense the role of the technology is to provide a basis for stimulating informed discussion of ethical and political questions.

The GBFP is based on the view that science and technology embed normative values that must be made explicit if informed choices are to be made (Jasanoff and

Wynne 1998). The project is testing the idea that complex public policy issues can be illuminated by the development and use of scenario analysis tools that allow citizens to express their views about their preferences and point out the consequences of their choices. The key is that these scenarios are created not by experts but by the users. This makes the process more engaging, creates a higher degree of user buy-in to the process and a greater sense of responsibility for the outcomes, can lead to significant learning, and produces results that embody ethical and moral judgments about the desirability and acceptability of alternative future scenarios.

JOHN B. ROBINSON
JAMES TANSEY

SEE ALSO *Models and Modeling; Participation; Science Policy; Stakeholders; Sustainability and Sustainable Development.*

BIBLIOGRAPHY

Caswill, Chris, and Elizabeth Shove (2000). "Introducing Interactive Social Science." *Science and Public Policy* 27(3): 154–157.

Gault, Fred, et al. (1987). "The Design Approach to Socio-Economic Modelling." *Futures* 19(1): 3–25.

Jasanoff, Shelia, and Brian Wynne (1998). "Science and Decisionmaking." In *Human Choice and Climate Change,* Vol. 1: *The Societal Framework,* ed. Steve Rayner and Elizabeth L. Malone. Columbus, OH: Battelle Press.

Kasemir, Berndt; Daniela Schibli; Susanne Stoll; and Carlo C. Jaeger. (2000). "Involving the Public in Climate and Energy Decisions." *Environmental Monitoring and Assessment* 42(3): 32–42.

Robinson, John (2003). "Future Subjunctive: Backcasting as Social Learning." *Futures* 35: 839–856.

Rothman, Dale; John Robinson; and Dave Biggs. (2002). "Signs of Life: Linking Indicators and Models in the Context of QUEST." In *Implementing Sustainable Development. Integrated Assessment and Participatory Decision-Making Processes,* ed. Hussein Abaza and Andrea Baranzini. Cheltenham, UK: Edward Elgar.

Tansey, James; Jeff Carmichael; Rob Van Wynesberghe; and John Robinson (2002). "The Future Is Not What It Used to Be: Participatory Integrated Assessment in the Georgia Basin." *Global Environmental Change* 12(2): 97–104.

Van Asselt, Marjolein, and Nicole Rijkens-Klomp (2002). "A Look in the Mirror: Reflection on Participation in Integrated Assessment from a Methodological Perspective." *Global Environmental Change* 12: 167–184.

GERMAN PERSPECTIVES

Contemporary discussions of science, technology, and ethics in Germany take place largely in the context of developments in the philosophy of technology. Although during much of the second half of the twentieth century philosophical discussion of technology was divided up into various schools and approaches, by the beginning of the twenty-first century such divisions were giving way to a new problem-orientated approach that emphasized the social, cultural, human, and ethical dimensions of the production and use of technoscientific knowledge. Reflections on technological development and transfer, for instance, became less ideological and more eclectic, pragmatic, and interdisciplinary than in the past. Nevertheless, discussions of ethics related to the hybridization of science and technology in such fields as information technology and genetic engineering continue to occur against a specifically German philosophical background. Thus the following notes on German approaches to science, technology, and ethics are themselves hybrid introductions to schools and problems, theory and practice.

Background: Gehlen and Heidegger

Arnold Gehlen (1904–1976) and Martin Heidegger (1889–1976) were the two main philosophers to deal with technology during the second half of the twentieth century. Gehlen's anthropological approach was to interpret human beings as deficient beings who use technology to compensate for their organic shortcomings. The characteristic activity of technology involves the creation and use of *Organersatzes*, that is, substitutes for or supersedings of those organs with which humans are endowed by nature. "There are two aspects to this tendency: artificial materials replacing those organically produced; and non-organic energy replacing organic energy" (Gehlen 1980, p. 5). The earliest humans strengthened their hands with wood and stone instruments, then replaced old materials in these instruments with new ones that defined entire ages (the Bronze Age, Iron Age, etc.), a substitution process that has continued into synthetic chemistry. But of even greater significance has been the replacement of human and animal power with coal, oil, electricity, and nuclear power.

Because of this substitution process technology develops a tendency to deny its roots and become independent. The technological world becomes progressively abstract and not tied to any immediate need. This is the starting point for Gehlen's criticism of modern technology as it has developed especially since the Industrial Revolution. According to Gehlen, technology develops an opposition to its previous cultural contexts and tends to become something pursued for its own sake. Coherent social orders decline under a flood of external stimuli, and social institutions lose their stability. Primitivisms such as "sex and drugs and rock-and-roll" become manifest throughout technological civilizations, along with extreme forms of individualism and subjectivism. In response Gehlen becomes a conservative critic of culture. Gehlen's anthropological analysis of the origin of technology leads to a criticism of technological culture.

Heidegger advanced two approaches to technology: first, in *Sein und Zeit* (1927; English trans. *Being and Time,* 1962), that of technology as an implicit or hidden presence in the human lifeworld; second, after the famous *Kehre* (turn), that of technology as a form of truth or revealing. The early Heidegger developed an understanding of (technological) experience in *Being and Time,* paragraphs 14–18. In the analysis of human existence as a *being-in-the-world* he discovered the everyday character of engagement with equipment as prior to any theoretical presence of objects. As is implicit in the Greek naming of objects as *pragmata,* Heidegger argues that technical praxis is the experiential context from which all science is abstracted. It is more accurate to describe science as theoretical technology than technology as applied science. But this *Being and Time* analysis of human interaction with entities or beings is no more than a moment in Heidegger's larger attempt to understand the "meaning of Being."

Turning from the focus on the meaning of Being that predominates in his early work, Heidegger's later thought develops a more explicit philosophy of technology. In "Die Frage nach der Technik" (1954; English trans. *The Question Concerning Technology,* 1977) he argues that technology is not just a practical engagement with the world but a revealing, a disclosure or truth about the world. What modern technology in particular reveals is the world as *Bestand,* that is, stock or resources subject to human manipulation. The coming upon the world as *Bestand* that is operative throughout modern technology as such Heidegger names *Gestell* (enframing), the promotion of which is for contemporary human beings not something that they simply choose to use or not but a *Geschick* (destiny). Like any destiny, however, technology as *Gestell* carries with it both opportunity and danger. The opportunities provided by technology are pervasive in the modern world, but the dangers are more hidden and go deeper than the simple risks so commonly associated with technology, such as the risks of automobile accidents or environmental pollution. The most profound danger is that the disclosure of the world as resource will overwhelm the event of disclosing itself, that the experience of one particular kind of truth will obscure the more primordial truth of Being. The ultimate challenge of modern technology is to be true to the greater human destiny of disclosing in the midst of a technological destiny.

The Frankfurt School and Social Risks

During the 1960s questions of ecological and social risks came to the fore in many discussions of science, technology, and ethics. But in the Frankfurt School it was social risks that held center stage, and a social risk of a particular kind: the risk of failure to use science and technology to realize the Enlightenment ideal of an autonomous humanity for which they were intended.

Criticism of technology in the Frankfurt School is based on the critical theory of Max Horkheimer (1895–1973) and Theodor W. Adorno (1903–1969), especially their post–World War II analysis of what they termed the "dialectic of Enlightenment." Analyzing the social histories of Nazism, Stalinism, and American capitalism they argued that formal rationality—positivism and pragmatism—had been transformed into an instrumental rationality that degraded its users and the things used. In the totalitarianisms of the twentieth century and even in consumer capitalism Enlightenment humanism had been used to justify dehumanization and exploitation. Enlightenment humanism thus runs the risk of becoming its dialectical opposite, a kind of antihumanism. The science and technology that emerged out of Enlightenment commitments have been used to promote new forms of irrationality and barbarism, which must thus be dialectically criticized in order to save the Enlightenment project.

The critical theory of technology may be summarized in four theses:

(1) Knowledge is power. In the modern world science has become functional and instrumental knowledge, developed in order to achieve the goals of the Enlightenment by establishing human power over nature.

(2) Modern technology leads to technocracy. The Enlightenment values of humanity, emancipation, and social justice are to be realized by means of technical instruments.

(3) But rather than realizing democratic enlightenment, technology develops surrogates for enlight-

enment, especially in the forms of film and advertisement. Entertainment and the culture industry become technological substitutes for the genuine enlightenment to be found in aesthetics and the arts.

(4) Progress thus calls for a dialectic criticism of false enlightenment in the name of true enlightenment. Critical theory points out the ambivalence of progress brought about by technology.

Horkheimer and Adorno thus saw instrumental or calculative rationality (scientific technology) as a paradox: It provided the knowledge and power necessary to liberate human beings from unenlightened subservience to their own superstitions and to nature, enabling them to become autonomous individuals. But instrumental rationality has in fact been deployed by ruling groups to pacify the masses either violently or through material goods and services. The Enlightenment project has failed to prevent itself from being misused. What is needed is a new assertion of the Enlightenment ideal, which Horkheimer and Adorno nevertheless find difficult to derive from their social scientific studies.

It is to this problem that Jürgen Habermas responded with a philosophical deepening of critical theory and an extended reaffirmation of the norms of the Enlightenment ideal in the face of its corruption in contemporary culture. The human lifeworld is characterized by self-reflection, language, labor, and morality. Technological development follows the logic of labor, which is necessary for interacting with nature; technology is not something that can be renounced. At the same time, communicative action through language or a symbolic interaction among human beings engenders social norms. This too is an important aspect of what it means to be human and is not to be renounced. Technological rationality becomes a threat when it overwhelms or obscures symbolic interactions and its cultural traditions from which arise all justifications for using power, whether political or technological. Insofar as Habermas criticizes such a technological colonization of the lifeworld he reiterates Horkheimer and Adorno. But insofar as critical theory only criticizes instrumental rationality, it fails to rehabilitate a sophisticated form of rationality. Only a recovery and articulation of the principles of the communication rationality that is the basis of symbolic interaction can substantiate the critical theory project.

Cybernetics and Systems Theory

Cybernetics and systems theory have developed a scientific conception of technological action in order to control and shape this kind of action. Günter Ropohl's work on "technological systems theory" and "technological enlightenment" is a good extension of this aspect of cybernetics. According to Ropohl, the social dimension of technology is best grasped as an extended action system. It is not technology that formulates aims but certain action systems. These action systems produce technological artifacts, which in turn open up possibilities for new action functions. In this way Ropohl criticizes the ideas of technological determinism or a technological imperative. The physical constraints addressed by technological developments, for instance, are not technical but social in character. According to Ropohl the legitimation crisis of technological progress—that is, public doubts about whether technological change is always for the better—cannot help but promote "enlightenment" about the true character of the technological process (Ropohl 1991).

Klaus Kornwachs has also developed systems theory in ways that can be used to describe technological systems. The principles of any system are as follows: Every system has an author. The term *system* has both descriptive and prescriptive dimensions: Descriptive dimensions involve explaining how a system is to be constructed; prescriptive dimensions involve explicitly identifying the interests a system serves. As people learn to deal with any system it takes on an objective character and can thus become an object of scientific study. The structure of a system is given by the relationships among its elements. Large technological systems can be described at more than one level, and these levels must be integrated in a full description. Paradoxically, expanding systems are often easier to control than systems in equilibrium (Kornwachs 1993).

Contributions from the German Democratic Republic

From 1949 to 1990 the German Democratic Republic (GDR) developed discussions of science, technology, and ethics—and of the philosophy of technology—that were heavily influenced by the thought of Karl Marx (1818–1883), especially as interpreted in the Soviet Union. At the same time, scholars in the GDR attempted to maintain a certain level of independence by analyzing the connection between science and technology against the background of social developments. This in turn was influenced by and influenced the Dresden school of the technological sciences, especially since reunification.

Although its origins are unclear, the term *Technikwissenschaften* (technological sciences) was already in use during the nineteenth century in Germany and the German empire. After what in the Soviet Union was termed the scientific-technological revolution, that is, the unification of science and technology in has also been called "technoscience," the engineering sciences increased in significance for the establishment of socialism. But even though the notion of science implies a (not always realized) degree of stability, the engineering sciences have undergone substantial changes to which engineers must adjust.

The inner structure of any technological science has emerged from a long historical process of analyzing cause-and-effect relations, structures, functions, combinations of materials, and classification principles (Banse and Wendt 1986). In the technological sciences technological rules may be thought of as request systems, which in the process of invention must negotiate oppositions between idea and material possibility. Extending new scientific knowledge into the technological sciences involves the formulation of new technological rules, which are also increasingly required to take into account changing social circumstances. Only in this way can a connection be maintained between technological and social progress. But there is often a tension between technological parameters and those of economic and social effectiveness, not to mention the long-range effects on economy and society.

According to Johannes Müller, who worked for many years with scientists and engineers in the GDR, the technological sciences deal with a class of scientific analyses, operations, procedures, and means for determinate human actions. Their objective is to find solutions for tasks and problems with the help of rules, methodologies, problem-solving operations, procedures, algorithms, and norms. Contemporary construction work has to negotiate the relations among epistemology, technological science, logic, and psychology. Yet the main criterion for technological action and technological design is not truth but fulfillment or, more precisely, the possibility of technological fulfillment or practicality. Scrutiny of the possible realization of technological designs is done on the base of what may be called systematic heuristics (Müller 1990).

Erlangen-Konstanz Constructionism

The universities of Erlangen and Konstanz in Bavaria and Baden-Württemberg, respectively, were in the 1960s sites for the revival of the philosophy of science in Germany. The distinctive approach of philosophers in these two universities was the development of a nonempiricist, constructivist philosophy of science that strongly distinguished itself from logical empiricism. This school of constructivism sought, for instance, to identify a "protophysics" or "prephysics" that could prescribe in advance the measuring instruments necessary to any empirical physics. Peter Janich has added a "protobiology" and "protochemistry" to this prototheory. And from the philosophy of science this type of constructivism, because it focuses on the instrumentization of science, has easily been extended to the interpretation of technology as a way to criticize naturalism, especially in the field of cognitive or information technologies.

Janich has further argued for a constructivism in anthropology that he and Dirk Hartmann (1998) term "methodological culturalism." Along with this "cultural turn" comes the priority of action theory over language philosophy. The claim is that cultural relativism can be rejected on the basis of a preactive and preconscious agreement whenever human beings have achieved a certain level of cultural development. Taking technological development as a model for cultural development, the artificial character of all technological products becomes subject to a means–ends assessment that takes place before subjective or consumer evaluations. That is, the suitability of certain means for certain ends can be judged by their success or failure in achieving or failing to achieve those ends. The success of technological action cannot be reduced to the acceptance or rejection of certain groups but must be demonstrated first by practical reliability at any time in any transcultural context. Rational justification nevertheless remains as a philosophical and ethical issue. The Europäische Akademie zur Erforschung von Folgen wissenschaftlich-technischer Entwicklungen (European Academy for the Study of the Consequences of Scientific and Technological Advances) in Bad Neuenahr-Ahrweiler, under the direction of Carl Friedrich Gethmann, has been inspired by this approach.

Technology Assessment

Extending the social sciences and social philosophy of technology, the basic concern of technology assessment (TA) is systematic research into the preconditions and (potential) consequences for the introduction and use of technologies in order to identify and analyze social conflict areas, especially those that may evolve from the use of technologies. TA thus demonstrates and evaluates action possibilities for the improvement of technologies or their modes of use. The aim of TA is not the obstruction of technological innovations but the reflective design of sociotechnological systems (Petermann 1992).

TA analysis should anticipate conditions of realization and the potential consequences of use of technologies, and thus function as an early warning system. The main theoretical problem of TA is to predict changes caused or influenced by technology. The development of early indicators for effect-chains, which can show the diffusion of technological developments with high reliability, is a major challenge.

A useful assessment of technology should not be satisfied with simply discussing technological innovations but should reflect on the basic human–nature relation as it varies from culture to culture and is practiced in concrete social organizations for action (Bungard and Lenk 1988). The development, production, and initial use of technologies require special knowledge and capital. The elite of the economy, politics, and technological sciences profit from early successful uses of technology, but it is difficult to develop a specific methodological program for the assessment of technologies. There is neither a sophisticated theory of technological consequences nor a well-developed theory of valuation (Ropohl 1996). TA must always contend with unintended, ambivalent, and uncertain consequences. It has to make a functional distinction between scientific identification of possible consequences and their assessment, but must also integrate both steps in a common discourse.

The aforementioned European Academy clearly stresses methodologies related to the technico-philosophical construction of an ethical TA program. Critics from the social sciences reject any such ethical analysis, and thus technological ethics, appealing instead to social pluralism, the differentiation of social subsystems, decentralized technology, and the unpredictability of technological consequences. But surely it is reasonable to pursue ethics as a reflective analysis of right behavior. The responsibility of engineers can at least be based on the way they take concrete actions that result in technological solutions, even if they are subject to a number of influences and basic conditions. The development of technological solutions, equipment, machines, control devices, or consumer goods always includes ideas about users (Grunwald and Saupe 1999) that can be subject to critical assessment.

The Society of German Engineers

The Verein Deutscher Ingenieure (VDI, or Society of German Engineers) has a long history of philosophical ethical reflection on modern technology, as has been surveyed by Alois Huning and Carl Mitcham (1993). In the 1920s the VDI was a locus for extended discussions of the cultural and metaphysical significance of science and technology. In the 1950s it became the primary site for efforts to renew the ethical tradition in German engineering after a period of collaboration with and corruption by the Nazi regime.

As part of this renewal the VDI created a special interdisciplinary "Mensch und Technik" (humanity and technology) study group to examine relations between engineering, the technological sciences, philosophical ethics, and the humanities. Beginning in the 1950s the Mensch und Technik group convened a series of conferences dealing with ethics, industrialization, social impact, education, and philosophy, and issued a wide-ranging series of publications. Out of these discussions—with participation by philosophers such as Huning, Hans Lenk, Friedrich Rapp, and Ropohl—came influential analyses of professional engineering responsibility and technology assessment. Indicative of how Mensch und Technik discussions, even though existing within a professional engineering framework, sought to go beyond what in other national contexts might be considered the appropriate boundaries of engineering interest, were expressed concerns about the way nature was coming to be treated in the same way as artifacts, available simply for human control and manipulation.

During the 1990s a new generation of philosophical contributors to VDI discussions continued their work. Representative of these contributions has been the studies of Christoph Hubig, who argues for an extension of analyses of instrumental action in ways that can lead to a rehabilitation of substantive value ethics (Hubig 1993). For Hubig, the challenge of applied ethics, especially in science and technology, is to build a bridge between principles and specific actions, with an awareness of the complex inner structure of practice. Such a pursuit of ethics in relation to science and technology can be done only by means of interdisciplinary dialogue. Within the technological practice there is always an implicit catalog of values, with conflicts between values being a regular occurrence. The task of discussion-management institutions and organizations is to provide standard approaches for dealing with such conflicts when they occur (Hubig 1997). Taking seriously his own recommendations to work in an interdisciplinary manner, Hubig has worked with the VDI to develop a report on *Ethische Ingenieurverantwortung* (2000), and then led the team that drafted the 2002 VDI code of ethics, *Ethische Grundsätze des Ingenieurberufs*.

Method versus Language, Practice versus Theory

Recent work in the philosophy of technology has tended to emphasize methodology over language, practice over theory. Descriptive propositional knowledge (knowing that) is seen as less important in technology and science than prescriptive skill (knowing how) or productive knowledge. Insofar as this is the case, the explanation–understanding controversy has been replaced by a more pragmatic epistemology (see Zimmerli 1997). From the mid-1980s the expansion of technology has brought with it transformational experiences such as the digitalization of everyday life and associated challenges to tradition and changes in values. Yet it is the lack of practical (not theoretical) orientation in these experiences that gives new life to philosophy. How should we live in the new world we are creating? What should we do with our artifice? During this second modernization the hybridization of technology and science has brought with it a new "dialectic of enlightenment" that is manifested in the philosophy of culture.

In order to address such practical questions philosophers such as Lenk, Walther Zimmerli, and Bernhard Irrgang have been developing a hermeneutic understanding of both technology and ethics. The structures of technological practice, professional activity, and everyday life, together with the background of an implicit technological knowledge, are the basis of collective technological action in a cultural context. The meaning of a technology does not necessarily have to be linguistically articulated in order to be present in a culture. The ways technological practices themselves structure actions include different forms of meaningfulness. This leads to a kind of existential pragmatics of technological action and its models of representation (Corona and Irrgang 1999). Such an approach provides a recursive and reflexive assessment of technological actions. But the impacts of any interpretation of technological actions must also prove successful in psychological, sociological, technical-historical, and cultural-historical terms (Irrgang 2001, 2002). At the same time, reflective modernization depends on the continued existence of such institutions as universities and research centers even as they are altered by globalization.

Reflective modernization must also distinguish the self-understandings of scientific and technical professionals from the external descriptions of their roles. The traditional epistemological foundation for a social role description has been the notion of science as knowledge, but technological science is not another science. Technological science is an action science and thus also contains prescriptive statements as well as descriptive ones. The integration of scientific method into the technological sciences has resulted in new disciplinary formations from more than one perspective: by objects studied, by methods, and by professional fields. A metatheory of the technological sciences is needed to determine the relation of these various disciplinary formations and to search for unity within the technological sciences. A related question concerns the relation between disciplinary, interdisciplinary, and transdisciplinary technoscientific knowledge. Epistemological and professional distinctions ultimately interact with practice-orientated and institutional differentiations in an integrated technology-reflective culture (Irrgang 2003).

Appendix: Ethics in Practice

To this point observations have indicated some of the abstract approaches brought to bear in Germany on issues related to science, technology, and ethics—approaches that serve repeatedly to emphasis the importance of practice. By way of a concluding appendix, it remains to comment on specific practices themselves. In this regard there are at least two practices within technoscience deserving special notice: those having to do with research misconduct and with stem cell research.

RESEARCH MISCONDUCT. In June 2000 the Deutsche Forschungsgemeinschaft (DFG), which is the main Germany research funding agency, after initial allegations of misconduct emerged in 1997, concluded an investigation into the practices of the hematologist and cancer researcher Friedhelm Herrmann of the University of Freiburg Medical Center. According to the DFG report, of Herrman's 347 scientific papers published between 1988 and 1992, at least 52 contained falsifications and another 42 were suspect. A previous investigation of more recent publications had identified 37 papers with falsification and data manipulation. This discovery of such egregious misconduct on the part of a respected member of the scientific community led the DFG in 2002 to require that any institution receiving DFG funds adopt a strong definition of scientific misconduct prohibiting falsification and fabrication of data, unacknowledged data selection, graph and figure manipulation, the inclusion of false information in a curriculum vitae, destruction of primary data, sabotage of others' work, and plagiarism. Previous German policies had been more relaxed; in one step this new policy placed the German scientific research community at the forefront of misconduct policy development.

STEM CELL RESEARCH. As has been explained by Jens G. Reich (2002), among others, the discussion of stem cell research in Germany reflects both philosophical and political history. Philosophically, under the influence of Immanuel Kant (1724–1804), German ethics tends to be strongly deontological, stressing the primacy of treating human beings as ends not as means. Indeed, the first article of the German *Grundgesetz* (Basic Law) of 1949 states that "the dignity of the human being is untouchable." There is also a strong awareness of German failures during the Nazi period to respect human dignity. In a determined stance to respect human dignity in the present, the German Embryo Protection Law of 1990, which was supported by a large majority of the public, explicitly defines human life as beginning at conception. It prohibits manipulation of a human embryo for any purpose other than its implantation into the uterus of the woman from whom the originating ovum was derived. This law thus forbids stem cell creation and applies to privately funded embryo research as well as to publicly funded research.

The law has, however, come under interpretative stress as a result of emerging opportunities for stem cell research. In 2002 the German parliament (Bundestag) reaffirmed the ban on stem cell creation but allowed the importation of stem cells created in other countries provided certain stringent conditions are met. Only stem cell lines created before 2002 are eligible, and then only with the informed consent of the parents of the embryo from which the stem cell line was derived, and on the conditions that the parents have received no payment and that the intention behind the original fertilization was a pregnancy that was abandoned for reasons not related to the embryo—that is, the embryo could not have been rejected as defective. Clearly stem cell research in Germany takes place under more detailed ethical guidelines than in perhaps any other country. It is also worth noting that human cloning, whether for reproductive or therapeutic purposes, is prohibited in Germany, but there are also more liberal positions in bioethics (Irrgang 1997, Irrgang 2005).

BERNHARD IRRGANG
TRANSLATED BY KATRIN FELDHUS

SEE ALSO *Anders, Günther; Central European Perspectives; Dessauer, Friedrich; Existentialism; French Perspectives; Habemas, Jürgen; Hegel, Georg Wilhelm Friedrich; Heidegger, Martin; Husserl, Edmund; Jaspers, Karl; Kant, Immanuel; Leibniz, G. W.; Luhmann, Niklas; Nietzsche, Friedrich W.; Phenomenology; Weber, Max.*

BIBLIOGRAPHY

Banse, Gerhard, and Helge Wendt, eds. (1986). *Erkenntnismethoden in den Technikwissenschaften: Eine methodologishe Analyse und philosophische Diskussion der Erkenntnisprozesse in den Technikwissenschaften* [Epistemological methods in the technological sciences: A methodological analysis and philosophical discussion of epistemological processes in the technological sciences]. Berlin: Verlag Technik.

Bungard, Walter, and Hans Lenk, eds. (1988). *Technikbewertung: Philosophische und psychologische Perspektiven* [Technology assessment: Philosophical and psychological perspectives]. Frankfurt am Main: Suhrkamp.

Corona, Nestor, and Bernhard Irrgang. (1999). *Technik als Geschick? Geschichtsphilosophie der Technik* [Technology as destiny? Historical philosophy of technology]. Dettelbach: Röll.

Gehlen, Arnold. (1980). *Man in the Age of Technology*, trans. Patricia Lipscomb. New York: Columbia University Press. Originally published as *Die Seele im technischen Zeitalter* (Hamburg: Rowohlt, 1957).

Grunwald, Armin, and Stephan Saupe, eds. (1999). *Ethik in der Technikgestaltung: Praktische Relevanz und Legitimation* [Ethics in technological design: Practical relevance and legitimation]. Berlin: Springer.

Habermas, Jürgen. (1984–1987). *The Theory of Communicative Action*, trans. Thomas McCarthy. 2 vols. Vol. 1: *Reason and the Rationalization of Society*. Vol. 2: *Lifeworld and System: A Critique of Functionalist Reason*. Boston: Beacon Press. Originally published as *Theorie des kommunikativen Handelns* (Frankfurt am Main: Suhrkamp, 1981).

Hartmann, Dirk, and Peter Janich, eds. (1998). *Die kulturalistische Wende: Zur Orientierung des philosophischen Selbstverständnisses* [The cultural turn: On the orientation of philosophical self-determination]. Frankfurt am Main: Suhrkamp.

Horkheimer, Max, and Theodor W. Adorno. (2002). *Dialectic of Enlightenment: Philosophical Fragments*, ed. Gunzelin Schmid Noerr; trans. Edmund Jephcott. Stanford, CA: Stanford University Press. Originally published, 1947.

Hubig, Christoph. (1993). *Technik- und Wissenschaftsethik: Ein Leitfaden* [Technological and scientific ethics: A guideline]. Berlin: Springer.

Hubig Christoph. (1997). *Technologische Kultur* [Technological culture]. Leipziger Schriften zur Philosophie 3. Leipzig: Leipziger Universitätsverlag.

Hubig, Christoph, ed. (2000). *Ethische Ingenieurverantwortung: Handlungsspielräume und Perspektiven der Kodifizierung* [Ethical engineering responsibility: Action areas and perspectives on code creation]. Düsseldorf: VDI Verlag.

Huning, Alois, and Carl Mitcham. (1993). "The Historical and Philosophical Development of Engineering Ethics in Germany." *Technology in Society* 15(4): 427–439.

Irrgang, Bernhard. (1997). *Forschungsethik Gentechnik und neue Biotechnologie. Grundlegung unter besonderer Berücksichtigung von gentechnologischen Projekten an Pflanzen, Tieren und Mikroorganismen* [Research ethics in genetic engineering and new biotechnology with a special respect to the projects on the genetic engineerings studies of plants, animals and microorganisms). Stuttgart: S. Hirzel.

Irrgang, Bernhard. (1998). *Praktische Ethik aus hermeneutischer Perspektive* [Practical ethics from the hermeneutical point of view]. Paderborn, Germany: Schöningh.

Irrgang, Bernhard. (2001). *Technische Kultur: Instrumentelles Verstehen und technisches Handeln* [Technological culture: Instrumental understanding and technological action]. Paderborn, Germany: Schöningh.

Irrgang, Bernhard. (2002). *Technische Praxis: Gestaltungsperspektiven technischer Entwicklung* [Technological practice: Design perspectives on technological development]. Paderborn, Germany: Schöningh.

Irrgang, Bernhard. (2003). *Von der Mendelgenetik zur synthetischen Biologie. Epistemologie der Laboratoriumspraxis Biotechnologie* [From Mendel's genetic engineering to synthetic biology. Epistemology of the laboratory practice and biotechnology]. Technikhermeneutik Bd. 3. Dresden: Thelem.

Irrgang Bernhard. (2005). *Einführung in die Bioethik* [Introduction to Bioethics]. UTB 2640. Munich: Fink.

Kornwachs, Klaus. (1993). *Kommunikation und Information: Zur menschengerechten Gestaltung von Technik* [Information and communication: On the human design of technology]. Berlin: Springer.

Lenk, Hans. (1994). *Macht und Machbarkeit der Technik* [Power and realization of technology]. Stuttgart: Reclam.

Lenk, Hans. (1995). *Interpretation und Realität: Vorlesungen über Realismus in der Philosophie der Interpretationskonstrukte* [Interpretation and reality: Lecture on realism in philosophy of construction interpretations]. Frankfurt am Main: Suhrkamp.

Lenk, Hans. (1998). *Konkrete Humanität: Vorlesungen über Verantwortung und Menschlichkeit* [Concrete humanity: Lecture on responsibility and humanity]. Frankfurt am Main: Suhrkamp.

Lenk, Hans, and Matthias Maring. (2001). *Advances and Problems in the Philosophy of Technology*. Münster, Germany: Lit.

Mittelstraß, Jürgen, ed. (1980–1996). *Enzyklopädie Philosophie und Wissenschaftstheorie* [Encyclopedia of philosophy and economy theory]. 4 vols. Mannheim, Germany: Bibliographisches Institut (Vols. 1 and 2); Stuttgart: Metzler (Vols. 3 and 4).

Müller, Johannes. (1990). *Arbeitsmethoden der Technikwissenschaften: Systematik, Heuristik, Kreativität* [Methods of technological science: Systematics, heuristics, creativity]. Berlin: Springer.

Petermann, Thomas, ed. (1992). *Technikfolgen-Abschätzung als Technikforschung und Politikberatung* [Technology assessment as technological research and political advice]. Frankfurt am Main: Campus.

Reich, Jens G. (2002). "Embryonic Stem Cells: The Debate in Germany." *Science* 296(5566): 265.

Ropohl, Günter. (1979). *Eine Systemtheorie der Technik: Zur Grundlegung der Allgemeinen Technologie* [A systems theory of technology: On the foundations of a general technology]. Munich: Hanser.

Ropohl, Günter. (1991). *Technologische Aufklärung: Beiträge zur Technikphilosophie* [Technological enlightenment: Contributions to philosophy of technology]. Frankfurt am Main: Suhrkamp.

Ropohl, Günter. (1996). *Ethik und Technikbewertung* [Ethics and technology assessment]. Frankfurt am Main: Suhrkamp.

Verein Deutscher Ingenieure (VDI). (2002). *Ethische Grundsätze des Ingenieurberufs/Fundamentals of Engineering Ethics*. Düsseldorf: VDI Verlag. This is the basic VDI ethics code.

Zimmerli, Walther. (1997). *Technologie als "Kultur"* [Technology as "culture"]. Hildesheim, Germany: Olms.

GIRARD, RENÉ

Born in Avignon, France, on Christmas Day, René Girard's (b. 1923) work has been a blend of history, literature, and philosophy with implications for science, technology, and ethics that have only begun to be appreciated. He graduated from the Ecole des Chartes in Paris in 1947 (as a specialist in medieval studies) with a thesis on private life in his hometown of Avignon in the second half of the fifteenth century. A year's trip abroad turned into a Ph.D. in history from Indiana University, after which Girard remained in the United States, where he retired as a professor of French Language, Literature, and Civilization from Stanford University in 1995.

Girard's early historiographic publications soon shifted to an avalanche of literary criticism. His first book, *Deceit, Desire and the Novel* (1966), contrasted the romantic lie of individualism with the novelistic truth of what he called *imitative* or *mimetic desire*. Among five major novelists Girard discovered a triangular structure to desire where the protagonists struggled with the fact that their deepest aspirations were mere imitations of a model or rival. Adultery remains the archetype for this phenomenon as illustrated in Dostoevsky's novella, *The Eternal Husband*. The husband is obsessed by his wife's lovers, who inflame, validate, and aggravate his own desire. Girard's students have likened his discovery of imitation in the social sciences to Newton's discovery of gravity in the physical sciences. The vast secondary literature on mimetic desire now extends these early insights into the diverse fields of economics, sociology, psychology, theology, and anthropology.

His second book, an anthropological study of *Violence and the Sacred* (1977), proposes a rational explanation for sacrificial rituals (as well as religious myths and prohibitions) in what he terms the *victimage mechanism*. Mimetic desire is inevitably conflictual. "Rivalry does not arise because of the fortuitous convergence of two desires on a single object; rather, *the subject desires the object because the rival desires it*" (Girard 1977, p. 145).

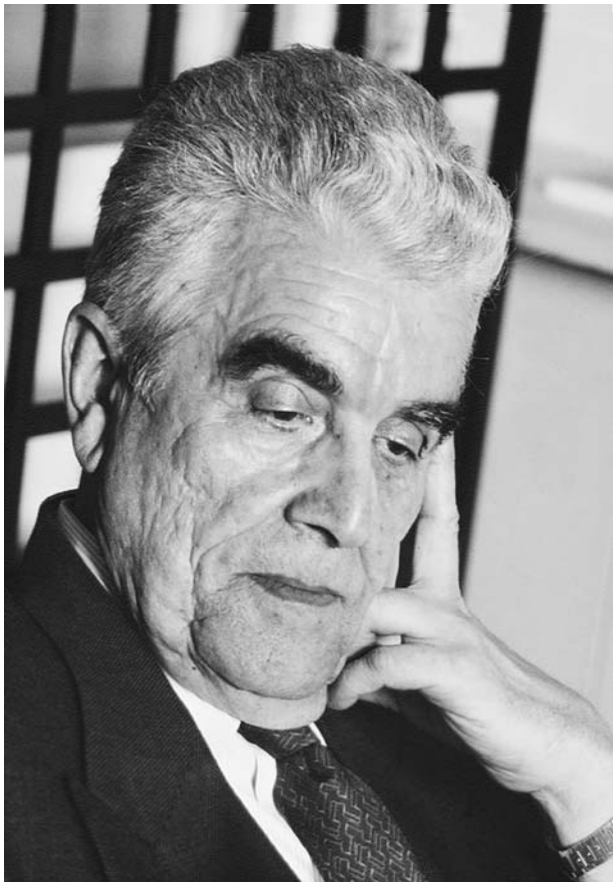
Ancient religion developed as an unconscious method of keeping the peace where the mimetic war of all against all is replaced by the more efficient war of all against one—the community's sacrifice of a scapegoat. Sacrifice acts as a kind of vaccination whose small doses of violence inoculate the community against greater violence.

The publication of *Things Hidden Since the Foundation of the World* (1987), a conversation with two French psychiatrists, included discussion of a *founding murder* among mimetically hysterical primates that initiated the long, slow process of hominization as well as sacrificial mechanisms. Girard sheds new light on the often-discarded speculations on primal murders found in Freud's *Totem and Taboo*. He also proposes the controversial thesis that the Judeo-Christian revelation of the victimage mechanism provides the anthropological tools necessary to demythologize pagan religious practices, which for Girard includes much of Western Christianity.

According to Girard, Christ's death was not a sacrifice willed by an angry God to atone for an original sin, but simply a revelation of human brutality and violence by a loving God. The remainder of Girard's major works (aside from a delightful work on Shakespeare) focus on biblical criticism, including *The Scapegoat* (1986), *Job: The Victim of His People* (1987) and *I See Satan Fall Like Lightning* (2001).

For Girard modern science and technology are an inevitable consequence of the demythologization of sacrificial violence and magical thought. Magical thought always seeks a social/moral explanation for pain. For example the Black Plague was often attributed to the Jews poisoning the water supply. As Girard quips, "Those who are suffering are not interested in natural causes" (Girard 1986, p. 53). However, with a loosening of magical thought, the search for natural causes slowly becomes a more reasonable path toward the "relief of man's estate" (Francis Bacon). "The invention of science is not the reason that there are no longer witch hunts, but the fact that there are no longer witch hunts is the reason that science has been invented. The scientific spirit, like the spirit of enterprise in an economy, is a by-product of the profound action of the Gospel text" (Girard 1986, p. 204).

Yet Girard's attitude toward science contains a certain Freudian ambivalence. Science is necessarily part of the Christian concern for victims and is a consequence of this charitable impulse. At the same time, modern technology has an apocalyptic edge to it. With the loosening of ancient sacred restraints and prohibitions, modern technology, like modern economy, unleashes the phenomenon of mimetic desire in a wave of consumerism, ethnic rivalry, media frenzy, and politically correct victimology. For Girard it is no accident that names for nuclear weapons are "taken from the direst divinities in Greek mythology, like Titan, Poseidon, and Saturn, the god who devoured his own children" (Girard 1987, p. 256).



René Girard, b. 1923. With work encompassing the disciplines of philosophy, literary criticism, theology, and anthropology, Girard is chiefly known for pioneering the mimetic theory of desire and the concept of the "scapegoat mechanism." *(© Bassouls Sophie/Corbis Sygma.)*

JIM GROTE

SEE ALSO *Christian Perspectives: Historical Traditions; Violence.*

BIBLIOGRAPHY

Girard, René. (1965 [1961]). *Mensonge romantique et verite romanesque* [Deceit, desire and the novel], trans. Yvonne Freccero. Baltimore, MD: John Hopkins University Press.

Girard, René. (1977 [1972]). *La Violence et le sacre* [Violence and the sacred], trans. Patrick Gregory. Baltimore, MD: John Hopkins University Press.

Girard, René. (1986 [1982]). *Le Bouc emissaire* [The scapegoat], trans. Yvonne Freccero. Baltimore, MD: John Hopkins University Press.

Girard, René. (1987a [1978]). *Des choses caches depuis la fondation du monde* [Things hidden since the foundation of the world], trans. Michael Metteer (Book I) and Stephen Bann (Books II and III). Stanford, CA: Stanford University Press.

Girard, René. (1987b [1985]). *La route antique des homes pervers* [Job: the victim of his people], trans. Yvonne Freccero. Stanford, CA: Stanford University Press.

Girard, René. (2001 [1999]). *Je vois Satan tomber comme l'éclair* [I see Satan fall like lightning], trans. James G. Williams. Maryknoll, NY: Orbis Books.

Williams, James G., ed. (1996). *The Girard Reader*. New York: Crossroad Publishing Company. The best introduction to Girard's thought.

GLOBAL CLIMATE CHANGE

Global climate change refers to the ways in which average planetary weather patterns alter over time. The term *global warming,* though common, is a misnomer, for under some scenarios it is possible that part of the earth could cool, even as most of the planet gets warmer. The global climate change debate offers a superb case study of the relations existing in the early twenty-first century among science, technology, politics, and questions of meaning and value.

Defining the Problem

Because of the long timescales involved, climate change is difficult to experience directly; knowledge of meteorological variation generally falls under the classification of "weather." Science and technology—in forms such as the uncovering of the basic physical principles of atmospheric science, geologic evidence such as glacial moraines and plant remains, and determinations of ancient atmospheric concentrations derived from ice cores taken from the Greenland and Antarctic ice sheets—is needed to identify even the possibility of climate change. This fact has encouraged the assumption that both the definition of and the human response to possible climate change should be fundamentally scientific and technological in nature.

Geologists have known since the mid-nineteenth century that local, regional, and global climate undergoes change through time. Indeed, adding the term *change* to climate is nearly a redundancy, because climate varies on all timescales from decades to millions of years. This makes it difficult to clearly distinguish between the concepts of *weather* (transient variations) and *climate* (the long term status of the system).

For instance, the earth experienced an ice age that peaked 18,000 years ago; but considering the larger span of the earth's history, it is still in an ice age. While the norm for humanity, geologic evidence suggests that the earth has had ice on its poles for only a very small fraction of its history.

It was the Swedish chemist Svante Arrhenius (1859–1927) who in 1896 first suggested the possibility of human-induced climate change through the burning of fossil fuels. Climate change came to general notice in the 1970s, when concern was voiced about the possibility of global *cooling* leading to a new ice age. This remains a live possibility: Evidence of ancient climates shows that in the last 800,000 years the planet has seen a series of oscillations between ice ages, of approximately 100,000 years in duration, and interglacials, of around 10,000 years in length. Earth is thus overdue for a cold spell.

The 1980s saw the rise of concern about the "greenhouse effect" caused by increasing levels of human-produced carbon dioxide and other gases that trap heat in the atmosphere. Concern exploded in the summer of 1988, which saw record warmth throughout the United States. This warming trend appears to be continuing: Nine of the ten hottest years since the beginning of record keeping in 1880 have occurred between 1990 and 2003.

Ethical, Political, and Philosophical Issues

What defines climate change as a "problem" at all? This question relates to a long-standing debate within environmental ethics on whether nature has only instrumental value for human beings or has intrinsic value outside of any considerations of its value to humans. The first (anthropocentrist) position claims that concern about the environment should be motivated by an interest in human welfare. The second (ecocentrist) position believes that animals, species, ecosystems, and even rock formations and climate patterns can have qualities that make them the objects of moral concern.

On the first view, climate change is a problem only from the perspective of human wants, needs, and obligations to one another. Rising sea level is a physical event; it is only when it floods New Orleans or the Maldives that it becomes a problem. From this point of view, climate change has become a crisis in two senses in the early 2000s. First, human populations, structures, or the ecosystems societies depend upon may be exposed to climate-induced dangers such as rising sea level, changes in temperature and/or precipitation, changes in the frequency of extreme events such as hurricanes, and changes in vegetation and the growing season. Second, if climate change is partially or wholly human-caused—that is, if it is anthropogenic in nature—then the persons, industries, or societies that have caused these problems may fairly be held accountable.

This latter question has spawned a global debate about the respective responsibilities of developed and developing nations to address climate change. The debate turns on the fact that most of the increase of greenhouse gases to date has been caused by industrial nations, especially the United States, whereas most of the future contribution of greenhouse gases to the atmosphere is likely to come from developing countries such as China. Should developed countries be required to address questions of greenhouse gas emissions first, because they caused the problem, allowing developing nations to pollute more as they develop their industries? Or is such an approach self-negating, in that any real solution to greenhouse gas emissions requires a common global effort?

On another view, however, climate change is a more than a human affair. Climate change is certainly an issue for any species driven to extinction by ecosystem change. It is here that the question of global climate change touches upon core questions within the philosophy of nature. Species come into and go out of existence constantly; does it matter whether a species' extinction is caused by natural climate variability or anthropogenic change? In the mind of some, the difference is crucial: Change (including extinction) that is natural in origin should be tolerated and adapted to, whereas human-caused change or extinction should be addressed and mitigated. Making the question even more vexed are claims that there is no "natural" left in the early twenty-first century. On this view the entire earth, including its atmosphere, has become an artifact through centuries of inhabitation, cultivation, and pollution (Allenby 1999, McKibben 1999). These aspects of the climate change debate point toward religious and metaphysical considerations concerning the status of nature rather than to more and better data and predictions. In ways similar to the current debate concerning genetic engineering, questions are increasingly being asked about whether nature represents a limit that should be acknowledged and in some sense obeyed.

The Scientific Effort

Concerns about global climate change have led to a massive, unprecedented, and worldwide scientific, technological, and political effort to understand the causes and consequences of climate change. The basic assumption underlying all of these efforts is that climate change science is necessary for the devising of climate change policy.

The United States leads the world in climate change research, funding more than half of all the work. Approximately half of the nearly $2 billion annual budget for the U.S. Global Change Research Program (USGCRP, The U.S. Government's Interagency Research Program On Climate Change) is devoted to satellites and other data systems. The rest supports research across a wide range of sciences such as physics, atmospheric chemistry, oceanography, and ecology. A significant part of this research is conducted through computer simulations, the best known of which are global climate models (GCMs) that run on the world's fastest computers. Products of a truly global scientific and technological effort, GCMs have produced sets of predictions concerning the possible state of the atmosphere in 2100. (There is, of course, nothing magical about the year 2100; it was picked for symmetry and because this period was thought to be within the moral horizon of most people. In fact, computer models predict that change will accelerate after this date.)

Research into the social and political aspects of climate change—broadly known as "human contributions and responses to global change"—receives around 2 percent of the USGCRP budget, or $50 million. Even then, the overwhelming majority of this investment goes toward quantitative (often economic) social science research. While questions of ethics and values have often been voiced in public debate, research into such questions has been pursued only at the margins. The overall definition of the problem of climate change thus remains deeply immersed in science: The USGCRP seeks to identify the basic facts of the matter, leaving questions of value and justice to the political realm. More to the point, the assumptions remain quite positivistic: It is assumed that ethical and political solutions will somehow be derived from advances in climate science.

After two decades of concerted research, the community of climate change scientists have reached a high degree of consensus on several basic points: The global climate is warming; this warming is largely anthropogenic in origin; and the consequences of this warming could be quite severe. In the words of the National

Research Council's Committee on the Science of Climate Change, "Greenhouse gases are accumulating in Earth's atmosphere as a result of human activities . . . Temperatures are, in fact, rising" (NRC 2001, p. 1).

Science Meets Policy

Climate science research in the United States and other nations (principally the European Union and Japan) feeds into a global political effort to manage the problem of global climate change. The Intergovernmental Panel on Climate Change (IPCC) lies at the center of these efforts. The World Meteorological Organization and the United Nations Environment Programme founded the IPCC in 1988 "to assess scientific, technical and socio-economic information relevant for the understanding of climate change" (IPCC). The IPCC consists of:

- Working Group I, which assesses the scientific aspects of the climate system and climate change
- Working Group II, which focuses on the vulnerability of socioeconomic and natural systems to climate change, the consequences (both negative and positive) of climate change, and possible options for adapting to climate change
- Working Group III, which evaluates options for restricting greenhouse gas emissions and other ways to mitigate climate change
- The Task Force on National Greenhouse Gas Inventories, which runs the IPCC National Greenhouse Gas Inventories Programme

In addition, a series of special reports supports the working groups, the most important being the Special Report on Emissions Scenarios (SRES), which provides baseline sociological, political, and economic parameters for GCMs. Since 1990 the working groups have issued a series of joint assessment reports on a five- to six-year basis. These reports represent a remarkable synthesis of technoscientific research. Each assessment directly involves hundreds of scientists who collectively spend thousands of hours collating and synthesizing the available information on the above topics in a thick set of volumes. After a series of reviews, each volume is then boiled down to a "summary for policymakers" that attempts to extract insights most relevant to decision makers worldwide.

These IPCC reports are created to support the United Nations Framework Convention on Climate Change (UNFCCC), which seeks to devise a global political strategy. In late 1997 the UNFCCC gathered representatives from more than 160 nations in Kyoto, Japan, to negotiate binding limitations on greenhouse gases for developed nations. The resulting Kyoto Protocol called for developed nations to agree to limit their greenhouse gas emissions as compared with the levels emitted in 1990. The bulk of the political efforts to address the challenges of climate change have centered on negotiating the particular provisions of the Kyoto Protocol.

The results, however, have not been encouraging. Even if the Kyoto Protocol were to be ratified—and the Bush Administration announced its rejection of the protocol in 2001—the proposed limitations to greenhouse emissions would not come anywhere near the estimated 50 to 75 percent reduction scientists believe is necessary to stabilize atmospheric levels of carbon dioxide. What is more, the $25 to $30 billion the United States spent on climate change research from the early 1980s to the early 2000s highlights the questionable structure of the existing global climate change debate. Across this twenty-year period, the range of uncertainty for the predicted amount of change in global mean temperatures by 2100 actually *increased*, from 1.4 to 5.4 degrees Celsius in 1980 to 1.4 to 5.8 degrees Celsius in 2001. This increase in the range of possible warming has provided cover for politicians to call for more research instead of devising plans of action.

Future of the Problem

The paradox is that at the same time that a scientific consensus has formed on the reality of climate change, the actual range of future outcomes has increased rather than shrunk. A number of factors contribute to this increase of uncertainty, including a greater appreciation of the complexity and attendant lack of understanding concerning some parts of the climate system (for instance, the behavior of clouds, and the ocean–atmosphere interface), the difficulties in matching differing types of data, and the possibility that a system as complex as world climate is fundamentally unpredictable in nature. But the core difficulty lies elsewhere: The computer simulations used to model the atmosphere for the year 2100 are themselves fundamentally dependent on future sociological and economic indicators that are essentially unknowable. This is the significance of the SRES scenarios, which provide the basic inputs and parameters for the GCMs.

The SRES scenarios consist of six different imagined future patterns of energy use, technological progress, and social, political, and economic development. These six possible development paths explore future choices concerning population, lifestyle, the degree of globalization and economic integration, the development of non-carbon-based energy sources, and the possibility of carbon sequestration—choices that are not predictable in ways analogous to physical systems. Moreover, the point is not just that future social conditions cannot be predicted, but that they are in large part a function of human choices. The future does not simply befall humanity; individually and collectively humans exercise a significant influence over what happens. Rather than treating the future as if it were beyond human control, the challenge of global climate change calls for public debate about desirable futures.

It is thus arguable that while scientific research on climate change has greatly increased the knowledge and appreciation of the problem, the focus of attention should now shift toward two other areas that complement climate science: better understanding the nature of the social, ethical, political, and political dimensions of the problem, and devising ways to increase the resilience of both natural and social systems to a global climate that is already undergoing alteration. This approach would involve a shift in attention away from precisely modeling the climate system and toward devising a "no-regrets" strategy tied to sustainable development, social justice, and the modification of desires. The problem, however, is that such a "soft" approach to global climate change runs up against 300 years of tradition in which humankind has attempted to engineer its way out of problems rather than developing personal and political means for modifying its behavior.

ROBERT FRODEMAN

SEE ALSO *Automobiles; Deforestation and Desertification; Environmental Ethics; International Relations; Oil; Pollution; Rain Forest; United Nations Environmental Program.*

BIBLIOGRAPHY

Allenby, Brad. (1999). "Earth Systems Engineering: The Role of Industrial Ecology in an Engineered World." *Journal of Industrial Ecology* 2(3): 73–93. Argues that climate change should be treated as an engineering problem.

Brunner, Ronald. (2001). "Science and the Climate Change Regime." *Policy Sciences* 34(1): 1–33. Excellent introduction to policy dimensions of the climate debate.

Drake, Frances. (2000). *Global Warming: The Science of Climate Change*. New York: Oxford University Press.

McKibben, Bill. (1999). *The End of Nature*, 2nd edition. New York: Anchor. Well-known and accessible account of cultural dimensions of human impact upon nature.

Miller, Clark A., and Paul N. Edwards, eds. (2001). *Changing the Atmosphere: Expert Knowledge and Environmental Governance*. Cambridge, MA: MIT Press. A rich collection of essays treating different aspects of the climate problem.

National Research Council (NRC). Committee on the Science of Climate Change. (2001). *Climate Change Science: An Analysis of Some Key Questions*. Washington, DC: National Academy Press. An important recent report summarizing the state of scientific knowledge.

Rayner, Steve, and Elizabeth L. Malone, eds. (1998). *Human Choice and Climate Change*. 4 vols. Columbus, OH: Battelle Press. A rich variety of essays on social science perspectives on climate change.

Sarewitz, Daniel, and Roger A. Pielke Jr. (2000). "Breaking the Global-Warming Gridlock." *Atlantic Monthly* 286(1): 54–64. An accessible and innovative treatment of policy questions concerning climate change.

Shackley, Simon; Peter Young; Stuart Parkinson; and Brian Wynne. (1998). "Uncertainty, Complexity, and Concepts of Good Science in Climate Change Modeling: Are GCMs the Best Tools?" *Climatic Change* 38(2): 159–205. A good review of the use of global climate models.

U.S. Climate Change Science Program and the Subcommittee on Global Change Research. (2002). *Our Changing Planet: The Fiscal Year 2003 U.S. Global Change Research Program and Climate Change Research Initiative, A Supplement to the President's Fiscal Year 2003 Budget*. Washington, DC: Author. Federal publication that annually summarizes the state of current research.

U.S. Climate Change Science Program and the Subcommittee on Global Change Research. (2003). *Strategic Plan for the U.S. Climate Change Science Program*. Washington, DC: Author. Another useful governmental report.

Weart, Spencer R. (2003). *The Discovery of Global Warming*. Cambridge, MA: Harvard University Press.

INTERNET RESOURCES

Intergovernmental Panel on Climate Change (IPCC). Available from http://www.ipcc.ch.

National Research Council (NRC). Committee on the Science of Climate Change. (2001). *Climate Change Science: An Analysis of Some Key Questions*. Available from http://books.nap.edu/books/0309075742/html/.

U.S. Climate Change Science Program and the Subcommittee on Global Change Research. (2002). *Our Changing Planet: The Fiscal Year 2003 U.S. Global Change Research Program and Climate Change Research Initiative, A Supplement to the President's Fiscal Year 2003 Budget*. Available from http://www.usgcrp.gov/usgcrp/Library/ocp2003.pdf.

U.S. Climate Change Science Program and the Subcommittee on Global Change Research. (2003). *Strategic Plan for the U.S. Climate Change Science Program*. Available from http://www.climatescience.gov/Library/stratplan2003/final/.

GLOBALISM AND GLOBALIZATION

Without science neither globalism nor globalization would be conceivable; without technology they would not be practical possibilities. The extent to which the internal ethics of science and the codes of behavior of various engineering professions influence globalism and globalization, or the degree to which independent ethical assessments should be brought to bear on all science, technology, and globalist synergies, remains open to critical discussion. What follows is an analysis that aims to provide a background for such considerations.

Terminology

The terms *globalism* and *globalization* came into use during the last half of the twentieth century. The question of when, and by whom, is contentious. But irrespective of origins the two terms are used in distinct ways. Globalization refers to a multidimensional economic and social process beginning in the late 1970s and early 1980s and that embraces a variety of interlinked economic, communicational, environmental, and political phenomena. Globalism, although it has older roots as a synonym for internationalism, has come to be used as the name of a broad *ideological commitment* in favor of the process of globalization—that is, of a view that sees the process of globalization as entirely or predominantly positive in its implications for humankind (Steger 2002).

Globalists are people who wish the process of globalization to continue, and indeed intensify, although they may also wish to have it politically regulated or controlled in various ways. Globalists are often (though not always) also convinced that globalization, whatever its implications for human welfare, is an *inevitable process* that cannot, and should not, be reversed. They are often contrasted with "localists," who seek to escape or overcome the problems posed by globalization through small-scale forms of economic and cultural development and political organization that minimize involvement in the global economy (Mandle 2003).

In short then, there are theorists and writers on globalization both for and against the process they are analyzing, but those in favor of the process are generally called "globalists" or advocates of "globalism." In the early twenty-first century, enthusiasts for globalization do not call *themselves* "globalists" (this terminology is used only by globalization's opponents), although there is the potential for this to change as the debate unfolds further.

Globalization: Its Characteristics

There are innumerable definitions of the term globalization in the academic literature, but all, in one way or another, refer to essentially the same phenomena. These are:

(1) The increased depth of economic integration or interdependence in the world economy as a whole. Increased depth here usually refers to the integration of different parts of the world and different working populations in the world in the process of economic production itself (Dicken 2003).

(2) The central role played by electronic means of communication and information transmission in facilitating this new deep integration of the world economy.

(3) The much increased importance of global markets in both money and capital in the world economy as a whole (Thurow 1996).

(4) The historically unprecedented scale of international population migration occurring in the world economy in response (primarily) to new work opportunities created by the development of a genuinely global economy.

(5) Sharply increased economic inequalities both within and between different parts of the globe occurring primarily as a result of the very social and spatial "unevenness" of the globalization process.

In addition, there are conceptions of globalization that embrace, but go beyond, these economic aspects of the process to encompass political and cultural phenomena. These include:

(6) The ineluctable spread of a single, materialistic, consumerist culture driven by the Western-dominated global mass media (including both the Internet and television), which in the early twenty-first century forms dominant images of the desirable or good life everywhere on the globe (Castells 1996).

(7) The more or less rapid weakening of the political power of the nation-state in the global economy, a weakening shown by the reduced ability of such states to control crucial economic variables that determine the welfare and standards of living of their populations (Martin and Schumann 1997).

(8) Enhanced cultural and political conflicts in the world caused both by the increasing intermingling of culturally diverse populations in states receiving ever-larger numbers of global labor migrants, and by the so-called clash of cultures or civilizations in

different parts of the world, a clash in part produced by the very information and communications revolution referred to in (2) above. Greatly increased cross-cultural contact also makes different populations aware both of the ever-increasing inequalities among them—see 5 above—and of the different value orientations different cultures may embody. In this conception both global terrorism and the security threats it poses are themselves aspects of globalization (Wade 2001).

Globalization: Its Causes

There is broad unanimity on the origins and causes of globalization. As an economic process globalization dates from the mid- or late 1970s when the postwar "long economic boom" came to an end. The ending of the boom, and the initiation of a much slower growth trajectory for the world economy as a whole, created much more competitive conditions for all firms operating in that economy. The most common firm responses to these heightened competitive conditions were to:

(1) Reduce labor costs by increased automation and "technologization" of production;

(2) Subcontract or "outsource" design, transport, customer service, and even some managerial functions to "independent" consultancy or other firms, thereby reducing "core" labor and payroll costs;

(3) Transfer labor-intensive production activities, that could not be automated to lower wage regions, either in the "home" country or outside the home country altogether.

In addition:

(4) the development and commercial application of computer and information technology from the 1970s onward much facilitated processes (1) to (3) above, and

(5) the ending in roughly the same period (late 1970s and early 1980s) of the postwar Bretton Woods regime of fixed exchange rates facilitated the rapid expansion of global capital and money markets, markets that are themselves deeply dependent on sophisticated information technologies—4 above—for their functioning (Dicken 2003).

In short then, globalization as an economic process dates back no earlier than the mid-1970s, and its political, cultural, and security aspects have also all developed since that time.

Globalization: Its Originality

Although the causality and chronology of contemporary globalization is not disputed, its originality or uniqueness is. Globalization skeptics argue that the nineteenth-century global economy saw flows of investment capital and of international labor migrants that were *proportionately* larger in relation to global economic output or to the then existing world population than contemporary flows are. The nineteenth century also saw very rapid average annual increases in world trade, at periods on occasion larger than contemporary increases. Globalization skeptics even doubt whether modern communications technologies (such as satellite television or the Internet) are any more "revolutionary" in contemporary conditions than was the nineteenth century introduction of the electric telegraph to a world that had previously moved international mail by horse or sail and steamship (Hirst and Thompson 1999).

Although such skeptical arguments have some merit, they understate both the multidimensionality and variety of contemporary communications technologies and the absolute size of current trade, capital, and labor flows. Both the absolute size of the global economy and of the world population are much greater than they were in the nineteenth century. Most importantly of all, such globalization skeptics appear to confuse the "shallow" integration of nineteenth-century economies with the "deep" integration of the contemporary global economy. That is, contemporary international trade is structured (through the massive movement of raw materials and of semifinished goods) so that national economies are tied together *within the production process itself*. The production of everything from cars and other motor vehicles, to electronics, to clothing, footwear, and fashion accessories involves dovetailing inputs from factories located in several different countries through the global trade in goods and services. In this process of deep global economic integration, trade and production become increasingly difficult to distinguish (Dicken 2003). This is a very different situation from that of the nineteenth century, and it makes all countries involved much more vulnerable than ever before to a breakdown, or even to any significant disruption, of the global trade/production system.

Globalization: Its Merits and Demerits

The most discussed and disputed aspect of globalization focuses on the human welfare and economic distributional aspects of the process.

There is broad unanimity that the globalization period in recent history has also been a period of rapidly increasingly income and wealth inequalities both within individual national economies and societies and within the global population as a whole. Agreement ends at this point, however, and there are fierce debates about:

(1) Whether this growing inequality is a product of globalization itself or of the political form globalization has taken—most notably the generally neoliberal political and policy framework—that tends to discourage significant political control or guidance of the process.

(2) Whether this growing inequality matters in any case, if globalization has a tendency to significantly reduce world poverty.

(3) Whether globalization is even achieving poverty reduction, however, is itself a matter of debate, specifically over such matters as how poverty is measured and how increases or reductions in its magnitude are to be assessed (Kitching 2001, Collier and Dollar 2002, Wade 2001).

(4) Whether economic globalization is environmentally sustainable. Here connections are made between economic globalization, especially the spread of industrialization in Asia, Central America, and elsewhere—and such phenomena as global warming.

(5) The strong regional disparities in the spread of globalization and its benefits (and especially the disparity between East and Southeast Asia, on the one hand, and sub-Saharan Africa and the Middle East, on the other).

(6) The very poor labor and environmental conditions existing even in those countries and regions of the world, such as China and East Asia, that are supposedly benefiting from the process. Here it is suggested that regional benefits may not convert into human benefits at all.

(7) Finally, whether there is any connection between the globalization process, and its admitted inequalities, and the upsurge of political terrorism in the world. It is widely admitted, however, that if there is such a connection it is not directly economic. For although contemporary Islamist terrorism is centered in a part of the world (the Middle East) that has fared comparatively poorly in globalization, its militants and activists do not appear to be particularly poor. Moreover there is no terrorist threat emanating from sub-Saharan Africa, the region of the world that is universally admitted to have fared worst in globalization. If there is a connection between globalization and terrorism it is much more likely to be of an indirect cultural and political sort, not of a direct economic sort.

Conclusion: Globalization, Regulation, and Ethics

Conflicting assessments of the merits and demerits of globalization are often tied to different assessments of alternatives to it. The most obvious "total" alternative to globalization is withdrawal of local or regional communities from the world trade/production system into some form of local self-sufficiency or autarky (so-called localism). But this response seems feasible, even in principle, only if populations opting for it are prepared to accept very large reductions in their material standards of living. And whatever may be the situation in the rich parts of the globe, such a policy is unlikely to be attractive to the already poor majority of the world population (Mandle 2003).

In practice therefore, debates and disputes over globalization are most often focused, not on entirely "undoing" its economics, but on the possibility and desirability of politically regulating it so as to reduce its economic volatilities, inequalities, and negative environmental impacts. The central issue at the heart of such debates (aside from whether such regulation is desirable or possible at all) is whether nation-states can continue to be the prime political regulators of the global economy or whether globalization has passed beyond the regulatory capacity of states, so that the task must be turned over to supranational economic and political bodies such as the International Monetary Fund (IMF), World Bank, World Trade Organization (WTO), and International Labour Organization (ILO). But if the latter are to do so, many believe that their responsibilities and powers will have to be enhanced. Advocates of the supranational regulation of globalization are often (though not always) also advocates of a more or less radical restructuring of such bodies in order to make them more genuinely responsive to global public opinion and not simply to the views and preferences of the richest and most powerful states in the world (Stiglitz 2002).

The latter notion recalls the original post-World War II understanding of globalism as a promotion of internationalism in response to the threat of nuclear warfare. Proposals for the international control of nuclear weapons were, for instance, often promoted and stigmatized as one-worldism. To what extent, one may ask, were mid-twentieth century efforts such as the creation of the United Nations and the formulation of the

Universal Declaration of Human Rights the foundations for subsequent economic globalization or institutions and ideals that may help guide it.

From this perspective one may also consider a host of issues related to science, technology, and ethics. Certainly globalization as a phenomenon would not be possible with both science and technology. But does globalization imply or require the universalization of ethics and ethical standards in the same way that it implies and promotes the universalization of technical standards? Can research protocols that are appropriate for HIV/AIDS drugs in Europe and North America be transferred to Africa and Asia? Do professional ethics codes for scientists and engineers function in the same way countries with strong and weak civil society institutions? It is such questions that suggest the importance of both globalism and globalization to the ethical promotion and assessment of science and technology.

GAVIN KITCHING

SEE ALSO *Development Ethics; International Relations; Modernism; Political Risk Assessment; Poverty; Television; Work.*

BIBLIOGRAPHY

Bhagwati, Jagdish. (2004). *In Defense of Globalization*. New York: Oxford University Press. An eloquent defense of globalization from orthodox economic premises.

Castells, Manuel. (1996). *The Information Age: Economy, Society, and Culture*, Vol. 1: *The Rise of the Network Society*. Malden, MA: Blackwell. Probably the best known single work dealing with the information technology dimension of globalization and its possible social and cultural implications.

Collier, Paul, and David Dollar. (2002). *Globalization, Growth, and Poverty: Building an Inclusive World Economy*. Washington, DC: World Bank; New York: Oxford University Press. The standardly optimistic "World Bank" view of globalization.

Dicken, Peter. (2003). *Global Shift: Reshaping the Global Economic Map in the Twenty-First Century*, 4th edition. New York: Guilford Press. An extremely comprehensive and empirically thorough standard textbook on globalization. An excellent non-dogmatic starting point for any beginning student of the subject.

Friedman, Thomas L. (1999). *The Lexus and the Olive Tree*. New York: Farrar, Straus, Giroux. The source of the "Golden Arches" theory of international relations: Countries that are sufficiently capitalistic and consumerist as to have at least one McDonalds franchise do not go to war with each other.

Hirst, Paul, and Grahame Thompson. (1999). *Globalization in Question: The International Economy and the Possibilities of Governance*, 2nd edition. Cambridge, UK: Polity. Perhaps the best singe statement of the skeptical view of globalization as any kind of genuinely new or original phenomenon.

Kitching, Gavin. (2001). *Seeking Social Justice through Globalization: Escaping a Nationalist Perspective*. University Park: Pennsylvania State University Press. Orthodox economic analysis combined with some rather unorthodox political prescriptions and implications.

Mandle, Jay R. (2003). *Globalization and the Poor*. Cambridge, UK: Cambridge University Press. Takes a rather similar view to Kitching but with a much tighter and deeper focus on the issue of poverty and its alleviation.

Martin, Hans-Peter, and Harald Schumann. (1997). *The Global Trap: Globalization and the Assault on Prosperity and Democracy*, trans. Patrick Camiller. London: Zed Books. One of the first and one of the best radical critiques of globalization.

Norberg, Johan. (2003). *In Defense of Global Capitalism*. Washington, DC: Cato Institute. Rather similar to Bhagwati in its analysis, but rather more polemical in tone.

Steger, Manfred B. (2002). *Globalism: The New Market Ideology*. Lanham, MD: Rowman and Littlefield. A text that provides a very useful contrast to Bhagwati and Norberg as an illustration of the levels of ideological polarization among scholars produced by globalization.

Stiglitz, Joseph E. (2002). *Globalization and Its Discontents*. New York: Norton. A very interesting "insiders" view of the financial dimensions of globalization. Deals with some technical economic issues but in a very accessible way.

Thurow, Lester C. (1996). *The Future of Capitalism: How Today's Economic Forces Shape Tomorrow's World*. New York: Morrow. Early text on the globalization phenomenon and still one of the most sophisticated and prescient.

Wade, Robert Hunter. (2001). "The Rising Inequality of World Income Distribution." *Finance and Development* 38(4): 37–39. Very useful statistical compendium on the inequality issue.

GLOBALIZATION

SEE *Globalism and Globalization*.

GLOBAL POSITIONING SYSTEM

The Global Positioning System (GPS) allows users to pinpoint their location anywhere on Earth to within a few meters. GPS technology was developed for military use, but by the early twenty-first century it had acquired numerous civilian applications including navigation, mapping and surveying, optimizing emergency response systems, and precision agriculture. The major ethical and legal challenges of this technology relate to national control and the potential end-uses of GPS-derived locational data. The U.S. Department of Defense provides the global GPS infrastructure; civilian use is maintained at the discretion of the U.S. government. Personal privacy is a concern because GPS capabilities, embedded in devices such as cell phones, can allow third parties to track the location of individuals. Regulations and laws covering such surveillance are not fully developed.

GPS almost always refers to the NAVSTAR system, the most widely used Global Navigation Satellite System, developed and maintained by the United States government. The U.S. Department of Defense originally developed GPS to locate submarines accurately and thus calculate trajectories for ballistic missile launches. The system depends on twenty-four satellites that continuously broadcast radio signals, positioned in precise orbits approximately eleven nautical miles above Earth. The first satellite was launched in 1978 and the network was completed in 1994. The signals and satellite locations are monitored and corrected as necessary from five ground control stations. A GPS receiver picking up signals from four satellites can compute its location, often to an accuracy of less than ten meters, anywhere on the globe.

GPS depends on the accurate maintenance of the satellites, signals, and related control systems—all of which are entirely under the control of the United States government. The United States deliberately degraded the signal available to civilian users until May 2, 2000. A full-precision civilian signal has since been available to all users, and the United States says that it intends to maintain free worldwide access to the signal. As a result, GPS is increasingly an international utility provided by one nation. The satellites broadcast a separate code for military use, and the U.S. military can jam the civilian signal to selected areas.

GPS itself is an inert provider of locational data. To be used as a tracking device, it must be linked to a communications system. Using GPS in monitoring, surveillance, or intelligence systems raises questions about the invasion of individual privacy, and the legal requirements for warrants and informed consent. GPS-communications devices are often placed on emergency and delivery vehicles to track their locations and optimize their usages. This technology can also be used to track the movements of personal vehicles and to monitor the movements of people including Alzheimer's patients and criminals. The U.S. Federal Communications Commission has directed that cell phones should be locatable in case of an emergency call; placing a GPS link in cell phones is one way to achieve this. The legal implications of being able to monitor a person's location and movements remotely have not been fully established.

An essential component of modern warfare, GPS is integrated in many advanced weapons and sensors. Combined with communications and geographic information systems, GPS provides comprehensive information on the location and movement of troops and assets, and allows accurate targeting of missiles. Some people have ethical concerns about the military applications of GPS, while others argue that accurate location information lowers collateral damage in warfare.

GPS has evolved from a military system into a widely used global utility, although the basic signal remains available at the discretion of the U.S. National Command Authorities. Individual jurisdictions have yet to decide acceptable parameters for the use of data derived from the GPS signal.

MAEVE A. BOLAND

SEE ALSO *Aviation Regulatory Agencies; Geographic Information Systems.*

BIBLIOGRAPHY

Balough, Richard C. (2001). "Global Positioning System and the Internet: A Combination with Privacy Risks." *CBA Record* (Chicago Bar Association) 15(7): 28–33.

Larijani, L. Casey. (1998). *GPS for Everyone: How the Global Positioning System Can Work for You.* New York: American Interface Corporation.

GLOBAL WARMING

SEE *Global Climate Change.*

GOVERNANCE OF SCIENCE

Scientific research is a human activity governed by human choice. Governance is exercised at many levels, from the individual scientist deciding how to design an experiment or interpret and report data, to scientific organizations that advocate research funding, to government bureaucrats allocating resources among various projects or programs, to elected representatives establishing budgetary and programmatic priorities, and citizens lobbying to support (or oppose) a particular type of research or technology. Because the consequences of science so powerfully affect the constitution and evolution of society, appropriate governance mechanisms are a key ethical issue for democratic society.

A Republic of Science?

In an influential and powerfully argued paper titled "The Republic of Science, Its Political and Economic Theory" (1962), Michael Polanyi made the case that science was best understood as an autonomous, self-governing activity. Scientists were best positioned not only to understand how to conduct their own research, but also to determine the appropriate directions and levels of effort for new investigations. Likened to the *invisible hand* of the economic marketplace, Polanyi portrayed the governance of science as an emergent consequence of a continual confrontation between an open community of researchers carrying out unconstrained inquiry and nature itself. Interference with this process would lead only to the automatic and inevitable diminution of the ability of science both to advance knowledge and to benefit society.

Polanyi's argument was provoked by attempts in the Soviet Union to subjugate certain scientific disciplines (notably agriculture and genetics) to Marxist dogma, and efforts in England to tie public research agendas more directly to social needs (Polanyi 1964). It also reflected the intellectual conviction that successful scientific endeavor demanded adherence to a clear set of behavioral norms, collectively characterized as "organized skepticism," that were shared by the scientific community as a whole, and which were the only appropriate constraints on the governance of scientific inquiry (Merton 1942).

The practical embodiment of these ideas was articulated by Vannevar Bush, director of the U.S. Office of Scientific Research and Development during World War II. Bush argued, in the seminal policy tract *Science, the Endless Frontier* (1945), that while the public interest would be advanced by a robust, publicly supported science enterprise, the governance of that enterprise was best left entirely in the hands of scientists.

Yet this view, at least in its most extreme form, was explicitly rejected by politicians who believed that no publicly supported enterprise should be fully shielded from democratic accountability (Kevles 1987). Moreover the tremendous expansion of publicly funded research and development enterprises in the United States and other developed nations since the middle of the twentieth century has been accomplished through a variety of political means, in response to a variety of external pressures (notably, the Cold War, but also societal concerns about health, economic performance, and the environment). The details of this political history utterly vitiate any notion of science advancing according to its own lights, and governed according to its own rules (Greenberg 1967, 2001). Thus, while it is certainly the case that the *conduct* of science is significantly governed by norms and practices that are internal to the research system itself, the more important point is that *directions and velocity* of scientific advance reflect a multitude of factors, many of which are external to science itself (Sarewitz 1996, Kitcher 2001).

Yet the power of Polanyi's position remains strongly in evidence to this day, in the rhetoric used to defend the scientific enterprise from the influence of politics, and in the attitudes of a U.S. public that continues to view science largely as an ungovernable and ungoverned activity whose benefits to society are at once inevitable and unpredictable. For example, National Science Foundation (NSF) survey data consistently show exceptionally strong public support for the statement: "Even if it brings no immediate benefits, scientific research that advances the frontiers of knowledge is necessary and should be supported by the Federal Government" (National Science Foundation, ch. 7).

Documents promoting particular avenues of publicly funded science do so not by invoking the right and obligation of a democratic polity to choose the kind of science it will have, but by repeating what are essentially metaphysical arguments about the autonomous progress of science and its automatic connection to social benefit (Sarewitz 1996). Indeed it is fair to say that a sort of schizophrenia exists between the reality of a science and technology enterprise that is highly governed by decisions made at many levels of society, and the rhetoric of public discourse that perpetuates the illusion of an autonomous, internally governed *Republic of Science* (see, for example, U.S. House Science Committee 1998). This tension is deeply problematic because, concealed by the illusion, is the diverse array of human beings, working in diverse institutions, and ranging from scientists in laboratories to legislators casting votes and corporate executives determining market strategies, that in fact do govern the enterprise by making choices every day about what science to do and how to do it. The persistent notion that science is ungoverned or self-governed, that is, shields from scrutiny those who actually govern.

Political Reality

Nor do different types of research activities—embodied, for example, in the axiomatic taxonomy of unguided basic research, applied research, and development—carry implications about levels or appropriateness of governance. While Polanyi and Bush before him were centrally concerned with an idealized notion of basic research, the politics of science have made no such distinctions. The advance of basic biomedical research has ridden such political campaigns as the *war on cancer* (which was initially much opposed by medical researchers), while such *pure* fields as subatomic physics were justified in practical terms of the Cold War or economic competitiveness. The Republic of Science has, at one time or another, systematically failed to pursue research relevant to vast areas of socially important inquiry, such as diseases characteristic of poor people and regions, and alternative (nonhydrocarbon and nonnuclear) sources of energy. Conversely political action, motivated by interest groups rather than scientists, has been responsible for moving scientific priorities toward areas that had been explicitly avoided by the Republic of Science, for example, research on women's health, and on alternative (non-Western) medicine.

Even the norms and practices of science itself are subject to external governance. Most obviously, the rights of human subjects who participate in scientific experiments are protected by external mechanisms ranging from the Nuremberg Code (a response to Nazi Abuses) and the Helsinki Declaration to decentralized Institutional Review Boards (IRBs) operating in U.S. universities and laboratories (Woodward 1999). These governance mechanisms dictate, for example, that human subjects can participate in experiments only if they have given prior informed consent, a condition that sharply limits the types of science that may be conducted on humans. Additionally, partly in response to political activism that highlighted instances of unnecessary, and unnecessarily cruel, use of animals in research, regulations, norms and practices have progressively evolved in the United States since the 1960s to both reduce the use of, and suffering by, animals in science.

Scientific practice is governed in other arenas as well; for example, national security concerns have dictated where and how certain types of science are conducted, and how scientists can behave in and outside the laboratory. In response to fears of biopiracy, a growing number of nations have passed laws that prohibit foreign scientists from collecting biological samples. The overall point is that, as a societal activity, science is necessarily, appropriately, and unavoidably governed by society. The scientific community, similar to other interest groups, reactively opposes new governance structures, but the scientific enterprise as a whole has demonstrated itself to be remarkably resilient and productive under a wide variety of governance regimes, provided that such regimes do not seek to influence or control the actual results of scientific research (Sarewitz 2003).

Governing the Genome

Some of the most far reaching questions of scientific governance in the early twenty-first century are those associated with human genomics. These questions can only partly be laid at the door of the ongoing debates over abortion and the moral status of embryos. With science already able to intervene in reproductive processes (for example, screening for genetic attributes ranging from sex to particular diseases), and on the verge of a capacity to engineer both individual humans and human germ lines (Stock 2003), profound and complex ethical questions emerge whose resolution may strongly influence future directions of both science and of society (Fukuyama 2002, Wolbring 2003). In most developed countries, these questions are sufficiently conspicuous to command the close attention of government leaders and citizens alike (for example, U.S. presidents Bill Clinton and George W. Bush both convened advisory panels on bioethics), and sufficiently troubling to legitimate the possibility that some lines of scientific endeavor, such as those that could lead to human cloning or manipulation of the human germ-line, should simply not be pursued.

Opposition to a stricter governance of genomics research relies on three lines of argument: first the need to protect freedom of inquiry from societal interference; second the loss of potential social benefits (for instance, enhanced medical treatments); and third the likelihood that even if one country decides to prohibit or restrict a given line of research, others will surely decide to move ahead at full speed.

The first two arguments have little practical validity. Inquiry is never entirely free, and while science surely should be protected from inappropriate societal interference, the definition of what constitutes *appropriate* governance is constantly being renegotiated within society. Similarly choices about what science will be supported by society are continually being made in the public and private sectors, and any such choices entail opportunity costs. There is no reason to believe that the organization of scientific inquiry at any given time will yield optimal results for society.

The third argument is ethically troublesome, but difficult to dismiss in practice. While nations may decide to forego areas of research for moral reasons, the global science enterprise is so institutionally, sectorally, and geographically diverse that uniform compliance with any particular governance decision is likely to be impossible. Despite a fairly broad, global consensus against reproductive cloning, for example, it is inevitable that humans will be cloned at some point simply because the state of the science will allow it to be accomplished. Similarly the vast commercial potential for a wide variety of genetic enhancement and germline interventions is likely to be attractive enough to ensure that they will be aggressively pursued somewhere. Of course this likelihood neither justifies participation in such research, nor implies that restraint is without value. For example, the choice not to engage in some lines of research may allow particular nations or cultures to protect cherished values, and could influence choices made by other nations in the more distant future. Moreover, by slowing the advance of science in some areas (just as progress toward reproductive cloning has been slowed), society affords itself more time to develop effective principles and regulations for governance of such unprecedented innovations.

Modulation, not Control

Thus while science is, and will remain, a highly governed activity, this governance should not be confused with control. Rather it is a process by which the momentum and direction of scientific advance are subject to some degree of modulation via human decision making. Particular governance decisions may (or may not) be wise, may (or may not) reflect a commitment to the common good, and so on. The point of this entry is simply to explain that such decisions cannot and *therefore should not* be avoided. As science acquires the capacity to reengineer humanity itself, the choice to slow down, or orient this capacity in particular directions while avoiding others, remains open, but the balance among the attraction of commercial opportunities, the prerogatives claimed on behalf of the Republic of Science, and ethical concerns about the appropriate limits of science remain to be negotiated.

DANIEL SAREWITZ

SEE ALSO *Atlantis, Old and New; Poliical Economy of Science and Technology; Political Risk Assessment.*

BIBLIOGRAPHY

Bush, Vannevar. (1945). *Science the Endless Frontier*. Washington, DC: Government Printing Office. Also available from www.nsf.gov/od/lpa/nsf50/vbush1945.htm. The seminal science policy document of the twentieth century.

Fukuyama, Francis. (2002). *Our Posthuman Future: Consequences of the Biotechnology Revolution*. New York: Farrar, Straus and Giroux. Conservative political theorist who argues that the implications of biotechnology demand to be regulated.

Greenberg, Daniel S. (1967). *The Politics of Pure Science*. New York: New American Library.

Greenberg, Daniel S. (2001). *Science, Money, and Politics. Political Triumph and Ethical Erosion*. Chicago: University of Chicago Press. Along with his earlier book, provides detailed chronicles of the political realities that underlies the "purity" of science.

Kevles, Daniel J. (1987). *The Physicists: The History of a Scientific Community in Modern America*. Cambridge, MA: Harvard University Press.

Kitcher, Philip (2001). *Science, Truth, and Democracy*. Oxford and New York: Oxford University Press. Elegant treatment of the role of human choice in determining the structure of scientific inquiry.

Merton, Robert K. (1942). "The Normative Structure of Science." *Journal of Legal and Political Sociology* 1: 115–126. Classic discussion of the internal cultural norms of science.

National Science Foundation. (2004). "Science and Technology: Public Attitudes and Understanding." In *Science and Engineering Indicators*. Arlington, VA: National Science Foundation, Division of Science Resources Statistics. Also available from http://www.nsf.gov/sbe/srs/seind04/c7/c7s3.htm#c7s3l20. Comprehensive compilation of data about the scientific enterprise.

Polanyi, Michael. (1962). "The Republic of Science: Its Political and Economic Theory." *Minerva* 1(1): 54–73. Classic statement of the argument for scientific autonomy.

Polanyi, Michael. (1964). "Background and Prospect." In *Science, Faith and Society*. Chicago: University of Chicago Press.

Sarewitz, Daniel. (1996). *Frontiers of Illusion: Science, Technology, and the Politics of Progress*. Philadelphia: Temple University Press.

Sarewitz, Daniel. (2003). "Science and Happiness." In *Living with the Genie: Essays on Technology and the Quest for Human Mastery*, eds. Alan Lightman, Daniel Sarewitz, and Christina Desser. Covelo, CA: Island Press.

Stock, Gregory. (2003). *Redesigning Humans: Choosing our Genes, Changing our Future*. Boston: Mariner Books.

U.S. House Science Committee. (1998). *Unlocking our Future: Toward a New National Science Policy*. Washington, DC: Author. Policy report of September 24. Also available from http://www.house.gov/science/science_policy_report.htm.

Wolbring, Gregor. (2003). "Confined to Your Legs." In *Living with the Genie: Essays on Technology and the Quest for Human Mastery*, eds. Alan Lightman, Daniel Sarewitz, and Christina Desser. Covelo, CA: Island Press. Provocative inquiry into the implications of human biotechnology, from the perspective of a disabled person.

Woodward, Beverly. (1999). "Challenges to Human Subject Protection in US Medical Research." *Journal of the American Medical Association* 282(20): 1947–1952.

GRANT, GEORGE

Philosopher and Canadian nationalist, George Grant (1918–1988), born in Toronto, Ontario on November 13, rose to prominence in the 1960s through his concern that the homogenizing nature of modern technology would lead to the destruction of Canadian independence. He came from a family of prominent Canadian educators. A Rhodes scholar, Grant taught at Dalhousie University in Halifax, Nova Scotia, and McMaster University in Hamilton, Ontario. His meditations on the character of technology led to election to the Royal Society of Canada, several honorary degrees, and an appointment to the Order of Canada.

Grant saw the origins of the Western predicament as follows: Natural law philosophers such as philosopher and religious Thomas Aquinas (c.1225–1274), following the tradition of antiquity, taught that there were moral laws beyond space and time that were absolutely and universally binding on all human beings. In the seventeenth century a British philosopher, Francis Bacon (1561–1626), envisaged a radically new scientific project equally binding: In the future, science was to make human beings the masters of nature. Their moral authority for this dominion was enhanced by the eighteenth century philosopher Immanuel Kant (1724–1804), who maintained that the essential characteristic of human beings was their freedom and that they were bound only by moral rules to which they had freely assented. Aquinas, Bacon, and Kant together had forged the modern world.

Each of their positions seemed, by itself, true and necessary for human well-being. Yet they were, in principle and in practice, incompatible. Grant's philosophical contribution was to reveal the implications of these contradictions and alert his contemporaries to the need for a resolution. Grant was genuinely perplexed. As his early writings show, he understood technology as the dominance over human nature, but the tools it developed—the automobile, the washing machine, penicillin—led to genuine improvements in the human condition and in human freedom. Yet the same technology also brought the holocaust and the atomic bomb. He laid out these contradictions in his first important work, *Philosophy in the Mass Age* (1958), but offered no resolution.

Grant's View of Technology

One quality of modern technology, Grant came to understand, lay in its tendency to impose uniformity. The French philosopher Alexander Kojève (1902–1968) theorized that the whole world was moving relentlessly toward a universal and homogeneous state. For Kojève such an outcome was desirable, since it was a prelude to a universal peace where war between classes or nations no longer existed. In the work that made him famous throughout Canada, *Lament for a Nation* (1965), Grant accepted this understanding of the impact of technology, but for him it was not a cause to rejoice. He maintained that Canada's geographical position next to the dynamic center of technological modernity, the United States, would lead to its eventual disappearance as a independent country, since Canadians and Americans shared the same commitment to technological modernity. "Our culture floundered on the aspirations of the age of progress." (Grant 1965, p. 54)

In *Technology and Empire* (1969), Grant's concerns about the dangers of technology became more intense. Science, he now argued, no longer limited itself to the domination over non-human nature; it now increasingly attempted domination over human nature as well. Some critics of technology believed that it was something *out there* that people could control should they so choose. Grant rejected this view. For him technology was not something outside of people that they could choose to use for good or ill. Human beings lived in a society (and increasingly a world) in which technology determined all existence. "For it is clear that the systematic interference with chance was not simply undertaken for its own sake but for the realisation of freedom . . . [but] how do we know what is worth doing with that freedom?" (Grant 1969, p. 138).

The predicament of modernity was that those men and women who were the driving forces behind technological modernity believe that their project promotes "the liberation of mankind" (Grant 1969, p. 27). The older tradition of Plato, Aristotle, and Aquinas held that there were some things that it was absolutely wrong to do and perhaps even wrong to contemplate. By contrast Grant often attributed to J. Robert Oppenheimer (1904–1967) the view that, in modern science, no matter how terrible the possible outcome of an experiment might be, if you see that something is technically balanced, you do it.

When asked whether computers were neutral instruments, Grant observed that their existence required the work of chemists, metallurgists, and mine and factory workers; the use of algebra and other mathematics, Newtonian and other physics, and electricity; as well as a society in which there are many large corporations. Such a society contains an elite trained to think in a particular way and excludes other forms of society. Technology can never be neutral because of its historical, social, and conceptual preconditions.

Technology for Grant, then, was not just a way of making things or even a way of doing business. It was a way of thinking and it was becoming a way of being. So when the U.S. Supreme Court handed down its historic decision in *Roe* v. *Wade*, 410 U.S. 113 (1973), an abortion case, Grant was profoundly worried. The account of justice given there, influenced as he thought by technological modernity, seemed to put into question what it was to be a person. Consequently modern liberalism seemed unable to answer the question: "What is it about any members of our species that makes the liberal rights of justice their due?" (Grant 1998, p. 78).

Grant never denied that science had delivered the dominance over nature it promised, but it failed in a much more important way. "Brilliant scientists have laid before us an account of how things are, and in that account nothing can be said about justice." (Grant 1986, p. 60) But above all justice mattered. In his last book, *Technology and Justice* (1986), he argued that the technological understanding of the world was fundamentally flawed. Love was a primary fact of human existence; modern human beings "cannot hold in unity the love they experience with what they are being taught in technological science" (Grant 1986, p. 67).

Grant's writings still actively influence Canadian politicians, political scientists, theologians, and scholars interested in technology. Most philosophers are indifferent or hostile.

WILLIAM CHRISTIAN

SEE ALSO *Ellul, Jacques; Heidegger, Martin; Justice.*

BIBLIOGRAPHY

Athanasiadis, Harris. (2001). *George Grant and the Theology of the Cross: The Christian Foundations of His Thought*. Toronto: University Of Toronto Press. Grant's critique of technology was rooted in a sincere and original theological vision. This work examines Grant's philosophy in relation to his understanding of Martin Luther.

Christian, William. (1993). *George Grant: A Biography*. Toronto: Univeristy of Toronto Press. A comprehensive scholarly biography of Grant that made extensive use of archival sources, letters, and personal interviews.

Grant, George. (1965). *Lament for a Nation*. Toronto: McClelland & Stewart. Grant's masterpiece, a complex interweaving of politics, philosophy, and religion that made him a nationally known figure. It explored the idea that technological modernity would lead inexorably to the destruction of Canadian independence.

Grant, George. (1969). *Technology and Empire*. Toronto: House of Anansi. The collection of essays that contained Grant's most concentrated meditations on technological modernity. In these essays Grant came increasingly to see technology in metaphysical terms. He saw it as darkness that prevented human beings from being aware of the absence of divine light in the world.

Grant, George. (1986). *Technology and Justice*. Toronto: House of Anansi. Grant's last collection of essays and his most positive affirmation that Simone Weil's understanding of love shows human beings an alternative to technological modernity.

Grant, George. (1995). *Philosophy in the Mass Age*, ed. William Christian. Toronto: University of Toronto Press. Grant's first book, originally a series of radio lectures, explored the problems of technology as they were arising in the aftermath of the second world war and the new materialism of the 1950s.

Grant, George. (1998). *English-Speaking Justice*. Toronto: House of Anansi. After the *Roe* v. *Wade* decision, Grant worried that technology threatened the very idea of what it was to be human. This work, written in the mid-1970s, attempts an examination of implication of the U.S. Supreme Court's ruling.

GREEN IDEOLOGY

Green is the color of vegetation, in particular of healthy, growing leaves. At least in the growing season it is the predominant color of undeveloped land in nonpolar, non-arid regions. Green as a quality of the landscape was what was destroyed or threatened by the Industrial Revolution in Britain. Thus William Blake, in the poem that has become the hymn *Jerusalem*, contrasted the *green and pleasant land* that England should be with the *dark satanic mills* of his time (early-nineteenth century). And Richard Llewellyn's 1939 novel *How Green Was My Valley* tells the heartbreaking story of the gradual transformation of a rural landscape, where young boys caught trout in the river, to a polluted industrial wasteland where the wastes from coal mining, dumped on the sides of the narrow South Wales valley, threatened to engulf the miners' houses.

Green as undeveloped land, free from industry, is what is evoked by the term *green belt*. Green belt is a planning designation of land around cities or towns intended to prevent urban sprawl, for the benefit of both city and countryside. Green belt land is to be permanently *open*, the presumption being against built development except in special circumstances (UK Office of the Deputy Prime Minister 2001).

Because green is the color of vegetation, and thus plants, it has been linked with agriculture. *Green Europe* was a newsletter on the European common agricultural policy, published by the European Commission. The *green revolution* of the late-1960s and 1970s was about increasing crop yields through the development of new varieties that required high inputs of fertilizers and pesticides. That this form of agriculture was, by the 1990s, considered very un-green is a sign that between the 1970s and 1990s green took on a particular political and philosophical meaning.

Greenpeace was the name taken by a small band of nonviolent, direct activists who, in 1971, tried to take a small boat to Amchitka, an island off the west coast of Alaska where the United States was conducting underground nuclear tests. Greenpeace subsequently became a major environmental nongovernmental organization, campaigning for a *green and peaceful future*. What Greenpeace sees as at stake, threatened by modern technology and economic growth, is not simply a green and pleasant countryside but *the ability of the Earth to nurture life in all its diversity*.

The first political party that took the name *Green* was the West German Green Party, *Die Grünen*. The federal party was formed at the beginning of 1980, but was preceded by numerous local or state-level groups that put up Green or *Rainbow* lists of candidates for elections and, in the case of Bremen Green Slate, won seats in the state parliament. The 5 percent barrier to representation under the West German system of proportional representation meant that there was considerable incentive for a wide variety of different groups to come together as Die Grünen in order to achieve political representation. These groups included those concerned with environmental pollution, protestors against nuclear power, feminists, Marxists, and socialists disillusioned with the Social Democratic Party. They united under the four pillars of ecology, nonviolence, social justice, and grassroots democracy, which have since come to define what it means to be Green.

In the federal elections of 1983 Die Grünen won 5.6 percent of the vote and sent twenty-seven members to the Bundestag. Following this success, parties in other countries with similar philosophies, such as the Ecology Party in the United Kingdom, changed their name to the Green Party. Green parties were also started in other countries, including the United States in 1984. The word *green* evokes rejection of industrialization and protection of life in all its diversity, but also freshness, immaturity, and naivety. The Greens have thus proclaimed themselves to be a fresh force in electoral politics, different from the political elites of the *grey* parties, who the public view as increasingly remote and answerable only to vested interests. Although Greens are often charged with being unrealistic, it is a measure of their success that being green no longer means being naïve.

Newness is also encapsulated in the idea that Green is *neither left nor right but forward*. The influence of anarchism on Green ideology and the resulting rejection of hierarchical structures, results in an emphasis on individual responsibility and initiative akin to that of the right. Greens can also be seen as conservative with respect to technology. They are often skeptical about new technologies that traditional socialism welcomes as enhancing human capacities, defending older technologies and smaller, close-knit communities, though they welcome other innovations, such as solar power and modern wind turbines. However, in their critique of capitalism and the free market, the Greens are firmly on the side of the left. What is new in the green critique is the emphasis on environmental limits: It is the environmental crisis, not the suffering of the proletariat, that makes it imperative to move toward a different economy, technology, and society. This new green society will protect the planet by respecting nature—ecosystems, non-human species, and the rights of animals—and will also be better for the health and well being of humans and their communities.

Green politics and philosophy presents a holistic vision in which monetary reform, participative democracy, meaningful work, social justice, and equality are all of a piece with renewable energy, organic agriculture, protection of wildlife, recycling, and non-polluting technologies. This vision can be sought by the green consumer as well as the voter through boycotting certain goods and buying others (Elkington and Hailes 1988).

Despite this broad holism, green is narrowed in many instances to refer simply to reduced environmental impacts. Thus *green travel plans*, now a condition of many planning permissions in the United Kingdom, are plans introduced by employers to attempt to reduce the use of car transport by their employees. A *green building* is one designed to have reduced impact on the environment during its construction and use.

ANNE CHAPMAN

SEE ALSO *Earth; Ecology; Environmental Ethics; Environmentalism; Green Revolution.*

BIBILOGRAPHY

Dobson, Andrew. (2000). *Green Political Thought*, 3rd edition. New York: Routledge. One of the many publications giving an account of green political thought and philosophy.

Elkington, John, and Julia Hailes. (1988). *The Green Consumer Guide*. London: Victor Gollancz.

Spretnak, Charlene, and Fritjof Capra, in collaboration with Rudiger Lutz.. (1984). *Green Politics: The Global Promise*. London: Paladin. An early account of Green politics in West Germany and the prospects for it in the rest of Europe and North America

INTERNET RESOURCES

Greenpeace. (2005). Available from www.greenpeace.org.

UK Office of the Deputy Prime Minister. "Planning Policy Guidance 2: Green Belts." Available from http://www.odpm.gov.uk/stellent/groups/odpm_planning/documents/page/odpm_plan_606905.hcsp.

GREEN REVOLUTION

The Green Revolution (not to be confused with "green" as in the environmental movement) was a dramatic increase in grain yields (especially wheat and rice) in the 1960s and 1970s, made possible by the Rockefeller Foundation's development of high-yielding wheat and rice varieties starting in the 1950s. The moral good of producing more food seems unquestionable. Indeed, Norman Borlaug (b. 1914), the scientist who spearheaded the Green Revolution, received the 1970 Nobel Peace Prize for his work. Yet the Green Revolution did spur ethical disputes over the social and environmental changes its technologies produced, especially in the developing world. Proponents argued that increased food supply benefited society generally; opponents pointed to the ways that poorer segments of societies were disproportionately hurt by the Green Revolution. In the early twenty-first century, Green Revolution technologies continue to promote conflict between those who see them as tools in service of society and those who argue that they promote injustice.

Competing Views of Development

The controversy over the social justice of the Green Revolution was apparent from the start of the Rockefeller Foundation work in Mexico. Encouraged by U.S. Vice President Henry Wallace, the Rockefeller Foundation in 1941 offered to send agricultural advisors to Mexico to help improve its wheat crop. The Rockefeller family had both a history of humanitarian work and valuable oil properties in Mexico. Both the family and Wallace were concerned about increasing social unrest in Mexico and sought solutions that would not reawaken interest in the previous Mexican administration's attempts to redistribute land to the poor (Wright 1990). The Rockefeller Foundation officers believed that they could stabilize Mexican society by increasing the supply of cheap, domestically-grown food. The Rockefeller Foundation's survey team of cutting-edge agricultural scientists, including plant breeders and agricultural chemists, unsurprisingly advocated technologies that had proved successful in the United States: the development of new, high-yielding varieties of major crops. North American farmers had profited from this system, despite the increased cost of purchasing new seed stock every year, and Rockefeller expected the same results of *modernization* in Mexico (Fitzgerald 1986).

Critics attacked the plan as inappropriate for small farms, which they believed ought to be the target of any agricultural improvement in Mexico. Carl Sauer, a geographer from the University of California Berkeley, argued that the plan would be disastrous for the peasant economy of Mexico, as peasant farmers would be unable to standardize on expensive new seeds. Other critics argued that by excluding experts on Mexican society from the survey team, Rockefeller risked forcing an inappropriate scientific solution on Mexico. The Rockefeller team fired back that Sauer and other critics simply wanted to keep Mexico backward, and were unwilling to let it modernize (Wright 1990).

Behind this sniping was a fundamental disagreement over how to benefit Mexican society. For Rockefeller's critics, improvement had to target economically-pressed peasants to be beneficial. Rockefeller argued Mexico had to rapidly start producing more food, using the best science and technology available. For Rockefeller, *modern* evoked the moral superiority of doing whatever was necessary, socially or technologically, to produce increases in the food supply. Critics argued that the science and technology should be *appropriate* for the majority of Mexican farmers. Both held moral commitments, but to different visions of the Mexican future.

Expected and Unexpected Consequences

Rockefeller adopted the survey team's recommendations. Borlaug's group employed traditional and novel scientific methods to produce high-yielding semidwarf wheat varieties that exceeded all expectations. Semidwarf varieties are stalky plants that can hold a heavy head of grain. These varieties, used with plentiful water, fertilizers, and pesticides, produced dramatically high crop yields. Interest in semidwarf varieties spread quickly, especially where food security was a concern. The Indian government asked Borlaug to help it develop wheat varieties for India; these were ultimately credited with preventing a major famine (Perkins 1997). Governments lauded the social good of the technology that allowed them to import less food despite growing populations and green revolution science was soon extended to other staple grains, especially rice. Rice-producing countries around the world adopted these new rice varieties as readily as had wheat producers. Those who adopted Green Revolution technologies often experienced increases in their standards of living, although in some places, government-mandated food prices sometimes undercut the economic benefits of higher yields (Leaf 1984).

The fears of critics were also realized, especially in the early years. Medium-sized and large farms could adopt the new technologies easily, and their high yields led to declining food prices. While urban populations benefited, small farmers watched the profits from their own harvests decrease. Some smaller farmers were able to adopt the technologies and improve their standards of living, but others were forced into rural labor or to move to the cities. Because people went hungry despite growing food supplies, critics argued that the Green Revolution could create food, but not relieve hunger (Sen 1981). They pointed to regional inequities, as areas suited to Green Revolution grains and favored by government attention flourished, while poorer regions fell behind. For critics, the Green Revolution failed the test of social justice (Shiva 1991).

Later, unanticipated environmental effects fed ongoing debates about social justice. The issue of monocropping highlights the environmental angle. Monocropping (producing a single crop in a field) helps produce uniform, high-yielding crops. However, it also produces microenvironments in which crops are more vulnerable to insects. Scientists responded by recommending heavy use of pesticides, with serious systemic consequences: sometimes toxic levels of pesticide exposure for farm laborers (who were often those disenfranchised by the Green Revolution), and rapid adaptation by insects requiring constant innovation and resulting in higher prices. Extensive monocropping sometimes led to less diversity in local food supplies, which critics have argued disproportionately affected the nutrition of the poor. In Green Revolution areas, the poor have come to depend almost exclusively on grains, decreasing the nutritional value of their diet (Shiva 1993). In each critique, the question of justice, whether for the poor or for future generations, is the central concern.

Reconsiderations

The attention that critics have paid to social justice, while sometimes questioned by supporters of the Green Revolution, have not fallen on deaf ears. The agency responsible for the scientific development of Green Revolution crops, the Consultative Group on International Agricultural Research (CGIAR), has responded vigorously. Scientists have decreased the amounts of pesticide needed, reducing risk to farm workers and lowering the cost of inputs. They increased the number of food crops for which they have developed high-yielding varieties, including some crops traditionally cultivated by the poor. Scientists have given attention to developing high yielding crops using less water, an important consideration in arid regions. In the 1990s, scientists began to research ways to introduce Green Revolution technologies to the poor regions of Africa that had been previously bypassed.

Advocates have also argued that making Green Revolution technologies socially just is not only the responsibility of scientists, but also of regional and national governments (Hazell 2003). In places where agricultural credit is accessible, more small farmers have been able to retain or expand their land and benefit from the technologies. Such efforts are not lost on critics, but neither have they quieted the criticism that Green Revolution technologies promote injustice. Supporters are equally steadfast that Green Revolution technologies produce social goods that outweigh shortcomings. A widely agreed-upon ethical judgment of the Green Revolution remains unlikely, because the complex social and environmental consequences of this technology continue to unfold.

SUZANNE M. MOON

SEE ALSO *Agricultural Ethics; Food Science and Technology; Green Ideology; Modernization; Poverty.*

BIBLIOGRAPHY

Fitzgerald, Deborah. (1986). "Exporting American Agriculture: The Rockefeller Foundation in Mexico, 1943–53." *Social Studies of Science* 16: 457–483. Historical look at the work of the Rockefeller Foundation during their earliest interventions in Mexico, exploring the reasons that they based their recommendations to Mexico on the "best practice" of U.S. agricultural science.

Hazell, Peter B. R. (2003). "Green Revolution, Curse or Blessing?" In *The Oxford Encyclopedia of Economic History*, ed. Joel Mokyr. Oxford, UK: Oxford University Press. A critical evaluation of the economics of the Green Revolution that argues that poverty reduction through Green

Revolution technologies is possible when appropriate government policies and credit programs are in place.

Leaf, Murray J. (1984). *Song of Hope: The Green Revolution in a Punjab Village*. New Brunswick, NJ: Rutgers University Press. An anthropological study of a Punjab village that explores the positive social and economic changes of the village since the introduction of Green Revolution technologies.

Perkins, John H. (1997). *Geopolitics and the Green Revolution: Wheat, Genes, and the Cold War*. New York: Oxford University Press. A comprehensive history of the science and politics of the Green Revolution focusing on wheat production.

Sen, Amartya K. (1981). *Poverty and Famines: An Essay on Entitlement and Deprivation*. Oxford, UK: Clarendon. Examines connections between food availability, poverty, and the occurrence of famine. Questions whether increases in the food supply eliminate famine.

Shiva, Vandana. (1991). *The Violence of the Green Revolution: Third World Agriculture, Ecology, and Politics*. Penang, Malaysia: Third World Network. Examines the socioeconomic results of the Green Revolution and argues that it does too much harm to poor communities.

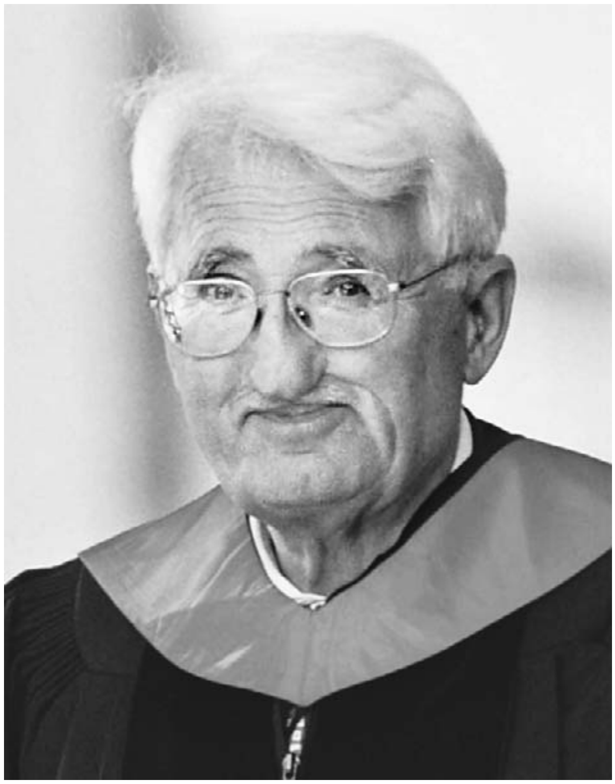
Shiva, Vandana. (1993). *Monocultures of the Mind: Perspectives on Biodiversity and Biotechnology*. London: Zed Press. A critical examination of the issue of monocropping, why it appeals, and its shortcomings as a model for agriculture.

Wright, Angus. (1990). *The Death of Ramón González: The Modern Agricultural Dilemma*. Austin: University of Texas Press. A study of agricultural change in Mexico focusing on sociopolitical background and consequences of the Green Revolution.

H

HABERMAS, JÜRGEN

Jürgen Habermas (b. 1929) was Germany's foremost social theorist and philosopher in the second half of the twentieth century. Born in Düsseldorf, Germany, on June 18, Habermas is the leading representative of the second generation of the so-called Frankfurt School of critical social theory, taking inspiration from Max Horkheimer, Theodor Adorno, and Herbert Marcuse. At the same time Habermas was strongly influenced by the linguistic turn in analytic philosophy from Ludwig Wittgenstein to John L. Austin and John Searle, as well as by the classics of German thought from Immanuel Kant and Georg W. F. Hegel to Karl Marx and Max Weber. In his magnum opus, *The Theory of Communication Action* (1981), Habermas explained the genesis of modern society in terms of basic categories derived from the philosophical study of language and rationality. This analysis reveals that the processes of rationalization characteristic of modernity have been crucially one-sided, privileging the *instrumental* or *strategic rationality* of selecting the most effective means to ends at the expense of the *communicative rationality* of reaching a shared understanding of ends on the basis of reasons that everyone can accept in free discussion.



Jürgen Habermas, b. 1929. The German philosopher and sociologist challenged social science by suggesting that despite appearances to the contrary, human beings are capable of rationality and under some conditions are able to communicate with one another successfully. *(© Darren McCollester/Getty Images.)*

Science, Technology, and Politics

A central strand in Habermas's narrative of modernity is thus the intrusion of quasinatural scientific and technological imperatives into the realm of politics. This raises the practical and theoretical issue of the proper relationship between science and politics. Habermas outlines three possible views of this in his early "Technology and Science as 'Ideology'" (1968). On Weber's *decisionistic* model, there is a strict separation between the functions of the politician and the expert: The former makes decisions on the basis of values that are at bottom irrational and the latter carries them out as effectively as possible on the basis of scientific knowledge. *Technocrats*, in contrast, see contemporary politics as bound by objective exigencies of preserving the stability of the system. Experts present policy alternatives as necessary for the achievement of goals like economic growth that are presumed to be grounded in objective needs. Thus whereas decisionists see values as irrational, technocrats consider them irrelevant.

But *techne* cannot be substituted for praxis. Needs must be interpreted in the light of values and cultural meanings before they can guide action. Habermas prefers, therefore, the third, *pragmatist* model of John Dewey. Means and ends are interdependent: On the one hand, the horizon of values in a society guides scientific research, on the other, value convictions persist only insofar as they are connected to potential satisfaction through instrumental action. Consequently technology cannot be value-neutral. Practically relevant scientific achievements must be subjected to free public discussion to make possible a "dialectic of enlightened will and self-conscious potential" (Habermas 1970, p. 73) that both allows new technologies to alter public self-understanding and lets that self-understanding determine the course of future research. Insofar as such discussion is governed by the "unforced force of the better argument," it yields decisions on ends that are rational in a sense decisionists failed to recognize.

Such domestication of technological development is impossible if technology as such amounts to ideology. Marcuse claimed that this is indeed the case since the progress of science and capitalism had undermined the legitimacy once enjoyed by religion and tradition. In partial agreement, Habermas argues in *Knowledge and Human Interests* (1968) that empirical science as such is bound up with an anthropologically deep-seated (and therefore *quasitranscendental*) *technical interest* in potential control and manipulation that is constitutive of its object domain. In contrast to Marcuse, however, he sees this interest as invariant, since it is rooted in the universal conditions of material reproduction of human life. As a result, there is no such thing as *alternative science*.

Normative Issues

Where, then, does one find the normative resources to counteract the insidious form of social domination that legitimizes existing inequalities with an appeal to scientific (such as economic) necessity and placates the public with commercialized mass media and slow but steady growth in material comfort brought about by technological development? Habermas's strategy in his early work is to locate two equally fundamental human cognitive interests pertaining to interaction rather than work. As social beings whose very identity depends on mutual recognition in linguistic interaction, people have a *practical interest* in solving problems of communication and understanding within and between traditions. This is the task of the hermeneutic or cultural sciences (*Geisteswissenschaften*). The *emancipatory interest* in countering the effects of *systematically distorted communication* through critical reflection is exemplified on the individual level by psychoanalysis and on the social level by critique of ideology that reveals the particular economic, political, and social interests that bias self-understandings embedded in human traditions. The ideological aspect of positivist views of science and technology consists in conflating the practical with the technical and thus obscuring the possibility of rationalization along these other dimensions. The problem is the universalization of instrumental thinking, not instrumental thinking itself.

In later work, Habermas replaces appeals to interests with references to the necessary structures of communication elaborated in *formal pragmatics*, but he remains concerned with the effects of technology on human interaction. *The Future of Human Nature* (2001) addresses the specific problem of *liberal eugenics*, genetic intervention designed not to prevent health problems but to create abilities that parents consider to be useful for the child. Habermas argues that this is ethically unacceptable. First, knowledge that they have been preformed according to someone else's preferences makes it impossible for children to view themselves as the sole ethically responsible authors of their own lives. Second, such engineering introduces a fundamental, irreversible asymmetry among the programmers and the programmed that is contrary to the basic principles of symmetric mutual recognition among free and equal persons that are grounded in the very structure of linguistic interaction.

In sum, Habermas's key contribution to the ethics of science and technology is a plausible theory of intersubjective rationality. Such rationality does not reduce to instrumental efficiency and can therefore be used to set nonarbitrary goals and limits to technical development, if implemented in suitable democratic institutions.

ANTTI KAUPPINEN

SEE ALSO *Critical Social Theory; Discourse Ethics; Marcuse, Herbert.*

BIBLIOGRAPHY

Habermas, Jürgen. (1968). *Technik und Wissenschaft als 'Ideologie'*. Frankfurt am Main, Suhrkamp. Trans. (in part) by

Jeremy J. Shapiro as *Toward a Rational Society: Student Protest, Science and Politics*. Boston: Beacon Press 1970.

Habermas, Jürgen. (1968). *Erkenntnis und Interesse*. Frankfurt am Main: Suhrkamp. Trans. Jeremy J. Shapiro as Knowledge and Human Interests. Boston: Beacon Press, 1971.

Habermas, Jürgen. (1970). "Technology and Science as 'Ideology.'" In *Toward a Rational Society: Student Protest, Science, and Politics*, trans. Jeremy J. Shapiro. Boston: Beacon Press.

Habermas, Jürgen. (1971). *Knowledge and Human Interests*, trans. Jeremy J. Shapiro. Boston: Beacon Press.

Habermas, Jurgen. (1981). *Theorie des kommunikativen Handelns*. Frankfurt am Main: Suhrkamp. 2 vols. Trans. Thomas McCarthy as *The Theory of Communicative Action*. Vol. 1: *Reason and the Rationalization of Society;* Vol. 2: *Lifeworld and System: A Critique of Functionalist Reason*. Boston: Beacon Press, 1984 and 1987.

Habermas, Jurgen. (1981). *Theorie des kommunikativen Handelns*, 2 vols. Frankfurt am Main: Suhrkamp. Translated by Thomas McCarthy as *The Theory of Communicative Action*, Vol. 1: *Reason and the Rationalization of Society;* Vol. 2: *Lifeworld and System: A Critique of Functionalist Reason*. Boston: Beacon Press, 1984 and 1987.

Habermas, Jürgen. (2001). *Die Zukunft der menschlichen Natur. Auf der Weg zu einer liberalen Eugenik?* Frankfurt am Main: Suhrkamp. Trans. Hella Beister and William Rehg as *The Future of Human Nature*. Cambridge, England: Polity Press, 2003.

Habermas, Jurgen. (2003). *The Future of Human Nature*. Cambridge, England: Polity Press.

McCarthy, Thomas. (1978). *The Critical Theory of Jürgen Habermas*. Boston: MIT Press. A classic study and critique of Habermas's early work that begins with a thorough discussion of his views on the scientization of politics and critique of instrumental reason.

HACKER ETHICS

Originally the term *hacker* was used to refer to someone who is enthusiastic about computing, spends a lot of time figuring out how computers work, and is adept at using computers to accomplish extraordinary feats. *Hacking* referred to the activities of hackers. In the early days of computing hackers were exploring the full potential of computers: They were figuring out what it was possible to achieve with computers, doing things that had never been done before. In this sense hackers were like the imaginative mechanics of the early Industrial Revolution, automotive hot-rodders, barnstorming airplane pilots, and ham radio operators. In those early days there were few laws or policies specifying what individuals were allowed to do or prohibited from doing with computers. Many of the feats that hackers accomplished subsequently became illegal, for example, breaking into private systems, examining what was in those systems and how the systems worked, copying and distributing information and programs, and telling others how to do the same things.

The meaning of the terms *hacker* and *hacking* changed somewhat over time, and *hacker* began to be used to refer to those who engage in illegal computer activity. Many hackers objected to that usage and insisted that a distinction be made between hackers, who are generally law-abiding, and crackers, who use their computer skills to engage in illegal activity. Currently, the term *hacker* is used in both ways. Occasionally the term "hack" is used more broadly to refer to a playful feat involving scientific or technological expertise, for example, when a group of students break into a campus building undetected and leave visible and fanciful evidence of their success at breaking in (Laszlo 2004).

The Hacker Ethic

Individuals who identify with the original concept of hacking continue to exist and share ideas with one another online. They constitute a subculture that has coalesced around computer technology and the Internet. Members of that subculture share an attitude toward computing and a set of beliefs about how computers and the Internet should be used. This attitude and set of beliefs often is referred to as the hacker ethic.

Although expressions of the hacker ethic have varied over time, at the heart of the subculture is a view of the potential of computing that has two elements: the principle that all information should be free and the belief that access to computers should be unlimited. Surrounding these elements are enthusiasm about computing, a sense that computing is fun and even joyful, and the conviction that computing can be used to bring about positive change in the world by countering mainstream trends toward centralization and privatization. On one Internet site (Raymond 2003) the hacker ethic is defined as follows:

1. The belief that information-sharing is a powerful positive good, and that it is an ethical duty of hackers to share their expertise by writing open-source code and facilitating access to information and to computing resources wherever possible.
2. The belief that system-cracking for fun and exploration is ethically OK as long as the cracker commits no theft, vandalism, or breach of confidentiality.

From an ethical perspective the vision put forward by hackers points to the potential of computing to create a world in which there is no gap, or at least a smaller gap, between the haves (information-rich people) and the have-nots (information-poor people) and in which those who have expertise use it to help others. Moreover, insofar as hackers create open source software and encourage data sharing and access to the Internet, their activities can be seen as furthering the potential of computer technology for social good.

Criticisms and Defenses

The activities of hackers become subject to moral criticism only when hackers engage in illegal activity; using more precise terminology, moral questions arise when hackers become crackers. Once the law is broken, cracking behavior is not just illegal but also seems likely to cause others to be treated unfairly and to harm their interests. For example, when hackers launch viruses that disrupt the use of the Internet, their behavior interferes with the activities of innocent users; when they copy and distribute proprietary software, they are violating the legal rights of individuals to own and license software; and when they break into systems and examine files, they are violating the privacy and property rights of others.

In their defense crackers may argue that (1) they are doing no harm, meaning no physical harm to human beings; (2) they are liberating information that should be free; (3) the laws involving computing are bad and even unjust; or (4) they serve in the role of vigilantes testing and revealing the vulnerabilities of computer systems. All these claims rely on the deeper or prior presumption that sometimes it is permissible to break the law.

In moral philosophy and in democratic theory cases of justifiable law breaking are well recognized. The defense of hacking sometimes is couched in terms of civil disobedience. Acts of civil disobedience are those in which an individual refuses to obey a law either because obeying the law would violate the individual's conscience or because an individual wants to protest the law on the grounds that it is unjust. Although there may be particular acts that fit the definition of civil disobedience, in general cracking does not seem to fit into that category. Indeed, most cracker behavior seems difficult to defend, though there may be particular actions that can be justified.

Cracking behavior is difficult to justify because the laws that have been created around computing, though far from perfect, are aimed at defining the rights and responsibilities of users, and once rights and responsibilities are allocated, illegal behavior becomes *prima facie* harmful. Viruses disrupt the activities of computer users and force them to invest more resources (time, effort, and money) in securing their systems, resources that could be used in other ways. Pirating software deprives individuals of their legal rights of ownership. Gaining unauthorized access to systems and files violates privacy and property rights.

In recent years scholars have begun to explore new forms of behavior on the Internet that are related to but different from hacking. For example, the term *hacktivism* is used to refer to activists who use their computer skills to make political statements and protest actions by government or industry; in other words, those persons engage in political activism by using computers. Hacktivism may or may not be illegal depending on the actions taken. *Cyberterrorism*, by contrast, refers specifically to political action that involves violence against persons or property.

DEBORAH G. JOHNSON

SEE ALSO *Association for Computer Machinery; Computer Ethics; Computer Viruses/Infections; Digital Divide; Free Software.*

BIBLIOGRAPHY

Himanen, Pekka. (2001). *The Hacker Ethic and the Spirit of the Information Age*. New York: Random House. A somewhat light look at hackers and what they think and do.

Laszlo, Pierre. (2004). "Science As Play." *American Scientist* 92(5): 398–400.

Levy, Steven. (1994). *Hackers: Heroes of the Computer Revolution*. New York: Delta. This book was one of the first to look at hackers and their place in popular culture; while not current, it is important for understanding the early history of hacking.

Thomas, Douglas. (2002). *Hacker Culture*. Minneapolis: University of Minnesota Press. Provides an in-depth look at hackers with a historical perspective and an emphasis on the place of hackers in popular culture.

INTERNET RESOURCES

Denning, Dorothy. (2000). "Cyberterrorism. Testimony before the Special Oversight Panel on Terrorism, Committee on Armed Services, U.S. House of Representatives, May 23, 2000." Available at http://www.cs.georgetown.edu/~denning/infosec/cyberterror.html. Denning is an expert on cyberspace security and in this testimony speculated on the potential for cyberterrorism.

Raymond, Eric S. (2003). "The Jargon File." Available at www.catb.org/~esr/jargon/. One of many Internet sites that provide definitions and information about cyberculture.

HALDANE, J. B. S.

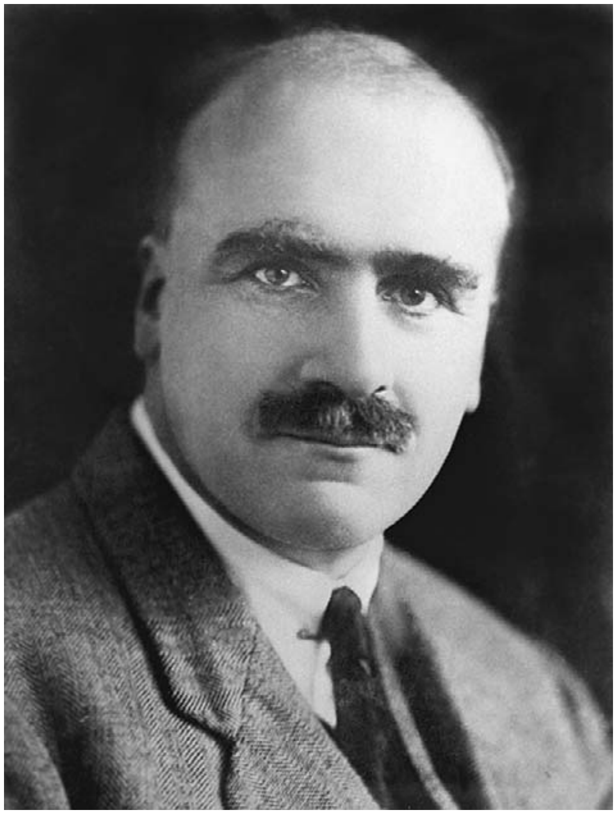
John Burdon Sanderson or J. B. S. Haldane (1892–1964) was born in Oxford on November 5 and, as the author of *The Causes of Evolution* (1932), became a founder of what was later called the modern evolutionary synthesis of population genetics. Haldane was also an influential popularizer of science who in essays, fiction, and even verse emphasized the need to develop an ethical framework within which human beings may assimilate emerging technologies. He died on December 1 in Bhubaneswar, India.

With remarkable prescience, Haldane foresaw discoveries in molecular biology and genetic engineering. In *Daedalus or Science and the Future* (1923), he argued that scientific progress in these areas would bring confusion and misery to humankind unless accompanied by progress in ethics. Ideas from Daedalus influenced his friend Aldous Huxley's novel *Brave New World* (1932), and Haldane served as the model for the biologist in Huxley's *Antic Hay* (1923). Forty years later, in 1963, Haldane also introduced the concept of clonal reproduction that has since inspired much controversy and discussion in bioethics.

Haldane further maintained that science provides at least one of the key ingredients to moral progress, this being high regard for truth and a refusal to jump to unjustifiable conclusions. Indeed in one statement of this agnostic attitude, Haldane suggested that "the Universe is not only queerer than we suppose, but queerer than we can suppose" (1927, p. 298).

Haldane's views in regard to the ethical influence of science were opposed by Bertrand Russell (1872–1970) in *Icarus or the Future of Science* (1924). Russell argued that technical scientific knowledge does not make people more sensible in their aims or more self-controlled and kind. In his advocacy of a science-based ethical framework, Haldane thought that science would exert an essentially progressive influence on society and politics, and that general agreement could be reached on conceptions of the good, a view that remains highly controversial.

Seeing it in part as a bridge between science and ethics, Haldane was also for years attracted to Marxist Communism, which he embraced during the 1930s. He later abandoned this affiliation when the science of genetics was suppressed in the Soviet Union under the direction of Trofim Lysenko (1898–1976). Ironically that crisis proved one of his own predictions about Soviet science, that "there is . . . a very grave danger for science in so close an association with the State . . . it may lead to dogmatism in science and to the suppression of opinions which run counter to official theories. . . ." (1932, p. 225.)



J. B. S. Haldane, 1892–1964. Haldane was an English biologist who utilized mathematical analysis to study genetic phenomena and their relation to evolution. *(The Library of Congress.)*

Another essay by Haldane, "On Being the Right Size" (1927), virtually created analytic morphology. By pointing out, for instance, that exoskeletons can only get so large before the internal organs collapse under their own weight, this essay has influenced fields as diverse as the criticism of mass urbanization, the alternative technology movement, and decentralized economics.

Also important is the fact that Haldane conducted many scientific experiments on himself (Dronamraju 1968, p. 267–275). His ethics precluded making others the subject of experiments when he himself could serve that role, a practice also followed by his father, Oxford physiologist John Scott Haldane (1860–1936).

Throughout his life Haldane emphasized how science and technology create new ethical situations, although different sciences impact ethics in different manners. Physics and biology affect our ethical outlook by altering views about the fundamental nature of the world and the interrelationships between all living beings. For Haldane, Darwinian evolution imposes a new set of ethical values on the relationship between humans and other species. Anthropology shows that any given ethical code is only one of a number practiced with equal conviction and almost equal success. Advanced communication technologies create new duties by pointing out previously unexpected responsibilities for world events.

In 1957 Haldane moved to India, where he was deeply influenced by Hinduism. He saw the Darwinian theory of evolution from a fresh perspective, noting that Christian theologians had drawn a sharp distinction between humans and other species, whereas no such distinction had been made in India. According to Hindu, Buddhist, and Jain ethics, for instance, animals have rights and duties, and the adherents of these religions are duty-bound to adopt a non-violent approach to biological research. He followed this principle in directing the research of his students in India in animal behavior, genetics, human genetics, and the biometry of both animal and plant species.

KRISHNA R. DRONAMRAJU

SEE ALSO *Brave New World; Posthumanism; Russell, Bertrand.*

BIBLIOGRAPHY

Clark, Ronald William. (1984). *J. B. S.: The Life and Work of J. B. S. Haldane.* New York: Oxford University Press. An extended biography.

Dronamraju, Krishna R. (1985). *Haldane: The Life and Work of J. B. S. Haldane with Special Reference to India.* Aberdeen: Aberdeen University Press. An account of Haldane's life and work in India.

Dronamraju, Krishna R. (1995). *Haldane's Daedalus Revisited.* Oxford: Oxford University Press.

Dronamraju, Krishna R., ed. (1968). *Haldane and Modern Biology.* Baltimore: Johns Hopkins University Press. A memorial tribute by distinguished colleagues.

Haldane, J. B. S. (1923). *Daedalus, or Science and the Future.* London: Kegan Paul.

Haldane, J. B. S. (1927). *Possible Worlds and Other Essays.* London: Chatto & Windus.

Haldane, J. B. S. (1932a). *The Causes of Evolution.* London: Longmans. Reprinted by Princeton University Press (1990). Established the foundation for the synthetic theory of evolution.

Haldane, J. B. S. (1932b). *The Inequality of Man and Other Essays.* London: Chatto and Windus. A collection of some of Haldane's outstanding popular essays.

Haldane, J. B. S. (1959). "An Indian Perspective of Darwin." *Centennial Review* 3: 357–363. Theory of evolution from a Hindu point of view.

Haldane, J. B. S. (1963). "Biological Possibilities for the Human Species in the Next Ten Thousand Years." In *Man and His Future,* ed. Gordon Wolstenholme. Boston: Little Brown.

Haldane, J. B. S. (1964). "The Implications of Genetics for Human Society." In *Genetics Today: Proceedings of the 11th International Congress of Genetics,* vol. 2, ed. S. J. Geerts. Oxford: Pergamon Press.

Haldane, J. B. S. (1985). *On Being the Right Size and Others Essays,* ed. John Maynard Smith. New York: Oxford University Press. Reprints the influential essay "On Being the Right Size" (1927).

Russell, Bertrand. (1924). *Icarus or the Future of Science.* London: Kegan Paul.

HARDIN, GARRETT

Garrett James Hardin (1915–2003), born in Dallas, Texas, on April 21, was sometimes called the "father of human ecology" for his efforts to popularize a biological understanding of human beings that also draws out ethical implications. He was a strong advocate for controlling population growth and limiting immigration into the United States, because of the ecological implications of these issues. His two best-known essays, "The Tragedy of the Commons" (1968) and "Lifeboat Ethics" (1972), in their description of a problem and presentation of a response, became standard points of reference in bioethics broadly construed. Hardin died in Santa Barbara, California, on September 14.

Hardin earned a B.A. in zoology (University of Chicago, 1936) and a Ph.D. in microbiology (Stanford University, 1941). His most influential mentors were microbiologist Cornelius Bernardus van Niel (1897–1985) and Nobel Prize–winning geneticist George W. Beadle (1903–1989). In 1946 Hardin accepted an appointment in human ecology at the University of California, Santa Barbara, where he spent the next thirty years of his career, retiring in 1976.

In "The Tragedy of the Commons," which was first published in *Science* magazine and then widely reprinted, Hardin employed the historical analogy of the deterioration of common pasturelands in seventeenth-century England to explore the contemporary problems of resource utilization and environmental pollution. When a common resource such as a pasture that will support three cows in good health is available to three families, any one family is tempted to introduce a second cow, because although now all four cows will, like the pasture, be slightly less healthy, the combined value of two modestly healthy cows is greater than one healthy cow. This tendency to exploit a public good for private gain, when the gain belongs to one person but the cost is shared by all, results in the overgrazing and deterioration of the commons.

To solve this problem, personal property ownership must be introduced so that owners have an interest in maintaining the productive capacity of the land because they now share the full costs of any excessive exploitation. The general principle is that individuals will exploit anything that is free to maximize their own gain, with a cost to society. The commons cannot possibly work once the population has become too great. Hardin applied this principle to human reproduction, arguing that people who have many children are imposing a cost on society that they do not fully bear. Hardin argues that coercion is necessary to reduce reproduction of children, just as the freedom to rob a bank is curtailed by criminal law.

In "Lifeboat Ethics," Hardin argues that immigration is a major cause of population increase in the developed world, and he advocates the reduction of immigration to nearly zero. The analogy is that a lifeboat (developed nation) can hold a certain number of people. If more people (developing nation) climb into a boat that is full (to carrying capacity), the lifeboat sinks and everyone drowns. The rational course of action for those already in the boat is to refuse additional passengers.

This is, Hardin admits, a "tough-love ethics" founded on the principle that Earth has a limited carrying capacity for the size of population it can accommodate. Hardin believes the optimum carrying capacity of the United States was reached in the middle of the twentieth century, and that further increases in population will degrade the quality of human life. As the number of people increases, so do pressures on the natural resource base, resulting in suffering and misery.

A further argument in Hardin's work is that multiculturalism provides another reason to reduce immigration. For Hardin, social disorder is promoted by increasing the diversity of the groups encouraged to reside in the United States: "Diversity within a nation destroys unity and leads to civil wars. Immigration, a benefit during the youth of a nation, can act as a disease in its mature state. Too much internal diversity in large nations has led to violence and disintegration" (Hardin 1993, p. 42).

Hardin's prescription for the Third World population explosion is for First World nations to cease food aid, allowing Third World nations to solve their problem of having exceeded their carrying capacity. Food aid leads to more babies being born and surviving, increasing population size, and requiring more assistance in the future. The only aid First World countries should give to the Third World is information about birth control and contraceptives. If a country is poor and powerless because of too many people, it will become even poorer and more powerless by increasing its population.

Merging biological principles with ethical considerations, Hardin argued for the responsible assessment of the environment to optimize the quality of life for present and future generations. He confronted the human condition and its intricate connection with the natural world in an effort to encourage society to effectively deal with the population-resource equation so that posterity will not be subjected to enforced processes of poverty, starvation, and social disorder.

CRAIG A. STRAUB

SEE ALSO *Environmental Ethics; Population.*

BIBLIOGRAPHY

Hardin, Garrett. (1968). "The Tragedy of the Commons." *Science* 162: 1243–1248.

Hardin, Garrett. (1969). *Science, Conflict and Society*. San Francisco: W.H. Freeman.

Hardin, Garrett. (1993). *Living within Limits*. New York: Oxford University Press.

Hardin, Garrett. (1999). *The Ostrich Factor: Our Population Myopia*. New York: Oxford University Press.

HARDWARE AND SOFTWARE

The invention of the computer hardware/software distinction is credited to computer scientist John Tukey (1915–2000), who also first used the term *bit* for memory capacity. Many think that the difference between hardware and software is obvious. One rule of thumb defines hardware as the computer stuff one can bump into. But others emphasize the logical equivalence of computer hardware and software: "Any operation performed by software can also be built directly into the hardware . . . any instruction executed by the hardware can also be simulated in software." (Tanenbaum 1999, p. 8)

Often computer hardware conjures up an image of a central processing unit (CPU) or a memory chip, not the wire that connects the mouse to a keyboard. But all physical entities that are part of a computer should be considered hardware, although some hardware is more directly involved with the symbol manipulation power of a computer than other hardware.

Tangibility and Functionality

Ruminations about the distinctions between hardware and software can lead to interesting contrasts. The hardware is a machine whose state changes as it operates, but whose form is difficult to change. (A light switch alternates between on and off positions, but one rarely changes its constituent parts.) As it executes, a software program remains static (except for self modifying programs, an exception that proves the rule), but the program causes changes in the hardware state (memory) and external devices (such as printers). And that same software that is static during execution is far easier to change between executions than the hardware that constantly changes its state during execution. To better understand the hardware/software distinction, it is useful to consider three distinct aspects of both: tangibility, functionality, and malleability.

Tangibility: If a computing entity is defined by its physical presence, it is hardware. If an entity is independent of any particular physical form, it is software. Notice that a tangible "hardware" can take many physical forms. The double helix spiral of DNA uses proteins as its hardware. The genetic patterns coded therein are software.

Functionality: If a computing entity has as its primary purpose a physical function, it is hardware. If the entity has as its primary purpose a logical function, it is software. Here "logic" is used to mean symbol manipulation, the transformation of bits according to syntactic and semantic rules. A particular set of bits could mean an integer or printable characters, depending on the rules in force. The bits themselves are represented by hardware, but the rules governing their interpretation are software.

Malleability: If a computing entity is relatively easy to change, it is software. If the entity is relatively hard to change, it is hardware. Of the three aspects, this is the one most in flux. The increasing range of options with respect to malleability has led to an intermediate designation, firmware.

Two early examples of computing illustrate the first two distinctions, tangibility and functionality. The first example is the Jacquard loom, the second a Turing machine.

In 1801 Joseph Jacquard invented a weaving loom using stiff pasteboard cards with holes that controlled rods for each step in the weave. These cards led to the punched cards used by Herman Hollerith for computing machines. Jacquard's physical loom, wood and metal, was hardware. The pasteboard of the punched cards was hardware. But the pattern of holes in the cards, and the desired pattern in the cloth, were software. Even in this *ancient* example of computing, there is an interplay between hardware and software. The software of the weaving pattern is realized in and by the loom hardware. In an almost mystical way, the cloth pattern is in, with, and under its hardware implementation. The threads that go through Jacquard's loom are tangible, and fall under the category hardware. But after the loom does its work, the threads become an embodiment of the software pattern represented (indirectly) by the punched holes in the pasteboard cards.

A Turing machine is a theoretical construct in computer science, and is composed of states, a recording tape, and a read/write head (Turing 1936). A computation proceeds by changing states and by reading and writing symbols to the tape. Turing machines are thought experiments, not physical objects, but *could* be manufactured. A recording head and its tape are tangible hardware with a primarily physical function, the recording of symbols. Whatever medium is used to represent different states inside the Turing machine would also be hardware. But the algorithm embodied in the states and the transitions between them is logical, and software. Note that whatever medium is used to embody an algorithm *is* tangible, but that the algorithm itself does not depend on the details of any particular medium. The same algorithm could simultaneously exist in a human brain, on a piece of paper, and in a Turing machine. Each manifestation would simultaneously be physically different and logically identical.

In the same way that a building embodies an architect's plans, a Turing machine embodies an algorithm. The Turing machine analog to an architectural plan is an algorithm; the Turing machine analog to a building is the Turing machine hardware. The architectural analogy is more apt for a Turning machine than for modern, multipurpose computers, because each Turing machine is customized to a single algorithm. Contemporary computers are far more complex than Jacquard's loom or a simple Turing machine. But the relationship between computer hardware and software is consistent with the relationship illustrated in these examples. In all computing machines, hardware implements software, and the software is embodied in the hardware. The software instructs the hardware, and the hardware manifests the actions described in the software.

Despite these examples, controversies remain. There is not much controversy about some hardware/software distinctions in modern computers. CPUs and memory chips are hardware. The algorithms implemented on that hardware are software. But not everyone agrees on other classifications. For example, some people label data as computer software, whereas others explicitly exclude data from being either computer software or hardware. But source code is a widely accepted example of software, and source code is data to the appropriate interpreter or compiler. If data is not software, then the same program is or is not software, depending on how one looks at it.

Some computing scientists and engineers include designs, user manuals, and online help as software, while others explicitly exclude such entities from consideration. It may be misleading to label all documents associated with a program as software. But designs and specification documents are closely related to algorithms. Some designs can be automatically transformed into machine language with minimal human intervention. It may thus be useful to classify as software documents directly related to program development.

Algorithms used when a computer is powered on are typically stored in special memory devices called read-only memory (ROM), that comes in various forms (PROM, EPROM, and EEPROM). These kinds of devices are easier to change than other hardware but harder to change than programs stored on a hard drive. The term *firmware* was coined to designate this intermediate form of malleability. Malleability (or its opposite, resistance to change) is the third criterion for hardware and software: If a computing entity is easy to change, it is software; if an entity is difficult to change, it is hardware; and if it is intermediate in this aspect, it is firmware. A closer argument is required here: The *state* of hardware may be easy to change (much computer hardware is a variation on the on/off switch); but the hardware itself (think of a light switch attached to a wall) is difficult to change. Thus an arithmetic/logic unit is hardware because it has permanently etched silicon algorithms for its calculations, and a C++ program residing on a hard drive is software because it can be more readily modified and recompiled. Although the use of firmware is commonplace, the ethical implications of the hardware/software distinction do not require this middle ground of malleability as a separate category.

Implications of the Hardware/Software Distinction

Some interest in the hardware/software distinction is associated with legal issues. Insofar as a computing entity is a mechanical device (hardware), it is subject to the same body of law that governs ladders and lawnmowers. Insofar as a computer entity functions as an algorithm (software), the laws of intellectual property and professional service are more germane. Hardware designs can be patented, software programs can be copyrighted.

The hardware/software distinction also has ethical implications. On an abstract level, algorithms are pure software. But to have a physical effect, an algorithm is embodied in some physical entity. The nature of the embodiment, the particular hardware chosen, has important ethical implications. For example, if an algorithm is embodied exclusively in a single brain, its ownership as a private thought is uncontroversial; but when the thought is shared as a written document, ethical issues of intellectual property instantly arise. Similarly an algorithmic thought has few consequences for others until it is implemented; when implemented, the algorithm can have important consequences.

When deciding how to embody an algorithm, one must select a location on the malleability continuum. Typically an emphasis on hardware implementation (for example, etched permanently in silicon) will encourage a more reliable implementation and less complex functionality than an implementation in software (such as using a high level programming language). Hardware implementations are more economically feasible when they are mass produced, so widely used algorithms for the many are more likely to be implemented in hardware, whereas customized algorithms for the few are more likely to be implemented in software. The questions of delivery schedules, *how good is good enough*, and a developer's obligations to customers are examples of the ethically charged issues inherent in any implementation decision. As the costs of fabricating hardware fall and the costs of writing software rise, judgments with regard to such issues may have to be reconsidered.

As computing becomes ubiquitous, software tends to replace hardware to deliver certain functionalities. Airplanes provide a dramatic example of this trend. First fighter jets and then commercial airliners have substituted complex computer algorithms for mechanical controls. The computer algorithms enable the newer airplanes to fly more efficiently and economically. But the redundancy of hardware is difficult to replicate in software (software defects tend to reoccur in a way that hardware defects do not), and this has consequences for the reliability of life-critical systems that rely increasingly on software for their safety. These differences result in ethically significant choices between more efficient operations using software and more expensive but safer hardware devices. As these tradeoffs becoming increasingly common, the different traditions of professionals in different engineering fields can become an ethical issue. For example, software engineers are rarely licensed (in the United States, only Texas issues a software engineering license, and corporate software engineers aren't required to obtain that license either), but other engineers in safety critical applications can be licensed. In this case, the hardware/software distinction may help determine the state's interest in certifying professional competence.

A final example of the ethical importance of the hardware/software distinction has less to do with computing professionals and more to do with the non-programming public and how they view problems with computing. Computers can be a handy scapegoat: "We can't help you with that right now; the computer's down." "Impossible. There's no way to type that into the computer." "I don't remember that email. I guess the computer ate it."

Most people know that *software bugs* are the responsibility of programmers. But organizations and individuals can sometimes hide behind the hardware of their machines. Emphasizing the hardware aspects of computers can help create an artificial distance between the general public and human errors in software. This de-emphasis of human accountability is a danger lurking in the hardware/software distinction. The reality is that algorithms are human artifacts for which humans are responsible, no matter how they are implemented.

The ethical challenges lurking within the hardware/software distinction are reflected in legal and political controversies. There is freeware, shareware, and open source software; but there is no parallel movement to declare computer hardware free. The patent system has been, in the main, successful at protecting hardware innovations, but copyright, patent, trademark, and trade secrecy have each proven problematic in a different way when applied to computer software. Controversies over new laws that criminalize what was once considered legitimate reverse engineering of software have highlighted the importance of understanding the differences between hardware and software.

KEITH W. MILLER

SEE ALSO *Computer Ethics; Free Software; Information Overload.*

BIBLIOGRAPHY

Tanenbaum, Andrew S. (1999). *Structured Computer Organization*, 4th edition. Prentice-Hall, Upper Saddle River, NJ.

Turing, Alan. (1936). "On Computable Numbers, With an Application to the Entscheidungsproblem." *Proceedings of the London Mathematical Society*, Series 2, 42: 230–267.

HASTINGS INSTITUTE

SEE *Bioethics Centers.*

HAZARDOUS WASTE

SEE *Waste.*

HAZARDS

Hazards are low-probability, high-magnitude phenomena that have the potential to cause large negative impacts on people. While this definition is unavoidably imprecise (what counts as a "phenomenon"? what probabilities qualify as "low"? and what impacts qualify as "large" or even "negative"?), in general hazards can be understood as acting outside of daily human expectations to adversely affect the quality of life of those exposed to them. Hazards refer to a prospect or risk of an occurrence; a particular occurrence of a hazard is more typically termed a "disaster" or sometimes an "extreme event"; when they are technological in origin they may be termed "accidents."

The remains of a trailer park in Miami, Florida, destroyed during Hurricane Andrew. Andrew was one of the most destructive hurricanes ever to hit the U.S., raging from August 16 to August 28, 1992. *(© Tony Arruza/Corbis.)*

Some types of phenomena—such as hurricanes, earthquakes, landslides, and reactor meltdowns—are unambiguously classified as hazards, whereas others, especially those that are less temporally or spatially discrete, such as droughts, famines, and epidemics, may or may not be included under the term, depending on who does the classifying. Wars and other types of human conflict are generally not categorized as hazards.

A related use of the word "hazard" refers to existing conditions of the environment that may pose a risk to humans, such as a toxic waste site or even the edge of a cliff. Similarly, hazardous materials are those that may create a risk to human or environmental health if exposure to them is not regulated and controlled. This entry, however, focuses on hazards as dynamic phenomena, not as static conditions or material properties.

In the ten-year period 1992 to 2001, hazardous events, or disasters, worldwide were responsible for more than 620,000 deaths. Drought caused almost 45 percent of these deaths; floods, earthquakes, and windstorms caused most of the remainder. An additional 2 billion people required immediate assistance (60% as a result of floods), and the direct costs due to the destruction of infrastructure, crops, homes, and so on was more than $600 billion (with earthquakes, floods, and windstorms making up about 90% of this total). To put these numbers in some perspective, every year hazards seriously disrupt the lives of as many people as the entire population of Brazil or Indonesia, and cost about as much as the entire economic output of Pakistan or Peru (World Health Organization, United Nations Development Programme 2002).

Hazards Are Not Natural

Hazards are commonly divided into two types: natural and technological. Technological hazards are those arising from the failure of technological devices or systems to behave as intended. Natural hazards arise from nonhuman forces and can be subdivided into geophysical hazards, such as volcanoes, earthquakes, and tsunamis, and hydrometeorological hazards, such as hurricanes, floods, and tornadoes. Natural and technological hazards, however, are often related to each other, in that natural disasters may trigger technological failures, for example of power grids or dams. Moreover, natural hazards must be understood not simply as the result of natural phenomena, but as arising from the socioeconomic context within which such phenomena occur.

Human *exposure* to hazards results from humans living in areas where hazards are present; human *vulnerability* to hazards arises from the types of development exposed to hazards. The consequences of hazards are determined as much or more by the extent of exposure and level of vulnerability than by the characteristics of the hazard itself. Thus, for example, when a magnitude 6.9 earthquake struck a densely populated region in Armenia in December 1988, more than 25,000 people died and 1.6 million were directly affected. When, ten months later, a similar magnitude earthquake struck a highly populated region of California (the October 1989 Loma Prieta event near Santa Cruz), sixty-three people died and fewer than 10,000 were affected. This stark difference in impacts was largely a reflection of poor design and construction standards for buildings in Armenia compared to those in California. Moreover, despite Armenia's much lower level of economic development, its economic losses from the 1988 event, estimated at about $14 billion, were greater than the estimated $6-to-$10 billion price tag of Loma Prieta.

The inseparability of hazards from their social context is clearly illustrated by historical trends in disasters, which show a continual and rapid increase in the number of disasters, rising from a worldwide average of about 100 per year in the early 1960s to between 300 and 500 per year by the early 2000s. ("Disasters" here is defined by the World Health Organization's Collaborating Centre for Research on the Epidemiology of Disasters [CRED] as events that kill at least ten people, affect at least 100, result in a call for international assistance, or result in a declaration of emergency.) While some of this increase reflects changes in reporting, most of it arises from increased exposure and vulnerability throughout the world because of growing population, expanding economies, migrations to coasts and other vulnerable regions, increasing urbanization, and related factors. These changes are especially reflected in the costs of major disasters, which according to the German insurance company Munich Re rose more than tenfold in the second half of the twentieth century, from an average—in real (2002) U.S. dollars—of about $4 billion per year in the 1950s to more than $65 billion in the 1990s.

It is important to emphasize that these increases are best explained by changes in social context, not changes in the occurrence or type of hazardous events. For example, it has been well documented that rapidly increasing economic losses from hurricanes striking the U.S. eastern seaboard are caused by growing population and wealth, not by increased frequency or magnitude of storms. The great Miami hurricane of 1926 caused about $76 million in damage (in inflation-adjusted dollars); when Hurricane Andrew, of similar force, struck south Florida in 1992, it caused more than $30 billion in damage (Pielke and Landsea 1998).

Complexity of Hazards

Because hazards are socially embedded, their impacts arise from the complex interaction of many variables. In Armenia, steel that had originally been produced to reinforce buildings was diverted to weapons construction instead, thus revealing cold war geopolitics as one source of vulnerability to the 1988 earthquake (Mileti 1999).

Hurricane Mitch, which in October and November of 1998 killed more than 10,000 people and caused severe economic and social disruption in Central America, was responsible for triggering a mudslide in Nicaragua that killed about 2,000 people (Olson et al. 2001). The mudslide, however, was created not just by the torrential rains brought by Mitch, but also by land-use patterns that led to deforestation of a steep mountain slope, which collapsed when it became saturated with water. Eighteen months later, a debris flow in Manila, Philippines, triggered by normal monsoon rains, killed about 200 people. But in this case the disaster occurred on the flank of a huge landfill where thousands of people scavenged garbage for a living.

In Chicago, a heat wave in the summer of 1995 led to the death of more than 700 people. The temperatures in Chicago were no higher than those regularly experienced in many places; the huge number of casualties was instead caused by a combination of failed social services (for example, insufficient number of emergency vehicles and workers) and the large number of people, mostly poor and elderly, living alone, without resort to social networks (Klinenberg 2002).

Such examples also show that a preliminary event may trigger additional hazards that may themselves be damaging or that may combine with the principal hazard to multiply damages. For example, the Chicago heat wave led to technological failures in the form of power outages and water service interruptions that made it more difficult for people to cope. Major disasters may also trigger disease outbreaks, especially when water supplies are cut off or contaminated. The 1906 San Francisco earthquake is often called the San Francisco Fire because of the disastrous conflagrations it caused throughout the city. These sorts of complexities also underscore the futility of making a clear distinction between natural and technological hazards.

Uneven Distribution of Hazard Impacts

The impacts of hazards are disproportionately borne by poor people living in poor regions and countries; thus, hazards are a manifestation of socioeconomic inequality and an issue of social justice. While the poorest thirty-five countries account for only about 10 percent of the world population, they suffered more than half of the disaster-caused deaths between 1992 and 2001. Of those directly affected by disasters during that decade, almost 90 percent lived in Asia, where dense populations combine with high vulnerability and widespread poverty in nations such as India, China, and Indonesia. As the contrast between the Armenia and Loma Prieta earthquakes starkly shows, the benefits of affluence include a capacity to protect against the most direct and devastating effects of hazards, and a significant component of this capacity is the scientific and technological infrastructure that typically accompanies (and fuels) the growth of affluence.

Not surprisingly, affluent nations suffer the greatest absolute economic losses from hazards. The disproportionately large sizes of their economies create the potential for much greater economic damage from the impacts of hazards. For the decade 1992 to 2001, the forty-five richest countries (making up about 18 percent of global population and accounting for 82 percent of global wealth) experienced about 62 percent of total global economic damage from hazards. As a percentage of gross national product (GNP), however, the economic effects of hazards on poor countries are about 100 times greater than for rich countries. Damages from Hurricane Mitch, for example, were estimated at between $5 billion and $7 billion, which was about the same as the annual combined total GNP of the two most affected nations, Honduras and Nicaragua. The magnitude 6.7 Northridge, California, earthquake of 1994 was the most costly disaster in U.S. history, causing between $20 billion and $40 billion in losses; the total, however, was equivalent to only between about 2 and 4 percent of California's economic activity for that year.

Disparities between rich and poor will compound over time. Global population growth is mostly concentrated in poor countries and leads to rapid urbanization, usually in vulnerable coastal zones, as well as dense rural populations. Unregulated land use translates into widespread environmental degradation, especially deforestation, which in turn exacerbates flooding and related phenomena such as mudflows, debris flows, and landslides. Design and construction standards are typically low, and even when adequate building codes exist, corruption, lack of enforcement, and insufficient resources result in an unsafe built environment. Emergency response capabilities are often inadequate, and hazard insurance is usually unavailable, slowing the recovery process. Technological infrastructure, such as communication and transportation systems, is typically fragile, and capacity to repair damaged systems is limited. Such factors reinforce one another to magnify the vulnerability of poor people and nations to hazards, and they act as a brake on development.

Mitigation

In the affluent world, numerous approaches have been adopted to mitigate the effects of hazards, including building codes that are appropriate to known risks; land-use regulations for floodplains, coastal zones, and seismic zones; and dams, levees, and other engineering interventions for floodplain management. There is little question that such measures, combined with early warning systems for hurricanes, tornadoes, and floods, and coordinated emergency response plans, have limited the human and economic toll of hazards in the developed world. Nevertheless, while the number of people killed and injured has declined for some hazards, and stayed relatively stable for others, the economic costs of hazards appear to be rising at an exponential rate. Absent mitigation efforts, they would be rising more rapidly still.

Despite aggressive mitigation efforts, affluent nations are not exempt from major disasters. The magnitude 7.2 earthquake that struck Kobe, Japan, in January 1995 killed 6,000 people and led to an estimated $100 billion in damages, yet Japan is justifiably considered to have the world's most sophisticated and effective earthquake hazard mitigation practices. In the U.S. Midwest, decades of flood control engineering preceded the 1993 Mississippi River basin floods that caused $18 billion in damages and that arguably constituted, in the aggregate, the worst flood in U.S. history (Changnon 1996).

Such events point to the complexity of mitigating hazards. While mitigation efforts may protect against anticipated or typical hazards, they may also have the effect of attracting more people to live and work in hazardous areas, thus increasing exposure over the long term to even larger events. (This trend is reinforced by the apparent security provided by hazard insurance and disaster relief programs.)

Mitigation of hydrological hazards in particular can alter the function of natural systems in ways that are not sustainable over the long term, both because such altered systems may behave in unanticipated ways and because "unprecedented," and thus unplanned-for, events will inevitably occur at some point, in some areas. Mitigation efforts, it seems—especially those focused on trying to control the behavior of the environment through engineered structures—may have the affect of trading a number of smaller, more manageable events in the short-to-medium term for much greater disasters in the more distant future. This can become a self-perpetuating and self-amplifying process, because after a disaster occurs political pressure inevitably focuses on allowing people to return to their homes and businesses to reopen, which in turn requires increased commitment to environmental control via structural hazard mitigation.

Policy Assessment

While societies have an obligation to limit the negative effects of hazards on people and economies, such action should be informed by the inevitability of hazards, rather than a vain quest to eliminate their impacts or occurrence. Such a perspective focuses on the characteristics of human development, rather than the control of nature, as the cornerstone of effective mitigation. For example, environmental degradation invariably exacerbates hazard damages by altering or destroying natural features that buffer the impacts of hazards—such as forests that stabilize steep slopes, floodplains that allow for dispersion of floodwaters, and coastal lagoons that absorb storm surges. Mitigation policies that keep such features intact, and govern land use in ways that protect them over the long term, are likely to be successful both because they preserve natural function and because they thereby limit human development in particularly hazard-prone areas. In acknowledgement of these realities, after the 1993 floods in the Midwest, the U.S. government increased efforts to *remove* floodplain structures—thus returning some of the natural function of the river—and relocate flood-prone communities to higher ground.

Yet it remains to be seen if it is possible to actually stabilize or reduce the costs of natural hazards in developed countries characterized by continual growth of wealth, infrastructure, urban centers, coastal and wildland development, and overall interconnectedness. Hazards may simply be an unavoidable overhead cost on the growth of affluence.

Outside of the developed world, however, the path to reducing the toll of hazards is clear, if difficult to follow. Poverty and the conditions associated with it—poorly constructed and maintained housing and infrastructure, degraded environmental conditions, rapidly increasing populations, insufficient or ineffective social and emergency services, lack of technical capacity—are the nutrients of hazards. At the global scale, reducing poverty, and the environmental degradation and failures of governance that accompany it, will continue to be the most effective strategy for hazard mitigation.

DANIEL SAREWITZ

SEE ALSO *Building Destruction and Collapse; Safety Engineering: Practices.*

BIBLIOGRAPHY

Changnon, Stanley A., ed. (1996). *The Great Flood of 1993: Causes, Impacts, and Responses.* Boulder, CO: Westview. Scientific and policy perspectives on this historical event.

Klinenberg, Eric. (2002). *Heat Wave: A Social Autopsy of Disaster in Chicago.* Chicago: University of Chicago Press. An analysis of the social imbeddedness of a hazard and its impacts.

Mileti, Dennis S. (1999). *Disasters by Design: A Reassessment of Natural Hazards in the United States.* Washington, DC: Joseph Henry Press. A comprehensive discussion of the social context of hazards.

Olson, Richard Stuart, et al. (2001). *The Storms of '98: Hurricanes Georges and Mitch; Impacts, Institutional Response, and Disaster Politics in Three Countries.* Boulder: University of Colorado, Natural Hazards Research and Applications Information Center. Basic facts and political interpretation of these catastrophic storms.

Pielke, Roger A., Jr., and Christopher W. Landsea. (1998). "Normalized Hurricane Damages in the United States: 1925–95." *Weather and Forecasting* 13(3): 621–631. Analysis of the causes of increasing coastal hazard losses.

United Nations Development Programme. (2002). *Human Development Report.* New York: Oxford University Press. Source for national economic data.

INTERNET RESOURCES

Munich Re. "Annual Review of Natural Catastrophes, 2002." Available from http://www.munichre.com/2/publications_db_e.asp. Data on costs of hazard losses worldwide.

World Health Organization. Collaborating Centre for Research on the Epidemiology of Disasters (CRED). "EM-DAT: The OFDA/CRED International Disasters Data Base." Available from http://www.em-dat.net/. Unless otherwise noted, all data on hazard losses in the entry are derived from this unique database.

HEALTH AND DISEASE

Why care about the precise definitions of the words *health, disease,* and *illness?* Their meanings seem self-evident: Health is the absence of disease, illness the experience of disease. However the multiple dimensions of these concepts, their moral underpinnings, and the purposes for which they are used are enormously complex, especially in a technological society strongly oriented toward the production of health.

Health and disease are more than just medical terms; they have social, political, moral, and economic dimensions. For example, a pharmaceutical company may advertise its new compound as the cure for a heretofore-unnamed disease such as erectile dysfunction or attention deficit disorder (ADD). Medical or disability coverage is granted or denied based on sociopolitical interpretations of what constitutes a disease or disability. A couple decides to use in vitro fertilization and preimplantation genetic screening to avoid creating a baby with a genetic disease or one who will be a carrier of a diseased gene. Or perhaps a soft drink producer enhances sales by touting the benefits of its new and improved *healthier* beverages. Professional codes of ethics commonly commit engineers to protect public safety, health, and welfare. The concepts of health and disease are invoked in various ways, for purposes weighty and mundane.

Indeed health has been construed not simply as the absence of disease (whatever that is), but much more. In the preamble to its constitution, the World Health Organization (WHO) defines health as "a state of complete physical, mental and social well-being not merely the absence of disease or infirmity." Such statements rely on medico-moral presuppositions of what a disease actually is, how and which diseases ought to be treated, and ultimately on visions of what it means to live the good life.

Recognition of the complexity of the concepts of health and disease has stimulated scholarship in the fields of history and philosophy of medicine, sociology of medicine, and the medicalization of deviance, as well as crucially important policy developments in managed care and resource allocation. Philosophical questions range from clarifying the ontological status of disease (What is a disease?) to understanding particular conditions and the meaning of being diseased. The social sciences, including medical sociology and anthropology, examine the extent to which disease is a value-laden concept shaped and socially constructed. How do power relations influence what is considered to be normal and healthy or abnormal and diseased? On the level of individual experience, still other questions emerge: What is the personal meaning of being healthy or sick? At what point, if any, are the sick blameworthy for their illnesses? What role ought a sick person play in society? How does stigma affect the sick? More broadly framed questions regarding matters of policy ask what responsibilities society has to care for those who are diseased or ill.

Different responses to such questions are associated with diverse historical and philosophical approaches to health and disease. Sociological contributions to the debate and their policy implications also deserve consideration. This simple conceptual breakdown is appropriate for present purposes, but it is important to note that a more holistic picture requires interdisciplinary dialogue.

Historical Sketch

The concepts of health and disease were foundational to the ancient medical arts and bound up with distinct philosophical perspectives. To explain illness or symptoms of disease, as well as to cure the sick, pre-Socratic philosophers and ancient Greek physicians in the Hippocratic tradition (c. 400 B.C.E.) developed a basic explanation of health as balance (*isonomia*). The balance of the four humors—black and yellow bile, phlegm, and blood—in conjunction with environmental and temporal factors was central to the formalized model of health created by the Greek physician Galen (130–199 C.E.). A rudimentary nosology (classification of diseases) was developed around the imbalance of the humors.

Galen's humoral model persisted through the Middle Ages when it was augmented by Christian ideals of salvific suffering. Although the link between disease and sin was not a new development, moral dimensions of health and disease were described in terms of tests from God, punishment for sin, or demonic possession (Gunderman 2000). Toward the end of the Middle Ages, a new model was espoused by the physician-philosopher Paracelsus (Philippus Aureolus Theophrastus Bombastus von Hohenheim 1493–1541) indicating three elemental components (salt, mercury, and sulfur) as critical to healthy physiology. Paracelsus went on to claim that diseases were not simply internal imbalances, but rather resulted from autonomous entities "springing from the body" (Vichow 1981, p. 192). The ontologists—those thinkers who viewed diseases as actual entities—find the roots of their approach in the work of Paracelsus.

Modern concepts of health and disease (and the practice of scientific medicine itself) are grounded in Cartesian dualism. René Descartes (1596–1650) separated the mind and the body, and described the body as a set of parts working together according to mechanical rules. Because disease was the malfunctioning of the bodily machine, treatment consisted of diagnosing the malfunction and repairing the body, bringing it back to normal functioning (von Engelhardt 1995).

Over the next few centuries, the locus of disease shifted from the macroscopic to the microscopic, and eventually to the molecular. Contributions by the anatomists at the University of Padua—in particular Giovanni Morgagni (1682–1771)—opened discussion on pathophysiology and etiology through postmortem dissections of diseased organs. Marie Francis Xavier Bichat (1771–1802) explained the origins of disease in terms of histopathology—disease in tissues. On the cellular level, Rudolf Virchow (1821–1902) synthesized breakthroughs in bacteriology and microbiology and described *mycotic* diseases in terms of *ens morbi* and *causa morbi* (a being with a cause), and as a disruption in interrelated cellular *territories* which, in turn, compound and spread the disease process. With the rediscovery of Mendelian genetics in the late-nineteenth century, *inheritance factors* were singled out as disease entities that caused such disorders as Huntingdon's Disease and sickle cell anemia. Indeed sickle cell anemia was the first modern genetic disease identified as such by Linus Pauling.

In contrast to the ontologists were the nomino-physiologists, such as François-Joseph-Victor Broussais (1772–1838), who opposed the idea that diseases were actual entities. Such entity-based nosologies, he claimed, were not classifications of disease entities but rather were driven by a physician's instrumental and pragmatic need to diagnose or prognosticate. Claude Bernard (1813–1878) emphasized the need for clinical experimentation and observation in describing diseases. Through his diverse research projects, particularly studies of digestion, glycogen function, and vasoconstriction and dilation, Bernard developed physiological models that emphasized homeostasis and feedback loops in the regulation and maintenance of health. So too, the American physiologist Walter Cannon (1871–1945), in *The Wisdom of the Body* (1932), described health and disease in homeostatic terms.

Philosophical Trends

Philosophers of medicine and science began a more formal analysis of the concepts of health and disease during the first half of the twentieth century. The medical history and epistemology of Georges Canguilhem (1904–1995) and his student Michel Foucault (1926–1984) stimulated a renewed discussion of the normal and the pathological. Eventually a cannon of philosophical writings on the concepts of health and disease was formed during the period 1960 to 1981, a development that was driven in part by the birth and development of bioethics and its need for definitional precision for basic medical concepts (Caplan et al. 1981).

During the 1970s, a conceptual dichotomy in philosophy of medicine developed as new accounts of the status of disease took two tracks. First, reminiscent of the earliest philosophical constructions of disease, various versions of naturalism reemerged. Naturalistic accounts explained disease as deviations in natural form and function. As such, a disease was described as an entity or causal factor of that deviation independent of social norms or cultural values. This perspective is sometimes referred to as nonnormativism (Caplan 1988). Christopher Boorse (1975) presented the quintessential nonnormative position by referring to an objective biological framework that guides the identification and diagnosis of disease:

> [B]ehind this conceptual framework of medical practice stands an autonomous framework of medical theory, a body of doctrine that describes the functioning of a healthy body, classifies various deviations from such functioning as diseases, predicts their behavior under various forms of treatment, etc. This theoretical corpus looks in every way continuous with theory in biology and the other natural sciences, and I believe it to be value-free. (Boorse 1975, p. 55.)

In contrast, normativist philosophers point to the value-laden nature of disease constructions, eschewing the possibility that natural is definable and that diseases are value-free. These scholars directly counter the Boorsian model by pointing to research in philosophy and sociology of science that described science and medicine as social endeavors. Because of this social embeddedness, an autonomous and value-free framework of medico-biological theory does not exist independently of values. (Kuhn 1962, Longino 1990, Engelhardt 1981). Arthur Caplan, H. Tristam Engelhardt, and Joseph Margolis are among those who write a defense of moderate normativism. Caplan (1981) points out that, while some objective criteria for defining disease exist, nonnormativism as characterized by Boorse is fraught with conceptual inadequacies. Some conditions generally considered to be normal or natural (e.g., the common cold, dental plaque, acne, and others) are disvalued, while others considered to be abnormal may be valued (for example, dysfunctional gonads in a person who does not wish to reproduce). Margolis (1976) claimed that while certain biological functions may be conceived in universal terms, the actual concept necessarily reflects the state of the technology, social explanations, division of labor, and the environmental conditions of a given population. Engelhardt (1974) describes the pragmatic and value-laden nature of the concept of disease particularly in his historical exposition of the *disease* of masturbation.

The philosophical debate about the nature of somatic disease spills over into the analysis of mental health and disease. With the rise of scientific medicine, the prevailing model of psychiatric illness became biologically based. Mental illness was considered similar to other somatic diseases, rooted in a dysfunction, or even an *ens morbus*. This model was vigorously challenged by physician George Engel (1913–1999) as being overly reductionistic; he offered his own biopsychosocial model to account for the role of relationships and society in health and disease (Engel 1977). Thomas Szasz's *The Myth of Mental Illness* (1961) attacked the notion that mental illness was a disease of the brain or that mental illness existed at all. Szasz claimed that the notion of mental illness was a way to subjugate dissidents of the community's collective ethos or assuage sick individuals of their responsibilities.

In the early-twenty-first century, genetic technology and medicine as well as the results of the Human Genome Project added another level of complexity to analyses of health and disease. A greater understanding of epigenetics and the complexities of gene-environment interactions show it is difficult to identify the genetic causes of diseases that are outside the basic Mendelian framework. Nonetheless health and disease are increasingly described in genetic terms. Reification of genetic anomalies as being diseases has raised the very real possibility that all people are *diseased* in some way (Jüngst 2000).

Sociological Perspectives and the Medicalization of Deviance

Philosophical debates about health and disease as normative concepts grade into descriptive analyses of how society constructs, describes, and reacts to the realities of health, disease, and illness. Talcott Parsons (1902–1979) explained the concepts of health and illness as manifestations of certain role-types.

In framing the *sick role*, Parsons took the first step in describing illness as a form of deviant behavior legitimized by the medical institution (Bosk 1995). The sick role is characterized first by an exemption from social duties, exculpating patients for their illness. Parsons described the physician-patient relationship as analogous to the relationship between a child and parent in which the patient follows doctor's orders in a team effort directed toward the patient's wellness. Often this is a form of social control because a sick person needs to enlist the help of persons who are not sick and their *therapeutic agencies*.

Some social scientists have theorized the construction of disease emerges out of power structures, sanctioned under the guise of medical objectivity. Looking back in history, an early example of this dynamic was the description of drapetomania—a disease of slaves that caused them to try to run away. Physician Samuel Cartwright (1793–1868) presented an account of this disease and potential cures, which included, first, kind treatment, but later various forms of severe bondage and punishment. Since then, health and disease have sometimes been hijacked in the name of ideology or the *betterment of common good*. In hindsight these instances are obvious, for example, eugenics movements during the early-twentieth century in the United States and in Germany in which *diseased* individuals, their families, or their entire race were *treated* (Caplan 1992b). In contrast to these more egregious cases, some social scientists suggest more insidious forms of disease construction have occurred through the medicalization of deviant behavior.

Peter Conrad (1975, 2000) describes how hyperkinesis—now called attention deficit and hyperactivity disorder (ADHD)—became a disease. Conrad explains that, with the invention of the stimulant Ritalin and observation of its paradoxical effect on children, the manufacturer, CIBA, sought to market the compound to parents and teachers of unruly children. The *cure* preceded the *disease*. The administration of a drug that reigned in nonconformist children strengthened the status quo: educational systems not equipped to accommodate certain children and parents released from blame for their children's behavior. Similar examples can be found in feminist accounts of the social construction and medicalization of menopause and premenstrual syndrome (McCrea 1983, Richardson 1995).

Labeling theorists, such as Howard Becker (1928), describe the actions of *moral entrepreneurs* who create and enforce social rules. In medicine, moral entrepreneurs may be physicians who ascribe the label *diseased* to those who break with accepted conventions, thus suppressing or stripping them of opportunity, thereby expanding their own domain of professional influence (Becker 1963, Pfohl 1977, Bosk 1995).

As a result of labeling, stigma is often closely associated with disease. In certain cases, sick people remain closeted because of the stigma of their illness. Norma Ware (1992) offers the example of chronic fatigue syndrome. Delegitimation of the subjective experience of illness leads to further suffering arising from the stigma of the disorder, the alienation resulting from a decision to keep the illness secret, and the shame of being *wrong* in one's own definition of reality.

Broad Policy Implications

The ways in which the concepts of health and disease are framed have significant impact on health policy. In particular, defining what constitutes the appropriate level of medical care provided by a just society has been difficult to determine.

Several nosological frameworks driving insurance schedules and socialized coverage plans have been espoused over the years. Norman Daniels, in *Just Health Care* (1994), proposes a policy framework based not on definitions of disease or health but on *species-typical functioning*. Daniels proposes that normal functioning is an important baseline not because it is *natural*, but because it is a convenient point at which to determine what society should owe to its members. Indeed a consensus of what society ought to give to all its members has been elusive precisely because a common framework of health and disease has been impossible to construct.

Equally important to providing care and treatment of disease is the scientific quest to prevent and cure disease. Operational definitions of health and disease ground biomedical research priorities in government and private funding agencies. The National Institutes of Health (NIH) determine research priorities based on a broad range of criteria related to severity of diseases, epidemiological evidence, cost-benefit analyses, as well as projects that offer promises and opportunities, and interest groups/patient lobbying. Investment in research and development and biotechnology, as well as in allied fields of technology, rest on the social framework and disciplinary matrix within which technicians work. As such core concepts such as health and disease have a profound, albeit overlooked, influence on the trajectory of important advancements in technology.

The concepts of health and disease underlie decisions to fund basic bench research through clinical biomedical research and public health initiatives. Clearly a robust understanding of the complexities of these concepts is crucial for policymakers, clinicians, and patients alike.

DOMINIC A. SISTI

SEE ALSO *Bioengineering Ethics; Cancer; Complementary and Alternative Medicine; Emergent Infectious Diseases; Eugenics; Galenic Medicine; Genethics; HIV/AIDS; Medical Ethics; National Institutes of Health; Therapy versus Enhancement; World Health Organization.*

BIBLIOGRAPHY

Becker, Howard. (1963). *Outsiders: Studies in the Sociology of Deviance*. New York: Free Press.

Bernard, Claude. (1999). *Experimental Medicine* [Introduction à l'étude de la medicine expérimentale], trans. Henry Copley Greene. New Brunswick, NJ: Transaction. First published in 1865.

Boorse, Christopher. (1975). "On the Distinction Between Disease and Illness." *Philosophy and Public Affairs* 5: 49–68.

Bosk, Charles. (1995). "Health and Disease: Sociological Perspectives." In *Encyclopedia of Bioethics*, ed. Warren T. Reich. New York: Simon & Schuster Macmillan.

Broussais, François-Joseph-Victor. (1821). *Examen des doctrines médicales et des systèmes de nosologie* [An examination of the medical doctrines and systems of nosology]. Paris: Mequignon-Marvis.

Cannon, Walter. (1932). *The Wisdom of the Body*. New York: Norton.

Caplan, Arthur L. (1981). "The *Unnaturalness* of Aging—A Sickness Unto Death?" In *Concepts of Health and Disease*, eds. Arthur L. Caplan; H. Tristram Engelhardt; and James J. McCartney. Reading, MA: Addison-Wesley Publishing.

Caplan, Arthur L. (1988). *Am I My Brother's Keeper?* Bloomington: Indiana University Press.

Caplan, Arthur L. (1992a). "If Gene Therapy is the Cure, What is the Disease?" In *Gene Mapping: Using Law and Ethics as Guides*, eds. George Annas, and Sherman Elias. Oxford: Oxford University Press.

Caplan, Arthur L. (1992b). *When Medicine Went Mad: Bioethics and the Holocaust*. Totowa, NJ: Humana Press.

Caplan, Arthur L.; Englehardt, H. Tristram; and James J. McCartney. (1981). *The Concepts of Health and Disease*. Reading, MA: Pearson Addison Wesley.

Cartwright, Samuel. (1981). "Report on the Diseases and Physical Peculiarities of the Negro Race." In *Concepts of Health and Disease*, eds. Arthur L. Caplan, H. Tristram Engelhardt, and James J. McCartney. Reading, MA: Addison-Wesley Publishing. Originally published in the New Orleans Medical and Surgical Journal in 1851, May: 691–715.

Conrad, Peter. (1975). "The Discovery of Hyperkinesis: Notes on the Medicalization of Deviant Behavior." *Social Problems* 23(1): 12–21.

Conrad, Peter, and Deborah Potter. (2000). "From Hyperactive Children to ADHD Adults: Observations on the Expansion of Medical Categories." *Social Problems* 47: 559–582.

Daniels, Norman. (1994). *Just Health Care*. Cambridge, UK: Cambridge University Press.

Engel, George L. (1977). "The Need for a New Medical Model: A Challenge for Biomedicine." *Science* 196: 129–136.

Engelhardt, H. Tristram. (1974). "The Disease of Masturbation: Values and the Concept of Disease." *Bulletin of the History of Medicine* 48: 234–248.

von Engelhardt, Dietrich. (1995). "Health and Disease: History of the Concepts." In *Encyclopedia of Bioethics*, ed. Warren T. Reich. New York: Simon & Schuster Macmillan.

Engelhardt, H. Tristram. (1981). "The Concepts of Health and Disease." In *Concepts of Health and Disease,* eds. Arthur L. Caplan; H. Tristram Engelhardt; and James J. McCartney. Reading, MA: Addison-Wesley Publishing.

Gunderman, Richard. (2000). "Illness as Failure: Blaming Patients." *Hastings Center Report* 30(4): 7–11.

Hofmann, Bjørn. (2001). "Complexity of the Concept of Disease as Shown Through Rival Theoretical Frameworks." *Theoretical Medicine* 22(3): 211–236.

Jüngst, Eric T. (2000). "Concepts of Disease After the Human Genome Project." In *Ethical Issues in Health Care on the Frontiers of the Twenty-First Century,* eds. Stephen Wear, James J. Bono, Gerald Logue, and Adrianne McEvoy. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Kuhn, Thomas. (1962). *The Structure of Scientific Revolutions.* Chicago: University of Chicago Press.

Longino, Helen. (1990). *Science as Social Knowledge: Values and Objectivity in Scientific Inquiry.* Princeton, NJ: Princeton University Press.

Magnus, David. (2004). "The Concept of Genetic Disease." In *Health, Disease, and Illness: Concepts in Medicine,* eds. Arthur L. Caplan, James J. McCartney, and Dominic A. Sisti. Washington, DC: Georgetown University Press.

Margolis, Joseph. (1976). "The Concept of Disease." *Journal of Medicine and Philosophy* 1(3): 238–255.

McCrea, Frances B. (1983). "The Politics of Menopause: The *Discovery* of a Deficiency Disease." *Social Problems* 31(1): 111–123.

Morgagni, Giovanni B. (1981). "The Seats and Causes of Disease: Author's Preface." In *Concepts of Health and Disease,* eds. Arthur L. Caplan, H. Tristram Engelhardt, and James J. McCartney. Reading, MA: Addison-Wesley Publishing. First published in 1827.

Parsons, Talcott. (1951). *The Social System.* New York: Free Press.

Pfohl, Stephen J. (1977). "The *Discovery* of Child Abuse." *Social Problems* 24(3): 310–323.

Richardson, John T. E. (1995). "The Premenstrual Syndrome: A Brief History." *Social Science and Medicine* 41(6): 761–767.

Szasz, Thomas. (1960). "The Myth of Mental Illness." *American Psychologist* 15: 113–118.

Szasz, Thomas. (1961). *The Myth of Mental Illness: Foundations of a Theory of Personal Conduct.* New York: Paul B. Hoeber.

Virchow, Rudolf. (1981). "Excerpt from *One Hundred Years of General Pathology.*" In *Concepts of Health and Disease,* eds. Arthur L. Caplan, H. Tristram Engelhardt, and James J. McCartney. Reading, MA: Addison-Wesley Publishing Company. Originally published in 1895.

Ware, Norma C. (1992). "Suffering and the Social Construction of Illness: The Delegitimation of Illness Experience in Chronic Fatigue Syndrome." *Medical Anthropology Quarterly* 6(4): 347–361.

Wolpe, Paul Root. (2002). "Treatment, Enhancement, and the Ethics of Neurotherapeutics." *Brain and Cognition* 50: 387–395.

INTERNET RESOURCE

World Health Organization. (1948). "Preamble to the Constitution." Available from http://whqlibdoc.who.int/hist/official_records/constitution.pdf. WHO Constitution adopted by the International Health Conference, New York, June 19–22, 1946; signed on July 22, 1946 by the representatives of sixty-one states and entered into force on April 7, 1948. Can also be found in the Official Records of the World Health Organization, no. 2, p. 100.

HEAVY METALS

Heavy metals is a common toxicological term covering a number of metallic substances that acutely damage human beings and ecosystems, and whose atomic weights fall between and 64 and 201. Those responsible for the most injuries and deaths are lead, mercury, and cadmium. Others with toxic properties—for example zinc, beryllium, chromium, aluminum, bismuth, manganese, and copper—are frequently listed as *heavy*, but because their atomic weights fall below 64 are not chemically regarded as such. A term better-suited to all these substances might simply be *toxic*.

Another toxic material, arsenic, is often included among the heavy metals but chemists see arsenic as a semimetal because its chemical and physical properties are only partially metallic. Thus they advocate a separate classification for this substance that since the 1980s has been poisoning well water and damaging the health of hundreds of thousands of villagers in Bangladesh and West Bengal, India.

Origin and Issues

Metals leach into living systems from natural ore deposits. But by far the major sources of toxic entry are emissions and wastes from mining and smelting operations, manufacturing processes, power plant emissions, waste incinerators, and through such consumer items as fuel additives, dental amalgams, toys, paints, light bulbs, plumbing, electronic devices, even vaccines and herbal dietary supplements. Toxic metals are ubiquitous, persistent, and controversial, and because they destroy critical enzymes can be savage in their toxic effects.

Accordingly the regulation of these substances has taken many forms, from public health and consumer protection laws to measures that control air, land, and water contamination. International treaties are probably inevitable, since these metals disperse throughout the ecosphere, cross national boundaries, essentially never degrade, and accumulate to toxic concentrations in fruits, vegetables, farm animals, and seafood. The major practical approach to their control is capture, followed by impounding.

Heavy metals history is replete with stories of environmental injustice and regulatory lethargy. Children and developing fetuses are the most tragic victims, usually suffering from cancer and serious neural disorders such as Parkinsonism and mental retardation. Increasing bodies of evidence indicate that high toxic chemical levels also correlate geographically with high crime rates, raising important legal and ethical questions as to whether polluters should be liable for offenses that promote criminal behavior in persons exposed to metallic emissions.

State, local, and federal regulations over the last three decades of the twentieth century reduced public exposure to these substances. But localized incidents remain frequent in the early-twenty-first century and the legacy of past abuses poses persistent problems through the presence, for example, of industrial waste or Superfund sites that have not yet been cleaned up (or in technical jargon, *remediated*). The history of heavy metals toxicity is a particularly tragic one, marked by bitter conflicts over surreptitious dumping, disposal in areas populated by poor people, exposure to children, lack of equitable compensation of victims, and corporations that are unwilling or unable to pay for control and cleanup.

Mercury

One of the earliest, most heartrending modern instances of heavy metal poisoning was the disaster that occurred in Minamata, Japan, during the 1950s and 1960s when mercury was discharged from a plastics manufacturing plant into the waters of Minamata Bay. The metal, in the form of methyl mercury, accumulated in the bodies of fish that were the food staple for the thousands of persons who lived in that section of southwestern Japan. The pathological result was painful neural disorders that had distressing physiological, social, and psychological effects on the people of Minamata.

Mercury's largest single source is the combustion of coal in power plants, a problem that grows as global industrial economies expand. The challenge is enormous and international health and environmental advisory bodies have urged regulations that call for removal of 90 percent of mercury from such emissions. (Cadmium and lead are also significant emission components.)

Mercury regulation has been a controversial issue in the United States for several years, mainly over government attempts to amend the Clear Air Act in favor of less stringent standards for emissions. Relaxation of standards and regulations has always been under fierce debate in toxic metals regulation, but in the case of mercury, the underlying conflict has been more closely related to the government's market-based approach to regulation as opposed to regulatory procedures specific to conditions near emission sites. The regulatory hope among experts in toxic metals research and regulation is to construct an international treaty similar to the Kyoto protocol that was established to reduce carbon dioxide emissions from industrial operations and thus decrease global warming. In other words, if all industrial operations adhered to low to zero emission standards, environmentalists believe the world would be a much safer place.

In any case, the public and environmental agencies at all levels of government are now acutely aware of the dangers of mercury. Disposal from mining operations remain a problem throughout the world and disputes over health effects and liability generate headlines almost daily. Likewise mercury contamination in ocean fish such as tuna, mackerel, and salmon remains a constant concern. Mercury in dental amalgam was for years a major cause of concern, but due to intense public attention that issue has subsided in recent years.

Lead

Lead contamination is more widely recognized than mercury contamination but vigilance over its dangers has helped to establish broad measures to bring exposure under control. A metal widely used since early times and treasured as a decorative and culinary material in ancient Rome, lead's toxic problems have been known for centuries. Since the mid-twentieth century, thousands of children have suffered the effects of lead poisoning by ingesting or absorbing lead from toys, painted household items, playground soil, and refuse left after the demolition of homes and buildings.

But in the broader sense, it was the overall public health implications of lead in gasoline (in the form of tetraethyl lead) that caused most of the initial furor over the need to control it in the environment. The U.S. petroleum and auto industries successfully fought efforts to end its use. However when the auto industry began installing catalytic converters to comply with U.S. air pollution laws, testing determined that lead rendered the devices inactive. The auto industry had no alternative but to demand development of lead-free gasoline. Leaded gasoline, however, is still in use in many countries.

Lead from mining has always been an environmental and public health problem and remains so in the early-twenty-first century. A typical industrial example is emissions from the smelter at the Bunker Hill lead mine in

Pinehurst, Idaho, during the 1970s. For years fallout from the smelter contaminated the air in the area around Pinehurst. The Center for Disease Control (CDC) tested children in the area for blood-lead levels and found the highest amounts ever recorded in human beings.

On the whole, however, laws, regulations, and a high degree of watchfulness have brought the lead problem relatively under control, though lead poisoning incidents, especially in old housing, continue to be of concern, as do lead emissions from mining and smelting facilities around the world.

Cadmium and Chromium

Cadmium and chromium come from a variety of sources from cigarette smoke to smelting operations to increasingly voluminous waste from electronic devices. They enter living systems from alloys, pigments, batteries, metal coatings, electronic devices, mining operations, and industrial emissions. Cadmium especially affects the kidneys and lungs, but it also causes testicular damage, lung disease, and bone disease.

Chromium, for its part, is an essential nutrient in very small amounts. It is involved in manufacturing chrome-plated materials, tanned leather, dyes and pigments, and wood preservatives. It enters living things mainly through the air and underground water. Extended exposure to chromium can cause asthma, lung cancer, and ulcers.

Controversies

Chemists dislike the term heavy metals because of its inherent imprecision and often urge that it be abandoned. In 2002 the International Union of Pure and Applied Chemistry—the organization that sets the standards for chemistry's precise nomenclature—issued a technical report titled, "Heavy Metals—A Meaningless Term?" that reflected the frustration felt by the chemical community over the term's loose usage by those outside the field of basic chemistry. The term heavy metal, the report pointed out, "has even been applied to semimetals (metalloids) such as arsenic, presumably because of the hidden assumption that 'heaviness' and 'toxicity' are in some ways identical" (p. 796).

The report bemoaned what it called "the persistence of the term and its continuing use in literature, policy, and regulations" (p. 797). It stated,

> There is no similarity in properties between pure tin, which has low toxicity, and tributyltin oxide, which is highly toxic to oysters and dog whelks. Nor is there any similarity in properties between chromium in stainless steel, which is essentially nontoxic, and the chromate ion which has been associated with causing lung cancer. Thus, the tendency to group certain metals and their compounds together for toxicity assessment under the title 'heavy metals' must lead to fuzzy thinking and is another reason to abandon the term. (p. 799).

Ethical issues surrounding the heavy metals parallel those associated with harm caused by toxic substances in general. Tension always exists between producers of these substances and those exposed to them, often leading to tort damage claims and prolonged litigation. Those who believe industry should be held liable for injuries caused by toxic metal emissions have been turning for support to a relatively new legal theory known as the neurotoxity hypothesis. This hypothesis derives from neurochemical research that suggests that criminal behavior in individuals correlates with high levels of lead, manganese, and cadmium in the bodies of those individuals. Further research reinforcing such new insights could lead to changes in tort law that would impose stricter regulatory standards for these substances and more criminally related penalties for violators.

WIL LEPKOWSKI

SEE ALSO *Environmental Ethics; Environmentalism; Environmental Regulation.*

BIBLIOGRAPHY

Crawford, Colin. (2000). "Criminal Penalties for Creating a Toxic Environment: *Mens rea*, Environmental Criminal Liability Standards, and the Neutotoxicity Hypothesis." *Boston College Law Review* 27(3): 341–290.

Duffus, John H. (2002). "Heavy Metals: A Meaningless Term?" (IUPAC Technical Report). *Pure Applied Chemistry* 74(5): 793–807.

Nriagu, Jerome O. (1966). "A History of Global Metal Pollution." *Science* 272(5259): 223–224.

Van der Voet, Ester; Jeroen B. Guinée; and Helias A. Udo de Haes, eds. (2000). *Heavy Metals: A Problem Solved?: Methods and Models to Evaluate Policy Strategies for Heavy Metals*. Dordrecht, The Netherlands; Boston: Kluwer Academic Publishers.

HEGEL, GEORG WILHELM FRIEDRICH

German philosopher Georg Wilhelm Friedrich Hegel (1770–1831), born in Stuttgart on August 27 and

Georg Wilhelm Friedrich Hegel, 1770–1831. The German philosopher and educator took all of knowledge as his domain and made original contributions to the understanding of history, law, logic, art, religion, and philosophy. *(The Library of Congress.)*

educated at the University of Tübingen, gained intellectual renown while teaching at the University of Berlin. A thoroughly systematic thinker, Hegel viewed philosophy, natural science, history, ethics, and religion as inherently connected in a whole that included difference while simultaneously transcending it. As a result, he presents the kind of comprehensive interpretation of science, technology, and ethics that is often implicit but seldom articulated in contemporary discussions, which, in light of Hegel, are challenged to move beyond particular case studies. Perhaps most famous for his *Phenomenology of Spirit* (1807), Hegel died suddenly on November 14 during a cholera epidemic.

Science and Technology in Hegel's System

For Hegel, the truths of the empirical (or special) sciences are justified only by the thinking at work in philosophy. Put another way, natural science occupies a middle point between sensation and philosophy. Just as sense experience needs science to grasp its deepest truths, so science requires philosophy.

The relationship between natural science and philosophy is best understood in terms of four modes of consciousness: sense-certainty, perception, understanding, and reason. The empirical sciences build on sense-certainty and perception to establish laws and theories. This move toward universality indicates that understanding is predominant in natural science. What the empirical sciences provide are nevertheless mere facts and concepts that are founded on fixed categories (for example, cause and effect, substance and accidents) that are accepted uncritically. Such a detailed explication of nature has a relative immediacy when viewed from the perspective of self-conscious reason and its characteristic philosophical thinking. It thus becomes the task of philosophy to give final meaning to what the sciences reveal by criticizing their inherent conflicts and contradictions on the way to establishing a unified synthesis in which these differences are preserved while being overcome. Ultimately, the empirical sciences are a necessary and integral phase in the development of consciousness and a crucial first step toward the rational unveiling of what Hegel calls Spirit in nature.

Hegel's view of technology emerges from his defense of the distinctly modern assertion that all knowing involves making. In accordance with this doctrine, Hegel maintains that human beings produce both themselves and their world. Individuals are only insofar as they are productive. In one's relationship with the natural world, such production manifests itself as work, a mediating activity pervaded by the tools one uses. Technology, therefore, emerges as formative for human beings insofar as it allows them to assert themselves over and against their physical environment. Though such is the case with even basic tools, it becomes most evident with the emergence of machines, the effectively self-reliant tools that deceive nature into working toward human ends. Whereas science aids in discovering the Spirit implicit in nature through observation, technology is the human way of actively manifesting Spirit in the natural world, which is continuously transformed through work.

Hegel's Influence

Hegel's initial influence rested with his ability to go beyond the distinction that his predecessor Immanuel Kant (1724–1804) made between phenomenal appearances (which are scientifically knowable) and things-in-themselves (which ground all phenomena, but remain unknowable in all respects other than their actual existence). Against Kant, Hegel argues that systematic philosophical reflection, in grasping the cognitive genesis of scientific knowledge and its contribution to self-consciousness, can indeed know reality in its entirety (that is, both phenomenal appearances and things-in-themselves), because there could not in principle be anything beyond such a synthetic whole.

The first generation of Hegel's followers nevertheless looked more to the practical implications of transcendence, thus proposing a further overcoming of Hegel himself that would make his philosophical synthesis, especially the notion of a self-consciousness that simultaneously makes the world and itself, into a lived reality. It was for this reason that Karl Marx (1818–1883) sought to turn Hegel right-side up and thereby place him on his feet (*The Holy Family*, 1845), not just to understand the world but to change it ("Theses on Feuerbach," 1845). Marx's critique centers around the plight of industrial workers and the alienation they experience in regard to the products of their labor, their work activity, and, above all, their humanity (*Economic and Philosophical Manuscripts*, 1844).

But it was another philosopher, Ernst Kapp (1808–1896), who took the technological implications of Hegel most seriously, and in doing so was the first to speak of a "philosophy of technology." Drawing on Hegel's theory of history, Kapp's materialism took historical evolution to be the result of humanity's various attempts to overcome the constraints of nature (*Vergleichende allgemeine Erdkunde*, 1845). Insofar as such an overcoming necessarily involves technological innovation, Kapp reflected extensively on the nature of tools, construing them as "organ projections" that essentially act as extensions of the human body (*Grundlinien einer Philosophie der Technik*, 1877).

The Master–Slave Dialectic

The historical and ethical import of Hegel's views on technology are best gleaned from his master–slave dialectic, a doctrine interpreted at length by Alexandre Kojève (1902–1968), whose post–World War II lectures, though idiosyncratic, proved influential. For Kojève history begins with the first battle that ends with a victorious master and a vanquished slave. In risking life for genuine human recognition, the master spurns a merely biological existence, thus triumphing over the slaves who, for fear of death, succumb to the master in order to preserve their lives. Through human conquest, the master achieves an independence that, at least for the time being, remains foreign to the slave. The slave works for the master, forced to struggle with an often recalcitrant nature in order to provide for the master's needs.

In spite of the seemingly unenviable position of the slaves, true human progress and genuine freedom would be impossible without them. Masters, freed from dealing with nature, live a life of leisure that consumes the products of nature without any compensatory replenishment. Slaves, by contrast, learn to confront nature, an imposition that obliges them to understand nature in order to control it. It is slaves, then, who develop science and technology and who, unlike masters, are the true creators. Only through such scientific and technological development is progress made and historical change enacted.

Furthermore, the path to true freedom finally becomes apparent as the freedom of the master ultimately reveals itself as false. Though a master achieves a measure of independence from the physical environment, this is an achievement that remains dependent on the activity of the slaves. Slaves, for their part, achieve scientific understanding and create technological innovations that clear the way for a genuine freedom by surmounting nature directly and becoming independent of the services of still other slaves.

Conclusion: The Ethical Dimension

The evolution of science and technology, for Hegel, has direct ethical implications. In marking desire as intrinsic to self-consciousness, Hegel maintains that real human satisfaction can be had only in and through the recognition of another self-conscious subject. Though the master sought such recognition in his relationship with the slave, slavish recognition is necessarily ungratifying insofar as it is given by a slave who is, by definition, less than fully human. Genuine human satisfaction, therefore, will be had only when the master–slave relationship comes to an end and the human beings involved recognize each other as equals.

This ethical ideal of reciprocal recognition is first envisioned by slaves who see how people can free themselves from their merely biological existence and thereby assert their dignity in a way other than the masterly domination of other human beings. Through scientific understanding and the technological mastery of nature, the master–slave relationship can be overcome, reciprocal recognition achieved, and genuine freedom finally won. For Kojève, such an occurrence will mark the end of history because the struggle for recognition, which is the principal cause of historical change, comes to an end.

CRAIG CONDELLA

SEE ALSO *Alienation; Freedom; German Perspectives; Marx, Karl.*

BIBLIOGRAPHY

Harris, Errol E. (1974). "Hegel and the Natural Sciences." In *Beyond Epistemology*, ed. Frederick G. Weiss. The Hauge, Netherlands: Martinus Nijhoff. Situates the natural sciences within Hegel's system, identifying understanding as the mode of consciousness predominantly at work therein.

Hegel, Georg Wilhelm Friedrich. (1970). *Hegel's Philosophy of Nature*, trans. A. V. Miller. Oxford: Clarendon Press. Part Two of Hegel's *Encyclopaedia of the Philosophical Sciences* (1817). This volume deals specifically with modern science, treating figures such as Galileo, Newton, Kepler, Linnaeus, Lamarck, and Lavoisier.

Hegel, Georg Wilhelm Friedrich. (1977 [1807]). *Phenomenology of Spirit*, trans. A. V. Miller. Oxford: Clarendon Press. Intended as an introduction to his philosophical system, Hegel's *Phenomenology* traces the psychological and historical development of human consciousness through various forms of alienation to its final fulfillment in "Absolute Spirit."

Kojève, Alexandre. (1980). *Introduction to the Reading of Hegel*, trans. James H. Nichols Jr. Ithaca, NY: Cornell University Press. This translation of Kojève's *Introduction a la lecture de Hegel* (assembled by Raymond Queneau) analyzes Hegel's *Phenomenology* while simultaneously reinterpreting it, making much of the master–slave dialectic as the driving force of history.

Strauss, Leo. (2000). *On Tyranny*, ed. Victor Gourevitch and Michael S. Roth. Chicago: University of Chicago Press. Taking its cue from Xenophon's *Hiero*, this volume includes Strauss's famous debate with Kojève and deals with the problems that tyranny and the possible end of history entail.

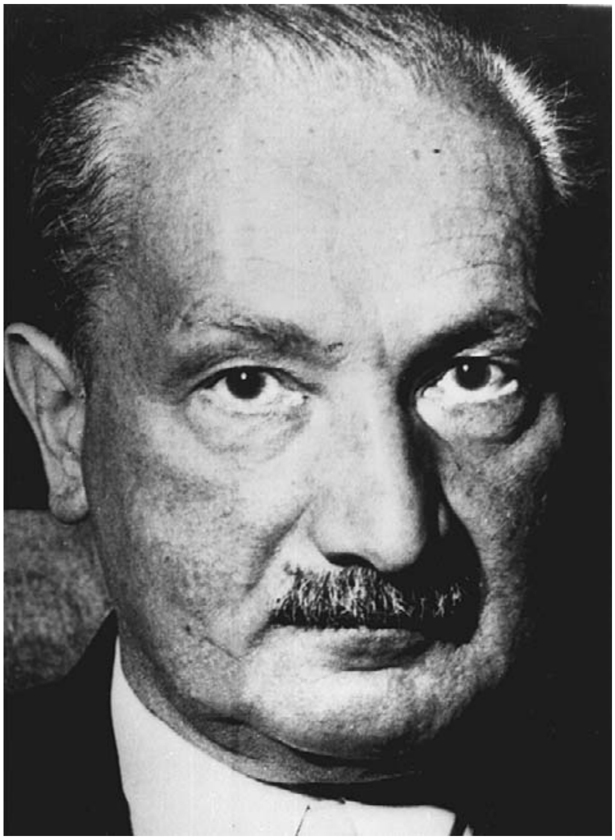
Westphal, Merold. (1998). *History and Truth in Hegel's "Phenomenology."* Bloomington: Indiana University Press. A careful summary of Hegel's *Phenomenlogy* that illuminates what is principally at stake in the text itself while locating Hegel more generally within the Western philosophical tradition.

HEIDEGGER, MARTIN

Martin Heidegger (1889–1976), who was born in Messkirch, Germany, on September 26 and died there on May 26, was among the most important thinkers of the twentieth century. His significance for science, technology, and ethics may be approached from four directions.

Theoretical Science and Practical Activities

Heidegger's first and still most important book, *Sein und Zeit* (1927; English trans. *Being and Time*, 1962), is a cornerstone of the existentialism that became prominent after World War II. The book's major terms—anxiety, resoluteness, everydayness, authenticity, concern, care,



Martin Heidegger, 1889–1976. The German philosopher has become widely regarded as the most original 20th century philosopher. Recent interpretations of his philosophy closely associate him with existentialism (despite his repudiation of such interpretations) and, controversially, with National Socialist (Nazi) politics. *(AP/Wide World Photos.)*

and the like—are concepts Heidegger helps make intellectually cogent. Albert Camus (1913–1960) and Jean-Paul Sartre (1905–1980) work on territory Heidegger opened up philosophically.

Heidegger's own goal, however, was not to outline a theory of human beings as radically insecure or irrationally committed, but to uncover the central openness of human beings to being as such. Humans are the entities for whom how to be is always an issue. This is true for everyone and not merely true generally or abstractly. Heidegger's goal is to clarify the question of being by working out what being is and how it matters for each human being.

Heidegger's analysis in *Being and Time* follows a path that begins with the significance of ordinary human concerns and concludes with the temporal meaning of being. The usual implicit meaning of being is that which is most fully or eternally present. As a result humans conceive all things as essentially static entities with fixed, general characteristics suitable for neutral measuring, spatially and temporally. People objectify even their own selves in this manner. The meaningful present, however, cannot exist apart from the ordinary worlds of significance into which people find themselves thrown. This richer temporality, not static presence, is the heart of being human, and the clue to being as such. There is a historical and temporal motion, indeed, a dizzying abyss beneath all presence.

The relation between theory and practice that Heidegger's analysis suggests has important implications for understanding scientific technology. Purely theoretical enterprises such as natural science or mathematics depend on views of time and space that flatten or narrow the rich meanings of being projected in the ordinary worlds of action and concern. Dealing with things as they are actually used is primary; theoretical and scientific analysis is secondary. The right time and place to use particular tools cannot be determined, for example, from the neutral coordinates of physics, but are inherent in use itself. Instead, physics abstracts from and narrows the richness of tools that do their jobs usefully in the appropriate place and time.

This narrowing does not mean, however, that what science discovers is false in its own realm. The relativism or inordinate human responsibility for meaning that is inseparable from Heidegger's understanding does not imply that everything is magically at human disposal. Rather, what natural science discovers may be correct, but humans must see how it is grounded on the broader truths of being and of human openness to being.

The History of Science

Many of the works of Heidegger and his followers include some notion that use, practice, and everyday concern precede the flattening on which modern science and technology are built. Indeed, this view has served as the basis for Heidegger's influence on academic studies in the history of science. Heidegger's teacher Edmund Husserl (1859–1938) and several of Heidegger's students or those he affected, such as Jacob Klein (1899–1978) and Alexander Koyré (1892–1964), made important contributions to the history of mathematics and science. Klein's *Greek Mathematical Thought and the Origin of Algebra* (1934) and Koyré's *Galileo Studies* (1939) may even be said to have transformed the field, because Heidegger's procedure, which influenced them, involved a relentless search for the experience and understanding at the heart of worn-out philosophical concepts commonly employed by academic history.

To grasp the existential origin of scientific concepts was to uncover their meaning, power, and range. Heidegger himself explored in various places the original Greek understanding of nature (*phusis*) and the changed understanding of nature and motion that differentiates Aristotelian and Newtonian physics. His 1936 lecture course "Die Frage nach dem Ding" (published in 1962; English trans. *What Is a Thing?* 1967) is especially cogent in this regard.

The Technology Question

Heidegger's most direct discussion of scientific technology is in his "Die Frage nach der Technik," delivered in early versions in the 1940s and published in 1954 (English trans. *The Question concerning Technology,* 1977). His analysis became a basic text for those worried about the power and dominance of contemporary technology. Both directly and indirectly it has influenced thinkers and activists (such as the German Greens) who in the name of the environment opposed growing industrialization and mechanization. Here and in other works, Heidegger's prescient sense of the importance of information science and life chemistry also connects his views to pressing controversies of the day.

Heidegger argues that the essence of technology is nothing technological, that is, that technology is not itself a tool or implement. Rather, the essence of technology involves the manner in which things first present themselves in the contemporary world, namely, as "standing reserve" to be manipulated or rearranged at will. Everything approaches humans as a source of energy, a human "resource," a matter to be organized. Lost in this scenario are the independence of things, their distinctive presence and shape, and the way in which they take place in a meaningful world they help to form. The simple bridge across a river allows the river to meander and stand forth in its own power; the dam that helps to generate electricity transforms this river into an implement interchangeable with other energy resources. Because people see themselves so generally as resources to be manipulated, they become alienated from their roots and traditions, and from the significance of birth and death. Technology sunders human beings from the lifetimes and the times of life that give individuals weight and direction.

Heidegger does not seek to solve the problem of technology directly or to overcome humanity's technological leveling. To do so would make his own effort one more link in the strangling technological chain. Rather, he tries to show that as the predominant presentation of beings today, technology itself must open to and be placed in being as such. The apparent technological annihilation of all other significance becomes a clue to the source of meaning generally. The results of uncovering this source cannot be predicted. But being and human openness to it can be addressed and discussed in the manner of *Being and Time*, or in the more direct yet more elusive way of some of Heidegger's work from the mid-1930s on, in which discussions of poetry and gods come to the fore.

The Nazi Question

Heidegger's work is tainted by his association with the Nazis. He joined the National Socialist Party when he became rector of Freiburg University in May 1933, whereupon he praised Adolf Hitler publicly. The intensity of his support subsequently diminished, and some remarks in his lectures may be read as opposition to the views of Nazi ideologues. Other remarks continued to defend the Nazis, however, and he remained a party member throughout World War II.

The important question for students of Heidegger and of technology is whether his support of the Nazis flows from his philosophical arguments or, rather, stems from personal idiosyncrasy or political naïveté. It would be difficult to take seriously a thinker whose discussions of what it is to be a human being were in no way linked to political actions and judgments; Heidegger's arguments do, in fact, display such a link. Heidegger's thought leads to immoderation and illiberalism because the standpoint from which he confronts issues is too encompassing to allow relevant ethical distinctions to matter or even become clear. Too many issues that to a responsible citizen or political leader involve significant differences between what is just and unjust look, from Heidegger's ontological point of view, to be the same. The substance of his understanding of human openness to being, moreover, with its emphasis on fate, authentic resolve, and the *Volk* (people), allows Heidegger to believe he has found essential links between his thought and the Nazis, and to accommodate his rhetoric to theirs.

It would be incorrect to claim that Heidegger's philosophical immoderation or basic concepts led him inevitably to support the Nazis or to approve all of Hitler's actions. The Nazis, he believed, ultimately failed to live up to what he called in 1935 "the inner truth and greatness of this movement." In the *Introduction to Metaphysics*, the version of 1935 lectures that he published in 1953, he described this "truth" and "greatness" as "the encounter between global technology and modern humanity. This same standpoint, however, led him not only (finally) to question the Nazis but to also treat the substance of Soviet Marxism, American democratic capitalism, and failed Nazism as essentially identical. The ethical and political immoderation to which Heidegger's view of technology can lead is strikingly captured not only in his political judgment but also in his identification of mechanized agriculture and the Holocaust: "Agriculture is now a motorized food industry, essentially the same as the manufacture of corpses in gas chambers and extermination camps, the same as the blockade and starvation of countries, the same as the manufacture of hydrogen bombs" (Polt 1999, p. 172, translating from Heidegger's "Das Ge-Stell").

Heidegger's thought cannot be reduced to his connection to the Nazis. His understanding of being and being human revitalized the study of philosophy by encouraging an encounter with the phenomena that the great works of Western thought have in view. His central concepts stimulated many to rethink the true sources of human freedom, excellence, and happiness. His view of scientific technology captures its breadth and centrality in a novel and still cogent manner. The paths he helped to open, however, can become closed by dogmatic application of his procedures. Heidegger's politics, moreover, encourage more than ordinary caution in dealing with his insights.

MARK BLITZ

SEE ALSO *Alienation; Arendt, Hannah; Existentialism; German Perspectives; Husserl, Edmund; Phenomenology.*

BIBLIOGRAPHY

Blitz, Mark. (1981). *Heidegger's "Being and Time" and the Possibility of Political Philosophy*. Ithaca, NY: Cornell University Press. A commentary on being and time.

Heidegger, Martin. (1962). *Being and Time*, trans. John Macquarrie and Edward Robinson. New York: Harper and Row. Translation of *Sein und Zeit*, 1927. Heidegger's major work

Heidegger, Martin. (1967). *What Is a Thing?* trans. W. B. Barton Jr. and Vera Deutsch. Chicago: Henry Regnery. Translation of *Die Frage nach dem Ding*, 1962. Includes a comparison of Aristotle and Newton.

Heidegger, Martin. (1977). *The Question concerning Technology*, trans. William Lovitt. New York: Harper and Row. Translation of *Die Frage nach der Technik*, 1954. Heidegger's chief essay on technology.

Heidegger, Martin. (1993). *Basic Writings*, rev. edition, ed. David Farrell Krell. San Francisco: HarperSanFrancisco. Includes "The Question concerning Technology," selections from *Being and Time* and *What Is a Thing?* and other works relevant to Heidegger's understanding of science and technology.

Heidegger, Martin (2000). *Introduction to Metaphysics*, trans. Gregory Fried and Richard Polt. New Haven, CT: Yale University Press. Translation of *Einfuhrung In Die Metaphysik* (1953). Important lectures delivered originally in 1935.

Klein, Jacob. (1968). *Greek Mathematical Thought and the Origin of Algebra,* trans. Eva Brann. Cambridge, MA: MIT Press. Originally published 1934. Early work in the history of science influenced by Heidegger.

Koyré, Alexandre. (1978). *Galileo Studies*, trans. John Mepham. Atlantic Highlands, NJ: Humanities Press. Originally published 1939. Early work in the history of science influenced by Heidegger.

Lovitt, William, and Harriet Brundage Lovitt. (1995). *Modern Technology in the Heideggerian Perspective*. 2 vols. Lewiston, NY: Edwin Mellen Press. Discussions of Heidegger and technology.

Polt, Richard. (1999). *Heidegger: An Introduction*. Ithaca, NY: Cornell University Press. Overall introduction to Heidegger's thought.

HIGHWAYS

SEE *Roads and Highways*.

HINDU PERSPECTIVES

Hinduism is the oldest of the major world religions, and also apparently one of the most accepting of modern science and technology. It provides a central place to consciousness in its approach to reality, which explains why it has appealed both to scientists looking for a role of observers in physics and biology and also to those who have been critical of standard science for its emphasis on mechanistic explanations.

The origins of Hinduism are not found in a single individual, and its texts go back to antiquity in India. Within the tradition, it is called the Sanātana Dharma or Vedic Dharma (*sanātana* meaning eternal, *veda* meaning knowledge); the term Hindu originally referred to the inhabitants of the Indian subcontinent. The various sects of Hinduism take the Vedas (second millennium B.C.E., or perhaps a bit earlier), which are collections of hymns, to be their canonical texts. But the Vedas are difficult to understand, and for practical reasons, most Hindus rely on later texts such as the Upanishads, the Bhagavad Gītā, and the Epics (first millennium B.C.E.), Sūtras, Āgamas, Shāstras, Purānas (whose time frames range from centuries B.C.E. to texts as late as about 1000 C.E.) for guidance.

Hinduism takes phenomenal reality to be a projection of God (Brahman), who is both transcendent and immanent. In its transcendent form, Brahman is beyond any attributes; in its immanent form it may be visualized in many different ways, leading to a multiplicity of representations. The evolution of the universe is by laws (*rita*), yet sentient beings have freedom. The law of karma constrains ordinary action, but a realized person is free.

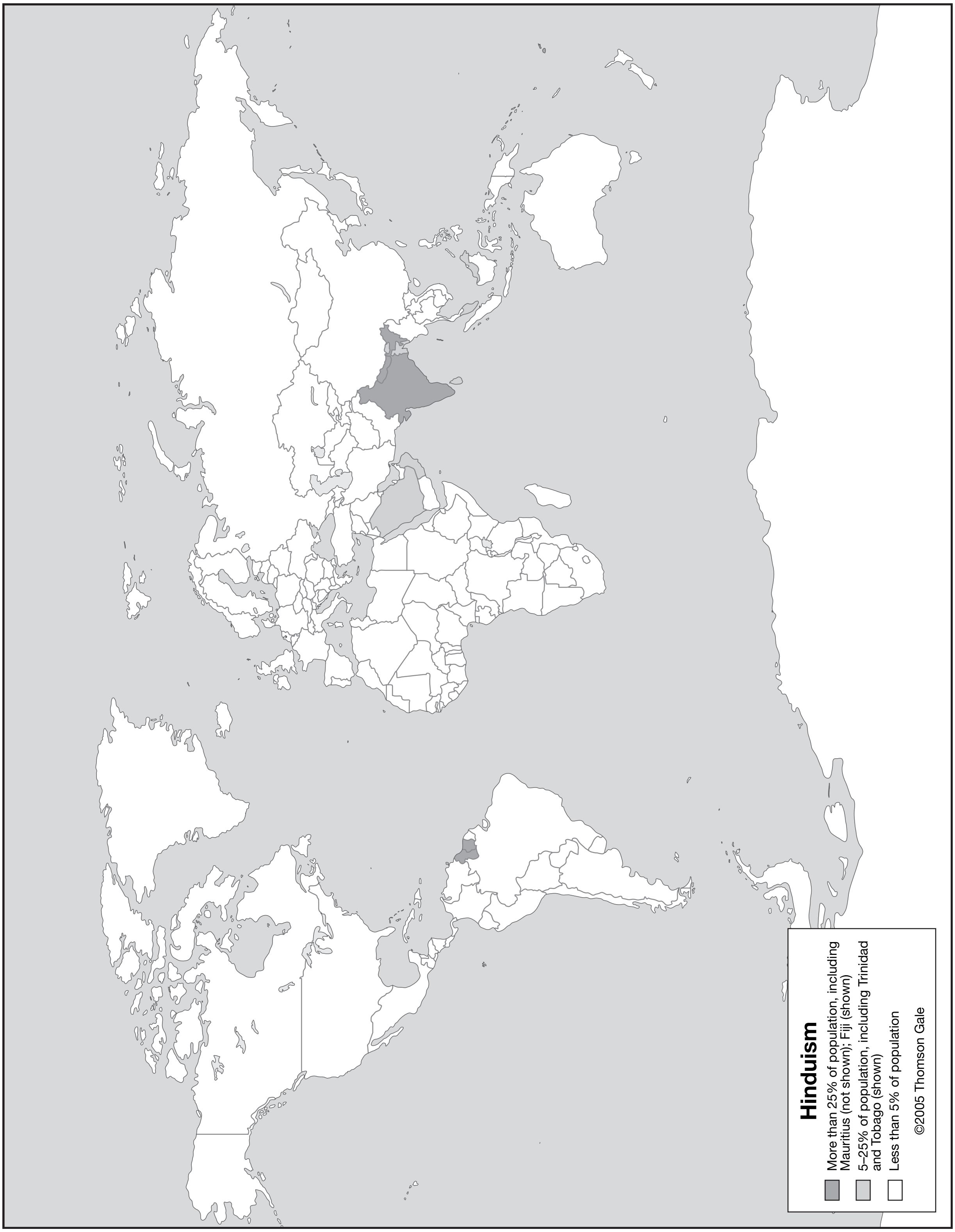
The Vedic texts claim that language cannot describe reality completely, although its mystery may be experienced fully. Knowledge is classified in two ways: the lower or dual; and the higher or unified. The lower knowledge, which describes the objective world, is obtained using logic and it is accessible by language. The higher knowledge concerns the experiencing self and is beyond ordinary language. The seemingly irreconcilable worlds of the material and the conscious are aspects of the same transcendental reality. Hinduism is supportive of all scientific exploration, believing that at its end one becomes aware of its limitations and the need to reach the mystery of the experiencing self. From a personal perspective, Hinduism is concerned with techniques that make self-transformation possible. Hinduism thus endorses both science and technology although not necessarily in their modern forms or for distinctly modern reasons.

Hinduism approaches the world in an ecological sense. Not only humans, but also animals, are conceived as sentient and, therefore, deserving of compassion. The Hindu approach to reality is through *jnāna* (intuitive understanding) that includes subjective and objective knowledge, value and fact, and consciousness and reality. *Jnāna* presupposes *jijnāsā,* a reaching out to understand, that leads to a spark of illumination. *Jnāna* requires the ethics of the individual as an indispensable condition for knowledge, which thus is not value free. Search for truth is a value orientation.

Historical Background

The history of early Hinduism is tied to the history of India. Its chronological time frame is provided by the archaeological record that has been traced, in an unbroken tradition, to about 8000 B.C.E. Prior to this are records of rock paintings believed to be considerably older. The earliest textual source is the Rigveda, which is a compilation of very ancient material. The astronomical references in the Vedic books recall events of the third or the fourth millennium B.C.E. and earlier. The recent discovery that Sarasvati, the preeminent river of the Rigvedic times, went dry around 1900 B.C.E. due to tectonic upheavals suggests that portions of the Rigveda were written prior to this epoch. According to traditional history, the Rigveda was written before 3100 B.C.E.

The other Vedic texts of the Yajurveda, the Sāmaveda, and the Atharvaveda borrow heavily from the Rigveda. The Brahmanas are prose works that describe


Hinduism
More than 25% of population, including Mauritius (not shown); Fiji (shown)
5–25% of population, including Trinidad and Tobago (shown)
Less than 5% of population
©2005 Thomson Gale

the Vedic ritual, and the Upanishads address philosophical issues. Ethical questions are directly addressed in the Sūtra literature, the Rāmāyana and the Mahābhārata, the Purānas, and the commentaries on these texts that have been written from time to time. Since the medieval times, the Bhagavad Gītā and the Rāmāyana have influenced millions, including Mahatma Gandhi.

Outside India, in the second millennium B.C.E., the ruling Mitannis in West Asia worshiped Vedic gods. The religion of Iran before Zoroastrianism was Vedic. Hindu religion spread to various countries in Southeast Asia in the first millennium B.C.E. and the largest Hindu temple in the world is found in Cambodia. In the twentieth century, Vedanta and Yoga have spread the popularity of Hinduism to Europe and North America.

Academic narratives of Hinduism emphasize issues related to social hierarchy, customs, and sectarian divisions around the worship of Vishnu, Shiva, and the Goddess. In reality, the social classes are not rigid, and most Hindus worship all the deities, although they might personally be more devoted to one or another. To understand why Hindus do not find it troubling to be devoted to more than one deity, it is necessary to examine the common thread of Vedic cosmology running through the tradition.

VEDIC COSMOLOGY. Briefly the Vedic texts present a tripartite and recursive view of the world. The universe is viewed as three regions of earth, space, and sky that in the human being are mirrored in the physical body, breath (*prāna*), and mind. The processes in these regions are connected as the consequence of a binding (*bandhu*) between various inner and outer phenomena. At one level, it means awareness that certain biological cycles, such as menstruation, have the same period as the moon. At another level, equations are postulated, such as the 360 bones of the infant (which fuse into the 206 bones of the adult) that correspond to the number of days in the civil year.

The connection between the outer and inner cosmos is seen most strikingly in the use of the number 108 in Indian religious and artistic expression. Elementary geometrical reasoning establishes that this number is the approximate distance from the earth to the sun and the moon in sun and moon diameters, respectively. The diameter of the sun is also approximately 108 times the diameter of the earth, but that fact is not likely to have been known to the Vedic sages. The number of dance poses given in the Nātya Shāstra is 108, as is the number of beads in a rosary. The *distance* between the body and the inner sun is also 108, which to span, symbolically, one uses 108 names of the deity in worship. The number of weak points in the body in Āyurveda, the Hindu medicine system, is 107, because in a chain 108 units long, the number of weak points would be one less.

The Vedas are primarily concerned about universal laws related to the inner self (*adhyātma vidyā*) that are true for all times. The Hindu experience is thus not contingent on a particular account of history, or an event that cannot be replicated. Complementing the Veda, which is the *heard* revelation (*shruti*), is the remembered tradition (*smriti*). As custom, *smriti* is considered appropriate for time and location and thus subject to change. This has allowed Hinduism to adapt to change over the millenniums.

VISHNU, SHIVA, AND THE GODDESS. Although the principles of Hinduism may appear very abstract, in practice Hindus relate to a personal deity much like followers of other religions. When viewed as the ethical principle, Brahman is Vishnu; as the inner Self, it is Shiva; and seen as the energy of Nature, it is the Goddess. Although at one level Vishnu and Shiva are the Preserver and the Destroyer; at another level, due to recursion, both Vishnu and Shiva, as well as the Goddess, are each the Creator, the Preserver, and the Destroyer. Furthermore each god has a goddess as consort, emphasizing the complementarity of the two. Shiva and the Goddess are also viewed as a single deity, as half of a whole, called Ardhanārīshvara, and Vishnu and Shiva as a single deity called Harihara.

Hinduism and Science

In Hinduism, the dividing line between objective sciences and *adhyātma vidyā* (spiritual knowledge) is the logical or linguistic paradox. Logical argument and rational proof using Nyāya is the way to obtain correct knowledge. But where paradox (*paroksha*) begins, one must let go of linguistic associations to experience paradox-free, deeper knowledge.

Nyāya's beginnings go back to the Vedic period, but its first systematic elucidation is Akshapāda Gotama's *Nyāya Sūtra*, dated to the third century B.C.E. Its text begins with the nature of doubt and the means of proof, and it considers the nature of self, body, senses, and their objects, cognition and mind.

The Nyāya system supposes that human beings are constructed to seek truth. Their minds are not empty slates; the very constitution of the mind provides some knowledge of the nature of the world. The four *pramānas* through which correct knowledge is acquired are *pratyaksha*, or direct perception; *anumāna*, or inference; *upamāna*, or analogy; and *shabda*, or verbal testimony. Four factors are involved in direct perception: the senses, their objects, the contact of the senses and the objects, and the cognition produced by this contact. The mind mediates between the self and the senses. When the mind is in contact with one sensory organ, it cannot be in contact with another. It is therefore said to be atomic in dimension. It is because of the nature of the mind that one's experiences are essentially linear, although quick succession of impressions may give the appearance of simultaneity.

The Nyāya attacks the Buddhist idea that no knowledge is certain by pointing out that this statement itself contradicts the claim by its certainty. One can check whether cognitions apply to reality by determining if they lead to successful action. Valid knowledge leads to successful action, unlike erroneous knowledge.

The evolution of the universe is ordained by cosmic law. Because it cannot arise out of nothing, the universe must be infinitely old. Because it must evolve, there are cycles of chaos and order or creation and destruction.

According to the atomic doctrine of Kanāda, there are nine classes of substances: ether, space, and time that are continuous; four elementary substances (or particles) called earth, air, water, and fire that are atomic; and two kinds of mind, one omnipresent and another that is the individual. The conscious subject is separate from the material reality but is, nevertheless, able to direct its own evolution.

The Mahābhārata and the Purānas address the question of creation. It is said that humans arose at the end of a chain, at the beginning of which were plants and various kind of animals. In Vedic evolution the urge to evolve into higher forms is taken to be inherent in nature. A system of evolution from inanimate to progressively higher life is a consequence of the different proportions of the three basic attributes of *sattva, rajas*, and *tamas*, which represent transparence, activity, and inertia, respectively. In its undeveloped state, cosmic matter has these qualities in equilibrium. As the world evolves, one or another of these becomes preponderant in different objects or beings, giving specific character to each.

Unlike the Abrahamic religions, whose eschatology is centered on the dead rising to the heavens, Hindu visions of the end of the world are naturalistic. For example, the Mahābhārata (Shānti Parva, Chapter 233) speaks of how a dozen suns will begin to burn when the time comes for universal dissolution a few billion years in the future. First all things mobile and immobile on Earth will disappear merging into the elements, making it, shorn of trees and plants, look as naked as a tortoise shell. Next Earth will melt, and then vaporize and become heat and wind. Then wind will be transformed into space, with its attribute of unheard or unuttered sound. Finally space will withdraw into Mind, ultimately merging into Consciousness, which is the origin of reality.

In Vedic discourse, the cognitive centers of the mind are called *devas*, deities or gods, or luminous loci. The Atharvaveda calls the human body the City of Devas. The number of devas is variously given, the most extravagant estimates are 3.3 million. All devas are taken to embody the same light of consciousness. The mind consists of discrete agents, although it retains a unity. Because each deva reflects primordial consciousness, one can access the mystery of consciousness through any of them.

When the cognitive centers nearer the sense-organs are viewed in anthropomorphic terms, they are called *rishis*, sages. The Yajurveda declares that seven sages reside within the body. The texts also divide the capacities of the mind into various dichotomies, such as high and low, left and right, and masculine and feminine.

MEDICINE. Āyurveda operates in the context that humanity's essential nature is the *ātman*, or Self, which is self-luminous, the source of all power and joy. Actions that aid in the manifestation of the divinity of the soul are beneficial and moral, and those that obstruct it are harmful and immoral. The Āyurvedic physician must help humans and nonhumans in their physical and mental health so that they can fulfill their quest for knowledge.

Āyurveda builds upon the tripartite Vedic approach to the world. Health is maintained through a balance between the three basic humors (*dosha*) of wind (*vāta*), fire (*pitta*), and water (*kapha*). Each of these humors has five varieties. Although literally meaning air, bile, and phlegm, the *doshas* stand for larger principles. The imbalance of these elements leads to illness. The predominance of one or the other leads to different psychological profiles. Charaka and Sushruta are two famous early physicians, and the beginnings of their compendiums have been dated to seventh century B.C.E.. According to Charaka, health and disease are not predetermined and life may be prolonged by human effort. For Sushruta, the purpose of medicine is to cure the diseases of the sick, protect the healthy, and prolong life. Indian surgery was quite advanced, even before 300 B.C.E.. The medical system tells much about the Indian approach to science. There was emphasis on observation and experimentation. The normal length of training appears to have been seven years. Before graduation, the students had to pass a test. Physicians were expected to learn through texts, direct observation, and inference. In addition, they attended meetings where knowledge was exchanged and were enjoined to obtain unusual remedies from herdsmen and forest-dwellers.

SCIENTIFIC IMAGINATION AND MODERN SCIENCE. A remarkable aspect of Indian literature is its scientific speculation. The epic Mahābhārata mentions embryo transplantation, multiple births from the same fetus, battle with extraterrestrials who are wearing airtight suits, and weapons that can destroy the world. The Rāmāyana mentions air travel. The medieval Bhāgavata Purāna has episodes describing how the passage of time can be different for different observers.

Conflict between science and religion has often arisen as a result of creation and end-of-the-world myths. Hindu views on these issues emerged from rational thought and are similar to some scientific views. Erwin Schrödinger, the cocreator of quantum theory, claimed to have been inspired by the Hindu mystical view of the identity of Brahman and the individual Self in his proposal of the quantum universal function that is a superposition of all possibilities. In fact, some philosophers of science see the evolution of quantum theory to be consistent with Vedānta. But because the bases for such beliefs in Hinduism and in modern science are quite different, it could also be argued that such relations are specious.

Hindu Ethics

The Vedas have many passages enjoining ethical behavior. The contemporary Hindu most often consults the Epics, Purānas, and the Bhagavad Gītā for such lessons. The Bhagavad Gītā is about the crisis facing Arjuna, hero of the Pandavas, as he confronts his relatives, the Kauravas, on the battlefield of Kurukshetra. Overcome by despair at the thought of killing his kinsmen in battle, Arjuna lays down his arms. But his charioteer Krishna, who is an incarnation of Vishnu, argues that Arjuna should do his duty and do battle. The human soul is not different from the universal soul and, thus, is immortal. When duties are performed without attachment to success or failure, one is not stained by action. Krishna teaches Arjuna the essence of *karma yoga* (yoga of works), *jnāna yoga* (yoga of knowledge), and *bhakti yoga* (yoga of devotion). He also teaches that the human being has a free will that permits him to make intelligent choices, which have a bearing on his karma. Using the battlefield of Kurukshetra as a symbol of life's struggles, the lessons of this text can be applied to everyday situations.

Elaboration of the social code is found in the Mahābhārata. The four great aims of human life are *dharma* or righteousness, *artha* or wealth, *kāma* or enjoyment, and *moksha* or spiritual liberation. Life runs through four stages: studentship, householdership, forest dwelling, and wandering ascetic. Society was divided into four classes: the teacher or *brahmin,* the warrior or *kshatriya,* the trader or *vaishya,* and the worker *shūdra.* These four were born from the head, the arms, the thighs, and the feet of *purusha,* the primal man. In reality, the aims of life run somewhat concurrently, and likewise, each individual, having the same *purusha* within, has attributes of each of the four classes.

Patanjali's Yoga Sūtra speaks of a system of eight limbs of which the first two emphasize moral and ethical preparation: moral restraint (*yama*), which includes to do no harm, truthfulness, to refrain from stealing, chastity, and to avoid envy; and discipline (*niyama*), which includes purity, contentment, asceticism, self-study, and devotion to the Lord. The remaining limbs prepare the individual for a mystical union with the Self: posture, breath control, sense withdrawal, concentration, meditation, and absorption. Thus ethical behavior is essential to prepare the individual to receive knowledge. This discipline connects the physical body to the energy sheath, which is the subtle body that envelops it.

Like the Yoga Sūtra, the law book of Gautama lists the following practices for a virtuous person: compassion for all beings, patience, contentedness, purity, earnest endeavor, good thoughts, freedom from greed, and freedom from envy.

Although its diverse texts point to corresponding diversity in practice, a common theme running in the various Hindu traditions is harmony in society and nature, necessitating obligations of different kinds. Humankind is enjoined with the stewardship of nature and a special responsibility towards animals that is symbolically represented in the veneration for the cow, the origins of which veneration rest in the central role of the animal in the economy of the village and because the Sanskrit for "cow" also means "Earth." These attitudes explain why vegetarianism is extolled in many Hindu communities.

PROSPECTS. Because Hinduism makes a distinction between higher and lower knowledge, it has no direct conflict with science, although it would take issue with technologies that do not promote social good. In the Hindu approach, logic and rationality is the means of obtaining outer knowledge that complements the inner science of the self. Hinduism does not contest scientific accounts of creation; in fact, its own accounts of creation and destruction are very similar. The appeal to a cycle of births helps the Hindu find order in events that might otherwise appear chaotic and unjust.

Hinduism recognizes that at one level all creatures are part of a food chain, in which the big fish eats the small. But this physical aspect of life represents the animal self. Hinduism's task is to raise the individual beyond the animal self to a state in which one appreciates the interconnectedness of reality and develops compassion for all beings. Nonviolence is lauded as the highest principle, with the acknowledgement that the real world has violence in it that reflects the level of the development of society.

Regarding the unborn, the Garbha Upanishad claims that the subtle body enters the embryo in the seventh month. Although Hindu law books condemn abortion, the early-twenty-first-century Hindu is likely to defer to the scientist in determining when the fetus is viable. Because the individual is not just the physical body but also the subtle body, cloning the physical body is not problematic. For similar reasons, Hindus are not opposed to stem cell research.

Because Hinduism acknowledges that animals are sentient like humans; it is opposed to the unnecessary medical testing of drugs and procedures on animals. Hindus have opposed genetic modification to crops in advanced countries with the major motivation of greater productivity, because it disrupts farming in the poorer countries and makes it likely that these farmers will become dependent on expensive patented seeds controlled by inaccessible corporations.

In medical practice, the Hindu approach stresses a holistic view to therapy that acknowledges connections between mind and body, which is part of the reason of the increasing popularity of Yoga and Ayurveda. But it is not clear yet to what extent these disciplines will be incorporated in mainstream medicine.

Many Hindus—and this included Mahatma Gandhi—are critical of those technologies that dehumanize the person, treating a human being as a mere cog in a machine, as happens to be the case in certain manufacturing processes. This is why Gandhi praised small-scale industry and urged for self-sufficiency in the village. Hindus believe that science and technology must be harnessed in a manner that furthers humanity's inherent quest for self-knowledge. Because individuals are defined not in isolation, but through their interactions with other persons, this quest cannot ignore the larger good of society, and requires ethical preparation on the part of the individual.

SUBHASH KAK

SEE ALSO *Buddhist Perspectives; Indian Perspectives.*

BIBLIOGRAPHY

Bose, D. M.; S. N. Sen; and B. V. Subbarayappa, eds. (1971). *A Concise History of Science in India.* New Delhi: Indian National Science Academy. Presents a good overview of Indian science.

Crawford, S. Cromwell. (1994). *Dilemmas of Life and Death: Hindu Ethics in North American Context.* Albany: State University of New York Press. Deals with questions of Hinduism and ethics in North America.

Kak, Subhash. (2001). *The Wishing Tree: The Presence and Promise of India.* New Delhi: Munshiram Monoharlal. This collection of essays deals with lesser known aspects of Hindu culture and science.

Kak, Subhash. (2002). *The Gods Within: Mind, Consciousness, and the Vedic Tradition.* New Delhi: Munshiram Manoharlal. Presents the Hindu view of how the Gods constitute the firmament of the inner space.

Klostermaier, Klaus K. (1994). *A Survey of Hinduism.* Albany: State University of New York Press. This is a comprehensive text dealing with the history and practice of Hinduism in its various sects.

Klostermaier, Klaus K. (1998). *A Short Introduction to Hinduism.* Oxford: Oneworld Publications. A very accessible introduction to Hinduism.

Moore, Walter J. (1992). *Schrödinger: Life and Thought.* Cambridge: Cambridge University Press. An excellent resource for the connections between Vedanta Hinduism and modern physics.

Pande, Gobind C., ed. (2001). *Life, Thought, and Culture in India.* New Delhi: Centre for Studies in Civilizations. This text covers the period 600 B.C.E. to 300 C.E. in the more than 80 volumes of the PHISPC series on History of Philosophy, Science, and Culture of India of which Professor D.P. Chattopadhyaya is the general editor.

Subbarayappa, B. V., and S. R. N. Murthy, eds. *Scientific Heritage of India.* Bangalore, India: The Mythic Society. Presents articles on different scientific contributions of India.

HIROSHIMA AND NAGASAKI

These two cities are etched in the collective consciousness of the world as scenes of utter destruction and inhumanity. The decision of President Harry S Truman to authorize the use of atomic bombs on the Japanese cities of Hiroshima and Nagasaki also remains one of the most contentious issues associated with the conduct of Allied forces in World War II.

Emotional Debates

The deep emotions that people feel toward this decision continue to resonate in American and Japanese life. These emotions were expressed in the reactions to the fiftieth-anniversary exhibitions about the dropping of the bomb at Hiroshima by the Smithsonian Institution's National Museum of American History and an exhibit in Hiroshima in 1995. Professional historians serving as museum curators prepared the Smithsonian exhibit. It was carefully vetted by a wider advisory group of American historians who represented varied views about the rationale and ethics of the American decision to use the atomic bomb. Yet when word leaked to members of Congress about the content of the exhibit, special hearings were held and a firestorm of controversy and publicity resulted in a complete redesign of the exhibit into a much more innocuous display of the *Enola Gay* bomber with a few selected images and commentary about the events of a half-century before.

A widely cited Gallup poll of the American public at the time found 85 percent approving of the use of the bomb on Japanese cities. Various public figures in Japan remonstrated about America's unwillingness to face fully the import of its actions, and public demonstrations occurred in both countries over this contentious exhibit. Yet in a similar manner, considerable controversy occurred in Japan over a new exhibit in Hiroshima on the eve of the fiftieth anniversary that highlighted Japanese aggression in the Pacific and suggested that some Japanese military units had committed war crimes in their prosecution of the war effort. Many Japanese public figures condemned the exhibit and called for its withdrawal.

What Happened

It is impossible from the vantage point of history to fully know what people in the United States and Japan knew, understood, surmised, and most importantly, felt, during the period when these momentous decisions were made. World War II by this point had seen more than 55 million deaths. By 1945 the Japanese military had lost 3 million men, including more than a million in the previous year. U.S. air forces dominated the skies of Japan, and bombers flew sorties in open daylight. More than a million Japanese civilians had been killed in air raids. Yet still the Japanese refused to surrender.

Across the Pacific plans were coming to life as men, materials, ships, communications systems, and so on were all being prepared for a momentous invasion of Japan that would involve in excess of a million troops in the initial assault in the south and another million in a second wave of assaults to the north. Intelligence sources indicated that the Japanese were massing troops all over key points in Japan and preparing to repel an invasion force they were sure was coming. American troops and their leaders who had studied the vicious fighting on Okinawa where U.S. marines suffered 67,000 casualties (about 35 percent of their total fighting force), including 7,700 dead, contemplated what it would be like to now try to take the Japanese homeland where a similarly high casualty rate might be anticipated. Naval personnel recalled the ferocious kamikaze attacks they had already endured and wondered how many thousands of more planes and pilots would be flung at their ships as they entered Japanese home waters and how many more U.S. ships would be sent to the bottom of the sea.

Oral accounts of major actors' thoughts, attitudes, convictions, actions, and beliefs after the fact is colored by those facts as well as the vicissitudes of public opinion such that these recollections may prove unreliable. Historians have amassed considerable written evidence that suggests that all of the following statements hold. Presidents Franklin Delano Roosevelt and Truman always believed the bomb could and should be used. The Soviet Union was already perceived as a major threat to world peace on the conclusion of hostilities against Japan, and containing the Soviet threat was paramount in the minds of America's senior policymakers. Estimations of casualties in the first (ninety-day-long) phase of the invasion of Japan varied widely from a low of 50,000 to a high of 250,000. The United States was willing to let the emperor remain on the throne—even though this was not communicated to the Japanese. Japan had made overtures to surrender through Russian and Swiss contacts as well as directly to General Douglas MacArthur's headquarters in January 1945. General Curtis LeMay, commander of the U.S.

The atomic bomb memorial dome in Hiroshima. The memorial consists of the ruin of the only building to survive the blast. *(© John Hicks/Corbis.)*

strategic bomber forces in the Pacific, was determined to maximize air power effectiveness. The broken Japanese code indicated in July that the emperor was contemplating intervening with the Japanese military to broker a surrender. The United States had advance notice that the Soviets were entering the war against Japan in early August. The atomic bomb possessed a psychological effect well beyond its military effect and was clearly a weapon in a class by itself.

The atomic bomb was dropped on Hiroshima (population 285,000 civilians along with 43,000 soldiers) on August 6, 1945, at 8:15 A.M. local time. The immediate death toll according to estimates from a joint Japanese and American report issued in 1966 was greater than 70,000, including two American prisoners of war, with another 70,000 casualties. Of the city's 76,000 buildings, all but 6,000 were damaged and 48,000 were totally destroyed over an area of about eleven square kilometers. A total of almost 232,000 have died up to the present from disorders and problems linked to this event in Hiroshima, including children from 1945 dying from various cancers caused by the intense radiation.

The bomb dropped on Nagasaki (population 195,000) three days later killed some 36,000 Japanese outright, injured another 40,000, and caused about another 25,000 subsequent deaths due to burns and radiation exposure. By U.S. Army estimates, about 44 percent of the city was destroyed, the remainder being spared by the steep hills and topography of the city. Although Nagasaki was on the list of potential target cities, the selection of Nagasaki was "accidental" that day because clouds obscured the preferred target city of Kokura.

It is important to view the casualty figures in the context of the air war with Japan. The U.S. firebombing of Tokyo on March 9–10, 1945, resulted in more than 100,000 Japanese deaths in a twenty-four-hour period during which ground temperatures reached 1,100 degrees Celsius (the heat at the center of the atomic blasts by contrast briefly equaled that of the interior of the sun). Two subsequent air strikes against Tokyo resulted in more than half the city being completely destroyed by late May. What made the atomic bombs different was the devastation from one single bomb coupled with visual and nonvisual effects that dwarfed nonnuclear devices and long-term effects that could not even be predicted.

Postwar Assessments

The development of the atomic bomb was a major scientific and technical feat that employed at its peak 160,000 people and consumed two-fifths of the entire U.S. war budget while remaining hidden from members of Congress and even most senior military leaders, and prompted considerable angst and second-guessing on its moral appropriateness on the part of many of the scientists intimately connected with its birth.

One scientist, Joseph Rotblat, left the Manhattan Project because of his ethical concerns. Others self-organized and created a series of written documents that expressed their collective ethical and moral concerns about the bomb and its use. Captain Claude Eartherly, a pilot who flew the reconnaissance plane over Hiroshima but did not view the drop itself, later expressed regrets over his involvement and the American decision. This admission was seized on by the German philosopher Gunther Anders in a book called *Burning Conscience* and by advocacy groups to support arguments against both the use of nuclear weapons as well as the American decision to deploy them during the war. Eartherly became somewhat of a hero in communist countries and among "ban the bomb" groups. His wartime colleagues, including his commanding officer colonel Paul Tibbets who flew the B-29 that actually dropped the bomb, viewed Eartherly as a gambler, drunk, and publicity hound. (He spent his later years in a mental health facility.) Brigadier-General Tibbets expressed no regrets over his decision, although his service as deputy director of the U.S. military supply mission to India in the mid-1960s was cut short when the pro-Communist press in India labeled him as the "world's greatest killer."

A small panel of senior military, political, and scientific leaders made the final recommendation to President Truman after an intensive but brief consideration of various options. J. Robert Oppenheimer, lead science director for the project and a participant in these deliberations, later concluded that the military had kept civilians considerably in the dark about the actual state of affairs in the Pacific and the estimated impact of the proposed invasion of Japan.

Admiral William Leahy, Truman's chief of staff, believed throughout the process and after that use of the atomic bomb on two Japanese cities was completely unwarranted. He called for a return to warfare that excluded women, children, and other noncombatants. (The Allies, following the lead of the Japanese in China in the 1930s and the German firebombing of Coventry, England, in November 1940, regularly firebombed Axis cities causing massive civilian casualties on the grounds that this would hasten the end of the war.)

Justifications for the use of the atomic bomb against Japan flowed swiftly after its use, both from the White House and from military press releases. The U.S. public was also reassured that the latent results from this new weapon were modest. The *New York Times* headline of September 13, 1945, amazingly declared, "No Radioactivity in Hiroshima Ruin." Even in the earliest years, however, doubts about the necessity of the bomb as a military option to expedite the surrender of Japan were expressed by senior U.S. military leaders including Supreme Allied Commander Dwight D. Eisenhower, Chief of Staff General George Marshall, and General Henry "Hap" Arnold, commander of the Army Air Forces.

Historians in the ensuing decades have built an extensive, well-documented argument that a complex set of factors determined the decision with a principal facet, as expressed forcefully by Secretary of State James Byrnes, focused on containing the Soviet threat to the postwar world. Demonstrating the bomb against a real target would place the United States and Great Britain in a much more powerful negotiating position with Soviet leader Joseph Stalin at the end of the conflict.

While the necessity of the atomic bomb to end the war with Japan will continue to be debated, as Robert Jay Lifton and Greg Mitchell (1996) noted, "You cannot understand the twentieth century without Hiroshima" (p. xi). The Memorial Cenotaph in Hiroshima Peace Memorial Park declares, "Let all souls here rest in peace; for we shall not repeat the evil." Atomic bombs and the even more powerful thermonuclear weapons that have followed them have spawned a true human capability for omnicide—the wiping out of all life on the planet humans inhabit.

DENNIS W. CHEEK

SEE ALSO *Atomic Bomb; Pugwash Conferences; Weapons of Mass Destruction.*

BIBLIOGRAPHY

Alperovitz, Gar. (1995). *The Decision to Use the Atomic Bomb and the Architecture of an American Myth.* New York: Knopf. One of the better known books that argues that the American decision to use the bomb was motivated by politics not military necessity and how this choice dramatically affected events in the post-war world.

Butow, Robert J. C. (1954). *Japan's Decision to Surrender*. Stanford, CA: Stanford University Press. The best single treatment about the discussions, debates, and maneuvers among military and political leaders in Japan regarding surrender or continued resistance to the allies leading up to and beyond the dropping the atomic bombs.

Goldstein, Donald M.; Katherine V. Dillon; and J. Michael Wenger. (1995). *Rain of Ruin: A Photographic History of Hiroshima and Nagasaki*. Washington, DC: Brassey's. Startling black and white photographs accompanied by text portray the cities before and after the bombings and in the years since, along with photos of survivors and military and political leaders.

Hershey, John. (1989). *Hiroshima*. New York: Vintage. A brief and powerful Pulitzer-Prize winner's account drawing upon first hand survivors recollections.

Lifton, Robert Jay, and Greg Mitchell. (1996). *Hiroshima in America: A Half-Century of Denial*. New York: Quill. An exploration of events surrounding the Hiroshima decision that focuses on its effects in America, including alleged government cover-ups and American insensitivities to violence.

Sekimori, Gaynor, ed. (1986). *Hibakusha: Survivors of Hiroshima and Nagasaki*. Tokyo: Kosei Publishing. "Hibakusha," Japanese for survivors, is a carefully created recollection of activities, emotions, and devastation experienced by the inhabitants of these two cities.

Takaki, Ronald. (1995). *Hiroshima: Why America Dropped the Atomic Bomb*. Boston: Little, Brown. This study by a cultural studies expert, argues that stereotypes of the Japanese influenced racist attitudes on the part of the American public and their leaders and led to the decision to use the atomic bomb to intimidate the Soviet Union.

Thomas, Gordon, and Max Morgan Witts. (1990 [1977]). *Ruin from the Air: The Enola Gay's Atomic Mission to Hiroshima*. Chelsea, MI: Scarborough House. A reconstruction of events leading up to and beyond the moment of the bombing based on interviews, diaries, and documents with a particular focus on the men who flew the Enola Gay.

Walker, J. Samuel. (1997). *Prompt and Utter Destruction: Truman and the Use of Atomic Bombs against Japan*. Chapel Hill: University of North Carolina Press. Concisely argues that the decision to use the bomb was sound and wise militarily, politically, diplomatically, and morally.

HIV/AIDS

The human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS) has reached pandemic proportions and has presented a multiple-dimension challenge for science, technology, and ethics. In 2004 approximately 39.4 million people worldwide were infected with HIV/AIDS, among whom about 3.1 million died in that year, including about 510,000 children under age fifteen. The Joint United Nations Programme on HIV/AIDS/World Health Organization (UNAIDS/WHO) estimates that in that year 4.9 million new infections occurred. Impacts have been more severe in southern Africa, where about one-third of the deaths occurred in 2004 and where life expectancies have dropped by more than 20 years in some countries. HIV/AIDS increasingly affects women and children; nearly half of those infected worldwide are female, with even higher infection rates for women in Africa. Infected pregnant and nursing women can pass the disease to their babies.

Between 2001 and 2004 global funding for HIV/AIDS relief tripled to $6.1 billion, with resultant improvements in treatments and services; this figure includes estimates of funding from all sources, ranging from individuals and families to national and international efforts. Like infections, however, services are unevenly distributed, with the poor and stigmatized remaining underserved. Analyzing the ethics and politics of scientific, technological, and other responses is a contentious issue.

Historical Perspectives

It is useful to compare the HIV/AIDS pandemic with the Spanish influenza epidemic of 1917–1918, which also was promoted by the global transportation network at an earlier stage of its evolution. In a little less than two years the Spanish flu is estimated to have killed from 21 to 50 million persons worldwide in a population of approximately 1.8 billion. While HIV/AIDS has not yet killed as large a percentage of the world's population as the Spanish influenza epidemic, HIV/AIDS infections are not self-limiting and infection rates are expected to remain high unless effective prevention programs are developed and implemented.

Mirko Grmek (1990) provides an extensive history of the emergence and identification of HIV/AIDS. In the late 1970s the disease began to appear in the United States and Europe as physicians noticed unusual symptoms in members of homosexual communities in California and New York. Those patients presented with a variety of symptoms, such as pneumonia, mononucleosis, thrush, and Kaposi's sarcoma. Some were relative benign conditions, yet the patients went into a rapid decline, and their immune systems appeared to be compromised. The U.S. Centers for Disease Control announced the disease on June 5, 1981, but the disease was not named acquired immunodeficiency syndrome until the summer of 1982. Most of the early cases involved homosexuals, but other cases developed in intravenous drug users and then in heterosexual males, women, and patients with no history of drug use. The disease eventually was recognized in equatorial Africa, where cases might have appeared as early as 1962.

Scientists eventually identified "Patient Zero," a flight attendant who apparently was responsible for infecting a large number of the early patients in the United States. Spread of the disease thus took advantage of a global transportation network, establishing a pattern that was repeated on a much less dramatic scale with the severe acute respiratory syndrome (SARS) in 2002–2003 and poses an ongoing challenge to world health management. Patient Zero continued to engage in unprotected sexual activity long after being diagnosed, posing questions about responsibility to both patients and the medical community.

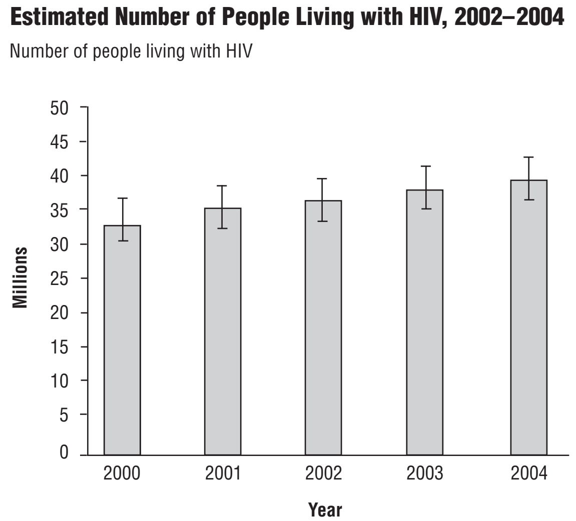
Science, Technology, and Responsibility

Since the early 1980s scientific research on HIV/AIDS has been involved in a series of controversies. For instance, immediately after the identification of AIDS researchers began to try to identify the cause. Priority in the 1983 identification of HIV as the infectious agent was claimed by both Robert Gallo at the National Cancer Institute in the United States and Luc Montagnier at the Institut Pasteur in France in what became a widely reported case of questionable scientific conduct. Even after the discovery of HIV a prominent researcher, Peter Duisberg, rejected it as the basic cause of AIDS and was accused of scientific irresponsibility.

HIV/AIDS research has divided scientists and has caused conflicts between scientists and the public about research strategies and priorities. Should the emphasis be on basic immunological science or on clinical treatments? Should treatment research be aimed at preventing human cell infection by HIV or attacking human cells that already are infected? More generally, what are the relative costs and benefits of spending money on HIV/AIDS research instead of on research into another disease, such as malaria or diarrhea? An estimated 300 million people are infected with malaria, among whom 1 to 1.5 million die annually. A fraction of the money spent on HIV/AIDS research and treatment would have a much greater impact on malaria, and the provision of safe supplies of public drinking water would cause a significant reduction in the over 1 million deaths each year from diarrhea.

Research, particularly drug testing, triggers further ethical questions. How much testing should be conducted before a potentially lifesaving drug is made available to the public? What rules apply when scientists conduct research in developing countries: the rules of the corporate home nation or the rules in the country where research is conducted? Are some policies, such as informed consent, so basic that they should apply anywhere in the world? Does consent always attach to the individual, or does it extend in some cases to communities with high infection rates? Should subjects and their communities participate in research design? How can information about research be explained effectively to people who are not familiar with scientific research and its implications? Can effective treatment be withheld for the purpose of advancing scientific understanding and the possibility of developing new drugs? How can participants be protected from or compensated for negative unintended consequences of research trials? What obligations do researchers have to provide short- and long-term health care to research subjects and their communities? How should societal needs for research be balanced against the rights of the individual? Vaccine research poses special problems because the subjects subsequently may test positive for HIV/AIDS.

FIGURE 1



SOURCE: Marais et al. (2004), p. 2.

Debate also continues over the relative merits of treatment and prevention. Is it better to ease suffering and prolong the lives of those already infected or to prevent new cases from occurring? Prevention will help only those who are not currently living with HIV/AIDS, whereas treatment is needed for the millions already infected to prolong lives, maintain family incomes, and promote general economic stability. Moreover, infected patients need relief from suffering

TABLE 1

Global Summary of the AIDS Epidemic, December 2004

Number of people living with HIV/AIDS in 2004	
Total	**39.4 million (35.9 – 44.3 million)**
Adults	37.2 million (33.8 – 41.7 million)
Women	17.6 million (16.3 – 19.5 million)
Children under 15 years	2.2 million (2.0 – 2.6 million)
People newly infected with HIV in 2004	
Total	**4.9 million (4.3 – 6.4 million)**
Adults	4.3 million (3.7 – 5.7 million)
Children under 15 years	640,000 (570,000 – 750,000)
AIDS deaths in 2004	
Total	**3.1 million (2.8 – 3.5 million)**
Adults	2.6 million (2.3 – 2.9 million)
Children under 15 years	510,000 (46,000 – 600,000)

The ranges around the estimates in this table define the boundaries within which the actual numbers lie, based on the best available information.

SOURCE: Marais et al. (2004), p. 1.

in addition to treatment to slow the progress of the disease. Should scarce human and financial resources be diverted from prevention and treatment to provide palliative care?

Additionally, some people see HIV/AIDS primarily as a behavioral problem; if the behavior changes, the problem will disappear. Controlling HIV/AIDS is about more than developing drugs and vaccines; social science also plays an important role. New drugs will not reach patients unless medical services and drug delivery systems in poor countries are improved. The public must be educated about both causes and treatment. Researchers should investigate reasons for stigma and develop strategies to reduce discrimination and protect the most vulnerable. Within the prevention camp some advocate abstinence as the only moral alternative, whereas others recognize the reality of sexual activity and believe it is more ethical to promote condom use to reduce infection. In such a complex scientific and technology context what is the proper mix of prevention, treatment, and care?

Social Responsibilities

The infectious nature of HIV/AIDS also raises questions about societal responsibilities to potential victims. Should doctors or health institutions inform others when a patient is diagnosed with HIV/AIDS? How should the need to prevent the spread of a deadly disease be balanced against a patient's right to privacy? Women may be particularly at risk from identification because their subordinate status in many places may subject them to social isolation or deprivation of home or property.

Society often discriminates against people infected with HIV/AIDS. Discrimination may be driven by fear of infection, and education should be provided so that people know that the disease is not spread through casual contact. The general stigma attached to homosexuals, drug users, and the poor also drives discrimination. UNAIDS attributes the lack of political will to deal with the pandemic in part to the high infection rates among "marginalized and stigmatized population groups such as women who sell sex, drug injectors and men who have sex with men."

HIV/AIDS exacerbates gender inequities. Women often lack both information about the disease and the power to refuse sex or demand that their sexual partners use condoms. Identification of affected women puts them at higher risk of stigmatization, expulsion from their families, and deprivation of property and employment. Poor women who lose their spouses to the disease may be unable to support their families. More than 2 million children are infected with HIV/AIDS. Millions of others live with infected family members or have been orphaned by the pandemic.

Earlier in the epidemic the high incidence of HIV/AIDS among American gay males juxtaposed prejudice against homosexuals with the increasing political influence of affluent gay men. The gay community effectively concentrated attention on the emerging disease; that resulted in the allocation of research dollars to develop new treatments. HIV/AIDS is now relatively controllable for those who can afford expensive antiretroviral treatments, but the epidemic continues to spiral out of control because millions of infected poor people cannot afford treatment. The needed antiretrovirals are too expensive for most HIV/AIDS patients, and 90 percent of those who need drugs cannot afford them; most of those patients live in sub-Saharan Africa.

Some countries, such as Brazil, have made antiretroviral drugs available for free or at low cost to poor people who need them. Such programs help current patients but may reduce incentives for future pharmaceutical research. Drug companies engage in research and development to make money; if developing countries can obtain drugs without paying market prices, profits will fall and pharmaceutical companies may be less likely to do research into diseases that occur primarily among the poor. Nevertheless, the World Trade Organization Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS Agreement) allows an exception to intellectual property rights in special cases such as emergencies, and that provision has been used to give developing countries access to HIV/AIDS drugs.

Michael Specter maintains that treatment is not enough; only a vaccine can stem the pandemic, yet drug companies lack sufficient incentives to develop a vaccine. This constitutes a case of market failure requiring government intervention.

Pharmaceutical companies in affluent industrialized countries conduct most research on new drugs and vaccines. Do they have a corporate responsibility to spend money on public health problems that may not produce profits? Do their countries have a responsibility to protect the less developed world by providing direct assistance or incentives for drug research? The developed world may have a direct stake in stopping the pandemic to reduce economic and political destabilization in many poor countries.

HIV/AIDS constitutes a global health crisis, but those in greatest need of assistance live in the poorest countries or are among the poorest and most stigmatized members of more affluent societies and lack strong political support. The crisis affects more than individuals; families are disrupted, and societies destabilized: "AIDS is accomplishing a sweeping undoing of past human development advances, especially in southern Africa". The HIV/AIDS pandemic requires strategies to address problems from the individual level to the international level.

MARILYN AVERILL

SEE ALSO *African Perspectives: HIV/AIDS; Drugs; Emergent Infectious Diseases; Health and Disease; Medical Ethics.*

BIBLIOGRAPHY

Attaran, Amir, and Jeffrey Sachs. (2001). "Defining and Refining International Donor Support for Combating the AIDS Pandemic." *Lancet* 357: 57.

Feenberg, Andrew. (1995). *Alternative Modernity: The Technical Turn in Philosophy and Social Theory*. Berkeley: University of California Press.

Grmek, Mirko D. (1990). *History of AIDS: Emergence and Origin of a Modern Pandemic*. Princeton, NJ: Princeton University Press. This book presents a detailed history of the HIV/AIDS pandemic and attempts to identify the emerging disease and considers both biological and social factors contributing to the pandemic.

The Global Aids Policy Coalition. (1992). *AIDS in the World: A Global Report*. Mann, Jonathan M., general editor; Tarantola, Daniel J. M., scientific editor; Netter, Thomas W., managing editor. Cambridge, MA: Harvard University Press, 1992). This comprehensive book provides detailed chapters on "The Impact of the Epidemic," "The Global Response," "Global Vulnerability," and "Critical Issues."

Marais, Hein, et al. (2004). *AIDS Epidemic Update: 2004*. Geneva: UNAIDS. The UNAIDS/WHO web site provides one of the most comprehensive sources for current information about HIV/AIDS and international responses to the pandemic.

Specter, Michael. (2003). "The Vaccine: Has the Race to Save Africa from AIDS Put Western Science at Odds with Western Ethics?" *New Yorker*, February 3.

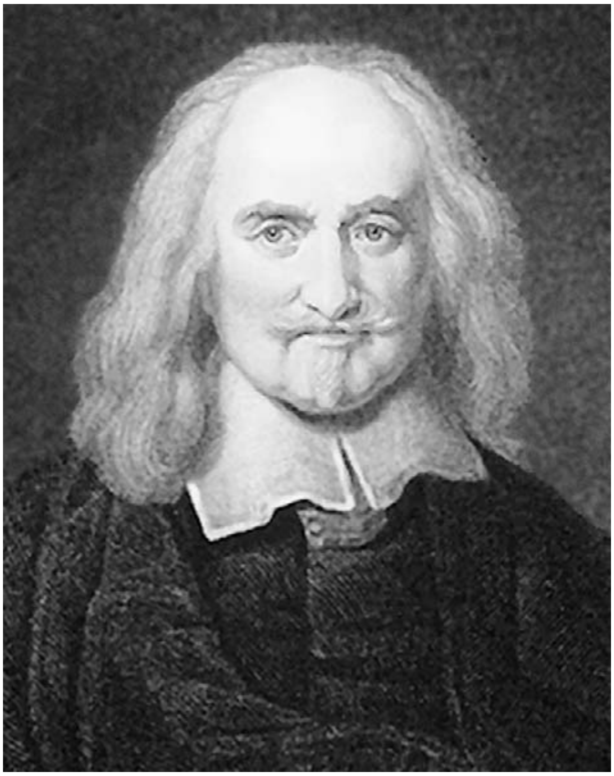
INTERNET RESOURCE

Wolf, Leslie E., and Bernard Lo. (2001). "Ethical Dimensions of HIV/AIDS." HIV Insite. Available from http://hivinsite.ucsf.edu/InSite?page=kb-08-01-05.

HOBBES, THOMAS

Thomas Hobbes (1588–1679) was born in Westport, England, on April 5, the son of a clergyman; he was a contemporary of Shakespeare. Hobbes developed a moral and political philosophy that was influenced greatly by geometry and the new sciences of the Enlightenment. After studying at Oxford University Hobbes became a tutor for the Cavendish family and escorted his charges on tours of the European continent. During those travels Hobbes became acquainted with science as it was being developed by Galileo Galilei (1564–1642), René Descartes (1596–1650), and Marin Mersenne (1548–1648), which he found more constructive than the political strife that characterized the English civil war (1639–1651).

Hobbes's political thought first was expounded at length in *The Elements of Law* (1640), which defended the monarchy, although on democratic grounds. He subsequently developed his arguments in *De cive* (1642), *De corpore* (1655), and *De homine* (1658), a trilogy on the state, physics, and anthropology in which Hobbes attempted to build a bridge between the new science and politics. His most widely read book both in his own day and up to the present has been *Leviathan* (1651). He also wrote a scientific dialogue, *Dialogus physicus* (1661), in response to the emerging experimental sciences and Robert Boyle's (1627–1691) work with air pumps. In 1666 Parliament nearly banned *Leviathan* as heretical, and Hobbes continually faced the threat of exile. He spent his later years composing a history of the English civil war and translating the *Odyssey* and *Iliad*. Hobbes died in Hardwick Hall near Chesterfield, England, on December 4.



Thomas Hobbes, 1588–1679. The English philosopher and political theorist was one of the central figures of British empiricism. His major work, *Leviathan,* expressed his principle of materialism and his concept of a social contract forming the basis of society. *(Archive Photos, Inc.)*

Moral and Political Philosophy

The avoidance of civil strife was one of the main intentions of Hobbes's work. His solution made him unpopular with both royalists and parliamentarians. Royalists argued that the king rules on the basis of natural or divine right; parliamentarians advocated democratic rule. Hobbes argued that the king should rule not by nature or divine commandment but because the sovereign is an artificial social construction fashioned by popular human reason motivated by the shared fear of violent death. It was the high probability of that fate in the state of war (or nature) that in earlier times had made life "solitary, poor, nasty, brutish, and short" (*Leviathan*, vol. I, p. 13). For Hobbes civil society is radically conventional because humans are not naturally social. People are compelled to form civil society by the laws of nature, understood as rational instructions on how to cooperate.

Hobbes argued for a subjectivist morality based on psychological egoism (all human action is selfishly motivated), with good and evil as names that signify appetites and aversions, especially those pertaining to self-preservation and peace. Social peace is possible because all people agree that it is good and are rational enough to cooperate. However, the plurality of tastes and definitions of good and evil means that a state of war will emerge quickly whenever the absolute authority of the sovereign is challenged.

Obedience even to arbitrary government is preferable to the state of war. The commonwealth is formed through social contracts, and the network of those contracts creates the Leviathan (from the Book of Job, meaning "King of the Proud"), or sovereign, which is an artificial "person" responsible for public welfare and social order. The sovereign could be a monarch, as Hobbes preferred, but it also could be a legislature or an assembly of all citizens. Hobbes's notion of the sovereign led to later contractarian philosophies, especially Jean-Jacques Rousseau's (1712–1778) ideal of the general will.

Fear of violent death thus brings humans to reason. In regard to the resulting self-regulating system of passions Hobbes constructed a political philosophy that foreshadowed liberal capitalism and its emphasis on individual rights and the primacy of material self-interest. However, his collectivist image of society comprising the body of the sovereign also has been interpreted as a forerunner of socialist thought. David Gauthier (1969, p. vi) sums up this duality: "Hobbes constructs a political theory which bases unlimited political authority on unlimited individualism." For Leo Strauss (1973) Hobbes marked the beginning of modern political philosophy (foreshadowed by Niccolò Machiavelli [1469–1527]) because he denounced aristocratic distinctions and virtues. He leveled all humans with his theory of natural equality and did not base morality on ideal virtues attainable, if at all, only by the few.

The Role of Science and Technology

A second basic intention in Hobbes's work was to put moral and political philosophy on a scientific basis. His civic science generally is regarded as being based on natural science in both method and material. Human thought and action are explained in mechanistic terms of matter in motion, and thus the laws governing political bodies can be derived from those governing physical bodies. Yet Hobbes held a compatibilist view that causal determination of human conduct is consistent with the freedom required for responsible moral agency.

Even though he worked briefly for the empiricist Francis Bacon (1561–1626), Hobbes was a rationalist who believed that science primarily meant geometry and the methodology of reasoning both from first principles, or causes, to effects and from effects to causes. The purpose of proper philosophy is universal assent attained through absolute certainty, and the first step in arriving at that certainty is an agreement to settle the definitions of words and their precise uses to avoid absurdities and disorder. Science is knowledge of the consequences of words established in that manner. Scholastic and religious reasoning breed controversy because they fail to define terms precisely.

Hobbes's political and natural philosophies are inseparable in the project of establishing consent on what is and how it can be known, thus leading to social order. Human will is the primary force of geometric proofs because humans determine original definitions. Geometry is an instance in which a diverse, subjective, and arbitrary human will has fashioned universal laws and truths by which all people can abide. Just as humans "make" the definitions in geometry (for example, "circle"), so too are the principles of politics (such as authority and justice) fabricated.

Strauss (1973), however, argues that modern natural science distorts Hobbes's moral and civic philosophy. The differences between the modern science of nature and human affairs outweigh the similarities. Indeed, in many places Hobbes stated that physical and political bodies are quite different. Furthermore, he did not take up science until he was forty years old, and he portrayed human nature as mutable and speech, reason, and sociality as products of free will. Vanity (the striving for absolute power) is a peculiarly human trait. Thus, Hobbes has a dualist philosophy (humans can will themselves out of nature) that is hidden by his monist (materialist-deterministic) metaphysics. Hobbes may wish to base his political theory on science because it progresses and produces real power, but a consistent scientific naturalism would ruin his moral philosophy.

The real basis of his philosophy was Hobbes's personal experience of human life. That experience actually has much in common with premodern science in that it proposes to disclose a teleology of human nature, even if a more debased teleology than argued for by the ancients. For that reason, "it can never, in spite of all the temptations of natural science, fall completely into the danger of abstraction from moral life and neglect of moral difference" (Strauss 1973, p. 29). It retains its moral basis precisely because it is not founded on modern science but instead on firsthand experience of humanity. As evidence for his claim Strauss points to the introduction of *Leviathan*, which states that one need not be trained in the physical sciences to formulate the right theory of human nature.

In another account Strauss (1965) argues that Hobbes posited two determinants of human willing—fear of violent death and the pursuit of domination over things—and that this underpins the distinction between the aims of politics and those of natural science. For Hobbes science is the methodical search for causes; in contrast, religion is the unmethodical search for causes. The purpose of science is the conquest of nature to make life more comfortable. It arises from human striving for power and honor, but that inexhaustible urge ensures that what is at stake is not the enjoyment of the object that is desired. Instead, the attainment of objects is only a means to more power: "the end becomes a means, the means becomes an end" (Strauss 1965, p. 89). Even if it is not properly based on science, Hobbes's politics is the foundation of modern technology.

The Politics of Knowledge: Hobbes versus Boyle

Strauss argued that the content of Hobbes's natural science obfuscates his political philosophy. Steven Shapin and Simon Schaffer (1985), however, argue that Hobbes's political theory holds true for the process of science. Both Strauss and Shapin and Schaffer see Hobbes as making constructivism and artifice superior to nature. Strauss uses this to purify Hobbes's politics of natural science; Shapin and Schaffer use it to justify Hobbes's insight that the two are inextricably connected in a single process: "Knowledge as much as the state, is the product of human actions" (Shapin and Schaffer 1985, p. 344).

Contrasting the philosophies of Hobbes and Robert Boyle, Shapin and Schaffer highlight the dynamics of the period when the modern relationship between scientific knowledge and the polity was being formed. The dispute between Hobbes and Boyle can be cast as different notions of what counts as science and legitimate knowledge. Hobbes's science was based on geometry and the deduction of irrefutable (moral and epistemic) truths from distinct first principles. Boyle proposed an experimental science that would be based on empirical observations made by a group with special training. Hobbes attacked this on epistemic grounds, claiming that the "facts" derived from sensory experience are mere "seeming or fancy" because they are too private.

However, this objection to Boyle's science is also moral. Both Boyle and Hobbes offered solutions to the problem of order in terms of ways to produce agreement and consent. Boyle attempted to remove natural philosophy from the "contentious link with civic philosophy" (Shapin and Schaffer 1985, p. 21). Hobbes attempted to erect a philosophy "that allowed no boundaries between the natural, the human, and the social, and which allowed for no dissent within it" (Shapin and Schaffer 1985, p. 21). Boyle's knowledge is produced among a community of experts, and that creates differences in the larger body politic, destroying natural equality, universal assent, and social order. Moreover, Boyle's scientific community allows for dissent about causes within its borders, which Hobbes found to be both a threat to civic order and a sign that it was not a true philosophy. Hobbes saw in Boyle's science the same socially corrosive element that exists in traditional monarchism and religion. The laboratory is a divisive and dangerous form of elitism pretending to a nonartificial hierarchy.

Arguing that "solutions to the problem of knowledge are solutions to the problem of social order," Shapin and Schaffer use the notion of "intellectual space" to distinguish Hobbes from Boyle (Shapin and Schaffer 1985, p. 332). For Hobbes philosophy is not the exclusive domain of professionals. He considered its intellectual space public because its purpose is the establishment of peace and order. In this regard natural science and civic science are the same. In Boyle's experimental science, however, there is a special place for doing natural philosophy—the laboratory—and access to it is quasi-open. In principle anyone could witness the goings-on in that space, but in practice it "was restricted to those who gave their assent to the legitimacy of the game being played within its confines" (Shapin and Schaffer 1985, p. 336). Boyle separates the study of nature, or objects, from the study of human affairs, or subjects. The existence of a separate community producing and legitimating knowledge was anathema to Hobbes, who argued that the philosopher's task was to establish peace and that this separate group threatened civic order. Bruno Latour playfully summed up his interpretation of Hobbes's reaction to Boyle: "we are going to have to put up with this new clique of scholars who are going to start challenging everyone's authority in the name of Nature by invoking wholly fabricated laboratory events!" (Latour 1993, p. 20).

For Hobbes philosophical and political spaces need masters who determine right knowledge and right conduct for all, thus constraining opportunities for interpretation and controversy. A chain is fastened from the lips of the sovereign to the ears of the people. This alleviates the problem of "seeing double" that occurs when loyalties are divided between different professional groups or different personal interpretations of events. Shapin and Schaffer claim that "Hobbes's philosophical truth was to be generated and sustained by absolutism" (p. 339). This was strictly opposed to Boyle's notion of intellectual space because the foundation of knowledge was considered to be free will. Truth claims are verified by free acts of witnessing. Boyle saw the experimental community neither as tyranny nor as democracy but as a group regulated by conventions of selectively restricted access. The experimental community gained such wide support because it offered solutions to practical problems and because its members presented it as a model of the ideal polity. Nonetheless, this does not deny the fact "that there is a power-structure to truth and a truth-structure to power" (Wolin 1990, p. 12).

In the end Shapin and Schaffer conclude that "Hobbes was right" (p. 344) in the sense that Hobbes's instrumentalism or social constructivism better explains science, society, and their relationship than does Boyle's realism. Knowledge, like society, is conventional and artifactual, and scientists do not produce objective truth claims. Shapin and Schaffer probably exaggerated their instrumentalism to call attention to the increasingly problematic aspects of the "boundary-conventions" that distinguish science from politics. Their main point is that the solution to problems of knowledge is always political in that it requires the establishment of conventions of interaction and rules for determining legitimacy and because the knowledge this community produces becomes an integral part of political action.

Boyle and the experimentalism of the Royal Society "won" not because they reflected nature objectively but because their use of rhetoric garnered the most political power. Even though Hobbes was the first modern mediator between science and society, historians have purified Hobbes of science and Boyle of politics, reinforcing the idea that the two realms are naturally distinct. Shapin and Schaffer work to expose the intellectual and historical roots of that distinction, which increasingly is being questioned on the basis of expanding democracy rather than, as with Strauss, on the basis of a reaffirmation of nature.

ADAM BRIGGLE
CARL MITCHAM

SEE ALSO *Human Nature; Science, Technology, and Society Studies; Scientific Revolution.*

BIBLIOGRAPHY

Gauthier, David P. (1969). *The Logic of Leviathan: The Moral and Political Theory of Thomas Hobbes*. London: Oxford University Press. Covers Hobbes's theories of human nature, morality, sovereignty, authorization, and God.

Latour, Bruno. (1993). *We Have Never Been Modern*. Cambridge, MA: Harvard University Press. Uses the controversy between Hobbes and Boyle over the distribution of scientific and political power to illustrate the beginnings of the "modern constitution," which entails an elaborate separation of nature and society.

Shapin, Steven, and Simon Schaffer. (1985). *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life*. Princeton, NJ: Princeton University Press. Includes a translation of Hobbes's *Dialogus physicus*.

Strauss, Leo. (1965). *Spinoza's Critique of Religion*. New York: Schocken. Contains a section on Hobbes titled "The Spirit of Physics (Technology) and Religion."

Strauss, Leo. (1973). *The Political Philosophy of Hobbes: Its Basis and Its Genesis*. Chicago: University of Chicago Press. First published in 1936.

Wolin, Sheldon S. (1990). "Hobbes and the Culture of Despotism." In *Thomas Hobbes and Political Theory*, ed. Mary G. Dietz. Lawrence: University Press of Kansas. Argues that Hobbes modernized despotism by founding it on scientific theorization but that he continues a chain of despotism from Plato, through medieval monarchs, to Popper's scientific social engineers.

HOLOCAUST

The word *holocaust* is derived from the biblical Greek term *holocauston*, meaning a "burnt offering" made in sacrifice to God. The term came to be widely used in the early 1970s to refer to the mass extermination of the Jews in the gas chambers of an organized system of death camps initiated by German dictator Adolf Hitler (1889–1945) and the Nazi Party during World War II. In the 1980s, some scholars argued that the word holocaust imputed more meaning to the event than it deserved and began calling it the *Shoah*, a Hebrew term referring to a time of desolation. The connotations of the latter have come to color even the meaning of the former.

In World War II nearly 30 million people died in combat or as random civilian victims of war. History is filled with wars and massacres, but genocide is something else. While the Turkish attempt to eliminate the Armenians (c. 1915) may be an earlier example of genocide, the Holocaust has come to be described as the archetypal example. Genocide is a systematic, state-sponsored, bureaucratically organized attempt to eliminate an entire people (usually identified in "racial," ethnic, or religious terms) from the face of the earth, not for any strategic military or political advantage but simply because they exist. The Nazi attack on the Jews was not an attempt to eliminate a foreign enemy but its own Jewish citizens first and then all the Jews in Europe. While others were also made victims in the death camps (such as the mentally retarded, homosexuals, and communists), the Jews and Gypsies were the only two peoples targeted for *total* annihilation. Thousands of Gypsies and 6 million Jews were murdered. A third of the world's Jews and two-thirds of Europe's Jews died in the Holocaust.

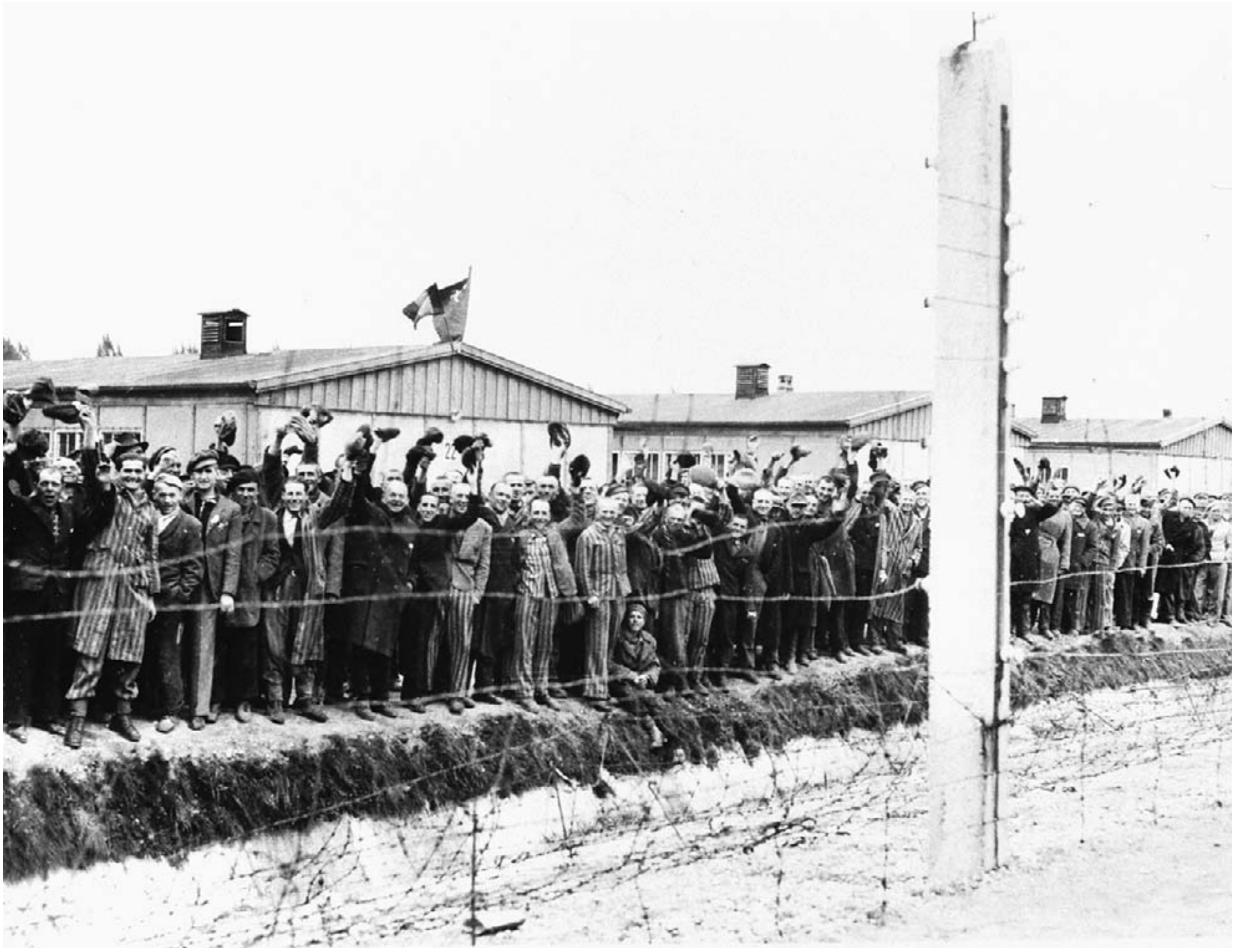
In the Nazi genocidal project, science was used to provide a biological theory of race that offered ideological justification for genocidal public policies of racial purity, and technology was used to provide the most efficient means to carry out these policies.

Science

The Nazis used English naturalist Charles Darwin's (1809–1882) biological theory of evolution to justify their program of genocide. Darwin posited the evolutionary differentiation of species as the product of "natural selection" in which only those organisms most successful in adapting themselves to a particular ecological niche survive to reproduce themselves and so shape the gene pool. This law of competition came to be known as the "survival of the fittest," meaning the survival of those most successful at adaptation.

In the nineteenth century this scientific theory was transformed into a political ideology known as "social Darwinism" by metaphorically extending Darwin's biological theory into the realm of society. In this way social phenomena such as class conflict or the conflict between nations were imagined to operate by the same laws of "natural selection." It seemed only "natural" to the Nazis to conclude that the ascendancy of the Nazi German nation-state was the outcome of a biological process in which the fittest race had survived to dominate all others, proving the superiority of the Aryan race. The greatest threat to this evolutionary outcome was, in their view, racial pollution—the biological mixing with "inferior races" that would weaken the purity of Aryan blood.

As Robert Jay Lifton (1986) noted, the death camps were viewed as public health projects in which the Jews were considered a cancerous growth on the body of the Aryan race, threatening its organic health (i.e., racial purity), and so had to be cut out in order to restore the body to health. It was no accident that physicians were required to fill the role of those who selected some victims for the work camps while sending others directly to the gas chambers. The doctor, as an elite scientifically trained professional, gave an aura of "scientific" legitimacy to the



Survivors of a concentration camp line up along a wire fence in Dachau, Germany. Many are still wearing the striped uniform of the camp. *(AP/Wide World Photos.)*

entire genocidal enterprise, and the "scientific theory" of racial purity gave the doctors a rationalization that allowed them to think of killing as a form of healing.

The Nazis had to ideologically twist science to justify their genocidal actions. Biologically all human beings are capable of interbreeding and therefore constitute a single species: There is only one human race. The Nazi "theory" of races was an ideological myth. Moreover, Darwin's theory suggested that it was genetic diversity not genetic uniformity that promoted survival. Finally, "survival of the fittest" had descriptive rather than normative status in Darwin's theory.

Technology

A technological civilization is one shaped by bureaucracies of technical experts who organize society to accomplish all its tasks using the most efficient solutions that science can discover. Richard Rubenstein (1975) notes that the turning point in the Nazi genocidal program occurred in reaction to Kristallnacht (The Night of Broken Glass, November 9–10, 1938), when Heinrich Himmler (1900–1945), head of the Gestapo, the German secret police, rejected and suppressed the further use of mob violence that been promoted by Joseph Goebbels (1897–1945), German minister of propaganda. Himmler recognized that the only way to efficiently organize mass death was to remove the element of personal emotion and replace it with the cool and efficient operations of the impersonal techno-bureaucratic procedures that typified the death camps.

As the Holocaust well demonstrates, techno-bureaucratic organization is impervious to ethical considerations, because bureaucracy separates ends and means. When persons choose both ends and means they feel the connection in their experience out of which a sense of personal responsibility can emerge. But in a bureaucracy, those higher up are viewed as being in a better position to choose the ends than the technical experts, lower down in the hierarchy, who are charged with developing the means to accomplish them. The Nazi doctors who did the selections in the death camps saw themselves as mere cogs in a complex bureaucratic machine. Even if one refused to participate that would change nothing. Like a replaceable part, one doctor would simply be substituted for by another, more accommodating one. These doctors did not feel responsible because the victims were dead long before they ever got to the camps, declared so by those higher up in the bureaucracy who alone had the authority and responsibility. Indeed, the Nuremberg war-crimes trials that followed World War II (1945–1949) demonstrated the prevalence of this logic in the repeated defense of those accused who plead non-responsibility because they were "just following orders."

Ethics after the Holocaust

The Nuremberg trials, by identifying "crimes against humanity" for prosecution, represent an initial attempt to think globally about ethics. Indeed, the horror of the atrocities of World War II sent a global moral shock through the human race that led to the creation of the first global ethic in history. For the movement for human rights arose in response to the trauma of the Holocaust and the other atrocities of World War II. This movement culminated in the formation of the United Nations (UN) in 1946 and the adoption of the Universal Declaration of Human Rights by the UN in 1948. The preamble to the declaration recalls the "barbarous acts which have outraged the conscience of mankind," preparing the way for the declaration's main body, which strongly affirms the unity of humanity. Consequently this document stands against all ideologies that would divide humanity, racially or otherwise, in order to claim the world and its resources for some superior *volk*—as the Nazis attempted to do.

Unlike the technical and esoteric language of most academic treatises on ethics, human rights language is a language that has spontaneously taken root in cross-cultural public discourse. The language of human rights has become embedded in the language of politics and international relations. Even if, in many cases, the political use of this language is hypocritical, still that is the homage that vice pays to virtue, which means that human rights can be used as a measuring rod for cross-cultural social and political criticism.

Moreover, in the aftermath of World War II, a plethora of both governmental and nongovernmental organizations committed to preserving and protecting the rights of all human beings across all religions and cultures has emerged, deeply influencing global social policies. Such organizations include the UN itself, especially its Commission on Human Rights and its various subcommissions, as well as the International Court of Justice and regional conventions on human rights in Western Europe, the United States, and Africa. Then there are the governmental offices of individual nations that monitor each other for rights violations and use this information to political advantage. (Motivations of self-interest aside, this political game does keep the pressure on to observe human rights.) Finally, there are nongovernmental voluntary associations committed to human rights such as Amnesty International, the Anti-Slavery Society, and the International Committee of the Red Cross as well as religious organizations, labor organizations, and professional associations.

In the last quarter of the twentieth century and into the twenty-first, the Holocaust or Shoah has become a symbol for the universal call to conscience and responsibility on behalf of the human dignity and human rights of all. In this context the rhetoric of the Holocaust and of human rights, as one might expect, has often become politicized and sometimes trivialized. And yet the moral climate of human history has been unarguably changed by the language of "human rights" and "human dignity" evolving into the global moral language of accountability and by the Holocaust becoming a powerful symbol of everything that would violate such dignity and rights.

DARRELL J. FASCHING

SEE ALSO *Arendt, Hannah; Dignity; Eugenics; Human Rights; Judaism; Levi, Primo; Nazi Medicine; Race; Social Darwinism.*

BIBLIOGRAPHY

Fasching, Darrell J. (1993). *The Ethical Challenge of Auschwitz and Hiroshima: Apocalypse or Utopia?* Albany: State University of New York Press. A study of the emergence of global ethics and its role in shaping public policy after Auschwitz and Hiroshima.

Lifton, Robert Jay. (1986). *The Nazi Doctors: Medical Killing and the Psychology of Genocide*. New York: Basic. A ground-breaking study of the psychological and institutional factors that together shaped the genocidal mentality of the Nazi doctors in the death camps.

Roth, John, ed. (1999). *Ethics after the Holocaust*. St. Paul, MN: Paragon House. An excellent collection of essays by scholars from diverse countries on ethics after the Holocaust.

Rubenstein, Richard. (1975). *The Cunning of History*. New York: Harper and Row. A brilliant and devastating study of the role of scientific and technical bureaucracies in facilitating the Holocaust.

HOMOSEXUALITY DEBATE

Homosexuality has been a subject of scientific study for many years. Much of the research has focused on whether homosexuality is a product of biology or psychological conditioning. That nature-nurture question often has entered into ethical and political debates about homosexuality. For example, in the early 1990s two studies were released that indicated that homosexuality may be biological. One study identified distinctive neural structures in homosexual men (LeVay 1993). The other correlated a genetic marker with male homosexuality (Hamer and Copeland 1994).

Those studies received significant media attention because they seemed to strike at the heart of the political debate about gay rights. Opponents of gay rights had argued that homosexuality is a choice and that homosexuals seek "special rights" for a deviant and destructive lifestyle. Consequently, gay rights advocates began to argue that the studies mentioned above showed that homosexuality is not a choice but an innate biological characteristic worthy of constitutional protection.

Early Studies of Homosexuality

These debates about homosexuality date back to the mid-nineteenth century, when Karl Heinrich Ulrichs (1825–1895), a German jurist, attempted to theorize homosexuality as a biological condition. Ulrichs believed that the embryo contains female and male "germs" and that as an embryo develops, one of the germs becomes dominant, producing either male or female sexual organs. These sexed germs, he argued, also produce the sex drive, and thus it is possible for the body of one sex to possess the sex drive of the other. Because Ulrichs was a jurist, not a scientist, his primary concern was to secure the civil rights of homosexuals, and he believed a biological theory would facilitate his efforts (Brookey 2002).

Shortly after Ulrichs introduced his theories, they were incorporated into the work of the neurologist Richard von Krafft-Ebing (1840–1902). Krafft-Ebing defined homosexuality as a predetermined sexual attraction brought about by either genetic or situational factors. *Situational homosexuality*, according to Krafft-Ebing, occurred when men were precluded from sexual intercourse with women or masturbated. He characterized situational homosexuality as an inherited condition that existed as the lingering residue of an animalistic bisexuality that would die out slowly in the process of evolutionary advancement (Brookey 2002). Krafft-Ebing's theories were influential for many years but would be eclipsed when Sigmund Freud introduced his own theories on human sexuality.

Freud argued that children are born into an innate state of bisexuality, but as they develop, this bisexual energy is directed into heterosexuality. However, if a child does not develop proper relationships with his or her parents, sexual development may be arrested and homosexuality can result. Freud did not believe that homosexuality is always the product of psychological pathology. Consequently, he regarded efforts to change homosexuals into heterosexuals with great pessimism (Lewes 1988).

Modern Theories

After World War II American psychoanalysts reinterpreted Freud's theories, particularly those regarding homosexuality. The psychologist Sandor Rado (1890–1972) led that effort when he rejected Freud's theory of innate bisexuality. Rado argued that bisexuality does not exist, rejected the possibility of biological homosexuality, and argued that homosexuality can only be a product of mental pathology. He claimed that homosexuality is a mental pathology and that the possibility for change is much greater than Freud supposed. Edmund Bergler (1889–1962) was a Freudian who advocated psychoanalytic therapy and claimed to have converted homosexuals. Bergler was also an active opponent of the early gay rights movement, and he often testified in government hearings that homosexuals should be precluded from public service.

The psychoanalytic position on homosexuality remained unchallenged until Alfred Kinsey (1894–1956) began publishing his research on human sexuality. Kinsey's work indicated that human sexuality is much more varied and fluid than psychoanalytic theories supposed. Rado's dismissal of bisexuality was challenged by Kinsey's empirical findings, which indicated that a significant number of adults had sexual experiences with persons of both sexes. Consequently, Kinsey's work also challenged psychoanalytic beliefs about homosexual pathology because it recognized that homosexuality was practiced by a variety of individuals and did not treat homosexuals as a distinct or deviant class. The psychiatrist Evelyn Hooker (1907–1996) also challenged many psychoanalytic assumptions about homosexuality. Specifically, Hooker's research concluded that many homosexuals did not suffer from severe mental disturbances and that homosexuals were just as diverse in their behavior and psychological profiles as heterosexuals were.

Kinsey's and Hooker's research established doubt in the psychiatric community about the pathology of homosexuality, and in 1973 the American Psychiatric Association (APA) voted to remove homosexuality from its list of mental diseases. That decision reflected suspicion of psychoanalytic approaches and concern about the use of behavior modification conversion therapy. Many psychoanalysts protested the decision, and *ego-dystonic homosexuality,* a condition experienced by homosexuals who wanted to change their sexual orientation, remained on the list so that therapists could continue to practice conversion therapy. Even that exception, however, was eliminated in 1997 when the APA determined that psychological therapies cannot cure homosexuality.

Judicial Decisions and Ethical Issues

The publication of LeVay's and Hamer's studies has renewed interest in biological explanations of homosexuality. Although gay rights advocates thought that research would yield political advantages, arguments about the biological basis of homosexuality did not acquire legal traction. A biological argument was presented to the Supreme Court in the 1995 hearing on Colorado's Amendment 2, an anti–gay rights initiative. Although the Court ruled against the initiative, the evidence demonstrating a biological basis for homosexuality was not mentioned in its decision (Keen and Goldberg 1998). In addition, the biological argument did not figure in the Court's 2003 decision to strike down state anti-sodomy laws.

Apart from the legal question, there are ethical concerns about the use of biological research to treat homosexuality (Murphy 1997). Would a "homosexual" gene lead to a genetic test for homosexual predisposition? Would couples choose to abort a fetus that tested positive for this genetic predisposition? Could homosexuals seek genetic therapy in order to change their sexual orientation? Could homosexuals be compelled to submit to that therapy? Currently, these ethical questions are moot because additional research has not verified Hamer's and LeVay's research conclusively. Both the legal and the scientific debates about homosexuality have not been resolved.

ROBERT ALAN BROOKEY

SEE ALSO *Feminist Ethics; Gene Therapy; Genetic Counseling; Nature versus Nurture; Sex and Gender.*

BIBLIOGRAPHY

Brookey, Robert Alan. (2002). *Reinventing the Male Homosexual: The Rhetoric and Power of the Gay Gene*. Bloomington: Indiana University Press. Provides an overview of the research on the biological aspect of homosexuality.

Hamer, Dean, and Peter Copeland. (1994). *The Science of Desire: The Search for the Gay Gene and the Biology of Behavior*. New York: Simon & Schuster. Summarizes research on the "gay" gene.

Keen, Lisa, and Suzanne B. Goldberg. (1998). *Strangers to the Law: Gay People on Trial*. Ann Arbor: University of Michigan Press. Covers the Supreme Court decision on *Romer* v. *Evans*.

LeVay, Simon. (1993). *The Sexual Brain*. Cambridge, MA: MIT Press. Summarizes research on the brain structures of homosexuals.

Lewes, Kennneth. (1988). *The Psychoanalytic Theory of Male Homosexuality*. London: Quartet Books. Discusses the APA decision to declassify homosexuality.

Murphy, Timothy. (1997). *Gay Science: The Ethics of Sexual Orientation Research*. New York: Columbia University Press. Provides an overview of ethical issues related to research on the biological aspect of homosexuality.

HORMESIS

Hormesis is a dose-response phenomenon in which a low dose of a toxin has the opposite effect on a biological system than a high dose of the same toxin. It is generally characterized as toxic effects that are beneficial at low doses and harmful at high doses. There is some ambiguity in the more precise definition of the term, however, because some speak strictly of low-dose stimulation of biological endpoints (for example, immune system strengthening), whereas others also use it to refer to low-dose inhibition of biological endpoints (such as tumor formation). Hormesis has long been marginalized in medical and environmental fields. A growing body of evidence suggesting hormetic effects across a wide range of biological organisms and systems, however, has brought increased credibility to the topic. The implications of hormesis are potentially huge, especially in terms of risk assessment policies and research paradigms. Skepticism and controversy persist surrounding the future status and impacts of hormesis as new research, aided by advanced technologies, yields uncertainty and more questions than answers.

History

Ideas similar to hormesis have been vaguely formulated for centuries, including Hippocrates' saying that "likes are cured by likes," Paracelsus's notion that "the dose makes the poison," and Friedrich Nietzsche's famous remark that "what does not destroy me makes me stronger." Hugo Schulz, a German pharmacologist who observed that small doses of poisons stimulated the growth of yeast, was the first to systematically describe hormesis in 1888. Rudolph Arndt, a German physician, found similar results in his research on the effects of low doses of drugs on animals. Arndt claimed that toxins in general produced stimulation of biological endpoints such as growth or fertility at low doses, which became known as the Arndt-Schulz law. It lost credibility in the 1920s and 1930s, however, because Arndt was an adherent of homeopathy (Kaiser 2003). Founded by Samuel Hahnemann (1755–1843), homeopathy parallels hormesis in two respects, namely the idea that likes cure likes (symptoms produced by toxic doses can be cured by a remedy prepared from the same substance) and the theory of infinitesimals, which stated that the more dilute a substance is the more potent it can become. The marginalization of Arndt's work meant that hormesis research did not receive federal funding during the formative years of toxicological development.

C. M. Southam and J. Erlich first coined the term hormesis in 1943 in research that showed an antifungal substance had stimulatory effects on fungi when administered in low doses. The term derives from a Greek root meaning to excite, indicating the ability of small amounts of dangerous substances to excite an organism's defense systems, thereby making it healthier than it would be otherwise. Hormetic effects have since been observed in organisms ranging from humans and rats to water fleas and various plants. Yet outside of low-level ionizing radiation studies (the field in which the concept of hormesis is best developed), these observations went largely unexamined and were usually treated as aberrant data.

Edward Calabrese and Linda Baldwin (2001) synthesized these disparate findings in the toxicology literature. They also found that hormetic dose-response curves outnumbered curves showing no effect at the lowest doses by 2.5 to 1 (2003). This coupled with older, extensive literature on the beneficial effects of minute doses of ionizing radiation for animals (Luckey 1980, 1991) sparked increased interest in hormesis. In 1990 a group of scientists representing several federal agencies, the private sector, and academia launched a program of analyses and workshops called Biological Effects of Low Level Exposure (BELLE) and a newsletter devoted to low-dose toxicology. The U.S. National Research Council (NRC) has sponsored research on radiation hormesis. Researchers in Japan note that victims from the World War II nuclear attacks, if they were sufficiently distant from the blast site, have lower death rates than peers not exposed to the radiation. Researchers at Johns Hopkins University found that tens of thousands of U.S. Navy shipyard workers exposed to radiation in the 1960s and 1970s have fewer cancers than nonexposed workers (Boice 2001). Others have found evidence that lung cancer rates are lowest in areas with the highest levels of radon.

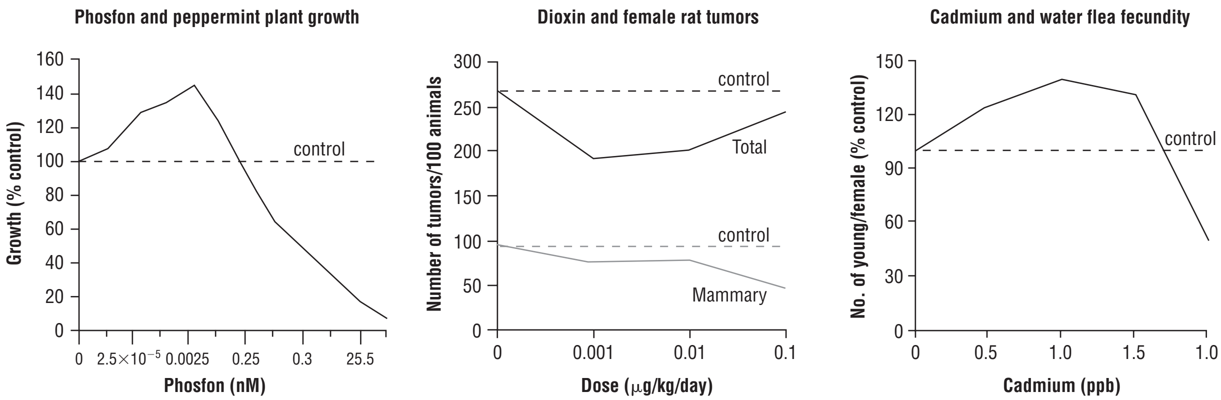
Explanation and Implications

The biological mechanisms underlying the details of hormesis are still poorly understood. In general hormesis is a manifestation of homeostasis, the fundamental property of living organisms to maintain internal conditions that are in a state of (dynamic) equilibrium. Biological systems, even at the molecular level, have adaptive responses to stress that can trigger a variety of effects including increased cellular repair, beneficial apoptosis (programmed cell death), and increased immunological strength (Stebbing 1982). For example, the cellular damage caused by exercise in the short-term stimulates beneficial long-term effects because certain physiological mechanisms overcompensate, thus making the body stronger. Caloric restriction has also been proposed as a hormetic phenomenon. Some researchers have found that low levels of dioxin reduce the occurrence of tumors in rats, low levels of cadmium increase water flea fecundity, and low levels of phosfon (a herbicide) stimulate peppermint plant growth (Kaiser 2003). These results show up as biphasic dose-response curves shaped like a *J* or an inverted *U* (see Figure 1). Such dose-response curves are not unique to hormesis, however, because they are found especially in studies of endocrine disruptors that have no beneficial effects at any dose.

When referring to nutrients, hormesis is rather straightforward. Iron, for example, is necessary for transporting oxygen throughout the body, but too much iron is poisonous. The largest scientific and political implications from hormesis come from research that shows beneficial effects from small doses of chemicals long believed to be toxic at any level, such as dioxin and certain pesticides. For example, heavy metals such as mercury spur synthesis of proteins that remove toxic metals from circulation and may prevent some DNA damage caused by free radicals. Because the relationship between dose and effect is the fundamental concept of toxicology, these kinds of results may bring about radical changes in environmental and medical sciences and regulatory practices.

FIGURE 1

The Puzzle of Hormesis



SOURCE: Kaiser (2003), p. 377

Low doses of phosfon, a herbicide, caused plants to grow better (left); small amounts of dioxin, a carcinogen, reduced tumors in rats (center); and a little cadmium, a toxic metal, caused water fleas to produce more young (right). The effects were reversed at higher doses.

Indeed some suggest that hormesis marks a revolution in toxicology, pharmacology, and risk assessment. The dominant environmental risk assessment model is twofold. For carcinogens, regulatory agencies use a linear, nonthreshold dose-response model that assumes no safe level of exposure. For noncarcinogens, regulatory agencies assume there is a threshold dose, below which there is no risk of harm. Both risk assessment models are riddled with assumptions due to extrapolations from high-dose laboratory experiments to the low doses characteristic of human exposure. Calabrese (2004) argues that the resulting uncertainty has led to a protectionist public health paradigm with stringent environmental standards that often come at high costs.

He claims that these two dose-response models erroneously calculate public health standards, poorly communicate risks to the public, lead to exorbitant cleanup costs, and provide the wrong cues about how to prioritize investments in the environment. Hormesis provides an alternative risk assessment model that harmonizes policies on carcinogens and noncarcinogens, eliminates the need to extrapolate data, and places environmental risk assessment on the same solid empirical grounding as health insurance and other forms of risk estimates. He also claims that hormesis has important implications for clinical medicine. It can improve the selection of dosages and help medical researchers avoid situations in which declining concentrations of drugs in the body (toward the end of treatment, for example) may actually stimulate the microbes or tumors they are intended to eliminate.

Clearly hormesis could radically alter environmental and biomedical practices. For certain carcinogens, for example, the benefits of hormesis may occur at levels higher than the recommended safe doses for humans. It could also change the way scientists perceive and measure risk. But major changes are not likely to occur swiftly. Beneficial hormetic effects differ by individual and are still poorly characterized, and military or industrial interests may compromise the integrity of some hormesis research. Furthermore much of the research done on hormesis has focused too narrowly on single endpoints such as cancer while ignoring others. This may mean that harmful effects at low doses are not registered. Regulators must understand complex interactive effects, which greatly increase the costs of research (Renner 2003). Most importantly Calabrese fails to consider the price paid for eliminating unverifiable extrapolations. Low-dose testing requires long-term experiments with much larger sample sizes than current risk assessment models, because at low doses small signal-to-noise ratios require researchers to collect more data in order to obtain acceptable confidence intervals. The long time periods required for such research are not suited to the needs of decision makers.

As Gary Marchant (2001) argues, the refusal by U.S. Environmental Protection Agency (EPA) regulators to consider the health benefits of ozone in their 1997 revision of air quality standards provides lessons for the regulatory implications of hormesis. First, regulatory agencies are highly resistant to considering hormesis because it is a nonintuitive phenomenon that departs from traditional toxicology assumptions. Second, scientific evidence for hormesis is severely scrutinized, which makes credibility difficult to achieve. Third, judicial review may be an effective mechanism for forcing regulatory agencies to consider hormesis.

The accumulation of scientific data and advances in the techniques of molecular biology have brought the phenomenon of hormesis and the attendant controversies once again to the forefront of science and society. Hormesis carries great economic, environmental, and public health implications, but conclusive data are hard to obtain because of the large sample sizes needed and ethical restrictions on human subjects research. Hormesis supports the argument put forth by Bruno Latour (1998) that science, rather than clearing away societal controversies, actually increases uncertainty. Continued research may resolve conflicts but it may just as well add new uncertainties to those currently generated by extrapolation in risk assessment models.

ADAM BRIGGLE

SEE ALSO *Dose Response Ratios; Radiation; Regulatory Toxicology.*

BIBLIOGRAPHY

Boice Jr., John D. (2001). "Study of Health Effects of Low-Level Radiation in USA Nuclear Shipyard Workers." *Journal of Radiological Protection* 21(4): 400–403.

Calabrese, Edward J. (2004). "Hormesis: A Revolution in Toxicology, Risk Assessment and Medicine." *European Molecular Biology Organization* 5: S37–S40. Proposes a new risk assessment model based on hormetic dose-response curves rather than linear or threshold models.

Calabrese, Edward J., and Baldwin, Linda A. (2001). "The Frequency of U-Shaped Dose Responses in the Toxicological Literature." *Toxicological Sciences* 62(2): 330–338. Surveys the toxicological literature and finds significant evidence that hormetic effects are widespread.

Calabrese, Edward J., and Baldwin, Linda A. (2003). "The Hormetic Dose-Response Model is More Common than the Threshold Model in Toxicology." *Toxicological Sciences* 71(2): 246–250. Tests the validity of dominant dose-response models in toxicology and argues that hormetic models fit the evidence more closely.

Kaiser, Jocelyn. (2003). "Sipping from a Poisoned Chalice." *Science* 302(5644): 376–379.

Latour, Bruno. (1998). "From the World of Science to the World of Research?" *Science* 280(5361): 208–209.

Luckey, Thomas D. (1980). *Hormesis with Ionizing Radiation*. Boca Raton, FL: CRC Press. Reviews the literature pertaining to radiation hormesis.

Luckey, Thomas D. (1991). *Radiation Hormesis*. Boca Raton, FL: CRC Press. The first complete report on radiation hormesis. Shows that many biological functions are stimulated by low doses of ionizing radiation.

Renner, Rebecca. (2003). "Nietzsche's Toxicology." *Scientific American* (September): 28–30.

Southam, C. M., and J. Erlich. (1943). "Effects of Extract of Western Red-Cedar Heartwood on Certain Wood Decaying Fungi in Culture." *Phytopathology* 33: 517–524. First study to coin the term hormesis.

Stebbing, A. (1982). "Hormesis—The Stimulation of Growth by Low Levels of Inhibitors." *Science of the Total Environment* 22(3): 213–234.

INTERNET RESOURCE

Marchant, Gary E. (2001). "A Regulatory Precedent for Hormesis." Biological Effects of Low Level Exposures. Available from http://www.belleonline.com/n8v92.html.

HUMAN CLONING

Human cloning, which occurs naturally but rarely with the birth of identical twins, became a technological possibility with the development of the technique of somatic cell nuclear transfer (SCNT) to clone the first mammal in 1996. As a result of this scientific advance, the prospect of human cloning quickly became a hotly debated ethical issue. As the debate developed it also became common to distinguish reproductive cloning from therapeutic cloning, each being subject to slightly different ethical assessments.

History and Science

Cloning (from the Greek word *klon*, a twig or slip) is a natural process of asexual reproduction found in many plants and some animals. When strawberry plants send out runners that set roots and turn into new plants, this is an example of a plant naturally cloning itself. Even artificial cloning is not entirely new. For hundreds of years gardeners have taken slips (small shoots or twigs cut from plants) and rooted them to produce new plants in a process that could also be described as cloning. Then in the 1970s scientists began experiments in artificial cloning with frogs and toads, and subsequently with other animal embryos. But it was not until the successful SCNT cloning of the sheep "Dolly," performed in 1996 and formally announced in February 1997 by the Roslin Institute in Scotland, that it became clear something similar might be possible with mammals.

Mammals have two kinds of cells: somatic cells (many of which can reproduce themselves by clonelike division, but only themselves and not a whole organism) and sex cells (which come in two forms, ovum in females and sperm in males). The SCNT process works as follows: The nucleus is removed from a somatic cell of either a female or a male. An unfertilized ovum is taken from a female and has its nucleus removed and then replaced with the somatic cell nucleus. The resulting ovum with a somatic cell nucleus is then stimulated and implanted in a female womb to grow to term. The resulting offspring is genetically identical to the individual that was the source of the original somatic nucleus.

The technology of cloning is thought to be feasible in many mammalian species, including humans. As of 2005, successes in cloning of many species have been achieved. But neither the cloning of primates nor of humans has been successful as yet. Human somatic cell nuclear transfer, if successful in producing offspring, would not be "duplication" because identical genomes do *not* produce identical phenotypes. Nevertheless, Korean scientists have used cloning technology to produce cloned embryos, and subsequent experiments have furthered such technologies, which are aimed at producing embryonic stem cells for research and therapeutic purposes.

The science and technologies of cloning remain in their infancy. Pharmaceutical companies have not expressed great interest in trying to work to clone people because they see much bigger markets in the cloning of animals and cells. Efforts to create a human clone have been limited largely to groups outside the mainstream of science and medicine, and no one knows for sure whether stem cells derived from cloned human embryos really will prove useful as a way to cure diabetes, liver failure, Parkinson's disease, spinal cord injuries, or any other disease or ailment.

Ethical Concerns

It is easy to see why there is so much interest in and concern about human cloning. There is seemingly no end to the parade of people who issue press releases proclaiming that they are close to success in cloning a human baby. And there is certainly a simple fascination with the technical possibility. Proponents of cloning have also suggested it might serve as a new, unusual, but perhaps efficacious treatment for infertility, enabling those unable to pass genes to future generations to do so in a way that is at least analogous to the familial linkage of twins. And, they point out, scientists have created animal clones and at least a small number of human cloned embryos with hardly any oversight or public accountability.

Dolly, the cloned sheep. The result of an experiment by Scottish embryologist Ian Wilmut, Dolly was the first cloned adult mammal. *(Archive Photos, Inc.)*

There are grave risks, however, to any resulting offspring: Mammalian cloning, through the SCNT process, has resulted in the birth of hundreds of organisms. But significantly more nuclear-transfer-generated embryos fail during pregnancy than would fail in sexual reproduction, and a substantial majority of cloned animals who have survived to birth have had some significant birth defect. For these and related reasons President Bill Clinton in 1997 issued a moratorium banning the use of federal funds for human cloning, a position subsequently endorsed by the National Bioethics Advisory Commission.

And for some who believe that any human embryo is a person from the moment of its creation, the fight over human cloning is a fight both about what constitutes membership in the human community and about the morality of abortion. Many opponents of abortion hope that if they can gain legal recognition for cloned human embryos they can then move on to get legal standing for any human embryo or fetus.

One such person is U.S. President George W. Bush. A few months after hearings at the United Nations in

TABLE 1

Chronology of Key Early Events in the Human Cloning Discussion

1932	Aldous Huxley publishes *Brave New World*, including the "Bokanovsky Process" for producing cloned children.
1938	German embryologist Hans Spemann publishes *Embryonic Development and Induction*, in which he speculates about the possibility that the nuclei of fully differentiated cells may be able to initiate normal development in enucleated egg cells.
1952	U.S. embryologists Robert Briggs and Thomas J. King first successfully transfer nuclei from early embryonic cells of leopard frogs to enucleated leopard frog eggs.
1960s and 1970s	British developmental biologist John Gurdon makes further advances in cloning frogs. Debates about the implications of cloning begin.
1966	U.S. biologist Joshua Lederberg publishes an article in *The American Naturalist* titled "Experimental Genetics and Human Evolution," in which he speculates on the implications of cloning humans.
1971	U.S. geneticist James D. Watson testifies before Congress on the subject of human cloning.
July 25, 1978	The birth of Louise Brown, the first baby conceived through in vitro fertilization (IVF), shows that human birth is possible from eggs fertilized outside the body and then implanted in the womb.
1994	The National Institutes of Health Human Embryo Research Panel issues a report that deemed research involving nuclear transplantation, without transfer of the resulting cloned embryo to a uterus, as one type of research acceptable for federal support.
1996	In the U.S. the Dickey Amendment is enacted, which prohibits federal funding to create human embryos for research purposes and research that destroys or discards human embryos.
July 5, 1996	Cloned sheep "Dolly," named after the country singer Dolly Parton, was born using somatic cell nuclear transfer (SCNT).
Feb. 1997	Ian Wilmut et al. (Roslin Institute), "Viable Offspring Derived from Fetal and Adult Mammalian Cells," *Nature*, vol. 385 (27 February), pp. 810–811, announces the birth of Dolly.
March 1997	President Bill Clinton issues moratorium banning the use of federal funds for human cloning, and asks the National Bioethics Advisory Commission (NBAC, also sometimes called the National Bioethics Advisory Board) to analyze the ethical issues involved. It issues its report in June 1997.
August 1997	Clinton Administration proposes legislation banning human cloning for at least five years, in order to give the NBAC sufficient time for reflection.
Sept. 1997	Thousands of U.S. scientists voluntarily commit to a five-year moratorium on human cloning.
Jan. 1998	Nineteen European countries ban human cloning. Dr. Richard Seed, a Chicago physicist, announces plans to clone a human being. U.S. Food and Drug Administration claims authority to regulate human cloning, making it a violation of federal law to attempt cloning without FDA approval.
Nov. 6, 1998	University of Wisconsin biologist James Thomson and Johns Hopkins biologist John Gearhart announce the isolation of human embryonic stem cells, sparking increased interest in therapeutic cloning.
Aug. 2000	President Bill Clinton announces new guidelines for the federal funding of embryo research, but in early 2001 President George W. Bush places them under review before they are implemented.
Nov. 2000	Japan outlaws human reproductive cloning.
July 2001	The U.S. House of Representatives passes the Human Cloning Prohibition Act to outlaw both reproductive and therapeutic cloning, but the bill dies in the Senate.
Nov. 2001	Scientists at Advanced Cell Technology make unverified reports of the first cloned human embryos.
Dec. 2001	Britain outlaws human reproductive cloning.
Feb. 2002	United Nations begins consideration of a world-wide ban on human cloning.
July 2002	The U.S. President's Council on Bioethics issues its report *Human Cloning and Human Dignity: An Ethical Inquiry*.
Sep. 2002	California becomes the first state to pass a law legalizing therapeutic cloning.
Dec. 2002	The Raelians make the unsubstantiated announcement that they successfully cloned a human being.
March 2004	Korean scientists announce they have used SCNT to clone human blastospheres.
June 2004	United Nations Conference on Human Cloning.

SOURCE: Courtesy of Carl Mitcham and Adam Briggle.

February 2002, Bush announced in a speech from the White House's Rose Garden that he favored a ban on all forms of human cloning, including the cloning of human embryos for the purpose of stem cell research (Bush 2002).

Bush warned that in our zeal to find benefits and cures we could also "travel without an ethical compass into a world we could live to regret." Throughout the rest of his speech were salted words and phrases such as "products," "design," "manufacturing," "engineered to custom specifications." Bush was concerned that cloning would lead to the literal manufacture of human beings. A few months later, on July 10, the President's Council on Bioethics issued a report concluding that moral concerns about human cloning were sufficient to warrant a complete ban on using cloning to make people and a moratorium of at least four years on using cloning for research purposes.

Bush was hardly acting alone in sounding the tocsin of moral concern about the dangers of cloning. He was simply the most prominent among a long list of conservatives, pro-lifers, and neoconservatives, along with a small number of neo-green thinkers, who saw cloning in general as holding the seeds of the degradation of humanity.

Reproductive Cloning

So is there a strong case against human cloning? Reproductive cloning raises the question: Would it be unethical for anyone to try to clone a human being today or at any point in the future? Those who oppose human cloning point to the repugnance of a style of reproduction with such profound potential for vanity, arguing that the freedom of children and the nature of the family are in danger.

There is little debate concerning the claim of most scientists and ethicists that it would be irresponsible and morally wrong to try to use cloning to make a human being anytime soon. The experience of using cloning to make sheep, cows, pigs, and mice has made it abundantly clear that cloning is dangerous. There is real risk of death for the clone and a high risk of disability, and there are also very real risks for the surrogate mother who carries cloned fetuses to term. Without better safety data from animals, including primates, there is no ethical justification for trying to clone a human being.

But safety, while a very real concern, is not a concern about cloning per se. Presume that cloning were to someday prove safe. Would it still be ethically wrong to use it to make people? Any answer that pins the dangers for early prospective clones on something other than mere physical harms novel to the cloning process can become diffused in two conceptual problems:

- one is attempting to protect future potential persons against harms that might be inflicted by their very existence, and
- societies around the world have indicated that they believe that the early cloning experiments will breach a natural barrier that is moral in character, taking humans into a realm of self-engineering that vastly exceeds any prior experiments with new reproductive technology.

Laws that would regulate the birth of a clone are philosophically difficult in part because they traverse complex jurisprudential ground: protecting an as-yet-nonexistent life against reproductive dangers, in a Western world that, in statutory and case law at least, seems to favor reproductive autonomy.

Many people seem inclined to put those philosophical issues, nonetheless, into a position of primacy in the human cloning debate, including President Bush and his chief bioethical adviser, Leon R. Kass. But the case against cloning when safety is taken out of the equation is a more difficult case to make than that which pivots upon safety alone. This is true whether one considers merely reproductive cloning or cloning for the sake of embryonic-based stem cell therapies.

One such argument against cloning people is that it is wrong to manufacture people. But cloning human beings is no more manufacturing them than using test-tube baby technology or artificial insemination or even neonatal intensive care. No one feels any less human for having been born in a neonatal unit or delivered by forceps or started up in a petri dish. Clones would be no less people with free will and human dignity than any other person.

Or would they? Some contend that cloning is wrong because everyone is entitled to their own unique genetic endowment. This too is not a strong argument because identical twins and triplets already exist and do quite well despite the existence of another person with the exact same genes. Even if one is worried that parents will try to manipulate or force the clone to behave or develop in certain ways, it has to be said that this is precisely what parents do with their children all the time whether they have a genetic tie to them or not. Should laws against cloning reach into social preferences about how children should be raised that are not enshrined in law?

Therapeutic Cloning

Even if the case against human reproduction by means of cloning is not as strong as it may initially appear, there remains the separate issue of human therapeutic cloning. Therapeutic cloning is not intended to create another human being. It employs SCNT to use the results for other purposes. Is it moral to create cloned human embryos simply to destroy them for the purposes of obtaining stem cells to use in medical research or for other potential uses?

Those who oppose the use of cloned embryos for research or therapeutic purposes do so on the basis of two arguments. First, they may oppose therapeutic human cloning weakly, on the grounds that the cloned embryos are potential human life and as such deserve respect. The opposition here is weak only insofar as it need not entail an opposition without compromise. Second, they may oppose therapeutic human cloning more strongly, on the grounds that embryos have the status of human beings from the moment of conception. Here this opposition is more likely to be one that resists any compromise.

In response to the stronger opposition the fact remains that left in a dish in a lab a cloned human embryo has no potential for personhood unless one assumes the voluntarism of highly trained specialists and of women with empty wombs. Even then such embryos are only dubiously embryonic in that their potential to develop in a human uterus has been anything but established, and their differences from "ordinary" embryos—whether or not one considers such embryos to be persons—have been shown to be abundant and significant. So it is not self-evident that it is immoral to make and destroy cloned embryos on the grounds that this is the same as killing a human being.

Assessment

National debates and those at the United Nations on whether or not to ban human cloning, either outright or merely for reproductive purposes, remain significant venues for science, technology, and ethics interactions. On the one hand, there may be considerable public policy difficulties in implementing any restrictions on reproductive cloning that does not also limit therapeutic cloning, because the initial SCNT technology (or some future technique of a related sort) would be the same for both purposes. On the other hand, it may be that reproductive cloning will remain morally unacceptable simply because it will always be too dangerous or too risky for the future offspring.

At the same time the irony may be that cloned human embryos, which arguably lack true personhood, will remain the best source for stem cells for research and therapeutic uses—uses that may enable humans to respond more effectively to dangers and risks from illness, disease, and injury. Yet because of the potential value of human stem cell research there are also active programs to develop ways to create such cells without involving human embryos. That there might be a technological fix for the moral divide between those in favor and those opposed to stem cell research remains a distinct possibility.

Either way, those who argue about the moral status of human clones and the processes that produce them represent the widest variety of perspectives—in what may almost be called the "kitchen sink" of bioethical debates, involving as they do as many obvious issues about cloning as one could conjecture, as well as a number of subtle issues that depend on careful science and good public policy. On the positive side are proponents such as Michael Fumento (2003) who see human cloning as part of a wave of historically unprecedented benefit and power. On the negative side are critics such as Francis Fukuyama (2002) who see threats to the very nature of humanity. How well society handles human cloning will demonstrate not only how it handles one of its most extreme and extraordinary cases of conflict in medicine, but also how prepared it is for a world in which different kinds of personhood and parenthood may become as ubiquitous as new kinds of food and transportation.

GLENN MCGEE

SEE ALSO *Embryonic Stem Cells; Eugenics; Playing God; Posthumanism.*

BIBLIOGRAPHY

Bush, George W. (2002). "President Bush's Remarks in Opposition to Human Cloning" (speech in the Rose Garden, Washington, DC, April 10). In *The Future Is Now: America Confronts the New Genetics,* ed. William Kristol and Eric Cohen. A brief articulation of the president's view of human cloning.

Fukuyama, Francis. (2002). *Our Posthuman Future.* New York: Farrar, Straus and Giroux. A defense of the position that cloning is dangerous because it changes human nature.

Fumento, Michael. (2003). *Bioevolution: How Biotechnology Is Changing Our World.* San Francisco: Encounter Books. An exploration of biotechnology and ethics.

Kass, Leon R., and James Q. Wilson. (1998). *The Ethics of Human Cloning.* Washington, DC: AEI Press. Leaders in genetics articulate a strategy for regulation of human cloning.

Klotzko, Arlene Judith, ed. (2001). *The Cloning Sourcebook.* Oxford: Oxford University Press. A compilation of essays concerning the global debate on cloning.

Kristol, William, and Eric Cohen, eds. (2002). *The Future Is Now: America Confronts the New Genetics.* Lanham, MD: Rowman and Littlefield. A conservative position on human cloning.

McGee, Glenn. (2000). *The Perfect Baby,* 2nd edition. Lanham, MD: Rowman and Littlefield. A pragmatic position on human cloning.

McGee, Glenn. (2004). *Beyond Genetics: A User's Guide to DNA.* New York: Harper Perennial. An introduction to cloning and genetic technology.

HUMAN GENOME ORGANIZATION

The Human Genome Organization (HUGO) is an international society of elected members with an interest in the scientific, commercial, and societal impacts of research on the human genome. HUGO should not be confused with the Human Genome Project (HGP), a U.S. program founded in 1990 and funded by both the U.S. Department of Energy and the National Institutes of Health. HUGO serves as a vehicle for the international coordination of human genome research.

A group of forty-two scientists founded HUGO in September 1988 after a discussion spurred by molecular biologist and Nobel laureate Sydney Brenner (b. 1927) began in April of that year. In the same year the Department of Energy and the National Institutes of Health signed a memorandum of understanding to cooperate in support of human genomic research. An eighteen-member executive council leads the organization, but the complete membership forms a general assembly with ultimate control of the organization. Members of the organization also serve on a number of committees on particular topics, such as ethics and intellectual property rights. New members are elected annually after receiving nominations endorsed by at least five previous or current members.

The purposes of HUGO are to assist the international coordination of research on the human genome, coordinate and facilitate the exchange of data and biomaterials relevant to human genome research, and encourage public debate and provide information and advice on the scientific, ethical, social, legal, and commercial implications of human genome projects (McKusick 1989).

The HUGO Council and its committees have released a number of statements concerning societal impacts, including statements on patenting, cloning, gene therapy, and benefit sharing. In 1996 the HUGO Council approved the first of those statements: "Statement on the Principled Conduct of Genetics Research," which was written by the ethics committee the previous year (Human Genome Organization 1995). The statement includes a general set of recommendations to address concerns about genetic discrimination, information access, and genetic reductionism, among other issues. The recommendations broadly urge the scientific community to meet those concerns through self-oversight and better training.

In statements on patenting in 1995, 1997, and 2000 HUGO argued that expressed sequence tags (ESTs) and single nucleotide polymorphisms (SNPs) do not merit patent protection without detailed knowledge of the biological function of the sequence in question. This position contrasts with patent laws in the United States and Europe, which allow the patenting of those sequences. HUGO argues that the sequences can be found easily with modern genetics computing but that patent seekers cannot determine the utility of a sequence without doing much more research. HUGO believes that granting patents on ESTs or SNPs prematurely creates disincentives for genetics research.

With regard to cloning HUGO has suggested that no one should attempt reproductive cloning of a human by means of somatic cell nuclear transfer but that basic research using that technique or other cloning techniques and therapeutic cloning should be pursued (Human Genome Organization 1999). However, HUGO also has suggested that embryos should not be created for the purpose of genetic research.

HUGO's statement on gene therapy in 2001 supported the pursuit of somatic gene therapy with strong safeguards, including public oversight and review (HUGO Ethics Committee 2001). The appropriateness of germline therapy that would affect a patient's descendants should be discussed widely. The draft stresses the need for public involvement in setting the limits and ethical principles that should guide gene therapy.

HUGO provides an avenue for the scientific community to communicate its position on the ethical and societal implications of biotechnology research. The organization's international membership includes many preeminent researchers in the field. However, membership is voluntary and the organization has no ability to sanction members or enforce its policies. Its contributions to discussions of the ethical and societal implications of human genome research have been minimal. The organization has not made those issues an important part of its mission.

TIND SHEPPER RYEN

SEE ALSO *Bioethics; Genethics.*

BIBLIOGRAPHY

Human Genome Organization. (1995). "Statement on the Principled Conduct of Genetics Research." *Eubios Journal of Asian and International Bioethics* 6: 59–60.

Human Genome Organization. (1999). "Statement on Cloning." *Eubios Journal of Asian and International Bioethics* 9: 70.

Human Genome Organization Ethics Committee. (2001). "Statement on Gene Therapy Research." *Eubios Journal of Asian and International Bioethics* 11: 98–99.

McKusick, Victor A. (1989). "The Human Genome Organization: History, Purposes, and Membership." *Genomics* 5: 385–387.

INTERNET RESOURCES

Eubios Ethics Institute. Available from http://www.biol.tsukuba.ac.jp/∽macer/index.html. This institute is run by one of the members of the HUGO Ethics Committee and contains many of the group's ethics statements.

Human Genome Organization. Available from http://www.hugo-international.org/. The official site of the organization.

HUMANISM

Humanism is a philosophy and way of life (a lifestance) based on empathy, reason, and experience. To humanists, empathy—which is the starting point for compassion and social action—is a product of human nature: the fact that humans are highly developed social animals. Reason is a product of human intelligence that, when combined with experience, leads to the scientific method. And humanists regard the scientific method as the only reliable tool for both acquiring and validating the knowledge necessary to realize the aims of human compassion. To the twentieth-century philosopher Bertrand Russell, the whole concept could be summed up this way: "The good life is one inspired by love and guided by knowledge" (Russell 1957, p. 56).

Given this premise, humanism is an essentially pro-science outlook. And because science becomes socially beneficial primarily through technology, humanists tend to be supportive of technology. Nevertheless, because empathic concerns are basic to humanism, and consequently to humanist ethics, any technology that proves itself more harmful than good in regard to humanity and living nature will be challenged by humanists. This is why humanists have been active in efforts to protect the environment, outlaw certain weapons, ensure product safety, minimize negative social impacts evident in widespread technologies, and so on.

On the other hand, because of the humanist focus on science as the primary means of knowing, there is no place for supernatural belief in humanist thought. Humanism is a completely naturalistic and nontheistic worldview. As such, it leaves humanists with the recognition that humanity alone must take responsibility for making the world better. Along these lines, Humanist Manifesto II (1973) states: "No deity will save us; we must save ourselves." Therefore humanists tend to be relatively fearless in the face of admonitions against scientific hubris and dire warnings that given technologies will allow humans to "play god." In the humanist view, science and technology are tools that allow humans to take charge of their lives, protect themselves from diseases and other dangers, and generally improve the human condition. Therefore, emerging technologies of great promise have tended to be welcomed by humanists rather than feared.

The roots of the humanist worldview are complex, so much so that this background is most clearly understood when pursued as three separate histories: that of the word *humanism*, the ideas of humanism, and the organized humanist movement.

The Word

The Roman grammarian Aulus Gellius, who flourished circa 160 C.E., noted (in *Noctes Atticae* [Attic nights] the dual usage of the Latin *humanitas* (humanity). One usage was comparable to the Greek concept of *philanthropia* and indicated an attitude of general benevolence or humanitarian sympathies, while the other was comparable to the Greek *paideia* and indicated the achievement of being humanized (*humanissimi*) through acquired learning in the liberal arts. Because this latter usage was seen as a capability that separated humans from animals—giving humans the power of independent judgment—it had been favored by the Roman orator and philosopher Cicero (106–43 B.C.E.) and the Roman scholar Varro (116–27 B.C.E.) as a civilizing force.

Such an autonomous, cultured view of life fell largely out of fashion during the Middle Ages, replaced by a notion that human beings were defined players within set hierarchies of the cosmic order, as maintained by the authority of the church, the empire, and the feudal system. But as a few cities and communes gained political independence in the fourteenth century, intellectual independence followed. And with it came a revival of the ancient Greco-Roman spirit. This took the form of a Renaissance literary and philosophic movement of scholars calling themselves *humanists*. Through a revival of classical letters and a focus on the humanities, Renaissance humanists promoted religious tolerance, worldly ethics, a sense of history, and an interest in nature. In the latter case, what had begun as a revival of humane letters became an impetus for the advancement of science, thus broadening humanism's meaning. Additional broadening occurred as humanist ideas came to be advocated not only by Roman Catholics but also by Protestants, Jews, and nonreligious skeptics.

During the subsequent period of the Enlightenment the term was little used. But in 1853 a democratic organization appeared in England, calling itself the Humanistic Religious Association of London and declaring emancipation "from the ancient compulsory dogmas, myths and ceremonies borrowed of old from Asia and still pervading the ruling churches of our age." Around the same time, in France, the pioneer sociologist Auguste Comte (1798–1857) formulated a "religion of humanity" out of his science-oriented, nontheistic philosophy of positivism.

In 1867 a group of radical Unitarians and freethinkers in the United States formed the Free Religious Association and eventually, by the end of the century, many came to propound what they called *humanistic theism*—essentially a mix of the most liberal Unitarianism, Universalism, and Reformed Judaism of the time together with freethought critiques of more traditional faith. Among the radical Unitarians was Edward Howard Griggs who in 1899 wrote a popular book, *The New Humanism: Studies in Personal and Social Development,* advocating science (particularly Darwinism), "the Greek ideal," Christian spirituality, and social change (including women's rights). These positions were all rolled into an idea for a new religion that would "teach the divinity of common things" and proclaim "the infinite significance of humanity." Another radical Unitarian was the Reverend Frank Carlton Doan, whose 1909 *Religion and the Modern Mind* set forth a more inner-directed, psychological humanism that promoted meditative self-awareness as the starting point for social progress.

Throughout the first three decades of the twentieth century, Irving Babbitt (1865–1933), Paul Elmer More (1864–1937), and Norman Foerster (1887–1972) developed what has been variously termed academic humanism, literary humanism, and the new humanism. This reactionary outlook called for a return to a classics-based education, declared the humanities superior to science, proclaimed human beings superior to nature, and advanced a puritanical morality of decorum. Vestiges of this viewpoint remain in the early twenty-first century among some specialists in the humanities (who sometimes term themselves humanists), often expressed through a distrust of science and technology.

Among philosophers, F. C. S. Schiller in England published *Humanism: Philosophical Essays* in 1903 and *Studies in Humanism* in 1907, advocating a subjectivist form of pragmatism. Later, Jean-Paul Sartre (1905–1980) developed an existential humanism and Jacques Maritain (1882–1973) a theocentric Catholic humanism drawing on the thought of Thomas Aquinas. There have even been both Marxists and Social Darwinists who have taken the humanist label.

While many or all of the above have been regarded as representing different types of humanism, it would be more correct to understand them as different usages of the same word. From this perspective, it is possible to see the current usage of the term humanism as more or less serendipitous and possessing largely superficial rather than substantive connections to the ideas of those who had used the word earlier. The origin of current usage is as follows.

During World War I, the American Unitarian minister John H. Dietrich (1878–1957), having doubts concerning his earlier Christian convictions, adopted a naturalistic, pro-science, ethical worldview linked to a progressive social outlook. But he had no name for this combination of ideas until he read a 1915 article by a positivist, Frederick M. Gould, published in a magazine of the British Ethical Societies. Gould used the term humanism to express a belief and trust in human effort. This was somewhat different from the Renaissance usage already familiar to Dietrich—which suggested that the word could be adapted to his own nontheistic form of Unitarianism. So Dietrich began using it.

Independently, in 1916, another American Unitarian minister, Curtis W. Reese, arrived at similar conclusions. His term of choice, however, was *the religion of democracy*. He argued that democratic religion is human centered in contrast with the authoritarianism of theocratic religion. Edwin H. Wilson, in his 1995 book, *The Genesis of a Humanist Manifesto,* tells how the two men met in 1917 at the annual Western Unitarian Conference: "While Reese was speaking . . . on 'The Religion of Democracy,' Dietrich pointed out: 'What you are calling the religion of democracy, I am calling humanism.' It was a momentous convergence of minds—and at that moment, a movement was launched" (pp. 7–8).

The Ideas

In *The Philosophy of Humanism* (1997), Corliss Lamont sees a number of historic ideas, trends, and movements as converging over time to create contemporary humanist thought: these being empirical science, ancient and modern philosophies of materialism and naturalism, free thought, liberal religion, democracy and civil liberties, Renaissance humanism, and literature and the arts—in other words, most of the Western intellectual tradition. There are similar trends in the histories of non-Western cultures, together with cross-pollination with the West, so Lamont also draws attention to relevant intellectual traditions in China, India, and the Middle East. This sort of approach, however, can be accused of creating a pedigree out of ancestors adopted for their compatibility.

Therefore, William F. Schulz, in his 2002 book, *Making the Manifesto,* focuses on more proximate antecedents: nineteenth-century science, the impact of Charles Darwin (1809–1882) and Sigmund Freud (1856–1939), cultural anthropology and the higher criticism of the Bible, free thought and religious modernism, progressivism and the social gospel, and the philosophies of pragmatism and critical realism. Nevertheless, because humanism is not the sum of these things, and because it continues to evolve, it is best described less in terms of its origins and more in terms of what it is: a worldview with the following features.

Humanism's epistemology is derived from the Instrumentalism (the view that the abstract concept of "truth" is best replaced by the more empirical concept of a "warranted assertion") of the American educator and philosopher John Dewey (1859–1952). Metaphysically it is naturalistic (the view that the universe is natural and there is no supernatural). Its worldly ethic is essentially altruistic but because of the humanist commitment to reason, it also involves elements of the Utilitarianism of the English philosopher John Stuart Mill (1806–1873), which holds that acts are good only to the extent that they have practical social benefits that can be rationally decided. Thus humanist ethics are situational (changing with situations) in a context of compassion as well as egoistically consequentialist (taking consequences into account from the standpoint of enlightened self-interest). In the social and political realm this dichotomy reveals itself in a recognition of the inherent conflict between individual liberty and social responsibility, leading to the conclusion that moral dilemmas are real and a necessary part of life and law. Democratic values—including social justice, the enfranchisement of the disenfranchised, and the open society—are central to humanism as an expression of the Golden Rule (do to others as you would have them do to you), which is itself a formula derived from the human capacity for empathy. In matters of personal self-development toward a meaningful life, humanism has been informed by Bertrand Russell's *The Conquest of Happiness* (1930).

The Movement

In 1876 the Society for Ethical Culture was founded by Felix Adler, a Reform Jew who was active in the Free Religious Association. Ethical Culture was a new religion that promoted ethical behavior and social service—deed above creed—with its values derived from neo-Kantian principles. By around 1950, however, the various Ethical Culture societies in the United States and England had evolved Adler's philosophy into humanism or had come to understand it as such. As a result, the American Ethical Union became one of the founding member organizations of the International Humanist and Ethical Union (IHEU), the world coalition of humanists.

In 1916 Reese and Dietrich began preaching humanist ideas from the pulpits of their Unitarian churches. Slowly humanism spread among Unitarians, aided by the creation of the Humanist Fellowship at the University of Chicago in 1927 and the founding of the *New Humanist* magazine one year later. In 1929 the Unitarian minister Charles Francis Potter left the denomination to found the independent First Humanist Society of New York, a church that would eventually count among its members Albert Einstein and Helen Keller.

Meanwhile in India in 1925 Periyar launched Self-Respect, a humanist political and social reform movement devoted to human rights and opposed to the caste system. Openly nontheistic and critical of Hindu and other religious beliefs, it was and remains a proponent of scientific and technological development.

A Humanist Manifesto, published in the *New Humanist* in 1933, was the first major document to lay down the basic principles of humanism. It was signed by prominent academic philosophers (including Dewey), clerics (Ethical Culture, Jewish, Unitarian, and Universalist), educators, journalists, scientists, and social reformers.

In 1941 a number of the manifesto signers founded the American Humanist Association and its magazine, the *Humanist.* Both continue into the twenty-first century, and the organization has counted among its presidents the Nobel Prize–winning geneticist Herman J. Muller and the science popularizer Isaac Asimov.

Following World War II a number of humanist organizations sprung up in Europe, India, and elsewhere. This international growth led to the founding of the IHEU in 1952 at a humanist conclave in Amsterdam chaired by the English biologist Julian Huxley. In the early 2000s the IHEU indirectly represents millions of humanists worldwide in national and local organizations on six continents.

In his 1957 book, *New Bottles for New Wine,* Huxley coined the term *transhumanism* out of a recognition that humanity "*is* in point of fact determining the future direction of evolution on this earth" and therefore a term is needed to signify "man remaining man, but transcending himself, by realizing new possibilities of and for his human nature" (pp. 14, 17). Huxley's word has been taken up by futurist-oriented humanists engaged in exploring the possibilities of radical improvements in the human condition and human capabilities through the likes of cyber-, bio-, and nanotechnology. To foster dialogue and advance this pursuit, the World Transhumanist Association was founded in 1998. Since then a growing number of people have been calling themselves transhumanists.

FRED EDWORDS

SEE ALSO *Humanization and Dehumanization; Science, Technology, and Society Studies.*

BIBLIOGRAPHY

American Humanist Association. (1973). "Humanist Manifesto II." *The Humanist* 33(5): 4–9. Though out of date, this remains the most frequently cited expression of humanism and its social applications.

American Humanist Association. (2003). "Humanism and Its Aspirations: Humanist Manifesto III." *The Humanist* 63(3): 13–14. The most recent basic expression of humanism.

Bragg, Raymond B., ed. (1933). "A Humanist Manifesto." *The New Humanist* 6(3): 1–5. The original, basic expression of humanism, with multiple authors and signatories.

Doan, Frank Carleton. (1909). *Religion and the Modern Mind, and Other Essays in Modernism.* Boston: Sherman, French & Company. An early example of the effort to make personal psychology and emotional well being a starting point for ethics.

Griggs, Edward Howard. (1908). *The New Humanism: Studies in Personal and Social Development,* 6th edition. New York: B.W. Hubesch. Modern religious liberals would find much to agree with in this expression of humanistic theism. First edition published in 1899.

Huxley, Julian. (1957). *New Bottles for New Wine.* New York: Harper & Brothers. Science intersects with moral and social questions in this popular collection of essays.

Kurtz, Paul. (2000). *Embracing the Power of Humanism.* Lanham, MD: Rowman and Littlefield. Offers an exuberant expression of humanism as a positive and personally rewarding lifestyle.

Lamont, Corliss. (1997). *The Philosophy of Humanism,* 8th edition. Amherst, NY: Humanist Press. Recognized as the standard work on humanism. First edition published in 1949.

Olds, Mason. (1996). *American Religious Humanism,* rev. edition. Minneapolis, MN: Fellowship of Religious Humanists. The most complete survey of the early history of religious humanism.

Russell, Bertrand. (1958 [1930]). *The Conquest of Happiness.* New York: Bantam Books, Inc. A practical book on achieving happiness that doesn't insult the intelligence of philosophically-minded readers.

Russell, Bertrand. (1957). *Why I Am Not a Christian and Other Essays on Religion and Related Subjects,* ed. Paul Edwards. New York: Simon & Schuster, Inc. A significant number of humanists and freethinkers name this book as the one most influential in bringing about their break with traditional religion.

Schiller, F. S. C. (1903). *Humanism: Philosophical Essays.* London and New York: Macmillan. The first book to approach humanism academically as a philosophy.

Schiller, F. S. C. (1907). *Studies in Humanism.* London: Macmillan and Co., Limited. The author further develops his philosophy of humanism as a subjective form of pragmatism.

Schulz, William F. (2002). *Making the Manifesto: The Birth of Religious Humanism.* Boston: Skinner House Books. An analytical history of the first Humanist Manifesto by a Unitarian universalist minister who personally interviewed a number of the original signers, all who are now deceased.

Wilson, Edwin H. (1995). *The Genesis of a Humanist Manifesto.* Amherst, NY: Humanist Press. The history of the first Humanist Manifesto told by one of the people most responsible for it.

HUMANITARIAN SCIENCE AND TECHNOLOGY

Humanitarian was first applied to organizations such as the International Red Cross/Crescent, founded in 1864 by the Swiss philanthropist Jean-Henri Dunant (1828–1910), in response to his experience with wounded soldiers at the Battle of Solferino, Italy, in 1859. From the beginning the term was thus allied with an ethical vision for the use of science and technology (initially in the form of medicine) to benefit human beings who may have previously been harmed by technology (at first in the form of military weapons).

Background

Humanitarianism is an ethical vision closely associated with the creation of the social sciences. During the nineteenth century, modern natural science began to explore social phenomena, in part to deal with the challenges presented by new human powers over the natural world. Industrial technologies created urban centers that needed better management for the benefit of the human beings who lived in them, not as members of some political or religious or ethnic group but simply as human beings, who could also be scientifically studied as such. Public health and public engineering is for the benefit of all, although the "all" was in the first instance understood within a national context.

Humanitarianism thus aims to extend compassion beyond traditional family or village limits, especially through the utilization of science broadly construed. Although this may appear to have been simply a secular version of Christian missionary work—especially since humanitarian organizations often attracted voluntary contributions from believers—the increasing number of middle-class persons involved in providing relief for the victims of warfare and the improvement of urban slums constituted a historically unique social movement (Morehead 1999).

The larger background is that the early-1800s gave science and technology major roles in the construction, organization, and maintenance of both nation-state and colonial empire. First in England and France and later in the United States, centers of raw materials extraction and industrial production also created an exploited working class. Witnessing the living conditions of these people, humanitarian scientists and engineers often responded to alleviate such situations as best they could through technical improvements. After 1830 in Lille, France, humanitarian physicians studied and denounced the deplorable conditions of working class people in order to improve their health and living conditions (Gerard 1999). In 1838 German-born naturalist Robert Schomburgk sought to use his knowledge to reduce the enforced slavery of Indians in British Guiana by establishing a political boundary in harmony with their natural territory (Riviere 1998). Indeed in the 1800s humanitarian science, by emphasizing the unity of all peoples as human beings in the eyes of science, was a significant contributor to abolitionist movements throughout the world.

Across the turn of the nineteenth to twentieth century, international conflicts and natural disasters affecting large populations further spurred efforts to utilize science, technology, and medicine to ameliorate the conditions of wounded and displaced peoples. The Franco-Prussian War (1870–1971), the Ohio and Mississippi River floods (1884), the Spanish-American War (1898), the San Francisco earthquake (1906), and World War I (1914–1918) all provided major tests for the International Red Cross and related humanitarian agencies. The continued involvement of scientists and engineers in humanitarianism was reflected in scientist and inventor Alfred Nobel's creation of the Nobel Prizes at his death in 1896; the first Peace Prize was awarded to Dunant in 1901.

The twentieth century witnessed the further institutionalization of humanitarian activities related to science and technology in labor movements, public health work (including family planning), and immigrant settlement and education (which often emphasized technical education). Finally in response to the horrible uses of science in World War II (1939–1945), especially in the death camps of Nazi Germany, humanitarianism led to adoption of the Universal Declaration of Human Rights (1948), which stipulates "the right freely . . . to share in scientific advancement and its benefits" (Article 27).

Some argue that all science and technology are inherently humanitarian in their basic orientation, which was the view of both early modern scientists and proponents of the Enlightenment. Over the course of the modern period, however, it became increasingly recognized not just by socialists that special efforts are often needed to protect science and technology from dehumanizing distortions caused by economic or political interests. Efforts to liberate the benefits of science and technology from pernicious influences have taken place in national and international regulatory agencies, which may in many instances be styled humanitarian. Especially during the last half of the century humanitarian science and technology were further encouraged by four interrelated phenomena: the consumer movement, the environmental movement, the alternative technology movement, and public interest science.

Engineers especially also have been major contributors to international development work. For instance, the idea for the U.S. Peace Corps originated in 1960 with civil engineer Maurice Albertson, who was also intimately involved in its creation.

However, by the last quarter of the century, disaster and refugee relief had taken on characteristics that exceeded the capacities of many traditional humanitarian organizations. The end of the Cold War (1989) and the subsequent rise of genocide and terrorism as an international threat promoted humanitarian missions by the armed forces, which relied heavily on engineering skills. Increasingly humanitarian action involved scientific and technological developments in psychological counseling, high-tech monitoring (of military movements or weather), and the use of specially designed equipment (mobile power plants, water purification systems, and more). But a further response was the creation of new kinds of not-for-profit and non-governmental organizations oriented toward humanitarian action as part of an emerging international civil society. The failures and inadequacies of post-Cold War ideology of humanitarianism have also been subject to extensive criticism (see, for example, Rieff 2002).

Science and Engineering without Borders

Humanitarian science and technology may be related to what Carl Mitcham (2003) has termed *idealistic activism* among scientists and engineers, as illustrated by organizations such as International Pugwash (founded 1957) and the Union of Concerned Scientists (founded 1969). Among a diverse collection of related organizations seeking to build bridges between humanitarianism and scientific technology are the Responsible Care initiative of the American Chemistry Council and the International Network of Engineers and Scientists for Global Responsibility (INES). Responsible Care, founded in 1988, is a voluntary program to improve environmental health and safety in the chemical and related industries, especially in developing countries. INES, founded at a 1991 international congress in Berlin, is an association of more than ninety organizations in fifty countries promoting the involvement of technical professionals in humanitarian and peace development activities.

In 1971, however, humanitarian science and engineering activism took a new turn with the formation of *Médecins sans Frontières* (MSF or Doctors without Borders). MSF, which has become the largest non-governmental relief agency in the world, grew out of dissatisfaction with the inability of the Red Cross/Crescent to react independently of national government controls, and its tendency to remain within safe boundaries. The idealistic physicians of MSF pioneered new ways to bring medical science and technology to people in crisis and to speak out against human rights abuses. Since its founding, MSF has responded to needs resulting from earthquakes, hurricanes, war, and famine in Central America, Africa, Russia, the Balkans, and the Middle East (Tanguy 1999).

Inspired by MSF, other science and engineering organizations followed suit. Examples include *Avaition sans Frontières* (1980), providing air deployment for humanitarian projects, and ORBIS ophtalmologists (1982), providing preventive and surgical eye care to poor communities throughout the world. In the early-1990s, there also emerged independently a number of groups going under some form of the name Engineers without Borders: *Ingénieurs Sans Frontières—Ingénieurs Assistance Internationale* (Belgium), *Ingeniería sin fronteras* (Spain), *Ingenièrer unden Graenser* (Denmark), *Ingenjörer och Naturvetare utan Gräser-Sverige* (Sweden), *Ingegnería Senza Frontiere* (Italy), and others. In 2003 these groups organized Engineers Without Borders—International as a network to promote "humanitarian engineering . . . for a better world." The process has also led to educational programs in humanitarian engineering, efforts that parallel others in public health and nutrition science, and policy programs that seek comprehensive, interdisciplinary understandings of humanitarian crises.

Undoubtedly one of the personal inspirations for engineering without borders efforts was the life and work of mechanical engineer Fred Cuny (1944–1995). Following relief work in Biafra (1969), Cuny sought to bring his engineering skills to bear in earthquake disasters in Central America (1971 and 1976), Sudan (1985), Iraq (1991), Somalia (1992), Sarajevo (1993–1994), and Chechnya (where he was assassinated). Cuny's book *Disasters and Development* (1983) outlines what became known as the *Cuny approach*, an effort to respond to disasters not just by returning people to their predisaster state, but as opportunities to help them improve their lives beyond what otherwise might have been possible.

Defining the Field

Although subject to continuing debate, the basic dimensions of humanitarian science and technology may be summarized as follows. While advances in science and technology have benefited many persons, they have also often increased rich–poor divides, to which specific organizations have tried to respond. Among these, many emphasize science and engineering expertise. Humanitarian science and technology projects, typically operated on a not-for-profit basis, aim either to provide fundamental needs (such as food, water, shelter, and clothing) when these are missing or inadequate in the developing world, or higher-level needs for underserved communities in the developed world.

In contrast to corporations, which aim for relatively near-term profit, and governments, which fund in light of election cycles and constituent dependencies, humanitarian projects are of longer-term importance for society as a whole. Humanitarian science and engineering ideally engage local communities in direct participation in determining project needs and directions. Additionally they seek strategies, designs, and technologies that promote both the sustainability of natural systems and cultural traditions.

CARL MITCHAM
JUAN LUCENA
SUZANNE MOON

SEE ALSO *Engineering Ethics; Globalism and Globalization; Humanization and Dehumanization; Science, Technology, and Society Studies.*

BIBLIOGRAPHY

Cuny, Frederick C. (1983). *Disasters and Development*, ed. Susan Abrams. New York: Oxford University Press. Highly influential.

Gerard, Alain. (1999). "*Action Humanitaire et Pouvoir Politique: L'Engagement des Medicins Lilliois au XIX Siecle*" [Humanitarian action and political power: the involvement of Lille physicians in the 19th century]. *Revue du Nord* 81(332): 817–835.

Mitcham, Carl. (2003). "Professional Idealism among Scientists and Engineers: A Neglected Tradition in STS Studies." *Technology in Society* 25(2): 249–262.

Morehead, Caroline. (1999). *Dunant's Dream: War, Switzerland, and the History of the Red Cross*. New York: Caroll and Graf. A broad and detailed historical narrative.

Rieff, David. (2002). *A Bed for the Night: Humanitarianism in Crisis*. New York: Simon and Schuster. A critical examination of contradictions in early-twenty-first-century humanitarianism.

Riviere, Peter. (1998). "From Science to Imperialism: Robert Schomburgk's Humanitarianism." *Archives of Natural History* 25(1): 1–8.

Tanguy, Joelle. (1999). "The *Médecins Sans Frontières* Experience." In *A Framework for Survival: Health, Human Rights, and Humanitarian Assistance in Conflicts and Disasters*, revised edition, ed. Kevin M. Cahill. New York: Routledge. The only general history that exists.

HUMANIZATION AND DEHUMANIZATION

To humanize is to engage with the human. In many instances this involves actions or constructions to accommodate the limits or needs of human beings, as in the "humanization of science and technology." While science and technology have themselves been extolled as humanizing the world, they have also been criticized as in need of humanization—that is, as dehumanizing. Indeed, it is the negative concept that is in more common use and has emerged to play important roles in at least four areas: psychology, theology, art, and social criticism.

Psychology, Theology, and Art

In social psychology dehumanization is defined as the process by which one person or group views others as not worthy of humane treatment. The dehumanization of enemies is common in personal conflict, civil strife, and warfare—and in the case of large-scale warfare perhaps even unavoidable. Extreme dehumanization leads to crimes against humanity and acts of genocide such as the Holocaust, where even technicians and other "innocent" German citizens were culpable in the dehumanization of victims. There are two types of dehumanizing agents here: those who actually commit the crimes and those who passively conform and silently witness them. In both cases, the act of characterizing others as less than human may serve as a coping mechanism to dampen the psychological effects of mass cruelty. The use of dehumanizing names to disparage others is not confined to extreme or fringe situations, however. Such disparaging language can also be found in mainstream elements of society including laws, magazine articles, and scientific journals (Brennan 1995). Research in conflict resolution and peace studies promotes techniques for the rehumanization of enemies (Stein 1996).

Psychological analyses of dehumanization have described it as a process by which individuals or groups project their own faults onto opponents. Dehumanization in this sense is thus a generalization of the scapegoat phenomenon (Girard 1986), which plays an important role in Christian theology. Moreover, in part because of the Enlightenment claims for the humanizing character of science and technology as opposed to the dehumanizing character of religion, religious and theological discussions have developed extended arguments for religion as a humanizing factor in human affairs. For example, Barbara Rumscheidt (1998) argues that the development of socially engaged Christian faith communities can counteract the dehumanizing effects of globalizing capitalism.

Two specific religious contexts in which the question of humanization has taken form are in Marxist-Christian dialogues and liberation theology. In both these cases the problematic of scientific and technological development is also important. For example, the roots of liberation theology stem in part from industrial development in Latin America, which benefited some but marginalized and impoverished others. Subsequent ecclesiastical developments addressed the question of how economic and technological modernization can promote genuine human progress for all.

José Ortega y Gasset (1925) used the concept of dehumanization to characterize art in the early twentieth century, which by abandoning traditions of romanticism and realism, deformed reality and shattered its merely human aspect. In avant garde art, all that is real, natural, and human is purged in favor of purely artistic elements—which, for Ortega, is actually a good thing. Dehumanization in this context is an aristocratic revolt against the industrial massification of culture, an effort to break through to a higher form of civilization, anticipating subsequent notions of post- and transhumanization.

Criticizing Science and Technology

Ortega was also one of the first philosophers to address both the humanizing and dehumanizing aspects of technology. For Ortega technology is an integral part of being human, but by overwhelming human beings with means to transform the world modern technology can undermine the more central human attributes of imagination and intentionality. As if reflecting Ortega's notion, social criticism of science and technology has tended to bemoan both unrealized possibilities and popular acquiescence to inertial trajectories in technoscientific development. Indeed, according to Carl Mitcham (1984), the question of humanization is one of the most broad and synthetic themes in the critical examination of technology. In what ways, and to what extent, do science and technology promote or obstruct human well being? In terms of the individual, this is an ethical question; in terms of social institutions it is a political one.

Three key arguments for science and technology as humanizing forces are as follows. First, science is a natural expansion of human knowledge that promotes material progress as well as intellectual and spiritual fulfillment. This dual humanizing quality of science was famously portrayed by novelist C.P. Snow's "two cultures" argument, in which scientific intellectuals are viewed as more humane than their literary intellectual counterparts.

Second, science has a normative structure that reciprocally reinforces democratic principles and practices, according to sociologist Robert Merton, scientist Michael Polanyi, philosopher Karl Popper, and others. Since the Enlightenment, the structures of the republic of science have often been presented as models for civil society.

Third, technology humanizes by freeing human beings from disease and other burdens of nature. Economist Julian Simon, for instance, has been an outspoken advocate of the view that technology has increased human prosperity and well-being and will continue to do so as long as humans are allowed to freely develop and deploy it. A collateral argument is that computers and artificial intelligence humanize not just nature by placing it under human control but the world of artifice as well by overcoming the limits of machines and making them more human-like.

In opposition there are also three key arguments for science and technology as dehumanizing forces. First, scientific knowledge is said to alienate humans from the natural, organic, or lived experience. Behaviorist psychology and rational actor theories in the social sciences reduce humans to bundles of calculations and reactions. More generally, Edmund Husserl, in analyzing how the sciences interact with the "life world," warned that modern science arose on the basis of a great forgetting of the immediate, which played out in a parallel amnesia in the human sciences (Rajan 1997).

Second, technology creates an artificial world that is even more burdensome than nature. Some versions of this argument lament the spiritual disease and the feelings of anomie and powerlessness engendered by the modern, Western world (for example, Montagu and Matson 1983, Ryan 1972). Technology has increased the tempo of life to a frantic pace and the massification of production processes and media images produce the foreboding by Ralph Waldo Emerson that "Things are in the saddle,/And ride mankind." Indeed social theorist Jacques Ellul argues that technique has shifted from success in the material world toward a broad spectrum of human activities from education to politics, art, and even ethics—each of which it transforms into a technical process aiming at some form of efficiency. For radical educational theorist Paulo Freire (1970), such dehumanization becomes perfected when it is welcomed rather than shunned, and rehumanizing begins by raising consciousness of one's less-than-human existence.

Third, the conquest of nature and the transformation of the social world leads to the conquest of human nature—and thereby its destruction. This argument, as advanced, for instance, by the literary scholar, novelist, and lay theologian C.S. Lewis, has been revised and deepened by, among others, intellectual historian John Hoberman and science policy philosopher Leon Kass. For Hoberman (1992), the use of drugs to enhance performance raises fundamental issues about the structure of human activity and the connection between performance and effort. For Kass, "Human nature itself lies on the operating table, ready for alteration, for eugenic and neuropsychic 'enhancement,' for wholesale redesign" (2002, p. 4). What is most disturbing about this situation, which was foreshadowed in Aldous Huxley's *Brave New World* (1932), is not the lack of freedom or equality, but the dehumanization and degradation of people who choose "nothing humanly richer or higher"—a fate that may emerge in regimes of individualist democratic consumerism more than totalitarian control.

Assessment

As this third critique of technology demonstrates, judgments of both humanization and dehumanization are necessarily based on visions of human nature. They are related to notions of humanism that likewise involve assessments of the character and influence of science and technology. As such, the concepts of humanization and dehumanization fail as primary ethical concepts for the judgment of science and technology, although they often figure in popular discussions as summary presentations of more fundamental views.

Cultural and philosophical visions of human nature can even create fundamentally opposed understandings of humanization and dehumanization. For example, some philosophical anthropologies envision humans as radically circumscribed by the limits of mortality and futility. From this perspective, dehumanization may occur when such limits are drastically altered or surpassed. Other treatments of human nature characterize humans as self-making beings with unbounded potentialities. From this perspective, the imposition or voluntary submission to certain limits could be regarded as dehumanizing acts.

CARL MITCHAM
ADAM BRIGGLE

SEE ALSO *Critical Social Theory; Dignity; Human Nature; Human Rights; Weil, Simone.*

BIBLIOGRAPHY

Brennan, William. (1995). *Dehumanizing the Vulnerable: When Word Games Take Lives*. Chicago: Loyola University Press. Examines the use and effect of disparaging language in several contexts.

Freire, Paulo. (1970). *Pedagogy of the Oppressed,* trans. Myra Bergman Ramos. New York: Seabury Press. Presents a radical educational theory that criticizes the "banking" model of education and argues for a reduction in the teacher-pupil dichotomy.

Girard, René. (1986). *The Scapegoat*. Baltimore: Johns Hopkins University Press. French original 1982.

Hoberman, John M. (1992). *Mortal Engines: The Science of Performance and the Dehumanization of Sport*. New York: Free Press. Explores social and philosophical implications of enhancement therapies in sports.

Kass, Leon. (2002). *Life, Liberty and the Defense of Dignity*. San Francisco: Encounter Books. Presents a "richer bioethics" to deal with issues of humanization and dehumanization raised by biomedical technologies.

Mitcham, Carl. (1984). "Philosophy of Technology." In *A Guide to the Culture of Science, Technology, and Medicine*, ed. Paul T. Durbin. New York: Free Press, pp. 282–363 and 672–675. See especially the section titled "Toward a Synthesis: The Question of Humanization," pp. 339–344.

Montagu, Ashley, and Floyd Matson. (1983). *The Dehumanization of Man*. New York: McGraw-Hill. A cultural critique that articulates the psychological and social ills produced by modernity.

Ortega, José y Gasset. (1925). *La deshumanización del arte. Ideas sobre la novella*. Madrid: Revista de Occidente. English translation: *The Dehumanization of Art: And Other Essays on Art, Culture, and Literature*. Princeton, NJ: Princeton University Press, 1968.

Rajan, Sundara R. (1997). *The Humanization of Transcendental Philosophy: Studies on Husserl, Heidegger, and Merleau-Ponty*. New Delhi: Tulika. An analysis of the problematic of humanization and its consequences for science, language, and philosophy.

Rumscheidt, Barbara. (1998). *No Room for Grace: Pastoral Theology and Dehumanization in the Global Economy*. Grand Rapids, MI: William B. Eerdmans. Offers avenues of action for religious communities to transform dehumanizing economic realities.

Ryan, John Julian. (1972). *The Humanization of Man*. New York: Newman Press. A cultural critique that diagnoses causes of dehumanization and offers an alternative way of life to humanize modern society.

Stein, Janet Gross. (1996). "Image, Identity and Conflict Resolution." In *Managing Global Chaos,* ed. Chester Crocker, Fen Hampson, and Pamela Aall. Washington, DC: United States Institute of Peace Press, pp. 93–111.

HUMAN NATURE

Many ethical judgments make appeals to human nature either as their foundation or as their standard. In the strongest case ethics is argued to be based on human nature; in other instances actions are proscribed if they fail to respect human nature or are recommended because they are said to be in harmony with human nature. Human nature is also an object of scientific investigation, raising questions related to both process and product: whether scientific investigation is undertaken in ways that respect human nature and whether the results of such investigations can contribute to the understanding of human nature in an ethically relevant sense. After a brief review of theories of human nature, the focus in this entry will be on the final question: the extent to which scientific knowledge of human beings can contribute to understanding or assessing these theories, especially in their role as foundations for ethics.

Theories of Human Nature in History

According to Leslie Stevenson (2004), theories of human nature entail theories about the world, human beings, what might be wrong with human beings, and how anything that is wrong might be corrected. Even those who deny any essential human nature in favor of a historical or cultural construction of human nature have views about what kinds of things human beings are and their place in the world. However, with regard to explicit theories of human nature, premodern theories generally viewed humans as properly subordinate to a larger order so that even though people on occasion rebel against that order (by means of what the Greeks calls *hubris* and the Bible calls sin), they are called upon to learn to control such rebellion by means of ethical or religious practices. By contrast, modern theories tend to see human beings as unjustly limited by the larger order and thus encouraged to overcome those limitations, often by means of science or technology.

More specifically, for Plato, in a famous analogy from the *Republic* (p. 437b ff.), the human soul is presented as being composed of three parts: appetite, reason, and spiritedness. Lack of order results whenever appetite or spiritedness predominates and steps outside the guidance provided by reason. In a similar manner, for Aristotle in *Nicomachean Ethics* (vol. I, p. v), human lives can be oriented toward pleasure, politics, or knowledge, but the perfection of human nature resides with rationality in both practice and theory. Thomas Aquinas (1224–1274) further develops this perspective by arguing that the lawful order of nature is manifest in human nature (in a form he terms natural law) in aspirations to life, affective sociability, and the rational pursuit of both politics and science. Although the Jewish, Christian, and Islamic views of human nature seek in some measure to subordinate rationality to faith in revelation, that faith, like reason, ultimately places boundaries on appetitive, political, and even scientific activities. Structurally similar views can be found in the Asian religious and philosophical traditions associated with Hinduism and Buddhism.

More typically modern theories such as those of Thomas Hobbes (1588–1679) and John Locke (1632–1704), even when they offer a materialist and mechanistic analysis of the workings of human nature, argue that humans are improperly constrained by the state of nature. In Hobbes's frequently cited description, the state of nature is one in which human life is "solitary, poor, nasty, brutish, and short" (*Leviathan,* vol. I, p. 13), a condition from which human beings justly seek any means of escape. This notion that people are unjustly constrained by the human condition is repeated and developed in philosophies as diverse as those of Jean-Jacques Rousseau (1712–1778), Immanuel Kant (1724–1804), Georg Hegel (1770–1831), and Karl Marx (1818–1883). According to Rousseau, for instance, "Man is born free, but everywhere is in chains" (*Social Contract,* vol. I, p. 1). The psychological theory of Sigmund Freud, with its distinction between id, ego, and superego, reverses Plato's theory by suggesting the primacy of id or appetite over both individual self (ego) and social restraint (superego).

Three Basic Approaches to Human Nature

What can science contribute to the assessment or criticism of these diverse theories of human nature? One scientific debate concerns the relative influences of nature and nurture in human affairs. Another focuses on degrees of rationality or nonrationality in human decision and action. Among the most fundamental questions is that concerning whether there is something—a rational or transrational mind or soul—that cannot be accounted for by the same material causes that govern all other things in the natural world.

Materialism (or physicalism) is the position that the physical world is self-contained or closed so that the physical world can be explained only through physical causes and effects. In considering human nature, a materialist would say that human beings must be explained as purely material mechanisms, as physical bodies governed exclusively by physical causes. Consequently, the human mind should be understood as an activity of the physical brain. All the thinking, feeling, and willing of the conscious self must be determined totally by the body, particularly the brain and nervous system.

Against such a materialist view of human nature a dualist would argue that mind is not fully reducible to body, that the mind can act as an immaterial cause on the material brain. An interactionist dualist would agree that the mind depends on the brain as its necessary but not sufficient condition. Thus, if some part of the brain is damaged or ceases to function normally, this can interfere with mental activity. Still, as long as the mind is supported by normal brain activity, the mind can exert its independent power over the brain. When people act through conscious thinking and willing, they use their immaterial minds to control their material brains. A religious believer might go further and claim that the immaterial mind was created by an immaterial God, and thus the mind or soul is supernatural. This supernatural character of the soul could render it immortal so that the human soul could survive the death of the human body.

There are, then, at least three fundamentally distinct views of human nature that are based on three views of the relationship between mind and body. The materialist believes that the mind has no immaterial power to act on the body. The interactionist believes that the immaterial mind interacts with a material body. The supernaturalist believes that the immaterial mind is supernatural and immortal. Each of these views implies more general perspectives on human beings and their place in nature.

Traditional Arguments for Interactionism

These conflicting views run throughout the history of natural science from Socrates to the present. In Plato's *Phaedo* (pp. 96a–100a) Socrates (470–399 B.C.E.) talks with his friends while awaiting execution. He recounts that as a young man he thought that a scientific investigation of nature would explain the causes of everything. He hoped to explain the physical causes of all things coming into being and passing away, including the causes of animal life and the causes of human thinking in the brain. He became frustrated when he found that a complete science of nature as governed by physical causes was beyond his grasp. To explain the world, Socrates insists, it is necessary to understand both physical causes and mental causes. For example, to explain why Socrates is sitting here awaiting his execution, one might describe the physical mechanisms in his body—the bones, muscles, ligaments, and so on—that control his movement. However, although these physical causes are necessary in explaining why he is sitting here, they are not sufficient. It is also necessary to explain how Socrates made up his mind to accept his punishment because this mental decision controls his physical body.

Socrates appeals to a person's ordinary experience of making up his or her mind and then freely choosing to act according to that conscious mental decision; this leads people to think that the mind has a power to act that changes the physical causes of the body. Holding oneself and others morally and legally responsible for their conduct assumes that freedom of thought and choice. People do not hold nonhuman animals or human children morally responsible for their behavior because it is assumed that they lack the moral freedom that is attained only by the development of rational choice in normal human adults through learning and habituation. If human conduct were fully determined by physical causes in the body, it would be impossible to hold people morally or legally responsible for their conduct.

From ancient Greece to the present this kind of Socratic thinking has led many scientists, philosophers, and theologians to conclude that human nature is characterized by a complex interaction of mind and body, mental causes and physical causes. The human mind acts upon the human body, or the mind exerts an immaterial power that is not reducible to the material causes of the body.

Modern Arguments for Materialism

Socrates was responding to a materialist or physicalist tendency that would become a strong tradition in Western science. That materialist tradition gained great power during the scientific revolution of the sixteenth and seventeenth centuries. Proponents of the new science saw the universe as a mechanism that could be explained by mechanical laws working through purely physical causes. It seemed that much of human nature could be explained similarly without invoking an immaterial soul.

Hobbes saw nature as matter in motion governed by laws of motion such as those discovered by Galileo (1564–1642). Animal life, then, including human life, is "but a motion of limbs." "For what is the heart, but a spring; and the nerves, but so many strings; and the joints, but so many wheels, giving motion to the whole body" (*Leviathan*, Introduction). Animal motion is driven mechanically by selfish passions that goad animals to seek pleasure and avoid pain. Although human beings are moved by some of the same selfish passions, humans are unique in their capacity for reason and speech. However, even this uniquely human intellectual activity can be understood mechanistically as the computational manipulation of informational symbols (*Leviathan*, vol. I, p. 5). The soul or mind cannot be immaterial. It must be the activity of the material body. This must be so if one accepts the claim of natural science that everything in the universe is matter in motion. Because of his materialism Hobbes was denounced by religious and political leaders as a morally corrupting teacher of hedonism, egoism, and atheism.

Hobbes's materialist science of the soul seemed to be confirmed by Thomas Willis's (1621–1675) studies of the brain. Working in England at the same time as Hobbes, Willis compared the anatomy of the human brain with that of other animal brains and combined experiments on brains with medical observations of brain-damaged patients to develop what he called "neurology." He reached five broad conclusions. First, all mental experience arises from the motion of "animal spirits" undergoing chemical changes in the brain. Second, different parts of the brain have different functions. Third, the human brain resembles other animal brains, particularly those of monkeys and apes. Fourth, this science of neurology could be used by medical doctors to cure diseases of the brain through the use of drugs that would alter the chemistry of the brain. Fifth, all this supports the general view of the "mechanical philosophy" of the seventeenth century that the human body and brain are both machines explainable by mechanical laws.

Although Willis was mistaken about many details, his broad conclusions are supported by modern neuroscience. What Willis called animal spirits can be understood as electrical and chemical signaling between neurons. Willis's observation that the brain has specialized functions has been elaborated by studies of the ways neurons are organized into modular networks with distinct functions. Willis's claim that the human brain resembles the brains of other animals can be explained by evolutionary biology. His hope that drugs could cure the diseases of the soul seems to have been fulfilled by modern psychopharmacology in its use of drugs to treat mental disorders and enhance mental function. Finally, Willis's mechanistic account of the mind has been elaborated with computer models of the mind as an information-processing system.

It may appear, then, that the science of the human brain initiated by Willis proves Hobbes's materialist view of the soul. However, Willis was not a strict materialist because he believed that his science showed the existence of two souls. The "sensitive soul" found in all animals was purely material and therefore vulnerable to physical diseases. In contrast, the "rational soul" found only in humans was immaterial and immortal, although it depended on the sensitive soul. Thus, Willis's account of human nature was interactionist in that he thought the material brain and the immaterial soul mutually influence each other. He was also a supernaturalist in that he thought the immaterial soul was created by God to be immortal.

In the early twenty-first century some scientists, such as James Watson (2003), Edward O. Wilson (1998), and Steven Pinker (2002), argue that natural science sustains a purely materialist view of human nature and refutes any belief in the human soul as immaterial or immortal. Those scientists dismiss belief in an immaterial soul as an unscientific superstition. However, other scientists, such as Wilder Penfield (1978) and John Eccles (1994), defend Willis's interactionist view of the mind as an immaterial cause that can act on the brain. Eccles, a Nobel Prize–winning neuroscientist, has argued that modern neuroscience is compatible with belief in the self-conscious mind as an immaterial power for thinking and choosing.

Ethical Implications

What difference do these debates over the science of mind-brain interaction make for an understanding of human nature and morality? Those who argue for an immaterial soul agree with Socrates that the capacity of the mind to act outside the laws of physical nature is necessary for moral freedom. They warn against scientific materialism as a denial of free will that would make it impossible to hold people morally responsible for their conduct. They also warn that a materialistic view of human nature would promote a Hobbesian hedonism in which people would see themselves as animals moved by selfish passions with no spiritual capacity for rising above their material interests. To explain the soul as merely biochemical activity in the brain would seem to deprive human life of any unique moral dignity. Moreover, if scientific materialism teaches that human nature has only limited dignity above the rest of nature and if the ultimate end of modern science is the conquest of nature, people may be tempted to use the technological power of science to alter human nature itself in ways that would be dehumanizing.

The history of eugenics illustrates the potentially corrupting effects of a materialist view of human nature. The Judeo-Christian view of human beings as having been created in God's image with immortal souls has supported the moral principle of the special sanctity of human life. However, by the end of the nineteenth century modern science, particularly Darwinian science, had persuaded many people that human beings are merely highly evolved animals and that they do not have immaterial or supernatural souls that set them above the rest of animal nature.

If human beings are products of an evolutionary process governed by survival of the fittest, it seemed that reproductive fitness would be the only moral value coming from nature. Proponents of eugenics argued that human beings should be bred just as other animals are to improve the genetic quality of the species. As a result many state governments in the United States passed laws that forced individuals regarded as genetically inferior to be sterilized so that they could not reproduce. In Nazi Germany, Adolf Hitler (1889–1945) used policies of eugenics, euthanasia, and genocide to eliminate people whom he identified as belonging to inferior races. Some historians, such as Richard Weikart (2004), have explained the horrors of eugenics and Nazism as having been caused partly by the influence of Darwinian materialism in devaluing human life.

Other philosophers such as Peter Singer (2001) have argued that because religious belief in the sanctity of human life has been refuted by scientific materialism, people may be morally justified in euthanizing infants born with severe deformities. Some posthumanist or transhumanist proponents of biotechnology see no moral limit on the power to use science to redesign human beings, perhaps even to the point of abolishing human nature itself. All this seems to confirm the fears of many people that modern science, insofar as it promotes a materialist view of human nature, subverts traditional morality.

At the same time some scientific reasoning about the human mind may support traditional morality by showing how it is rooted in the brain. In *The Descent of Man* (1871) Charles Darwin (1809–1882) argued that a natural moral sense was implanted in human nature by evolutionary history. As naturally social animals, human beings evolved to have a natural sense of right and wrong that would support social cooperation on the basis of ties of kinship and reciprocity. To reinforce this cooperative behavior they were endowed with emotional propensities to moral emotions such as love, guilt, and indignation and also were endowed with the intellectual capacity to formulate social norms of cooperation rooted in those moral emotions.

Some neuroscientists have found that moral experience depends on the moral emotions sustained by the emotional control centers of the brain and on the moral reasoning carried out in the prefrontal cortex of the brain. If these parts of the brain are not functioning normally, people cannot act as moral beings. For example, psychopathic criminals apparently have an abnormality in their brain circuitry that prevents them from feeling the moral emotions that support the moral conduct of normal human beings. Such scientific research suggests that morality is part of the biological nature of human beings.

LARRY ARNHART

SEE ALSO *Christian Perspectives: Historical Tradition; Dignity; Enlightenment Social Theory; Hobbes, Thomas; Humanization and Dehumanization; Hume, David; Natural Law; Posthumanism.*

BIBLIOGRAPHY

Arnhart, Larry. (1998). *Darwinian Natural Right: The Biological Ethics of Human Nature*. Albany: State University of New York Press.

Barbour, Ian G. (2002). *Nature, Human Nature, and God*. Minneapolis: Fortress Press. A survey of the ethical and religious issues in the scientific study of human nature.

Damasio, Antonio R. (1994). *Descartes' Error: Emotion, Reason, and the Human Brain*. New York: Putnam. A seminal work on the emotional basis of ethics in the brain.

Darwin, Charles. (1871). *The Descent of Man, and Selection in Relation to Sex,* 2 vols. London: J. Murray.

Eccles, John. (1994). *How the Self Controls Its Brain*. Berlin: Springer-Verlag.

Greene, Joshua D.; R. Brian Sommerville; Leigh E. Nystrom, et al. (2001). "An fMRI Investigation of Emotional Engagement in Moral Judgment." *Science* 293: 2105–2108. Images of the brain making moral judgments.

Hobbes, Thomas. (1957). *The Leviathan,* ed. Michael Oakeshott. Oxford: Basil Blackwell.

Penfield, Wilder. (1978). *Mystery of the Mind*. Princeton, NJ: Princeton University Press.

Pinker, Steven. (2002). *The Blank Slate: The Modern Denial of Human Nature*. New York: Viking. A vigorous defense of a scientific theory of human nature against the major criticisms.

Plato. (1961). *The Collected Dialogues of Plato,* ed. Edith Hamilton and Huntington Cairns. Princeton, NJ: Princeton University Press.

Popper, Karl R., and John C. Eccles. (1983). *The Self and Its Brain: An Argument for Interactionism*. London: Routledge & Kegan Paul. A history of the mind-body problem in philosophy and neuroscience and an argument for the immaterial nature of the mind.

Richards, Janet Radcliffe. (2000). *Human Nature after Darwin*. London: Routledge. A study of the philosophic implications of Darwinism for human nature.

Singer, Peter. (2001). *Writings on an Ethical Life*. New York: Ecco.

Stevenson, Leslie Forster, ed. (1999). *The Study of Human Nature: A Reader,* 2nd edition. New York: Oxford University Press. A companion volume to the editor's *Ten Theories of Human Nature,* collecting texts from twenty-four different sources.

Stevenson, Leslie Forster, and David L. Haberman. (2004). *Ten Theories of Human Nature,* 4th edition. New York: Oxford University Press. Includes three ancient religious views (Confucian, Hindu, biblical), five philosophical views (Plato, Kant, Marx, Freud, and Sartre), and two scientific views (behavioral and evolutionary psychology).

Watson, James D. (2003). *DNA: The Secret of Life*. New York: Knopf. A history of how genetics illuminates human nature.

Weikart, Richard. (2004). *From Darwin to Hitler: Evolutionary Ethics, Eugenics, and Racism in Germany*. New York: Palgrave Macmillan.

Wilson, Edward O. (1998). *Consilience: The Unity of Knowledge*. New York: Knopf. A defense of scientific materialism.

Zimmer, Carl. (2004). *Soul Made Flesh: The Discovery of the Brain—and How It Changed the World*. New York: Free Press. A history of Thomas Willis's neurology.

HUMAN RIGHTS

At first glance human rights might seem to have little relevance for science, but this is not the case. Science is dependent on respect for human rights, particularly freedom of thought and freedom of speech. In many countries, however, the human rights and academic freedoms of scientists are violated by government or by groups that enjoy government support. Science can play an important role in helping to protect and promote human rights. In addition, international human rights law recognizes a substantive right to the freedom necessary for scientific research and a right to have access to the benefits of scientific progress. Yet in some circumstances scientists and health professionals have contributed to human rights violations.

Human Rights

What then are human rights? Rights in moral philosophy and political theory are understood as justified claims. A right is an entitlement of a person or group to some good, service, or liberty. As entitlements, rights differ from ideals, guidelines, or acts of charity. A right creates correlative obligations or duties to secure or not interfere with the enjoyment of that entitlement.

Human rights are a special class of rights, the rights one has by virtue of being a human being. Human rights are predicated on the recognition of the intrinsic value and worth of all human beings. As such, human rights are considered to be universal, vested equally in all persons regardless of their gender, race, nationality, economic status, or social position. Cumulatively human rights represent the minimum conditions for a decent society.

Contemporary twenty-first century conceptions of human rights were formulated at the end of World War II. The Universal Declaration of Human Rights (Universal Declaration), adopted without dissent by the U.N. General Assembly on December 10, 1948, represents an international consensus regarding the core rights and freedoms necessary to realize the inherent dignity and rights of all members of the human family. The Preamble to the Universal Declaration proclaimed "a common standard of achievement for all peoples and nations." As a declaration of the General Assembly, the Universal Declaration does not have direct legal force, but in the past fifty-six years it has become recognized as international common law. Moreover a series of international and regional human rights instruments based on the Universal Declaration are legally binding on countries that ratify them and thus become state parties bound by their provisions.

Many of the rights and standards set out in the Universal Declaration and other human rights instruments are essential to the conduct of science. Science is a worldwide enterprise requiring freedom of thought, communication, and travel, and the freedom to pursue professional activities without interference. The International Covenant on Civil and Political Rights, to which the United States is a state party, recognizes the following rights relevant for scientific inquiry:

- The right of everyone to freedom of thought (article 18);
- The right to hold opinions without interference and the right to freedom of expression, including the right to seek, receive, and impart information and ideas of all kinds, regardless of frontiers, through any media (article 19);
- The right to freedom of association with others (article 22);
- The right to liberty and security of person (article 9);
- The right to liberty of movement and freedom to choose one's residence and to be free to leave any country, including one's own (article 12);
- The right not to be subjected to medical or scientific experimentation without consent (article 6).

Provisions of other international human rights instruments also have important effects on the progress of science. The Universal Declaration includes the following additional rights that have counterpart provisions in the International Covenant on Economic, Social and Cultural Rights to which over 140 countries, but not the United States, are state parties:

- The right to education, including free and compulsory primary education, with technical and professional education generally available and higher education equally accessible to all on the basis of merit (article 26);
- The right to share in scientific advancement and its the benefits (article 27a);
- The right of everyone to the protection of the moral and material interests resulting from any scientific, literary, or artistic production of which he is the author (article 27b).

Protection of Scientists' Rights

Like other members of society, scientists are vested with basic human rights. Those rights are, however, violated in some countries. Scientists are persecuted for their work, for the expression of their opinions or beliefs, and for their peaceful efforts to oppose human rights violations or promote political change. The independent thinking and international connections of members of the scientific community can sometimes seem threatening to repressive or ideologically rigid governments. Scientific reverence for truth, reliance on empirically verifiable facts and measurable data, open dissemination and communication beyond national borders, and universality of discourse and goals by their very nature challenge some regimes.

This potential vulnerability has led scientists in some countries to form networks to protect the international human rights of members of the scientific community and scientific organizations. The Science and Human Rights Program of the American Association for the Advancement of Science (AAAS) is one such organization. Working with AAAS members and affiliated professional societies, the Program conducts casework on behalf of scientists, engineers, and health professionals whose human rights have been violated; prepares statements and reports; convenes meetings on human rights issues of special concern to scientists; organizes humanitarian and fact-finding missions; and assists other scientific organizations with cases and issues of special importance to the scientific community. The Program focuses its individual casework on three main areas: (a) violations of scientific freedom and the professional rights of scientists, engineers, health professionals, students in any of these fields, scientific organizations, and professional groups representing their interests; (b) violations of the human rights of scientists not directly related to the conduct of science, and (c) participation by scientists in practices that infringe on the human rights of others.

Initiated in 1993, the AAAS Human Rights Action Network uses electronic mail to inform AAAS members and other subscribers of cases and developments deserving special attention, and to coordinate the efforts of scientists to appeal to governments on behalf of their colleagues whose human rights are being violated. The network builds on the long-standing tradition of letter writing as an effective means of reminding governments that their transgressions have not gone unnoticed.

Science in the Service of Human Rights

Scientists have unique skills that can help promote and protect the human rights of all people. Scientific applications to human rights involve both utilizing scientific expertise and taking methodologies developed for other purposes and adapting them for human rights uses.

Human rights work requires accurate documentation of violations. Governmental authorities and the general public may be skeptical of reports of human rights violations. In some cases governments may deny that abuses have taken place in their country. Scientific methodologies can help establish the credibility of those who publicize violations and try to bring about change or institute legal action on behalf of victims. Scientifically based methods of data collection, storage, and analysis are particularly necessary when dealing with large volumes of data on human rights violations typical of truth commissions and tribunals. Adaptations of information management technologies for human rights have included specialized research and survey designs, interviewing techniques, database designs, controlled vocabulary structures for database processing, and analytic strategies for quantitative data analysis.

As human rights workers increase their use of electronic media for data storage and electronic communication, they become increasingly vulnerable to a variety of electronic attacks. Cryptographic applications enable human rights groups to secure their information against surveillance, ensure that their communications cannot be faked, and even hide their communications in digital images or sound files.

In the early-twenty-first century, extrajudicial executions and *disappearances* continue to occur in perhaps fifty countries. Independent forensic investigations can be crucial in determining the cause and manner of suspicious death and in proving whether a victim was tortured. Often the judiciary in these countries is reluctant to investigate killings perpetrated by the army or police or other regular security forces, special units outside of the normal chain of military command, paramilitary units, *death squads* sanctioned by the government, or armed groups opposed to the government. To respond to these blatant violations of human rights, forensic pathologists have investigated individual incidents of suspicious deaths by conducting initial and second autopsies, observing official inquests into deaths in detention, and assisting court-ordered investigations of suspicious deaths. In addition, teams of forensic anthropologists exhume mass graves to document murders of groups and communities.

Rights to Scientific Freedom and Access to the Benefits of Science

International human rights law recognizes a substantive right to the freedom necessary for scientific research and a right to have access to the benefits of scientific progress. Building on a parallel provision of the Universal

Declaration, Article 15 of the International Covenant on Economic, Social and Cultural Rights (ICESCR) specifies that state parties "undertake to respect the freedom indispensable for scientific research and creative activity" (Article 15[3]). This article also instructs states parties to "recognize the right of everyone" both "to enjoy the benefits of scientific progress and its applications" (Article 15[1][b]) and "to benefit from the protection of the moral and material interests resulting from any scientific, literary or artistic production of which he is the author" (Article 15[1][c]). To achieve these goals, the text mandates that states parties undertake a series of steps, including "those necessary for the conservation, the development and the diffusion of science and culture" (Article 15[1][c]). More specifically, states parties make the commitment to "recognize the benefits to be derived from the encouragement and development of international contacts and cooperation in the scientific and cultural fields" Article 15[4].

A government can best show respect for the freedom indispensable for scientific research and creative activity by adhering to basic human rights norms recognized in the Universal Declaration and the International Covenant on Civil and Political Rights. In addition, the pursuit of science requires an environment that supports the freedom to pursue scientific research in accordance with ethical and professional standards without undue interference. Conversely the freedom to undertake scientific research and creative activity implies a need for scientific responsibility and self-regulation. Scientific societies in many developed countries have adopted codes of professional ethics in pursuit of these goals. Many of these codes, however, are primarily concerned with the ethics of individual conduct and do not place the scientific enterprise in a broad social context.

Protection against Human Rights Abuses

Much has been written about the challenges posed by science and technology to human rights and human dignity. In the years since the publication of Jacques Ellul's pioneering work *The Technological Society* (1964), for instance, an increasing number of thinkers have called attention to the potential of technology to diminish human dignity and to erode moral values. While the vast majority of health professionals and scientists have sought to be faithful to ethical values, some have been tempted or forced to facilitate harmful practices. Health professionals have been implicated in torture and other cruel and degrading treatment (Amnesty International French Medical Commission and Marange 1989). Psychiatric institutions have been misused to incarcerate political dissidents. Scientists have developed chemical and biological weapons for regimes that intended to use them on their own populations.

The Universal Declaration on the Human Genome and Human Rights, prepared by UNESCO and then adopted by the U.N. General Assembly in 1999 is an example of an initiative that addresses the potential impact of a new technology on human rights and dignity. It emphasizes that genetic research and applications should fully respect human dignity, freedom, and rights and prohibits all forms of discrimination based on genetic characteristics. The declaration affirms the principle of freedom or research related to the genome (Article 12b), but with the caveat that researchers respect principles of caution, intellectual honesty, and integrity (Article 13). The document assigns responsibility to states to take appropriate measures to foster the intellectual and material conditions that promote freedom in the conduct of research on the human genome and safeguard respect for human rights in the process (Articles 14–16). The declaration further recommends that benefits from advances in biology, genetics and medicine, concerning the genome, should be made available to all (Article 12a).

Human cloning constitutes another issue. In October 2003, the U.N. General Assembly considered a treaty to ban human cloning. Delegates agreed that the treaty should prohibit reproductive cloning, the creation of cloned embryos to produce babies, but they deadlocked on the issue of whether the prohibition should extend to "therapeutic" or "research" cloning. Nor could they agree on going forward with a treaty that only addressed reproductive cloning. Confronted with this disagreement, the General Assembly voted to delay discussion of the treaty until its 2005 session (Aschwanden 2003).

AUDREY R. CHAPMAN

SEE ALSO *American Association for the Advancement of Science; Dignity; Globalism and Globalization; Holocaust; Human Nature; Humanization and Dehumanization; Libertarianism; Natural Law; Rawls, John; Rights Theory; Science, Technology, and Law.*

BIBLIOGRAPHY

Amnesty International French Medical Commission, and Valerie Marange. (1989). *Doctors and Torture: Resistance or Collaboration?* London: Bellew Publishing.

Claude, Richard Pierre. (2002). *Science in the Service of Human Rights*. Philadelphia: University of Pennsylvania Press.

Ellul, Jacques. (1964). *The Technological Society*, trans. Johns Wikinson. New York: Vintage Books.

Lauren, Paul Gordon. (1998). *The Evolution of International Human Rights*. Philadelphia: University of Pennsylvania Press.

Morsink, Hohannes. (2000). *The Universal Declaration of Human Rights: Origins, Drafting, and Intent*. Philadelphia: University of Pennsylvania Press.

United Nations General Assembly. "International Covenant on Civil and Political Rights." G.A. Res. 2200 (XXI), 21 U.N. GAOR, Supp. No. 16, at 52, U.N. Doc. A/6316 (1966). Adopted December 16, 1966, entered into force March 23, 1976.

United Nations General Assembly. "International Covenant on Economic, Social and Cultural Rights." G.A. Res. 2200 (XXI), 21 U.N. GAOR Supp. No. 16, at 49, U.N. Doc. A/6316 (1966). Adopted December 16, 1966, entered into force January 3, 1976.

United Nations General Assembly. "Universal Declaration of Human Rights." G.A. Res. 217A (III), U.N. GAOR, 3rd Sess., U.N. Doc. A/810 (1948).

INTERNET RESOURCES

AAAS Science and Human Rights Program. Human Rights Action Network. Available from http://shr.aaas.org/aaashran. Membership in the network is free; subscriptions are available through the website. Approximately one individual case or issue is circulated each week, with all the information necessary to take action, in a succinct bulletin.

Aschwanden, Christie. (2003). "Nations Fail to Agree on Extent of Human Cloning Ban." *Bulletin Of The World Health Organization*, Vol. 81. no. 11. Available at http://www.who.int/bulletin/volumes/81/11/en/news1103.pdf

UNESCO. "Universal Declaration on the Human Genome and Human Rights." Available from http://portal.unesco.org/en/ev.php@URL_ID=13177&URL_DO=DO_TOPIC&URL_SECTION=201.html.

HUMAN SUBJECTS RESEARCH

In the field of ethical issues in scientific research, the two most controversial topics concern involve the use of humans as research subjects and the use of nonhuman animals as research subjects. Each of those debates goes back over a hundred years, to the final decades of the nineteenth century, and thus has a substantial literature that has developed a sophisticated level of discussion. This article will briefly summarize the history of the field first, and then explain some of the regulations that have resulted, and close with identifying some of the most important future issues.

Historical Developments

By 1900 there was ample evidence of an appreciation in the medical and scientific communities of the ethical issues that would have to be resolved before a person was used as a subject in experiments. In Prussia a ministerial directive issued in 1900 restricted research to the use of persons who could benefit from the research, who were told in advance of the risks of participation, and who gave their consent. This was in response to well-known experiments with the leprosy bacillus on unwitting subjects in Prussia around that time.

At around the same time in Cuba, United States General Walter Reed (1851–1902) conducted yellow fever studies but required that both soldiers and civilians volunteer first, be informed of the risks (including the risk of death), and sign a consent form. The form was written in both English and Spanish. This is said to have been the first use of a signed consent form and also could be considered the first example of ethical international research informed by cultural competence. Reed's caution was a response to an experiment in Italy in which five persons were infected with yellow fever without being told and an initial experiment in Cuba by two colleagues of Reed who intentionally infected themselves that led to the death of one of them.

In light of the degree of awareness shown at the beginning of the century, it is surprising that by mid-century some of the most barbaric things ever done in the name of science would come to pass. A combination of factors contributed to that decline in standards, including racism and anti-Semitism, exacerbated by nationalism and xenophobia; those problematic social elements were long established but were pushed to extremes by World War II.

Three examples of well-known and frequently cited unethical research involving human subjects occurred in the middle third of the twentieth century. The Tuskegee experiments, observing the consequences of untreated syphilis in American blacks, began in 1932, when there was no effective treatment, but continued until 1972, long after the discovery of penicillin. The research done by Nazi doctors was by far the most brutal and murderous. Those experiments included testing the limits of human endurance up to and including death from causes such as bullet and knife wounds; decompression at high altitudes, which was tested by putting people in decompression chambers and measuring when their lungs burst; and hypothermia, which was tested by keeping subjects immersed in ice water. Japanese experiments in the notorious unit 731 were just as grievous as the Nazi experiments, though less well known. The thalidomide tragedy revealed the importance of the oversight of drug trials and the recognition of the problems of self-policing by pharmaceutical companies that have a financial investment at stake. That experience propelled the U.S. congressional hearings known as the Kefauver hearings.

Ethically disturbing human experiments were done well after that period. Two examples in the United States were performed on institutionalized populations: testing gamma globulin treatment of hepatitis after infecting children at the Willowbrook State School in Willowbrook, New York, and tracing differences of rejection of live cancer cells in subjects after injecting those cells into people at the Jewish Chronic Disease Hospital in Brooklyn, New York without explaining what was in the injections. These were among twenty-two experiments described by Henry K. Beecher in an influential paper published in the *New England Journal of Medicine* in 1966, "Ethics and Clinical Research."

There are many ironies in this history. For example, the most brutal and murderous research was done in Germany, the country that had promulgated the first modern code for ethical research. Then the country that provided all the judges and all the lawyers at the Nuremberg Trial of Physicians (1946) that led to the Nuremberg Code (1947) acted as if the code did not apply to its citizens in the years after World War II. This history of the field seems to show that some of the lessons need to be learned and relearned periodically and that only revelations of scandals and abuses have the power to restrain research.

Regulations

The last third of the twentieth century saw the codification of many of the lessons that had been learned and left a number of areas of great import that are still very much disputed. Several of those lessons have been accepted widely and codified into U.S. and international law.

In 1964 the original Declaration of Helsinki was passed by the World Medical Association. It reiterated the famous first line of the Nuremberg Code, stating that the voluntary consent of the human subject is absolutely essential, though it still left it up to the researcher to decide what to say, how much to disclose, and how to document the informed consent process. It has been revised and strengthened a number of times, most recently in 2000. The most important difference from U.S. regulations involves placebo controls, which generally are encouraged in the United States (especially by the Food and Drug Administration) and discouraged (though not forbidden) in the Declaration of Helsinki.

As a result of the public reaction to the Tuskegee experiments in 1974, the U.S. Congress authorized the National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research. The National Commission resulted in the publication of the Belmont Report (1979) and the issuance of federal regulations in 1981 known as 45 CFR 46. Those regulations led to the requirement of prior review of research protocols by independent committees known as Institutional Review Boards (IRBs). This was modeled on prior peer review, which had been required at the National Institutes of Health (NIH) since 1965 and for all NIH-sponsored research since 1966. The basic protections of the regulations (outlined in subpart A) were consolidated into "the Common Rule" in 1991 and adopted by sixteen federal agencies.

IRB oversight, in contrast to peer review, required that there be at least one nonscientist, one community member, and should not be either all men or all women. Although many people still have concerns about the real independence one can expect in light of the fact that most of the members of the committees are usually employees at the same institution where the research is being done, it was an important innovation.

Before approving a proposed research protocol, the IRB must ascertain that the research is scientifically valid (the goals are worthwhile and achievable by the methods proposed) and that the risks to the subjects are kept to a minimum and are justified by the potential benefits to be gained. It also must determine that the selection of subjects has been equitable (no groups are excluded without good reason) and that the subjects have been recruited without any deception or coercion, that the confidentiality of the subjects has been adequately protected, that the subjects have been fully informed about the risks and have given voluntary consent that has been documented, that proper steps have been taken to ensure that the subjects understand all the information they have been given, and that they understand that they can withdraw from the research at any time. The IRB is also responsible for monitoring the research and has the power to stop any study that is dangerous to the participants, a task often assigned to a separate Data and Safety Monitoring Board (DSMB).

An IRB has the responsibility to ensure the voluntary participation of the research subjects as well as their safety. Thus, IRBs often focus on the informed consent form that will be given to potential subjects to ensure that the risks are portrayed realistically and not underplayed and that there is no misleading of the subjects about the likelihood of benefit. Terms such as *the doctor*, *medicine*, and *therapy* can be used by researchers without any intent to deceive yet can be read by subjects as meaning that they are enrolled in an experiment whose purpose is to help them rather than to improve the understanding of a drug or disease process. This is referred to as the therapeutic misconception. The same concern for language has made some IRBs to suggest using the term "participants" instead of "subjects" as a reminder to the researcher that she is seeking the cooperation of well informed volunteers, not passive recruits who don't ask questions. The regulations also require that extra attention be paid before any members of certain groups of persons known as vulnerable populations are used. These groups include children, the mentally handicapped or mentally ill, prisoners, pregnant women, and fetuses.

Ironically, since the 1990s there has been recognition in the United States by the Food and Drug Administration that drugs have been tested disproportionately on white men too frequently and that it would be scientifically helpful to have more studies with women, minorities, and children to test for variations in effectiveness and safety. However, the history of abuse probably has made researchers hesitant to enroll persons in these categories, not to mention the distrust that members of these groups might feel after the historical record at Tuskegee, Willowbrook, and the Jewish Chronic Disease Hospital.

All government funded research with human subjects is required to be reviewed by an IRB. This includes the behavioral and social sciences as well as biomedical sciences. Many of the same ethical issues arise, though the potential harms may be of a psychological nature, such as risk to privacy or to self-image, rather than a physical one. A concern that may occur with greater frequency in psychology is that fully informing a subject of the nature of the research could bias the answers the subject gives. Thus researchers will seek to reveal less of the purpose of the study than would be the case in medical research. This type of purposeful deception will have to be justified to the IRB, and assurances that any risks to the subjects are minimal. Assessing this kind of risk is difficult, as seen in the fact that the highly innovative and influential milgram experiments conducted in the 1960s are deemed controversial by some commentators to this day. The primary harm to the subjects was a loss of self-esteem as they reflected on their own willingness to submit to the orders of an authority figure and inflict pain on strangers. But it would not have been possible to do the experiment had the consent process told them in advance that the strangers in apparent pain were only actors. An honest debriefing, with counseling if necessary, may help to alleviate possible harms in cases where some initial deception cannot be avoided.

This also brings up the question of non-government funded research. Much pharmaceutical research and research on medical devices is funded by the FDA, and so falls under the common rule. But beyond government funding sources, there is currently no review needed in the U.S. for privately funded research. Should private enterprise, from marketing research to genetics and biotechnology, be unencumbered by regulations whose intent is to ensure the safety of citizens? Should civil rights and human rights be allowed to set restrictions on private companies in cases where there is, as yet, little risk identified? When one pictures marketing questionnaires, it is easy to be swayed towards a libertarian distrust of unnecessary and intrusive government regulations. But when one considers the potential profits from genetics and biotechnology research, there may be more reason to consider preemptive regulation, such as already exists with state commissions in many European Union countries concerning IVF.

Future Issues

Soon after the Belmont Report the Council for the International Organization of Medical Sciences (CIOMS) produced a report on the special issues that occur in international research. The beginning years of the twenty-first century have seen growth in funding for international research. Although some of this increase in funding could be due to economic globalization and the lessening of national identity for multinational corporations, there may be more ominous motivations. For example, funding sources for pharmaceutical research are often in first world countries such as the United States, the United Kingdom, France, Germany, Belgium, and Switzerland. However, when an even larger proportion of research in is done developing nations, it could be because of lax regulations (including ethical regulations) in the developing world.

A second topic that inevitably will grow in importance is the range of new research resulting from the Human Genome Project. That project was completed in less time than originally planned and has provided an enormous amount of raw data with which biologists hope to map a deeper understanding of normal development and pathogenesis. However, all genetic information has ethically complex properties, such as providing information about the relatives of research subjects as well as about the persons who volunteered to be involved in the research.

Another challenging ethical issue unique to genetics is the possibility of curing a disease by means of germline gene therapy, removing the disease from human history but at the risk of altering the human genome. Similarly, genetic interventions have the potential to blur the intuitive distinction between medical treatment for an illness or dysfunction and enhancement of traits which a person may find unsatisfactory yet fall within the normal range of human beings. Either way we are on the cusp of gaining the knowledge of the human genome that would allow genetic engineering with the purpose of improving the race (using Nazi terminology, creating a new master race). Might we soon enter a phase of deliberate evolution, or worse, develop into two sub-species, the feral and the enhanced?

The third topic of concern is stem cell research and the related issue of human cloning. Advances in invitro fertilization (IVF) and other assisted reproduction technologies (ARTs) have made the possibility of human cloning real. Many species of mammals already have been cloned, and it may be only a matter of time before a human is cloned. Although some people have argued that this should be considered an alternative technique for infertile couples to have a child, it has been outlawed in many countries as threatening the dignity inherent in the uniqueness of each life.

Stem cell research, which would find its best source of human embryonic stem cells in the excess embryos created by IVF programs, also has been opposed by critics who believe it violates the respect owed to human embryos or treats them as means rather than ends. However, attempts at broad bans have been less successful than with cloning for a number of reasons: The therapeutic potential could benefit many more people, and the majority of scholars and researchers in both ethics and developmental biology believe that there is a fundamental moral difference between a preimplantation embryo and an embryo or fetus that has been implanted successfully in a human womb.

Beyond issues related to transnational experimentation, genetics, and stem cells research, one might suggest that as the scientific and technological enterprise advances, all people become the subjects of scientific research. Mike Martin and Roland Schinzinger (1996) have argued for understanding engineering as a form of social experimentation. But even more broadly, the increasing use of medicines that often create therapeutic dependencies, unregulated uses of IVF and frozen embryos, and the popularization of plastic surgeries and advanced prosthetics all point toward people treating themselves (not just scientists treating people) as human subjects in scientifically based actions the full outcomes of which remain uncertain.

JEFFREY P. SPIKE

SEE ALSO *Fetal Research; Nazi Medicine; Responsible Conduct of Research; Scientific Integrity; Tuskegee Experiment.*

BIBLIOGRAPHY

Altmann, Lawrence K. (1998). *Who Goes First?* Berkeley: University of California Press. A book that's fun to read, on an approach to choosing research subjects that was once quite honorable but is now strongly discouraged: try it on yourself first.

Dunn, Cynthia McGuire, and Gary L. Chadwick. (2004). *Protecting Study Volunteers in Research: A Manual for Investigative Sites*, 3rd edition. Boston: Thompson-Centerwatch. A very complete users manual for IRB coordinators and members.

Emanuel, Ezekiel E.; Robert A. Crouch; John D. Arras; Jonathan D. Moreno, and Christine Grady. (2003). *Ethical and Regulatory Aspects of Clinical Research: Readings and Commentary*. Baltimore: Johns Hopkins University Press. An excellent collection of primary sources; includes the Belmont report, Helsinki, CIOMS, and the Henry K. Beecher article mentioned in the text.

Martin, Mike W., and Roland Schinzinger. (1996). *Ethics in Engineering*, 3rd edition. New York: McGraw-Hill.

Milgram, Stanley. (1974). *Obediance to Authority: An Experimental View*. New York: Harper and Row.

Shamoo, Adil E., and David B. Resnick. (2003). *Responsible Conduct of Research*. New York: Oxford University Press. A useful textbook for a graduate level course in research ethics; includes many topics besides human subjects.

Zoloth, Laurie, Jane Maienschein, and Ronald M. Green, "Ethics of Stem Cell Research: A Target Article and Open Peer Commentaries." *American Journal of Bioethics* 2(1): 1–59. Three introductory target articles are followed by 19 diverse short commentaries.

HUME, DAVID

David Hume (1711–1776) is one of the most influential philosophers of the modern period. He was born in Edinburgh, Scotland, on April 26. His first and most

David Hume, 1711–1776. The Scottish philosopher developed a philosophy of "mitigated skepticism," which remains a viable alternative to the systems of rationalism, empiricism, and idealism. (*© Corbis.*)

important work, *A Treatise of Human Nature* (published in two installments in 1739 and 1740, before Hume turned thirty years old), was supplemented in later life by *Essays, Moral and Political* (two volumes, 1741–1742), *An Enquiry Concerning Human Understanding* (1748), and *An Enquiry Concerning the Principles of Morals* (1751). The latter two books restate in more accessible form the arguments of the *Treatise*. He also wrote a six-volume history of England (1754–1762) and *Dialogues Concerning Natural Religion*, published posthumously in 1779. Hume, who died in Edinburgh on August 26, applied what he considered the experimental method of science to an examination of ideas and morals, thereby developing an ethics that bases moral judgments on feelings. Because emotivism is so frequently assumed in the contemporary West, to read Hume can be an exercise in cultural self-understanding.

Empiricism

Hume begin his *Treatise* arguing that human knowledge is limited to sense-experience. The contents of sense-experience can be distinguished into impressions and ideas. Impressions, which include all sensations and passions, are more forceful and lively than ideas, which are "the faint images of these in thinking and reasoning" (Hume 1888 [1739–1740], p. 1). Ideas are thus epistemologically inferior to impressions, and the secondary status that Hume gives them remains characteristic of popular denigrations of their relative impotence. This distinction also suggests that the logical analysis of conceptual relations is less important than the knowledge of matters of fact.

Hume further distinguishes between the simple and complex. Simple impressions and ideas, such as the seeing or imagining of a particular shade of red, admit of neither distinction nor separation. Complex impressions and ideas, such as the seeing or imagining of an apple, can be analyzed into their component parts. Whereas all simple ideas are derived from and exactly represent simple impressions, many complex ideas are not, and so their veracity must be called into question. In *Enquiry Concerning Human Understanding*, Hume remarks, "When we entertain, therefore, any suspicion that a philosophical term is employed without any meaning or idea (as is but too frequent) we need but enquire, from what impression is that supposed idea derived? And if it be impossible to assign any, this will serve to confirm our suspicion" (Hume 1894 [1748], p. 22). Something like this view is often employed when people appeal to science in rejecting ideas of God or the soul.

But the most famous subject of Hume's criticism is the relation of cause and effect. Philosophers and scientists traditionally believed that to know something fully requires knowledge of the cause on which it depends. For Hume, such knowledge is impossible. Although the causal relationship provides the basis for all reasonings concerning matters of fact, all such reasoning is quite contingent. This is because one can always imagine, without contradiction, the contrary of every matter of fact (e.g., "the sun will not rise tomorrow" neither is nor implies a contradiction). For Hume, the causal relationship between any two objects is based strictly on experience, and all that experience establishes concerning causal relationships is that the cause is prior in time and contiguous to its effect. Experience cannot establish a necessary connection between cause and effect, because one can imagine without contradiction a case in which the cause does not produce its usual effect (e.g., one can imagine that a cue ball violently strikes another billiard ball and then, instead of causing the billiard ball to move, the cue ball bounces off it in some random direction). The reason why a person might mistakenly infer that there is something in the cause that necessarily produces its effect is because past experiences have habituated the person to think in this way (see *Treatise*, Book

I, Part III; first *Enquiry*, secs. IV–V). In thus arguing that humans have no direct impression of anything more than spatial and temporal contiguity, Hume sees himself extending empirical science. At the same time, he reduces science's epistemic power by depriving it of any deep knowledge about what lies beyond experience.

Theory of Morals

Hume's argument with regard to morals is similar. For Hume, moral distinctions are derived from feelings of pleasure and pain of a special sort, and not—as held by many Western philosophers since Socrates—from reason. Working from the empiricist principle that the mind is essentially passive, Hume argues that reason by itself can never prevent or produce any action or affection. Because morals concerns actions and affections, it cannot be based on reason.

Reason can influence human conduct in only two ways. First, reason can inform a person of the existence of something that is the proper object of a passion, and thereby excite it. Second, reason can deliberate about means to an end that a person already desires. But should reason be in error in either of these areas (for instance., by mistaking an unpleasant object for one that is pleasant, or by mistakenly selecting the wrong means to a desired end), it is not a moral but an intellectual failing. As a final point, Hume argues for a distinction between facts and values. According to Hume, one cannot infer conclusions about what *ought to* or *ought not* be the case based on premises of what *is* or *is not* (see *Treatise*, Book III, Part I, sec. 1).

Because moral distinctions are not based on reason, Hume infers that they are based on sentiments that are felt by what he calls a "moral sense." When a person describes an action, sentiment, or character as virtuous or vicious, it is because its view causes a pleasure or pain of a particular kind. Hume is well aware that not all pleasures and pains lead to moral judgments (for example, the pleasure of drinking good wine). Rather, it is "only when a character is considered in general, without reference to our particular interest, that it causes such a feeling or sentiment, as denominates it morally good or evil" (Hume 1888 [1739–1740], p. 472). Finally, Hume argues that even though moral distinctions are based on feelings, this does not lead to moral relativism. This is because the general moral principles and the moral sense faculty that recognizes them are common to all human beings.

Influence

As indicated, Hume's view that the source of moral approval and disapproval is not reason but the sentiments that are felt has been widely influential. In the twentieth century this view was restated as the emotive theory of ethics. According to A. J. Ayer's *Language, Truth, and Logic* (1936), once statements of the form "*X* is wrong" are distilled of their factual components, they merely evince the speaker's moral disapproval, for example, "Boo *X!*"

In contemporary times, such a view is often deployed against anyone who attempts to make ethical criticisms of science or technology, with the claim that critics are simply stating their own personal preferences. Abandoning Hume's belief in a moral sense faculty common to all humans as itself unjustified by empirical science, it is argued that in a pluralistic society, with many different sentiments and preferences, scientists and engineers should be at liberty to research or invent as they see fit—with perhaps the sole proviso that they do not materially harm other persons. Whether or to what extent this is an adequate ethics for science and technology is a question that Hume's philosophy obliges us to ponder.

SHANE DREFCINSKI

SEE ALSO *Enlightentment Social Theory; Human Nature; Locke, John; Risk and Emotion; Scientific Ethics.*

BIBLIOGRAPHY

Ayer, A. J. (1936). *Language, Truth, and Logic*. London: Gollancz.

Ayer, A. J. (1980). *Hume*. Oxford: Oxford University Press.

Hendel, Charles William. (1925). *Studies in the Philosophy of David Hume*. Princeton, NJ: Princeton University Press.

Hume, David. (1741–1742). *Essays, Moral and Political*, 2 vols. Edinburgh.

Hume, David. (1754–1762). *History of England*, 6 vols. London.

Hume, David. (1777). *The Life of David Hume, Esq., Written by Himself*, ed. Adam Smith. London. Included in the 1955 Macmillan edition of the *Enquiry Concerning Human Understanding*.

Hume, David. (1888 [1739–1740]). *A Treatise of Human Nature*, 3 vols., ed. L. A. Selby-Bigge. Oxford: Oxford University Press.

Hume, David. (1894 [1748 and 1751]). *Enquiries Concerning Human Understanding and the Principles of Morals*, ed. L. A. Selby-Bigge. Oxford: Oxford University Press.

Hume, David. (1935 [1779]). *Dialogues Concerning Natural Religion*, ed. Norman Kemp Smith. Oxford: Clarendon Press.

Smith, Norman Kemp. (1941). *The Philosophy of David Hume*. London: Macmillan.

HUSSERL, EDMUND

Born in Prossnitz, Moravia (now Prostêjov, Czech Republic) on April 8, Edmund Husserl (1859–1938) inaugurated the phenomenological movement in philosophy. Trained as a mathematician at Vienna, where he received his Ph.D. in 1883, Husserl began studying philosophy in 1884 under Franz Brentano (1838–1917) and went on to teach in the philosophy faculties at Halle an der Saale, Göttingen, and Freiburg. His most notable works—*Logical Investigations*, *Ideas* (Volumes I, II, and III), *Cartesian Meditations*, and *The Crisis of European Sciences and Transcendental Phenomenology*—seek a philosophical grounding for mathematics, logic, and science by analyzing the intentional or essential structures of consciousness in its relation to objects in the world relations between subjectivity and objectivity. After his death on April 26 in Freiburg, a substantial body of posthumously published work extended his account of subjectivity and its correlative world into the domain of intersubjective experience, and the development of an ethical system that exhorts a fully rational human existence in which all persons repeatedly justify their beliefs and actions.

The fundamental method of phenomenology is the "reduction," which entails suspending the philosopher's own participation in our natural beliefs about the world. Not a denial of the external world, the reduction simply neutralizes dogmatic assumptions about experience in order to examine more closely experience and its objects just as they are given; hence, phenomenology calls itself a "presuppositionless" enterprise.

Husserl's most overtly relevant work for science, technology, and ethics, *The Crisis* (1936), argues that science and technology constitute a nonneutral transformation of life rather than a simple neutral extension of ahistorical human concerns. Neither pro– nor anti–science and technology, Husserl's *Crisis* suspends the typically modern commitment to science in order to disclose and examine the repercussions of those unreflectively accepted scientific presuppositions and practices that transform the prescientific life-world of human experience. Husserl values the way science tests and retests experience, thereby contributing to a fuller sense of objectivity than everyday judging. In their great success, however, science and technology create "fact-minded" citizens blinded by promises of objectivity and control. In their narrow view of reason as mere calculation, science and technology consider themselves value neutral and thus exempt from responsibly advising about how to make difficult decisions arising from the means

Edmund Husserl, 1859–1938. The German philosopher is considered the father of phenomenology, one of the most important trends in 20th-century philosophy. *(The Granger Collection, New York.)*

they produce. Moreover, one could argue, science and technology evolve in rarefied discourses unavailable to most citizens and beyond democratic control. Followers of Husserl thus are able to argue that humankind's historical circumstance marks a crisis in which science and technology develop independently of value questions and democratic voice, yet are unreflectively and passively received and deployed.

To philosophers of technology, however, Husserl's corrective measure in the form of a relentless search by the subject for a fuller sense of evidence to justify beliefs and actions often appears to be a formal, abstract quest for ideal essences. Ethical discussions of science and technology thus often disregard Husserl's phenomenology. Husserl's protégé, Martin Heidegger (1889–1976), for example, believes Husserl's emphasis on cognition lands him squarely in the path of human technological domination of the world. The phenomenological reduction, Heidegger argues, "reduces" the world to human "intentional" activities and sacrifices world independence to consciousness's drive to explain and predict experience with absolute certainty. American pragmatist philosopher Larry A. Hickman (2001) argues that privileging conscious reflection and increased objectivity over lived experience renders phenomenological inquiry a private enterprise tied to "ideal essences." Unable to reconfigure its ideals, Hickman finds phenomenology incapable of a providing a viable program for the reform of technology. And the American post-phenomenologist Don Ihde (1990) reiterates Heideggerian and pragmatist criticisms. Because Husserl neglected the inseparability of sense-extending technologies from scientific discovery, Ihde argues he never reached beyond an intimation of a philosophy of technology.

Yet Husserl's contribution to the philosophy of technology can be found in these criticized notions intentionality and objectivity, which form the basis of his ethics of a self-conscious community founded on intuitionally fulfilled beliefs and actions, and provide the basis for a critical assessment of technology. For Husserl, consciousness, in its very nature as activity, is intentional. In its care for and interest in the world, consciousness transcends itself. Always outside of itself, a subject experiences the world in a public and intersubjective rather than private and solipsistic way. Intuitional fulfillment denotes the correlation of a subject's intentional anticipations with the evidence found in experience. When experience does not confirm a subject's anticipation, the intention goes "unfulfilled" and demands that the subject revise prior beliefs, thus achieving a degree of objectivity. When experience confirms a subject's anticipation, the intention gets "fulfilled," again achieving a degree of objectivity. Because Husserl advocates self-critique and reflection as a lifelong task, even fulfilled intentions require further experiential confirmation over time and across subjects. Rather than a fixed ideal, objectivity remains open to reconfiguration according to experiential evidence given in the fluxing relation between subject and world.

An interesting instance of the kind of self-critical agency that Husserl advocates can be found in the life of the Polish scientist Joseph Rotblat (b. 1908), who worked on the atomic bomb. Rotblat initially justified his participation by reasoning that only Allied bomb development would counter potential German development. After the German defeat, Rotblat reflected on the standard attitude of the scientists working on the project—many of whom believed it was not their job to advise about how the atomic bomb should be used—leading him to leave the project before the first testing and use of the bomb. Rotblat resolved to henceforth carefully choose each of his future projects, accepting only assignments he judged of definite benefit for humanity. Rotblat's revised outlook on his career as a scientist follows in the spirit of Husserl's ethics based on a subject's vow to live a life guided by a repeated and critical evaluation of beliefs. Rotblat's decision to withstand the heedless activity that Husserl believes characterizes the contemporary relation to science and technology exemplifies the self-reflection and self-responsibility for which Husserl argues when he exhorts subjects to continuously assess their experiences.

MICHAEL R. KELLY

SEE ALSO *Axiology; Existentialism; German Perspectives; Heidegger, Martin; Leibniz, G. W.; Phenomenology.*

BIBLIOGRAPHY

Hickman, Larry A. (2001). *Philosophical Tools for Technological Culture*. Bloomington: Indiana University Press. Develops John Dewey's pragmatist philosophy of technology, and criticizes phenomenology along the way.

Husserl, Edmund. (1973). *The Crisis of European Sciences and Transcendental Phenomenology: An Introduction to Phenomenological Philosophy*, trans. David Carr. Evanston, IL: Northwestern University Press. Discusses the value of reason and the life-task of seeking intuitional fulfillment and increased objectivity beyond its mere facts and calculation.

Husserl, Edmund. (1982). *Ideas Pertaining to a Pure Phenomenology and to a Phenomenological Philosophy*, Book 1: *General Introduction to a Pure Phenomenology*, trans. Fred Kersten. The Hague, Netherlands: Martinus Nijhoff. Extended, detailed discussion of the phenomenological "reduction."

Ihde, Don. (1990). *Technology and the Lifeworld: From Garden to Earth*. Bloomington: Indiana University Press. A clearly written overview and analysis of relevant phenomenological literature.

Melle, Ullrich. (1991). "The Development of Husserl's Ethics." *Études Phénoménologiques* 13–14: 115–135. Overview of the chronological development of Husserl's ethical thought.

Melle, Ullrich. (1998). "Responsibility and the Crisis of Technological Civilization: A Husserlian Meditation on Hans Jonas." *Human Studies* 21(4): 329–345. In place of Jonas's heuristic of fear, Melle discusses Husserl's notions of self-critique, objectivity, evidence, and intuitional fulfillment as methods for ensuring responsible engagement with technology.

Rotblat, Joseph. (1986). "Leaving the Bomb Project." In *Assessing the Nuclear Age: Selections from the Bulletin of Atomic Scientists*, ed. Len Ackland and Steven McGuire. Chicago: University of Chicago Press.

Aldous Huxley, 1894–1963. The novels, short stories, and essays of the English author Huxley explore crucial questions of science, religion, and philosophy.

HUXLEY, ALDOUS

Aldous Leonard Huxley (1894–1963) was a British writer best known for his 1932 novel *Brave New World,* which portrays the dehumanizing aspects of scientific and technological progress. Born in Godalming, Surrey, England on July 26, Huxley's poor eyesight kept him from an early goal of becoming a scientist. After attending Oxford University and achieving fame as the author of several novels, in 1937 Huxley moved to California, where he became a screenwriter. Later he experimented with psychedelic drugs and incorporated mysticism into his work. Huxley died from throat cancer in Hollywood on November 22.

A moralist, social satirist, and interdisciplinary intellectual, in *The Perennial Philosophy* (1942) Huxley sought to identify the origin of being, prior to the fragmentation of experience into diverse languages, religions, and systems of knowledge. In the present age, however, he realized that reconnecting with such a foundation would involve reconciling humanity to the social and spiritual consequences brought about by science and technology (Murray 2002). To this end, Huxley often used literature to advance the causes of social sanity and personal enlightenment. Three themes are central to this life-long project: relations between literature and science; science, technology, and the abuse of power in emerging mass societies; and the potential for science and technology to enrich or corrode human nature.

Science and Literature

Huxley believed it was crucial to connect science and literature. Indeed, his novel *Point Counter Point* (1928) has been described as an "application of the theory of relativity to the art of fiction" (Deery 1996, p. 31). But he also felt it mistaken to define literary theory as a progressive, systematic, and verifiable body of knowledge employing the scientific method.

Huxley sought to reclaim a unified human experience by achieving the proper balance between different forms of knowledge. In this respect, he was the intellectual descendant of the debates about science and humanism held between his grandfather, Thomas Henry Huxley (1825–1895), and his great uncle, Matthew Arnold (1822–1888). The issue was particularly impelling because the secularization of society placed a great burden on literature to uphold the humanist tradition just when scientific discoveries were undermining traditional understandings of the world and the human place within it.

Huxley also saw literature as a vehicle for critiquing the social and moral consequences of scientific progress. The seriousness with which Huxley took up this task distinguished him from contemporaries, most of whom distanced themselves from social criticism. He held that "one of the prime duties of the twentieth-century artist is to draw attention to the evil ends for which a morally neutral science is being used" (Deery 1996, p. 25).

Science, Technology, and Power

Huxley believed that the "most profoundly important sociological factor of modern times [is] the growth of technology and what may be called the technicization of every aspect of human life" (1978, p. 18). Indeed, it was Huxley who caused Jacques Ellul's *The Technological Society* to be translated into English in 1964. Although he portrayed the relationship between science, technology, and social control in *Brave New World,* Huxley also examined the issue in essays such as "Science, Liberty and Peace" (1946), where he argued that science and technology tend to perpetuate and intensify inequalities and threaten peace and freedom. Mass production and mass media are used by the few to manipulate and control the many, as the rationalization of society reduces citizens to mere cogs in the machine. Huxley also recommended that scientists boycott harmful work and take action to foster positive scientific research. In *Brave New World Revisited* (1958), he argued that individual liberties must be protected from abuses of power.

This issue also dominates Huxley's last novel, *Island* (1962), which portrays a utopian society. It is a small, self-sustaining community removed from the pernicious effects of industrialization and the materialistic mindset of a scientific culture. Education, tranquility, and spirituality take the place of indoctrination, consumerism, and carnality portrayed in *Brave New World*. Multi-parent families and disciplined sexual practice replace machines and artificial stimulation. It is a society characterized by the pursuit of personal fulfillment and selfless care for the community. Although technology is not dominant, *Island* is not a pre-modern utopia. Its technologies serve community and spiritual flourishing rather than social power and personal distraction.

Science, Technology, and Human Nature

The difference between the drug "soma," in *Brave New World* and "moksha," in *Island* raises a basic question in Huxley's work and suggests the connections between his work and later developments in biomedical technology. Whereas soma flattens and attenuates human experience, moksha enhances and enlightens it, posing the question of what it means to be truly human. In fact, many of the central themes of Huxley's work (love, family, mortality, happiness, authenticity, consciousness, and the human spirit) highlight this basic issue. Huxley was aware that technoscience, especially biomedical science, could fundamentally alter these aspects of life.

There is disagreement about whether the *Brave New World* scenario of a dehumanized, or post-human, future is a likely consequence of biomedical technologies such as psychotropic drugs and germline engineering. Some argue that as long as individuals freely choose these technologies, there is no threat to human dignity (Blackford 2004). Others claim that human nature itself is under threat, even if these technologies are adopted within a liberal democratic system (Kass 2004). Hard, top-down attempts to control human behavior are not the only threats; there are also soft, bottom-up threats that appeal to the lowest common denominators in human desire.

Huxley also considers the dehumanizing potentials of scientific and technological change in other works. In *Point Counter Point*, he argues that liberal democracies and autocracies share a common faith in the powers of science and technology to deliver human happiness. Realizing that this happiness is oftentimes shallow and inauthentic, the protagonist in the novel proclaims that the only difference is "whether we shall go to hell by communist express train or capitalist racing motor car" (p. 414). In *Antic Hay* (1923), Huxley lampooned a decadent society of lost souls searching for meaning and true happiness, but only on the surface of the latest fads. In *Ape and Essence* (1948), he warned of the catastrophes that can result from humanity's hubristic search for knowledge and control of nature. He also satirized the scientific quest for immortality in *After Many a Summer Dies the Swan* (1939).

Huxley's most telling interpretation of the proper use of technology to enhance rather than corrupt human nature comes from his two books about psychedelic drugs, *The Doors of Perception* (1954) and *Heaven and Hell* (1956). These works present a philosophy of the prudent use of technology as an aid in the search for truth, goodness, and beauty, which Huxley believed to be the purpose of human life. Drugs can assist someone in this search, but he warned that they must be used cautiously. They are not an excuse to forgo the responsibilities that come with freedom. Rather, "Ethical and cognitive effort is needed if the experience is to go forward from this one-shot experience to permanent enlightenment" (Deery 1996, p. 109). As John the Savage remarked in *Brave New World,* experience has to "cost" us—it has to be difficult—if it is going to be truly meaningful.

Huxley was not opposed to new developments in science and technology. His message is that these developments must be guided by moral inquiry and held to the standards of individual dignity and enlightenment as well as social sanity and peace. They must further be directed and adopted by a free and well-educated populous, and not forced by the hand of technocrats or the mantras of mass society. As his utopian *Island* illustrates, this will mean science and technology play much smaller roles in human life, not because they are inherently nefarious, but rather because they can only go so far in assisting the good life. It is a thin line, after all, between enhancing the human soul and erasing it.

ADAM BRIGGLE

SEE ALSO *Brave New World; Haldane, J. B. S.; Science Fiction; Science, Technology, and Literature; Utopia and Dystopia.*

BIBLIOGRAPHY

Bowering, Peter. (1969). *Aldous Huxley: A Study of the Major Novels*. New York: Oxford University Press. Contains critical essays on nine of Huxley's novels as well as introductory material on the "novel of ideas" and morality and a conclusion on morality and art.

Deery, June. (1996). *Aldous Huxley and the Mysticism of Science*. New York: St. Martin's Press. Focuses on Huxley's view of the connection between literature, science, and mysticism.

Huxley, Aldous. (1923). *Antic Hay*. London: Chatto and Windus.

Huxley, Aldous. (1928). *Point Counter Point*. London: Chatto and Windus

Huxley, Aldous. (1932). *Brave New World*. London: Chatto and Windus.

Huxley, Aldous. (1939). *After Many a Summer Dies the Swan*. London: Chatto and Windus.

Huxley, Aldous. (1942). *The Perennial Philosophy*. New York: Harper.

Huxley, Aldous. (1946). *Science, Liberty and Peace*. New York: Harper & Brothers.

Huxley, Aldous. (1948). *Ape and Essence*. New York: Harper.

Huxley, Aldous. (1954). *The Doors of Perception*. New York: Harper.

Huxley, Aldous. (1956). *Heaven and Hell*. New York: Harper.

Huxley, Aldous. (1958). *Brave New World Revisited*. London: Chatto and Windus.

Huxley, Aldous. (1962). *Island*. London: Chatto and Windus.

Huxley, Aldous. (1963). *Literature and Science*. New York: Harper and Row.

Huxley, Aldous. (1978). *The Human Situation: Lectures at Santa Barbara*, ed. Piero Ferrucci. New York: Harper and Row.

James, Clive. (2003). "Out of Sight: The Curious Career of Aldous Huxley," *The New Yorker* March 17. A lucid insight into Huxley's world, with particular attention paid to his political beliefs and their consequences for social organization and the regulation of technology.

Kass, Leon R. (2004). *Life, Liberty, and the Defense of Dignity: The Challenge for Bioethics*, 2nd ed. San Francisco: Encounter Books. Advances the argument that certain biomedical technologies threaten human dignity. Also discusses the meaning of liberty, as opposed to libertarianism, in an attempt to formulate a way for liberal democracies to answer the challenges posed by technologies.

Murray, Nicholas. (2002). *Aldous Huxley: An English Intellectual*. London: Little, Brown. First new biography of Huxley for thirty years, draws upon unpublished sources and interviews with family and friends.

INTERNET RESOURCES

Blackford, Russell. (2004). "Debunking the Brave New World." Betterhumans. Available from: http://www.betterhumans.com. Argues that biomedical technologies do not endanger human dignity.

Pearce, David. (1998). "Brave New World? A Defence of Paradise Engineering." Available from: http://www.huxley.net. Claims that *Brave New World* has become a pernicious slogan of fear that prohibits humans from unlocking their full potentials through biomedical technology.

HYPERTEXT

Hypertext is a way to organize information in a digital format that makes use of traditional text structures (words, sentences, pages, articles or chapters, books, and libraries) as enhanced by the multiple linkages (words to words, words to sentences, sentences to sentences, sentences to pages, pages to pages, pages to chapters, and so on) possible in cyberspace. When hypertexts further employ graphics, images, audio, and video, they become hypermedia. By both enhancing and subverting traditional assumptions about the linear reading of a text (i.e., word after word, sentence after sentence, page after page) hypertexts also both expand ethical reflection and create ethical issues related to access, the implications of linking choices, and more.

Structures and Opportunities

The architecture of information in the digital context consists of three basic elements: nodes, links, and anchors. In hypertext, information is distributed in building units called nodes. Nodes store a large amount of information, anything from a printed page to an entire book. Nodes can include text, graphics, images, and sounds (hypermedia). They are connected by links; a link between two nodes allows the reader to switch from one to another.

Anchors allow readers or users to determine whether a link exists and if so, to access it.. The reader can switch from one informational unit to another by clicking an anchor zone. Anchor zones are identifiable by some kind of emphasis; they may be a different color than other text, cause changes in the shape of the cursor, appear as icons, and so on, and usually give an indication of the link destination.

With these three basic construction elements, among others, designers can build simple and reduced hypertextual organizations, as well as large, complex ones. Well-designed hypertextual organizations are of great help in translating information to the computer screen. If providers of digital support were limited to using traditional methods of information dissemination, such as print matter, the efficiency and value of that support would be severely reduced.

Providing information through hypertext creates different ways of reading. Readers have more paths open to them because nodes offer a variety of links. Sequential or traditional reading does not allow such multiplicity. Thus hypertextual reading is termed *navigation*.

Historical Development

Vannevar Bush presented a precursor to modern hypertext technology in "As We May Think" (1945). Using the technology available at that time, Bush proposed the Memex, a device that could present independent documents in much the same way that memory works, jumping from one to another. In 1965 Theodor (Ted) H. Nelson coined the term *hypertext* and discussed the *Docuverse*, a universe composed of a range of documents, including international literary works. He argued that one should be able to navigate through all the documents and their interrelated fragments and parts. The very same year J. C. R. Licklider published *Libraries of the Future*.

These ideas and concepts could not be realized until devices to implement them were created. Douglas Engelbart, for example, not only proposed theoretical concepts but played a key role in inventing devices which are now integral parts of the modern computer, including the mouse, computer windows, and other graphic interfaces.

Hypertext is the result of technological achievements in hardware and software as well as the creativity of authors who experimented with different structures. Hypertext requires communication networks, computers, authoring tools, and browsers that allow readers to see the hypertext on the computer screen and interact with it. Hypertext also requires continued exploration of the possibilities in this new information framework.

Developers, designers, and inventors have achieved major technological advances in this nascent field. Among them are Tim Berners-Lee's invention of the World Wide Web (www, the largest and best-known hypertextual construct) and HyperText Markup Language (HTML); Peter Brown's development of the first software guide for hypertext production in personal computers, accessible to computer users of all levels of expertise; and Bill Atkinson's design of the HyperCard for Macintosh, which uses the programming language HyperTalk.

Achievements and Ethics

Information on the www is like an unbound book. Any author can add to the work by using a link. Readers navigate through this information and each binds the material into an individual *book* composed of different authors' pages. Boundaries that define the notions of intellectual property are difficult to maintain and traditional methods of protecting copyrights are becoming obsolete. New legal and cultural tools are needed to deal with such changes.

The Wiki Wiki Web is an example of a hypertext construct based on the unrestricted access of users. Each user contributes to the collective work and decides where to create links. There are no webmasters or any central control. Each reader is an author and has the power to eliminate or change the contributions of others. Individual responsibility and self-control and a sense of collaboration on a collective work are guiding forces in these activities, one of which is the continuous creation of the online Wikipedia. Robert McHenry (2004), however, has challenged the quality of this "faith-based encyclopedia."

Hypertext technology allows virtually unrestricted linking of information nodes. Links to information that is clearly related to the subject matter of a particular text are certainly acceptable. But when the destination of a link is not visible, or when readers are diverted to a destination despite their intent to go elsewhere, ethical issues arise.

Likewise decisions to link to certain materials or web sites and not to others, while understandable and arguably defensible, could result in the marginalization of groups with less scientific or social prestige and power. The need to discriminate among the vast amount of information available on the Internet could lead to *cherry-picking* sources of information and experts in fields, thus virtually excluding access to other sources and experts. This situation raises the potential for what has been called *a balkanization of the global village* by Marshall Van Alstyne and Erik Brynjolfsson.

Transcending the barriers of traditional text is certainly an achievement with positive implications that are still being explored. However the potential misuse of hypertext technology or the unforeseen negative results of its use are causes for concern and thoughtful examination.

ANTONIO RODRÍGUEZ DE LAS HERAS
CARL MITCHAM

SEE ALSO *Computer Ethics; Cyberculture; Free Software; Internet; Networks; Science, Technology, and Literature.*

BIBLIOGRAPHY

Landow, George P. (1997). *Hypertext 2.0.* Baltimore, MD: Johns Hopkins University Press. A revised version of *Hypertext: The Convergence of Contemporary Critical Theory and Technology* (1992).

Licklider, J. C. R. (1965). *Libraries of the Future*. Cambridge, MA: MIT Press.

Van Alstyne, Marshall, and Erik Brynjolfsson. (1996). "Could the Internet Balkanize Science?" *Science* 274(5272): 1479–1480.

INTERNET RESOURCES

Bush, Vannevar. (1945). "As We May Think." Originally published in the *Atlantic Monthly* (July 1945), the text is available on a number of Internet sites, including http://ccat.sas.upenn.edu/~jod/texts/vannevar.bush.html.

McHenry, Robert. (2004). "The Faith-Based Encyclopedia." Available at Tech Central Station, http://www.techcentralstation.com/111504A.html.

Nelson, Theodor Holm. The best single source for information on Ted Nelson and his ideas, with links to other pages, is an article on the Wikipedia at http://en.wikipedia.org/wiki/Ted_Nelson.

I

IBERO-AMERICAN PERSPECTIVES

To introduce a Spanish- and Portuguese-speaking perspective on science, technology, and ethics is difficult and somewhat artificial. From the beginning it must be acknowledged that Spain and Portugal on the Iberian Peninsula of Europe together with the more than twenty Spanish- and Portuguese-speaking countries that can be identified in the Americas compose a heterogeneous group. In many respects differences outweigh similarities. Nevertheless, the differences are perhaps no greater than those present in other large-scale linguistic or cultural perspectives such as are represented by Africa, China, or India. Provided that this introduction is not taken as a substitute for more particular assessments of the situations in Argentina, Brazil, Chile, Colombia, Cuba, Ecuador, Guatemala, Mexico, Peru, Portugal, Spain, and Venezuela (to mention only a dozen of the most populous countries), it may serve to highlight some modest commonalities that do in fact exist.

Context

Understanding relations between science, technology, and ethics in the Ibero-American countries requires some appreciation of the historical relations between Spain and Portugal on the Iberian peninsula and those countries in the Americas that emerged from Iberian colonization. The sixteenth and seventeenth century Iberian colonizations of the Americas brought with them ideals of the Counter Reformation rather than the ideals of liberalism the practice of exclusion that were more characteristic of English colonialism. From the very beginning, there was thus little enthusiasm for science and technology in themselves, and even considerable skepticism regarding their benefits. The local cultures that emerged in the eighteenth century and then sought independence in the nineteenth century adopted a sense of being on the periphery that was reinforced, especially in Spain, by its sense of separation from Europe and then the loss of its last major possessions to the United States in Spanish-American War of 1898.

Subsequent early twentieth century attempts by Latin American countries to modernize and become players in international affairs had to struggle with the increasing influence of the United States and continuing marginalization in the mother countries of Spain and Portugal. Virtually all Ibero-American countries were also afflicted until the 1970s with civil wars and economic difficulties. The last decades of the twentieth century were then characterized by attempts to recover cultural roots and establish regional identities, often through ambitious political projects of international cooperation and development such as the Alliance for Progress (which was proposed by American president John Fitzgerald Kennedy [1917–1963] in 1961 but petered out by the late 1960s), or through more modest academic projects, including the formation of regional networks promoting scientific education and research. The failures of major development programs to achieve their stated goals, and the difficulties that emerging cadres of scientists and engineers had in securing adequate employment in their home countries, nevertheless sponsored an ongoing sense of skepticism and dissatisfaction with scientific and technological initiatives.

Against such a background it is thus appropriate to review in slightly more detail various indicators concerning the role of science and technology in various Ibero-American situations. This will be followed by an assessment of social and academic attitudes toward science and technology, including those manifested in Latin American social thought. Finally it will be appropriate to comment on the reception and development of science, technology, and society (STS) studies in the region, and to review recent initiatives to promote a proper regional reflection on the social meaning of science and technology.

Science and Technology in Ibero-American Countries

Until the latter decades of the twentieth century, the role of scientific research and technological development (R&D) in Ibero-American countries can be encapsulated in a well-known phrase from Miguel de Unamuno y Jugo (1864–1936): "¡Qué inventen ellos!" (Let others invent!). Unamuno was one of the leading members of the "Generation of 1898," the year that Spain lost the last of its major colonies, and a philosopher who struggled to come to a new self-understanding of what it meant to be Spanish. Unamuno's manifesto was to make a virtue of history: Spain should not compete with others in science and technology, but seek a non-technical identity in its cultural traditions. Although Unamuno himself was adamantly opposed to the traditionalists who made up the base for Francisco Franco (1892–1975) during the Spanish Civil War (1936–1939), the fascist triumph can be interpreted as an initial victory for such an ideology. Only in the 1950s did this victory evolve into a kind of technocratic development that, after Franco's death in 1975, could serve as a foundation for major scientific and technological change. (Changes of a comparable character took place in Portugal after the death of António de Oliveira Salazar [1889–1970].)

The increasing social and political belief in a link between economic development and technoscience that characterized the last half of the Franco regime was also reflected in Latin America in emerging public policies for the promotion of R&D. It was especially at the exhaustion of the development model known as "industrialization by import substitution" during the 1980s, when a large number of national science and technology organizations were created, that many governments began to recognize a need to support their science and technology systems. The loss of a dream of self-sufficiency in the midst of globalization was coincident with the diffusion of new discussions of innovation. The new discourse has nevertheless brought its own worries, especially a tendency to subsume science policies under economic policies—a view that at the beginning of the twenty-first century serves as the guiding principle for the reorganization of R&D in many Latin American countries. In such a context, economics trumps science—as well as ethics.

Yet good intentions have seldom equaled actions. In the decade of the 2000s, it has remained the case that only around 0.5 percent of the gross domestic product (GDP) is allocated to R&D in most Latin American countries. Because there is little privately supported higher education, universities absorb the major portion of public R&D funding; there is no significant demand for R&D in the private sector. In spite of public declarations and formal documents, Unamuno's spirit remains strong. Indeed, with regard to science and technology, the inequality of Latin America in relation to other regions is even more pronounced than the much better known economic inequalities. This is well documented by a wide variety of indicators: funding, active researchers, science students, scientific publications, patents, and more.

Relevant data is available on the Ibero-American and Inter-American Network on Science and Technology Indicators Website (www.ricyt.org), as well at regular United Nations Educational, Scientific, and Cultural Organization (UNESCO) and Organisation for Economic Co-operation and Development (OECD) publications on the state of science and technology throughout the world. For example, while in developed countries about fifty percent of the student-age population pursues some level of higher education, in Latin American this number is below twenty percent. This is after a doubling of university graduates during the 1990s. From this scarce percentage, in 1997 only eleven percent were graduates in mathematics, science, or engineering. It is against this scarcity and imbalance that the efforts of research groups in Brazil, Colombia, Cuba, Mexico, and Venezuela must be appraised.

A certain imbalance among these countries must also be recognized. Over seventy percent of Latin American scientific researchers are concentrated in three countries: Argentina, Brazil, and Mexico. While some countries, such as Brazil and Cuba, are making a strong economic and political effort to promote R&D, others, such as Peru and El Salvador, were not even investing 0.1 percent of their GDP in science and technology as of the late 1990s. The situation in Spain and Portugal is also distinctive. Particularly since joining the European Union, Spain and Portugal have worked to reach European standards with regard to science, technology, and innovation indicators. Although they have yet to match the general European standards, especially in relation to their weak public funding and poor investment from the private sector, their indicators are significantly better than those of most Latin American countries. For example, publications from Spain included in the Science Citation Index (around 25,000 in year 2000) were almost as great as those from all of Latin America (around 28,000 in the same year)—but still far below a single North American country such as Canada (with 38,000 in 2000).

Clearly much work remains to raise the profile of science and technology in all the Ibero-American countries. Mere awareness of the problem is not enough. Instead, decisive steps are required from many social actors in order to promote science and technology and to develop their economic potential. At some level, such work will rest on an ethical assessment of the value of science and technology that does not ignore their potential dangers. Indeed, the issues concerning relationships between science, technology, and development have been themes of critical social reflection in Latin America—a tradition of reflection that is in the process of being modified by the regional emergence of STS studies.

Latin American Social Thought

Relevant in the present context is the evolution of a distinctive school of Latin American social thought on science and technology, especially as reflected in a number of thinkers concerned with both the foundations of science and regional political change. Although the most significant of these were born and based in Argentina, they had a much wider influence during the 1970s and since. What follows is a brief review of the work of three representatives of this school.

OSCAR VARSAVSKY. Oscar Varsavsky (1920–1976) was an Argentinean mathematician and physicist who was also one of the most politically engaged scientists of his generation. He developed a criticism of what he called "scientism," particularly in Latin America: that is, the ideological attitude often assumed in science in which scientists focus their professional interest on their own careers, adopting them to the patterns operative in leading foreign scientific centers, thus developing an external dependence while ignoring immediate social needs and the political meanings of their work. According to Varsavsky, it is a prevailing obsession for quantitative methods and an illusion of freedom in research that obscures the scientists' dependency on capitalist economic forces and market laws.

Adopting a relativist viewpoint, Varsavsky held that there is more than one way to do science and technology. There are different styles in science and technology, linked to different national projects and eventually to different social values. Varsavsky thus developed a normative criticism of contemporary science, rejecting the linear model of innovation as dependent on basic science—a science policy ideology that became very influential in Latin America during the 1970s. In a more positive vein, Varsavsky argued for a new style in science and technology in Latin America: a science for the people or, better, a science from the people, providing the region with a certain scientific and technological autonomy, and linked to a style of society that he called *socialismo nacional creativo* (creative national socialism).

JORGE SÁBATO. Jorge Alberto Sábato (1924–1983) was an Argentinean metallurgist and self-educated physicist who had an important role as the promoter of research in the Argentine Atomic Energy Commission. He was also influential in the creation of the Physics Institute in Bariloche, Argentina. A sharp and lucid thinker, Sábato had a strong influence from the 1960s concerning the way to conceptualize scientific and technological development in Latin America. His most widely cited contribution is his 1968 paper "La ciencia y la tecnología en el desarrollo de América Latina" (Science and technology in the development of Latin America), coauthored with Natalio Botana. In this paper he introduces the metaphor of the triangle of scientific and technological development, whose three vertices are government, the production sector, and the knowledge-generation sector. This has come to be known as the "Sábato triangle," which he used as a heuristic tool for analyzing problems posed by the lack of innovation in the periphery.

According to Sábato, it is the weak connections between those three vertices, in contrast to the situation in developed countries where they constitute a system, that explains the weakness of innovation capacities in Latin America and its technological dependency. These ideas were contrary to the then-prevalent linear model of innovation, and clearly anticipated forthcoming theories on systems of innovation.

AMÍLCAR HERRERA. Amílcar Herrera (1920–1995) was an Argentinean geologist and eldest, but also longest-lived, of the three the thinkers under review. His main book, *América Latina: Ciencia y tecnología en el* *desarrollo de la sociedad* (1970), an edited volume that included Sábato's 1968 paper, outlines his primary intellectual orientation: developing a Latin American view about the problems of underdevelopment and their relation to science and technology. Immediately afterward, his *Ciencia, tecnología y desarrollo social: ciencia y política en América Latina* (Science, technology, and social development: science and politics in Latin America, 1971), critically analyzed the social and historical context of science and science policy in the Latin American region. It is in this second volume that Herrera, adopting a structural and contextual approach, introduced a now widely used distinction between explicit and implicit science policies. An explicit science policy is the one that can be found in standard formal documents, a modernizing and progressive policy in accordance to universal ideals. The implicit science policy is the one really at work, characteristically at the service of the ruling social classes.

Herrera also criticized the use of conventional socioeconomic indicators for development in Latin America, and argued in favor of an orientation of the scientific and technological capacities toward proper regional problems such as those of undernourishment, misery, and ignorance. Finally, shortly before his death, his *Las nuevas tecnologías y el futuro de América Latina: Riesgo y oportunidad* (New technologies and the future of Latin America: risk and chance, 1994) proposed a strategy for scientific and technological development appropriate to the Latin American countries and sensitive to the type of society to be pursued.

Of course, none of these authors considered himself a STS scholar. They were simply critical scientists interested in the social realities of Latin America, as connected to science, technology, and innovation, and as such they anticipated some of the ideas that could subsequently find a home in STS scholarship. Indeed, they created a social thought tradition that has molded the later reception of STS authors and ideas.

Moreover, they are not alone in the movement of Latin American social thought on science and technology. Others who deserve mention are the Chilean Fernando Fajnzylber (who focused his work in the study of the relationship between economic development and inequity) and the Venezuelan Marcel Roche (founder of the journal *Interciencia* and promoter of science studies in his country). Still others have also made lively contributions to STS research, in countries such as Brazil, Colombia, Cuba, and Uruguay.

The tradition of Latin American social thought was not, however, particularly influential in promoting an ethical assessment of science and technology in relation to developments in either Spain or Portugal. In Spain one primary influence was the work of José Ortega y Gasset (1883–1955) who, as a member of the "Generation of 1927" (the generation associated with the second Republic), criticized the views of Unamuno. Ortega's *Meditación de la técnica* (1939) provided a positive but critical analysis of technology as central to human life. Another influential philosopher of Spanish origin, Juan David García Bacca (1901–1992), who spent most of his adult life in Ecuador, Mexico, and Venezuela, adopted an even more positivist perspective that virtually ignored any negative political implications of scientific and technological progress. More recently the critical phenomenological analyses of the Venezuelan Ernesto Mayz Vallenilla on the tendencies of technology to be transformed into what he terms a meta-technology have also had some limited influence.

STS in Ibero-American Countries

It is within the previously noted contexts that STS studies—as the basic framework within which discussions of science, technology, and ethics have been manifest—have emerged in Spain, Portugal, and Latin America. Before turning to this emergence, however, it is necessary to provide some commentary on the underlying interpretation of science studies in these countries.

In Spanish- and Portuguese-speaking countries there is a certain ambiguity concerning how to interpret and translate the English acronym "STS." Some translate it as "science and technology studies" (*estudios sobre ciencia y tecnología*); others take it to stand for "science, technology, and society" (*ciencia, tecnología, y sociedad*). The well-known distinction between the two STS subcultures—an academic subculture focused on the study of technoscientific change as a social process, and the social factors that might be rendered responsible for shaping such a change, versus an activist subculture focused on the social and environmental effects of technoscientific products, upon their educational, ethical, or political aspects—is repeated in the Ibero-American perspective. But this repetition is a weak one, and the fact is that in Latin America especially the two approaches have tended to merge even when the interpretation of STS as "ciencia, tecnología, and sociedad" predominates.

The STS subcultures, whether disciplinary or activist, originated in the late 1960s and the early 1970s in the United States and the United Kingdom, and from there were transferred to other industrialized countries mostly in continental Europe. It was during the 1980s and 1990s that STS penetrated the academic and educational institutions of more peripheral European countries, such as Spain or Portugal, and other peripheral regions, such as Latin America. In Spain, Colombia, and Cuba, it was only in the late 1980s that such things as social constructivism, technology assessment, gender issues in scientific research, along with new trends in science education, began to be pursued. The academic and institutional consolidation of STS, however, did not reach the region until the 1990s, and even then in a slow and hesitant way that has continued into the twenty-first century.

There are nevertheless some exceptions worth mentioning, both in research and education. With regard to research, a number of groups linked to universities have had some important results. Examples include

- the STS postgraduate program and research group organized by José Sanmartín in the University of Valencia, which started the first formal STS education program in Spain in the 1980s;
- the group led by Mario Albornoz at the Ibero-American Science and Technology Indicators Network (RICYT) in Buenos Aires, which gathers scholars from many Latin American countries;
- the Hebe Vessuri group at the Venezuelan Institute of Scientific Research (IVIC) in Caracas, with its tradition of collaboration with UNESCO;
- the team arranged by Javier Echeverría and Emilio Muñoz at the STS Department, Spanish Research Council, Madrid;
- the scholars gathering around Renato Dagnino in the University of Campinas, near Sao Paulo in Brazil;
- the research group linked to Maria Eduarda Gonçalves and José Luís Garcia at the Institute of Social Sciences at the University of Lisbon;
- the network of Jorge Núñez, Director of Postgraduate Studies, Havana University, Cuba;
- the research group led by León Olivé and Rosaura Ruiz in the National Autonomous University of Mexico (UNAM), hosting many editing and teaching STS activities.

Not included in this list are other important researchers who have made no less significant contributions in countries such as Colombia (Mauricio Nieto, Carlos Osorio) and Uruguay (Judith Sutz, Rodrigo Arocena).

With regard to education, STS has been making a strong impact on the Spanish secondary school system and on higher education in Cuba since the mid-1990s. More modest impacts are to be found in Mexican secondary education, where a certain implementation of STS content has taken place in natural sciences subjects and is underway in technological education. There are also a number of particular universities where STS research groups have flourished when linked to diverse graduate or postgraduate programs (see above). However, these are rather exceptions to the general rule of slow consolidation of a regional STS scholarship.

The case of Cuba is worth special note. After the end of the Cold War, reforms in Cuba began also to affect education. Under the title of "Social problems of science and technology," the content of STS experienced an impressive expansion in the Cuban system of higher education. STS largely replaced the previously obligatory study of Marxism, and so is now taught as part of practically all university degrees. It constitutes a compulsory examination for Ph.D. candidates and for any scholar applying for promotion within the faculty system.

Discourse Transfer Issues

STS and related discussions of science, technology, and ethics can be understood as cultural constructs. Such discourses arose initially in more economically and technologically developed countries in response to certain social demands. These demands included calls for alterations in the academic image of science, desires to increase scientific literacy among non-scientist citizens, needs for reforms in science education, political efforts to extend public control over technological change, concerns for social accountability related to science and technology policies, and more. Discussions of the professional ethical responsibilities of scientists and engineers and efforts to enhance the responsible conduct of scientific research were especially associated with the intensified interactions between science, technology, economics, and politics. The transfer of such discourses to the more peripheral Ibero-American countries, despite the differences that exist among them, has confronted a number of common problems.

First, an obvious but important fact is that many of the social demands out of which STS originally emerged in the Anglo-American center of scientific and technological advance in the 1960s did not exist until much more recently in Spain, Portugal, or Latin America. With no significant interest in the classic sociology of science, one should not expect there to be much interest in the sociology of scientific knowledge and related analyses of the academic status of science. Where large sections of the population are illiterate, it is unlikely that there will be desires to increase scientific literacy. Without democracy, it would be nonsensical to argue for an extension of democracy into the regulation of science and technology.

Second, the constitution of a critical mass of STS scholars in every country requires an established research infrastructure in the natural and social sciences. It depends on reasonable input and output indicators in those fields, as well as institutional structures for facilitating interdisciplinary research. Unfortunately, in Ibero-American countries there has traditionally been an important lack in both respects. At the same time, the creation of small national groups of STS scholars, who could be put together and form a critical mass in the region as a whole, has faced serious difficulties because of severe restrictions on academic support and communication.

Finally, third, there has been an excessive peripheral focusing on the English-speaking center. Spanish STS scholars, for example, tend to read STS literature in English, produced by American, British, Dutch, or French authors. They thus largely ignore what their cultural neighbors are doing in Colombia, Venezuela, or even Portugal.

Fortunately, the situation in Ibero-American countries is changing. The effort of a number of international governmental organizations, such as UNESCO, the Programa Iberoamericano de Ciencia y Tecnología para el Desarrollo (CYTED), and the Organización de Estados Iberoamericanos (OEI), as well as some national science teachers associations (such as those in Chile or the Brazil), are promoting research and breaking down communication barriers. Traditionally isolated local universities and research centers are increasingly cooperating to promote STS throughout the region. This will undoubtedly stimulate discussions of science, technology, and ethics, as well.

Recent Initiatives

Two significant recent examples of recent initiatives are the creation of an Ibero-American STS Thematic Network and the promotion of a number of university Science, Technology, Society, and Innovation (STS&I) chairs, in both cases as initiatives of the OEI—an intergovernmental organization that depends on the ministries of education of the Spanish- and Portuguese-speaking Latin American countries, plus Spain and Portugal.

The Ibero-American STS Thematic Network gathers STS scholars from some fifteen countries in the region, focusing their work around typical STS subjects such as science and gender, social impact indicators for R&D activities, or ethical aspects of new technologies. The central goal of this network is to stimulate an endogenous STS scholarship in the Ibero-American region, while promoting a constructive dialogue with the international forefront in the field. Among the tools that are already in use are the support of STS publications (in Spanish and Portuguese), electronic diffusion and distance learning courses, and the sponsoring of STS conferences and meetings in the region (see http://www.oei.es/cts.htm).

The network draws applications to the fields of science education, communication, and management. For example, in the field of science and technology management, the OEI has made use of network resources and included a STS orientation in Science Administration courses that have been organized since 1998. These courses are addressed to young high officials of the Latin American ministries of science (or whatever ministry holds science policy competencies) as well as national organizations responsible for science policy in the region. The inclusion of STS content in these courses, comprising fifteen to thirty percent of the lecture time, has been well received.

As to the research guidelines of this initiative, its critical focus has been the urgent need to promote economic development in the region and a central place for science and technology in such a process. According to this view and reflecting the critical tradition of Latin American thought, a social critique of science should be compatible with the encouragement of science and science policies. In more practical terms, policy, ethics, and history-based applied analyses, often assuming the form of interdisciplinary studies, have taken precedence over theory-oriented and disciplinary stances. "Science, technology, and society" has dominated over "science and technology studies."

The creation of STS+I Chairs in Ibero-America exhibits similar tendencies. STS+I chairs are an OEI initiative in collaboration with national science and technology agencies, and in some cases ministries of education. Basically, the idea underlying STS+I Chairs is to constitute networks of universities (both public and private) that, duly supported by other public organizations, will be able to strengthen particular lines or research and education (linked to STS and innovation issues), thus making better use of the potentialities of participant institutions. To date, chairs have been established in El Salvador (September 2000), Argentina-Uruguay (April 2001), Colombia (September 2001), Cuba (November 2001), Costa Rica (July 2002), Panama (April 2003), Mexico (May 2003), and Peru (June 2003).

The organizational model is different in each case, respecting each country's characteristics (with a strong or weak national differentiation, with one or another higher education system, etc.). But basically a STS+I chair is constituted by a named professorship with supplementary funds to support education and research activities. What unifies the various STS+I chairs is the attempt to promote a dialogue between the scientific and humanistic cultures, as well as the social projection of scientific knowledge generated in the university by means of teaching seminars and other initiatives of knowledge diffusion, as well as the support of research. The general idea is the creation of a common working ground for higher education and research institutions, a common space conceived for sharing and rationalizing human and material resources. Not only banks and corporations, but also education and research institutions, need to establish alliances and common projects in order to be competitive and make an optimal use of their potentialities.

STS+I Studies

The STS+I acronym emphasizes the particular perspective in which STS studies are being developed in the Ibero-American region, receiving international STS scholarship and adapting it to the tradition of critical thought on science and public policy represented by Varsavsky, Sábato, and Herrera. The STS+I perspective also tries to cope with the two major challenges of the so-called knowledge society, as seen from a regional perspective: the appropriation of such knowledge by the production sector, and its appropriation by the civil society.

A pragmatic approach to the region's sensibilities is perhaps the best way to characterize these fields and their interrelation in the present geographic and cultural context. On the one hand, in the STS field, through the study of academic themes such as science and gender, science education, or engineering ethics, the goal is to achieve an understanding of the relationships between science and technology in their social context in order to promote social interests for scientific issues, scientific and technological literacy, and public participation in public policies related to science and technology. On the other hand, in the innovation field, through the study of themes such as university-corporation relationships, national systems of innovation, and technological management, the goal is to understand institutional and socioeconomic conditions underlying the phenomenon of innovation in order to support innovation and the creation of innovation systems in countries of the region. The great challenge and novelty of the STS+I approach has been the combination of these lines of work in a common framework of interdisciplinary reflection, with a strong practical or policy orientation.

"Society" and "innovation" are the key terms of the so-called "Declaration of Santo Domingo," from a regional summit on science and technology held in March 1999 as a preparatory meeting of the World Congress on Science, arranged by UNESCO and the International Council of Scientific Unions (ICSU) and held in Budapest in June-July 1999. It is not by chance that these two points were also emphasized in the final declaration of the Third Ibero-American Course for Science and Technology Administrators, held also in March 1999 in Bogota, Colombia, which gathered participants from twelve Latin American countries.

In fact, in the contemporary world, and especially in Latin America, these two goals—to open science and technology systems to social sensitivities and public participation, and to reorient these systems toward economic development—are not only compatible but mutually interdependent. Technological innovation, the process that begins with the organized creation of an idea and concludes with the social diffusion of its material realization, requires social support and participation for its feasibility and consolidation. Just as a country with half its population in poverty cannot pretend to be internationally competitive or to enjoy sustainable economic development, the consolidation of such growth and competitiveness requires public interest, democratic support, and confidence in institutions among all the citizens. Moreover, from the perspective of the periphery, technological innovation is necessary for national economic competitiveness and also for the creation of the material conditions that make possible, among other things, the modernization of political and administrative structures and the generation of a participatory culture.

Acknowledgment

Although only the author is responsible of any omissions or mistakes, this article draws on a number of experiences and personal communications involving the STS Network of the OEI. Due credit must be given to the Network scholars who provided many clues and much information. Particularly helpful have been Elsa

Beatriz Acevedo (Colombia), Rodrigo Arocena (Uruguay), Renato Dagnino (Brazil), José Luis Luján (Spain), Jorge Núñez (Cuba), and Sara Rietti (Argentina).

JOSÉ A. LÓPEZ CEREZO

BIBLIOGRAPHY

Arocena, Rodrigo, and Judith Sutz. (2003). *Subdesarrollo e innovación: navegando contra el viento* [Underdevelopment and innovation: sailing against the wind]. Madrid: Cambridge University Press/OEI.

Bazzo, Walter Antonio. (1998). *Ciência, tecnologia e sociedade, e o contexto da educação tecnológica* [Science, technology, and society in the context of technological education]. Florianópolis, Brazil: UFSC.

Buch, Tomás. (1999). *Sistemas tecnológicos: contribuciones a una teoría general de la artificialidad* [Technological systems: contributions to a general theory of artificiality]. Buenos Aires: Aique.

"Ciencia, tecnología y sociedad ante la educación" [Science, technology, and society before education]. (1998). Monographical issue of *Revista Iberoamericana de Educación* 18(Sept.-Dec.).

"Ciencia, tecnología y sociedad" [Science, technology, and society]. (1999). Special issue, *Revista Pensamiento Educativo* 24(July). Pontificia Universidad Católica de Chile.

Dagnino, Renato, ed. (2000). *Amílcar Herrera: un intelectual latino-americano* [Amílcar Herrera: a Latin American intellectual]. Campinas, Brazil: UNICAMP.

Echeverría Ezponda, Javier. (2003). *La revolución tecnocientífica* [The technoscience revolution]. Madrid: FCE.

Funtowicz, Silvio, and Jerome Ravetz. (1993). *La ciencia posnormal: ciencia con la gente* [Post-normal science: science with the people]. Buenos Aires: Centro Editor de América Latina.

González García, Marta; José Antonio López Cerezo; José Luis Luján López; et al. (1996). *Ciencia, Tecnología y Sociedad: Una introducción al estudio social de la ciencia y la tecnología* [Science, technology, and society: An introduction to the social study of science and technology]. Madrid: Tecnos.

Herrera, Amílcar, ed. (1970). *América Latina: Ciencia y tecnología en el desarrollo de la sociedad* [Latin America: Science and technology in the development of society]. Santiago de Chile: Editorial Universidad.

Herrera, Amílcar. (1971). *Ciencia, tecnología y desarrollo social: Ciencia y política en América Latina* [Science, technology, and social development: Science and politics in Latin America]. Mexico City: Siglo XXI.

Herrera, Amílcar. (1994). *Las nuevas tecnologías y el futuro de América Latina: Riesgo y oportunidad* [New technologies and the future of Latin America: Risks and opportunities]. Mexico City: Editorial de la Universidad de las Naciones Unidas and Siglo XXI.

Hoyos Vásquez, Guillermo. (2000). *Ciencia, tecnología y ética* [Science, technology, and ethics]. Medellín, Colombia: Instituto Tecnológico Metropolitano.

"La educación ciencia-tecnología-sociedad" [Science-technology-society education]. (1995). Special issue, *Alambique. Didáctica de las Ciencias Experimentales* 3(January).

López Cerezo, José Antonio, and Andoni Ibarra, eds. (2003). "Studies in Science, Technology and Society (STS): North and South." Special theme issue, *Technology in Society* 25(2).

Martínez, Eduardo, ed. (1994). *Ciencia, tecnología y desarrollo: interrelaciones teóricas y metodológicas* [Science, technology, and development: theoretical and methodological interrelations]. Caracas: Nueva Sociedad.

Martins, Herminio, and José Luís Garcia. (2003). *Dilemas da civilizaçao tecnológica* [Dilemmas of technological civilization]. Lisbon: ICS/Universidade de Lisboa.

Muñoz, Emilio. (2002). *Biotecnología y sociedad* [Biotechnology and society]. Madrid: Cambridge University Press/OEI.

Nieto Olarte, Mauricio. (2000). *Remedios para el Imperio: historia natural y la apropiación del nuevo mundo* [Remedies for the empire: natural history and the appropriation of the New World]. Bogota: Instituto Colombiano de Antropología e Historia.

Núñez Jover, Jorge. (1999). *La ciencia y la tecnología como procesos sociales: lo que la educación científica no debería olvidar* [Science and technology as social processes: what scientific education should not forget]. Havana: Ed. Félix Varela.

Olivé, León. (2000). *El bien, el mal y la razón: facetas de la ciencia y de la tecnología* [Good, bad, and reason: aspects of science and technology]. Mexico City: Paidós.

Queraltó Moreno, Ramón. (2003). *Ética, tecnología y valores en la sociedad global* [Ethics, technology, and values in a global society]. Madrid: Tecnos.

Pérez Sedeño, Eulalia, ed. (2001). *Las mujeres en el sistema de ciencia y tecnología: estudios de casos* [Women in the science and technology system: case studies]. Madrid: OEI.

Sábato, Jorge, and Natalio Botana. (1970). "La ciencia y la tecnología en el desarrollo de América Latina" [Science and technology in Latin American development]. In *Ciencia, tecnología y desarrollo social: Ciencia y política en América Latina* [Science, technology, and social development: science and politics in Latin America], ed. Amílcar Herrera. Mexico City: Siglo XXI.

Sábato, Jorge, ed. (1975). *El pensamiento latinoamericano en la problemática ciencia-tecnología-desarrollo-dependencia* [Latin American thought about the issues on science-technology-development-dependency]. Buenos Aires: Paidós.

Sábato, Jorge, and Michael Mackenzie. (1982). *La producción de tecnología. Autónoma o transnacional* [The production of technology. Autonomous or transnational]. Mexico City: Nueva Imagen,

Sanmartín, José. (1990). *Tecnología y futuro humano* [Technology and human future]. Barcelona: Anthropos.

Santos, Lucy; Elisa Ichikawa; Paulo V. Sendin; and Doralice Cargano, eds. (2002). *Ciência, tecnologia e sociedade: O* *desafio da interação* [Science, technology, and society: The challenge of interaction]. Londrina, Brazil: IAPAR.

Vaccarezza, Leonardo, and Juan Zabala. (2002). *La construcción de la utilidad social de la ciencia* [The construction of the social utility of science]. Buenos Aires: Universidad Nacional de Quilmes.

Varsavsky, Oscar. (1969). *Ciencia, política y cientifismo* [Science, politics and scientism]. Buenos Aires: Centro Editor.

Varsavsky, Oscar. (1972). *Hacia una política científica nacional* [Toward a national science policy]. Buenos Aires: Ediciones Periferia.

Varsavsky, Oscar. (1974). *Estilos tecnológicos* [Technological styles]. Buenos Aires: Ediciones Periferia.

ILLICH, IVAN

Most well known as a 1970s social critic of the technologies of schooling, development, and health, Ivan Illich (1926–2002) was born in Vienna, Austria, on September 4, and died in Bremen, Germany, on December 2. In the 1980s Illich shifted from social criticism to cultural archeology, that is, an effort to expose *modern certainties* or assumptions, in order to provide an ethical perspective on the ways technology has transformed human experience in the late twentieth and early twenty-first centuries.

Ivan Illich, 1926-2002. Theologian, educator, and social critic Illich sought bridges between cultures and explored the bases of people's views of history and reality. *(The Library of Congress.)*

Early Years and the Centro Intercultural de Documentación

Illich was born in Vienna, of French and Serbo-Croatian descent. During World War II he was in some danger because of the Jewish heritage on his mother's side. After the war he undertook studies in science, philosophy, theology, and history; was ordained a Catholic priest; and in the 1950s was posted to the United States, where he became a protégé of the conservative Cardinal Spellman, head of the New York archdiocese. There he acted as a pastor to Puerto Rican immigrants, and as a result of sympathies with their plight, was appointed Vice-Rector of the recently established Catholic University of Puerto Rico. His work in Puerto Rico galvanized an emerging criticism of policies promoting economic and technological development, and led him in the 1960s to establish the Centro Intercultural de Documentación (CIDOC) in Cuernavaca, Mexico, as an institutional base for the exploration of alternatives. CIDOC became a locus for visits by many dissatisfied with technosocial trends and the inspiration for a generation of social critics, from Paul Goodman (1911–1972) to Paolo Frerire (1921–1997). Accused by the Vatican of thereby becoming a scandal to the Church, Illich resigned his institutional ministry, although he was never laicized or married.

It was from CIDOC that Illich published his most widely read books: *Deschooling Society* (1971), *Tools for Conviviality* (1973), and *Medical Nemesis* (1976). In each case Illich identified what he termed the phenomenon of *counterproductivity*: that is, the pursuit of a technical process to the point where it undermines its original goals. The system of public schooling, originally conceived to advance learning, had become an impediment to real education. Advanced technological tools were at odds with autonomous human development and the culture of friendship, in the name of which they were often invented. High-tech health care was making people sick. Iatrogenic illnesses, that is, illnesses caused by physicians—as when patients have negative reactions to drugs, are harmed by diagnostic x-ray treatments, or are otherwise misdiagnosed and mistreated—had, he argued, become a counterproductive epidemic.

The correct response, for Illich, was to learn to practice a more disciplined and limited use of science and technology, and to invent alternative, especially low-scale, technologies. In many instances, however, the practice of such an ethical imperative was made difficult by what Illich termed *radical monopolies*: Although no car manufacturer has a monopoly on the automobile market, cars themselves have a overwhelming monopoly on roads so as to crowd out pedestrians and bicycles.

Living His Theory: After CIDOC

Practicing what he preached, and fearing that CIDOC itself might become counterproductive, Illich closed the center in 1976. He divided up its accumulated assets equally among all those who worked there, from the teachers to the gardeners, and became for the remainder of his life an itinerant scholar. During this period he held posts as visiting professor at a number of universities, from the University of California at Berkeley and the United Nations University in Tokyo to Pennsylvania State University and the University of Bremen, Germany. Two early collections from these years—*Toward a History of Needs* (1978) and *Shadow Work* (1981)—stress counterproductivity in the economics of scarcity, or the presumption that economies function to remedy scarcities rather than to promote community sharing of available goods. Technoeconomic progress was, Illich argued, actually undermining society and culture, the possibilities for friendship and solidarity, and specifically increasing the gap between the rich and the poor both within developed countries and between developed and developing countries.

Toward a History of Needs also hints at a new project in historical archeology that takes its first full-bodied shape in *Gender* (1982), an attempt to recover those social experiences of female/male complementary obscured by the modern economic regime of sex. *H_2O and the Waters of Forgetfulness* (1985) explores the possibility of a history of *stuff*. *ABC: The Alphabetization of the Popular Mind* (1988) carries historical archeology forward into the area of literacy, as does *In the Vineyard of the Text* (1993). Both examine how the techniques of reading transform human beings' experience of themselves and each other, thus inviting contemporary consumers of automobiles and computers to consider that they might not be wholly unaffected users of neutral technologies. Modern technology, for Illich, tends to emerge from and then reinforce a distinctive ethos, the recognition of which is best appreciated by investigations into the moral environments of previous techniques.

In the 1980s Illich became afflicted by a mascular tumor for which, again in accord with his beliefs, he refused high-tech medical treatment. Although he was in increasing pain during the last two decades of his life, he sought to practice what he understood as the traditional arts of suffering, and continued to develop his ideas. He was in his last years especially critical of the notions of "environmental responsibility" and what he saw as the new ideology of "life." Calls for environmental responsibility were, he argued, often just another excuse for advancing technological management of the world, and even the Christian pro-life movement gave too much ground to science insofar as it defined human life in terms of a molecular-biological genesis that cannot be directly experienced. What was at work in history was a counterproductivity writ large that he often described with a Latin phrase, *corruptio optimi que est pessima*, the corruption of the best is the worst. Just as the sweetest flowers, when they rot, smell worse than weeds, scientific and technological attempts to better the human condition, not to mention Christian efforts to institutionalize the friendship of charity, ultimately undermine their own ends.

Illich's criticism itself often was criticized as being overstated and polemical—too much a radical, anarchistic prophesy to be taken seriously. Many of his specific historical claims seemed exaggerated to more sober historians, and he was sometimes unfair to those who questioned his ideas. Yet popular recognition of counterproductivities in government regulation were an ironic echo of Illich's more sweeping analyses. And precisely because of his efforts to live friendship as a fundamental human good, he remained until his death at a friend's home in Bremen, Germany, a charismatic figure who continued to influence cultural criticism and to inspire students seeking alternatives to the standard paths of worldly success.

CARL MITCHAM

SEE ALSO *Bioethics; Development Ethics; Science, Technology, and Society Studies.*

BIBLIOGRAPHY

Cayley, David. (1992). *Ivan Illich in Conversation*. Concord, Ontario, Canada: Anansi. Personal and autobiographical in character.

Hoinacki, Lee, and Carl Mitcham, eds. (2002). *The Challenges of Ivan Illich: A Collective Reflection*. Albany: State University of New York Press. Includes nineteen original reflections by close Illich associates, with an epilog by Illich, and an annotated bibliography.

Illich, Ivan. (1971). *Deschooling Society*. New York: Harper and Row.

Illich, Ivan. (1973). *Tools for Conviviality*. New York: Harper and Row.

Illich, Ivan. (1976). *Medical Nemisis*. New York: Pantheon.

Illich, Ivan. (1978). *Toward a History of Needs*. New York: Pantheon. Includes the essay "Energy and Equity," which argues the counterproductivity of increased energy consumption.

Illich, Ivan. (1981). *Shadow Work*. London: Marion Boyars.

Illich, Ivan. (1982). *Gender*. New York: Pantheon.

Illich, Ivan. (1985). *H_2O and the Waters of Forgetfulness: Reflections on the Historicity of "Stuff."* Dallas, TX: Dallas Institute of Humanities and Culture.

Illich, Ivan. (1993). *In the Vineyard of the Text: A Commentary to Hugh's "Didascalicon."* Chicago: University of Chicago Press.

Illich, Ivan, and Barry Sanders. (1988). *ABC: The Alphabetization of the Popular Mind*. San Francisco: North Point Press.

IMMATERIALIZATION

SEE *Dematerialization and Immatrialization*.

INCREMENTALISM

In its most generic form, incrementalism is a normative theory of problem solving and decision making. Incrementalist strategies favor small-scale changes, monitoring, flexible positions, and decentralized organization. Incrementalists have been inspired by the epistemology of Karl Popper (1902–1994) and the economic views of Friedrich Hayek (1899–1992). These connections tie the theory of incremental development to controversies over democratic versus totalitarian forms of government and over socialist versus capitalist economic systems. Incrementalist principles thus have wide application but are explored particularly in the search for solutions to social problems and more specifically in the effort to intelligently control technology.

Basic Arguments

As a means of addressing social problems, Robert Dahl and Charles Lindblom give incrementalism a clear standing relative to other approaches.

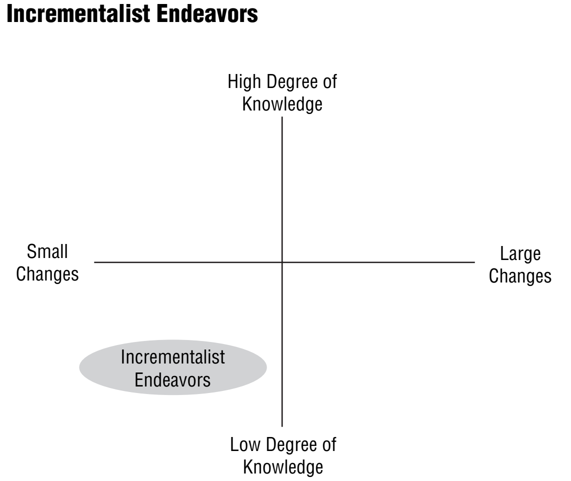
> Incrementalism is a method of social action that takes existing reality as one alternative and compares the probable gains and losses of closely related alternatives by making relatively small adjustments in existing reality, or making larger adjustments about whose consequences approximately as much is known as about the consequences of existing reality, or both. Where small increments will clearly not achieve desired goals, the consequences of large increments are not fully known, and existing reality is clearly undesirable, incrementalism may have to give way to a calculated risk. Thus scientific methods, incrementalism, and calculated risks are on a continuum of policy methods. (Dahl and Lindblom 1953, p. 82)

Incrementalism is here conceived as one of several processes that facilitate rational calculation by reducing sources of complexity. By emphasizing alternatives that differ from existing reality by only small degrees, prediction of consequences is improved, identification of causes is made possible, reversibility of decisions is maintained, and the cost of altering organizational hierarchies is avoided.

David Braybrooke and Charles Lindblom (1963) develop these views by criticizing deductive systems, welfare functions, and other synoptic models (including Bayesian methods) that achieve quantitative rigor by assuming that options and states of the world can be exhaustively and exclusively specified. Such models are too formal, centralized, and idealistic to apply to practical decision making. By laying out two intersecting axes, one for degree of knowledge (low to high) and one for size of proposed change (small to large), four quadrants of decision making are established (Figure 1). Incrementalist strategies flourish in the quadrant defined by small changes in the context of low degrees of knowledge. The strategy of *disjointed incrementalism* proceeds through partisan mutual adjustment by which agreements are negotiated among individuals with no need of an overarching design. Lindblom's classic statements (1959, 1979) characterize incrementalism as *muddling through* (a term delivered to incrementalists via Popper's critique of its denigration by Karl Mannheim [1940]). These statements often present a more extreme form of incrementalism, no longer merely one of several alternatives (including calculated risk) but rather as the only viable approach to resolving social problems.

For David Collingridge, incremental advances are prudent where consequences of choice are unclear. Such is the case in the emergence of new technologies, and here incrementalist concepts provide a framework for controlling technological development. Collingridge's early work (1980, 1982) attacks the Bayesian account of decision making and articulates the role of flexibility and corrigibility in decision making. In particular the

FIGURE 1



SOURCE: Courtesy of Marvin J. Croy.

Bayesian model is blind to the fact that earlier choices, prescribed by the model, may serve to prevent the adoption of new, better options at a later date. Yet one should choose such that one's future flexibility is not precluded by current choices. The art of choosing options that maintain flexibility thus becomes the cornerstone of Collingridge's theory of decision making and technology control. Controlling technology depends upon two factors, the ability to anticipate undesirable consequences and the ability to avoid such consequences once predicted, but this generates the *dilemma of control.*

> Attempting to control a technology is difficult, and not rarely impossible, because during its early stages, when it can be controlled, not enough can be known about its harmful social consequences to warrant controlling its development; but by the time these consequences are apparent, control has become costly and slow. (Collingridge 1980, p. 19)

This dilemma, which has sometimes been termed the *Collingridge dilemma,* can be resolved either by improving predictability or by increasing controllability. Efforts to improve predictive reliability in the context of infant technologies are absolutely hopeless on Collingridge's view, so resolution occurs only by focusing on the control issue. The manner in which technologies become resistant to change must be understood. Entrenchment occurs because technologies become intertwined so that changing one requires changing many, thus making change costly and slow, if even possible. The solution is to develop technologies in ways that avoid rigidity and maintain flexibility. This may be achieved by implementing corrigible technologies whose flaws can be detected quickly and corrected easily. Continuous monitoring with the aim of finding error is thus imperative. Decisions that keep future options open should always be favored. Collingridge's later work (1992) provides close analyses of several contemporary technologies. These analyses show that the cost of inevitable mistakes can be further reduced through decentralized decision making and non-hierarchical organizational structures. Significantly concern about the unpredictability of technology is no longer limited to the emergence of *new* technologies. The inevitability of error and of predictive unreliability are seen as general conditions of human existence. "We are indeed poor naked creatures . . . People have to make choices under great adversity, where the levels of uncertainty seem bottomless" (Collingridge 1992, p. 3). Like Lindblom, Collingridge's later work takes a more extreme view of the nature and promise of incrementalism.

Additional support for incrementalist principles can be found in the work of Joseph Morone and Edward Woodhouse (1986) where the aim is to explain the *infrequency* of technological disasters. Several strategies facilitate intelligent control of technology, one of which is to "Be actively prepared to learn from error, rather than naively expecting to analyze risks in advance or passively waiting for feedback to emerge" (Morone and Woodhouse 1986, p. 160). In the realm of business operations, James Quinn (1980) concludes that, while most companies have formal planning structures, formal planning has little to do with effective operations. Major strategic decision making occurs outside of the formal planning process. Managers maintain flexibility and avoid premature decisions, delay action as long as feasible to increase feedback and communication, and promote interactive learning. So incremental development may account for successful business management as well as technology development per se.

Theory and Criticism

As indicated, incrementalist thinking emphasizes flexibility and responsiveness, values with roots in the philosophy of Popper and the economic theory of Hayek. Popper's epistemology (1972) emphasizes the inevitability of error and the necessity of devising effective means for learning from mistakes. This is achieved by maximizing opportunities for feedback via experience, especially by subjecting proposals to critical tests and by continuously reshaping ideas in the face of failed predictions. Hayek (1960) opposes the concentration of power in the hands of the few and top-down management via pre-planned, large-scale solutions. Rather he argues that market activity conveys information so as to exploit knowledge distributed throughout society, which results in a bottom-up problem solving. Even effective social institutions can arise by means of decentralized action. These concepts of decentralized decision making, continuous expectation of error, and iterative improvement through active exploitation of mistakes resonate throughout incrementalist thinking.

In respect to criticisms of incrementalism, Collingridge (1992) identifies two categories: critiques that point to successful, non-incremental development and critiques that point to unsuccessful incremental change. Ian Lustick (1980), for instance, argues that non-incremental approaches are superior in achieving safety in nuclear power. Other examples of this type include Paul Schulman (1975, 1980) and Jennifer Hochschild (1984). By contrast, incrementalism is also criticized as too plodding to resolve certain social problems. Sometimes radical innovations are called for in response to radical socioeconomic contingencies. Problems whose severity has quantitative measures, such as air pollution, prove that small-scale change allows desirable goals to gradually slip further away. Or threshold and *sleeper* effects may occur in which large unpredictable changes result from small steps (Dryzek 1987; Mushkat 1987).

A related worry concerns the extent to which incrementalism is too extreme in its distrust of prediction and knowledge. This distrust may derive from concerns expressed by Adam Ferguson and Baron de Montesquieu, and later echoed by Hayek, over the unanticipated consequences that attend all technological innovations. In its extreme forms, incrementalism justifies limiting technological or social programs on the basis of general unpredictability and inadequate knowledge. Nevertheless more than mere inevitability of error is required to justify restricted development. The fact that unexpected consequences, even undesired consequences, will occur fails to make the case. What is needed is some assurance that the magnitude of the unexpected, undesirable consequences will outweigh the magnitude of the expected, desirable consequences. For this, substantial and reliable predictability is required.

Collingridge admits, for example, that not all resources can be committed to maintaining flexibility and that corrigibility and monitoring have costs. These costs must be weighed against that of making an error. Yet if predictability is forsaken, such *error costs* cannot be accurately estimated (Croy 1996). By granting accurate estimation of error costs, Collingridge's case assumes predictive reliability and lapses into inconsistency.

Incrementalism has also been criticized for insensitivity to the political process, both in the attempt to develop technology and to solve social problems. Collingridge has been admonished for not recognizing that determining what counts as an error or mistake is essentially a politically driven judgment (Johnston 1984), and more recent work on incrementalist theory takes pains to deal with the deleterious effect of special interest groups on incremental development (Hayes 2001). In each case, political process complicates the speedy responsiveness to error so crucial for flexibility.

Critiques such as these reveal the connection between incrementalism and controversies surrounding attempts at social progress, particularly those that pit utopian reform against incremental development. Popper's distinction between piecemeal social engineering and utopian engineering paves the way for this connection and for the wide reach of incrementalist concepts. When taken in its less extreme form as one problem solving strategy among many, one that is warranted or not by the nature of the problem confronted, incrementalism withstands critical scrutiny, provides a helpful methodological tool in the quest for improving society, and stimulates questions about the nature of social reform.

MARVIN J. CROY

SEE ALSO *Popper, Karl; Social Engineering.*

BIBLIOGRAPHY

Braybrooke, David, and Charles Lindblom. (1963). *A Strategy of Decision; Policy Evaluation as a Social Process*. New York: Free Press of Glencoe. Collaboration between the philosopher, Braybrooke, and the social scientist, Lindblom, brings early incrementalist thinking into focus. Lindblom's chapters foreshadow future development of incrementalist concepts.

Collingridge, David. (1980). *The Social Control of Technology*. New York: St. Martin's Press.

Collingridge, David. (1982). *Critical Decision Making*. New York: St. Martin's Press.

Collingridge, David. (1992). *The Management of Scale: Big Organizations, Big Decisions, Big Mistakes*. London: Routledge.

Croy, Marvin. (1996). "Collingridge and the Control of Educational Computer Technology." *Techné: Journal of the Society for Philosophy and Technology* 1(3–4): 1–14.

Dahl, Robert, and Charles Lindblom. (1953). *Politics, Economics, and Welfare: Planning and Politico-Economic Systems Resolved into Basic Social Processes*. New York: Harper and Row. Seminal, lucid characterization of incrementalism and its relation to other strategies.

Dryzek, John. (1987). "Complexity and Rationality in Public Life." *Political Studies* 35: 424–442.

Hayek, Friedrich. (1960). *The Constitution of Liberty*. London: Routledge and Kegan Paul.

Hayes, Michael. (2001). *The Limits of Policy Change: Incrementalism, Worldview, and the Rule of Law*. Washington, DC: Georgetown University Press. This work provides a contemporary elaboration of incrementalist principles critically compared against recent case studies. The contributions of Popper and Hayek are clearly delineated.

Hochschild, Jennifer. (1984). *The New American Dilemma: Liberal Democracy and School Desegregation*. New Haven, CT: Yale University Press.

Johnston, Ron. (1984). "Controlling Technology; An Issue for the Social Studies of Science." *Social Studies of Science* 14: 97–113.

Lindblom, Charles. (1959). "The Science of Muddling Through." *Public Administration Review* 19: 79–88.

Lindblom, Charles. (1979). "Still Muddling, Not Yet Through." *Public Administration Review* 39: 517–526.

Lustick, Ian. (1980). "Explaining the Variable Utility of Disjointed Incrementalism: Four Propositions." *The American Political Science Review* 74: 342–353.

Mannheim, Karl. (1967 [1940]). *Man and Society in an Age of Reconstruction; Studies in Modern Social Structure*. New York: Harcourt, Brace & World.

Morone, Joseph, and Edward Woodhouse. (1986). *Averting Catastrophe: Strategies for Regulating Risky Technologies*. Berkeley: University of California Press.

Mushkat, Miron. (1987). "Towards Non-Incremental Strategies in Developing Public Products and Services." *European Journal of Marketing* 21: 66–73.

Popper, Karl. (1972). *Objective Knowledge: An Evolutionary Approach*. London: Oxford University Press.

Quinn, James. (1984). *Strategies for Change: Logical Incrementalism*. New Haven, CT: Yale University Press.

Schulman, Paul. (1975). "Non-Incremental Policy Making." *The American Political Science Review* 69: 1354–1370.

Schulman, Paul. (1980). *Large-Scale Policy Making*. New York: Elsevier.

INDIAN PERSPECTIVES

India (along with China and Egypt) is home to one of the oldest and perhaps the most continuous cultural tradition on the earth. Although it occupies only 2.4 percent of the global land area, it is home to fifteen percent of the population, and by 2050 is projected to be the most populous country in the world. India spends approximately six billion dollars every year on science and technology; science and technology have been central to the country's development since its independence in 1947, while themselves being subject to distinctive assessments and adaptations.

Historical and Cultural Context

Knowledge enjoys sacred stature in Indian culture and civilization. Saraswati, the goddess of knowledge, occupies a place of pride in the Hindu pantheon, while India's much-reviled caste system accorded the highest social status to Brahmins, whose profession was to create and disseminate knowledge. Ancient India's sometimes contested scientific contributions—including theories of gravity, the age of the universe, modern numerals, trigonometry, and the conception of zero—were often first described in religious scriptures. Utilitarian and empirical observations about agriculture and medicine that survived generations were often couched in idioms and expressions with religious connotations. Even during Mughal rule (1526–1707), respect for Indian mathematics was instrumental in its spread to places as far as Central Asia, Spain, and North Africa (Teresi 2002).

Respect for knowledge workers—scientists and doctors—turned to awe during British rule, when science as practiced in Europe took hold through the Geological, Botanical, and Trigonometric Surveys established through the efforts of the Asiatic Society (founded 1784). Although the first voices of dissent—notably of the philosopher Ananda Kentish Coomaraswamy (1877–1947), poet and literature Nobel laureate Sir Rabindranath Tagore (1861–1941), and the father of India's freedom struggle, Mohandas Karamchand Gandhi (1869–1948)—against this surrender to Western science were voiced as early as 1905, they had to wait till the 1970s and 1980s to gain traction through democratic people's movements.

When India became independent after two hundred years of British rule, Gandhi anointed Jawaharlal Nehru (1889–1964) the country's first prime minister. While

Nehru was popular in his own right and received three overwhelming electoral mandates following his appointment in 1947, his elevation to the highest office—although a foregone conclusion—was a curious one.

It was curious because Nehru's and Gandhi's visions of independent India could not have been more different. Nehru's vision of India was that of a highly industrialized and progressive economy where dams, laboratories, industrial facilities, and mechanization would be revered as "temples of modern India" (Nehru 1958, p. 3). Gandhi's vision, conscious of India's predominantly rural base, focused on the rural village as the central element of development and opposed all products of science and technology that displaced human labor. Few, however, shared Gandhi's economic views in the Congress party, and a desire to undertake rapid (state-sponsored) industrialization was articulated as early as 1931 (Chandra, Mukherjee, and Mukherjee 1999).

To Nehru's credit, then, goes the rapid growth of India's industrial infrastructure, the creation of the Council of Scientific and Industrial Research (CSIR), the world's largest chain of publicly-funded research laboratories, the founding of the Indian Institutes of Technology, the country's nuclear and space research programs, and most importantly, the faith that "science alone . . . could solve . . . problems of hunger and poverty, of insanitation and illiteracy, of superstition and deadening custom and tradition, of vast resources running to waste, of a rich country inhabited by starving people" (Gopal 1972, p. 807).

Nehru's investment in science and technology produced the Green Revolution, which is arguably the first significant achievement of mainstream Indian science. India's Green Revolution refers to the enormous improvement in agricultural productivity the nation achieved starting mid-1960s. Thanks to Green Revolution's introduction of a high-yield variety of seeds, fertilizers, and scientific agricultural practices, India's production of food grains increased by thirty-five percent between 1967 and 1970. India, which imported 10.3 million tons of food grains in 1966, had food grain reserves of 128.8 million tons in 1984 and exported 4.8 million tons of food grains in 2001 (Chandra et al. 1999).

While its ecological legacy is sometimes disparaged, the Green Revolution vindicated Nehru's "temples of modern India" and established their legitimacy as effective instruments of development. These institutions have since notched several accomplishments, including supercomputers in response to technology denial from the United States; the production, launch, and utilization of satellite technology; processes to produce raw materials for fuels and textile fibers; and a cheap but effective telecommunication network (Parthasarathi 2003).

Yet academics complain that scientific work accomplished entirely in India is yet to win a Nobel Prize, and the number of peer-reviewed papers decreased by almost twenty percent between 1980 and 2000, even as the number of universities and research institutions almost doubled and funding grew seventeen times (Balaram 2002). Further, corporate innovation and science-based entrepreneurship, notwithstanding several promising efforts, has been limited in scope and success (Turaga 2000). At the same time, China, South Korea, Brazil, and Israel have registered impressive growth, leaving critics to suggest that mainstream Indian science is of a mediocre quality.

Technocracy versus People's Science

Even so, the rapid advent of globalization has dulled dissent and absolute devotion to the technocrat was witnessed as late as 2002, when the renowned missile scientist A. P. J. Abdul Kalam (b. 1931) became independent India's eleventh president. Although elected indirectly, Kalam's nomination received a landslide vote, nationwide support, and near fanatical endorsement from India's educated middle class.

Kalam's disheveled long hair, soft-spoken demeanor, and spartan lifestyle (a bachelor, he lived in a one-bedroom government apartment until he became president) reinforced stereotypes of scholarship and suggested integrity uncommon to recent Indian public life. Kalam became a national icon and household name following India's May 1998 nuclear tests, of which he was the widely recognized scientific architect. What fired the imagination of the nation's educated, however, were Kalam's dreams of a *developed* India constructed through the apolitical pursuit of science and technology as an entirely objective and value-free activity (Kalam 2002).

In sharp contrast to Kalam is the articulate activist Sunita Narain, chairperson of the New Delhi-based radical environmental advocacy group Centre for Science and Environment. Narain has marshaled scientific research, data, and opinion to create immensely popular media campaigns for clean air, water, and food that have eventually influenced public policy. Narain commands enough influence for *India Today*, a leading Indian newsmagazine, to list her as one of India's fifty most powerful and influential citizens in 2004. However, "development is not a road" for Narain, who is severely critical of India's scientific, political, and social establishment (Narain 2003).

The lopsided battle being fought at the crossroads of these conflicting definitions of *development* constitutes a central theme in the emerging interdisciplinary field of Science, Technology, and Society (STS) studies in India. The stronger side in this battle is the statist version of science promoted by the likes of Kalam, whose vision of development is sanitized, crystalline, and sees power plants, dams, roads, factories, and software firms as both instruments and milestones in the quest for India's development. The rapidly growing ranks of the country's educated middle class see in Kalam an unprecedented opportunity to achieve this vision.

Cast against this powerful technocracy is a motley crowd of academics, environmentalists, and social critics with diverse but strong intellectual views. These are people who agitate against dams because of their inhumane consequences on marginalized tribal groups, picket government offices to protest power plants in protected forests, and advocate indigenous, small-scale technologies to harvest water and energy. Not half as focused or strong resource-wise as the statist agenda, these constituents of civil society have covered ground using imaginative ideas, rich rhetoric, moral leadership, articulate spokespersons, and successful grassroots political action.

Critics also question why a developing country like India should invest in supercomputers, satellites, and atomic energy, especially when more Indians sleep hungry than elsewhere in the world, one in three is illiterate and subsists on less than a dollar a day, infant mortality is at sixty-eight per one thousand births, nearly half of all Indian children are malnourished, access to affordable drugs is heterogeneous and available to every other Indian in the best of communities, and only twenty-eight percent of India's population has access to improved sanitation (United Nations 2003, pp. 237–339). That the Indian discourse of ethics in science and technology should raise these questions indicates that Nehru's "temples of modern India" have not been successful enough.

According to critics, the Nehruvian model was never suited to address these problems in the first place and instead has aggravated them. The Booker Prize-winning author Arundhati Roy, for example, estimates that the 3,600 dams India has built have "displaced maybe up to 56 million people" from their farms and livelihoods to the growing ranks of the urban poor (Roy 2001, p. 10). Things would have been different in Gandhi's village-based economy, they argue. Gandhi, however, was not alone critiquing the application of science and technology in the Indian context.

The Swadeshi Movement

The role and effects of modern science on Indian traditions, people, and society was intensively debated as early as 1905, during the *Swadeshi* (local, native, indigenous) Movement, when "the boycott of foreign goods . . . met with the greatest visible success at the practical and popular level" (Chandra, Mukherjee, Mukherjee, et al. 1989, p. 129). Although Swadeshi was a political movement belonging to the larger freedom struggle, "it was accompanied by an efflorescence of cultural debates . . . around the civilizational question of science and state" (Visvanathan 1987, p. 15).

Coomaraswamy was a leading figure in this debate; he was concerned that, lacking concerted effort, India's great craft traditions and art cultures would be lost to modern science. Intermediate technologists such as the British civil servant and founder of the Indian National Congress, Allan Octavian Hume (1829–1912), appreciated, if reluctantly, the rationality of traditional technologies but questioned their viability against the "onslaught of modernity, capitalism, and imperialism" (Visvanathan 1987, p. 17). If intermediate technologists exhorted blending both medieval and modern technological traditions to facilitate meaningful industrialization, Tagore was convinced that the two cultures could converse only after the differences between them were first recognized. It was to facilitate such studies that Tagore created Visva-Bharati University at Santiniketan in eastern India in 1925.

Most of these Swadeshi arguments, however, have gone unaddressed and modern India would disappoint Coomaraswamy, Hume, and Tagore. India's current and future economic growth rests on exporting software services, rendered by engineers educated at institutions (for example, the Indian Institutes of Technology) built with the support of Western universities. Curricula at such universities rarely include STS studies or the traditional technologies that Coomaraswamy wanted to preserve. Globalization and liberalization have relentlessly destroyed Indian communities practicing traditional agriculture and medicine, art, and handicrafts. Although governmental and voluntary initiatives seek to preserve the few remaining bastions of India's cultural traditions, they are a far cry from the "gene pools of an alternative imagination which had to be sustained and eventually made available to the West" (Visvanathan 1987, p. 16).

Future Prospects

Not all is lost, however, and there is cause for optimism in contemporary India. One heartening illustration is the pioneering work of Sulabh International, which has worked with local governments, communities, and vendors to develop a low-cost, environmentally sustainable, and socially acceptable sanitation system for both rural and urban communities. In the past thirty-five years, Sulabh has created fifty thousand jobs through its one million latrine units that have served over ten million people. Similar efforts by several voluntary outfits, people's science movements, and public-spirited initiatives have helped achieve social equity, improved literacy, and better and affordable public health care (United Nations 2003, p. 105).

Even the mainstream scientific establishment is better engaging traditional and indigenous knowledge systems. In the mid-1990s, CSIR successfully contested and overturned a U.S. patent on the use of turmeric powder to heal wounds. The U.S. Patent and Trademark Office upheld CSIR's claims that turmeric has been used in India for centuries and its medical properties are well ingrained in Indian folklore.

Indian scientific agencies have since aggressively espoused the intellectual property rights of India's indigenous communities and encourage research, development, and commercialization of traditional knowledge. Fundamentally, however, India has made a decisive shift towards the Western scientific and technological traditions to derive the same economic and human development benefits realized by developed nations. Thus, when CSIR succeeded in overturning the turmeric patent, it chose to project the victory as the best possible evidence of the integrity, transparency, and objectivity of the international patenting regime, which India began conforming to completely starting 2005.

India is, however, yet to embrace STS concepts such as risk assessment, informed consent, engineering ethics, right to information, and transparency to the extent they are ingrained in the practice of science in the developed West. This will change with economic and technological development, which is occurring rapidly, as well as grassroots people's movements. A greater impetus, however, might come from Western collaborators, who are increasingly using India's modern infrastructure, engineering talent, and large population to cheaply develop products, design cars and factories, and conduct clinical research (Turaga 2003). Illustrating this growing trend is a 2001 controversy involving Johns Hopkins University and a cancer hospital in southern India, where some patients participating in a clinical trial were not informed of the new drug's consequences (Bidwai 2001).

The foremost of Indian polity and society's concerns for the future relate to advancing the quality of its people's economic status, health care, and education. Science and technology are now widely accepted as important to such development. This unquestioning acceptance has been tempered to some extent with grassroots activism and people's movements, which have their origin in India's successful practice of and absolute commitment to democracy. Further, India's globalization will enable the quick assimilation in its public policy of Western principles shaping scientific and technological progress. Thus, the relationship between India—one of the world's most profound civilizations—and science, technology, and ethics will be shaped by two important trends that differ in size and methods, but have goals that share some philosophical similarity.

UDAY T. TURAGA

SEE ALSO *Buddhist Perspectives; Hindu Perspectives.*

BIBLIOGRAPHY

Balaram, P. (2002). "Science in India: Signs of Stagnation." *Current Science* 83(3): 193–194.

Bidwai, P. (2001). "The Misuse of Science." *Frontline* 18(17): 53–55.

Chandra, Bipan, M. Mukherjee, A. Mukherjee, et al. (1989). *India's Struggle for Independence, 1857–1947.* New Delhi: Penguin.

Chandra, Bipan, Aditra Mukherjee, and Mridula Mukherjee. (1999). *India after Independence.* New Delhi: Penguin.

Gopal, Sarvepalli. (1972). *Selected Works of Jawaharlal Nehru,* 15 vol. New Delhi: Oxford University Press.

Kalam, A. P. J. Abdul, and Y. S. Rajan. (1998). *India 2020: A Vision for the New Millennium.* New Delhi: Viking.

Kalam, A. P. J. Abdul. (2002). *Ignited Minds: Unleashing the Power Within.* New Delhi: Viking.

Narain, Sunita. (2003). "Development is Not a Road." *Down To Earth* December 15: 1.

Nehru, Jawaharlal. (1958). *Jawaharlal Nehru's Speeches, March 1953—August 1957,* Volume III. Calcutta: Publications Division, Ministry of Information and Broadcasting, Government of India.

Parthasarathi, Ashok. (2003). "India: A Champion of New Technologies." *Nature* 422: 17–18.

Roy, Arundhati. (2001). "Scimitars in the Sun: N. Ram Interviews Arundhati Roy on a Writer's Place in Politics." *Frontline* January 19: 4–18.

Teresi, Dick. (2002). *Lost Discoveries: The Ancient Roots of Modern Science—from the Babylonians to the Maya.* New York: Simon & Schuster.

Turaga, U. (2000). "India's Techno-Economic Revolution." Chemical Innovation 30(8): 43–49.

Turaga, U. T. (2003). "Outsourcing R&D." *Chemical Engineering Progress* 99(9): 5.

United Nations Development Programme. (2003). *Human Development Report 2003*. New York: Oxford University Press.

Visvanathan, Shiv. (1987). "On Ancestors and Epigones." *Seminar* 330: 14–24.

INDICATORS

SEE *Science and Engineering Indicators*; *Social Indicators*.

INDIGENOUS PEOPLES' PERSPECTIVES

The term *indigenous* is used to refer to the original inhabitants in a region. With regard to human populations, this term can be politically ambiguous, but the concept is still helpful in referring to small-scale societies with distinct languages, mythic narratives, sacred places, and kinship systems. Located on all the major continents (except Antarctica) as well as the Pacific Ocean areas, more than 500 million peoples are considered indigenous. In many contemporary settings these native societies are so marginalized within their nation-state settings and so subject to the extractive exploitation of multinational corporations that their existence is threatened. In these traditional societies the distinctive activities of understanding nature, the technology of subsistence, and an ethics of balance are not separate from one another. Rather, in diverse ways in these different native settings, the interactive relationships of knowing, producing, and thinking about behavior constitute coherent social wholes that can be called worldviews. Indigenous worldviews change over time, yet they also manifest symbols shared with the larger human community in rituals and myths that bind the quest for personal identity, the spirit of community, and ways of knowing the cosmos.

The term *lifeway* is used here to indicate this cultural integration of thought, production, and distribution among indigenous societies. These diverse and integrated perspectives of native peoples have often been dismissed as animism, or *failed epistemologies*, that posited a vitality or life force within the world that entered into all technological activities and ethical considerations. From a social science perspective, no such life force could be measured or consistently observed, and, thus, the worldviews, ethics, and technologies of native peoples were seen as too limited for attention by modern urban societies. However in the early-twenty-first century, the philosophical subtlety and social creativity evident in such native technologies as astronomical and ethnobotanical knowledge, healing therapies, cosmological narratives, and aesthetics of performance evident in ritual performances and rock art petroglyphs (rock incisions) and pictographs (applied paint) are being reassessed.

Approaches to Indigenous Peoples

Early encounters by Western Europeans with indigenous peoples were generally interpreted in the context of the Bible. When indigenous peoples manifested empirical knowledge, productive technology, or disciplined behavior, observers judged the achievements to be God-given and their genesis related to Western scriptures. Thus a naïve view of native peoples as prelapsarian, or living in the original innocence of the edenic paradise, gave rise to a romantic view of indigenous peoples as *noble savages*. From a similar but negative biblical perspective, indigenous peoples, their arts, and their activities were seen as spawned by the devil and deprived of the divine grace of the Western civilized arts. Thus any striking architecture, such as the mounds of the river valleys of Ohio or the Mesoamerican pyramids, was attributed to *lost* biblical tribes, or prehistoric Caucasian influences from Viking navigators or Irish monks. Lacking a coherent social science, early encounter-period European views dismissed as childlike the petroglyphs and pictographs of indigenous peoples. Thus the lyrical hunting scenes in the cave art of Zimbabwe, Botswana, and South Africa, or the numinous presences manifest in the cave art of Australian indigenous peoples was largely interpreted as psychological projection, sympathetic hunting magic, or primitive aesthetic. For indigenous peoples, however, these varied forms of symbolic expression symbolically made present their commitments to place, the numinous forces in local regions, and often their knowledge base regarding animals, plants, land, and weather.

Beginning with the sixteenth-century early modern period, new intellectual perspectives in Western Europe associated with critical, skeptical thought allowed for innovative views of indigenous lifeways. Influenced by the *Jesuit Relations* (1632–1673) as well as limited exchanges with Brazilian native peoples, Michel Montaigne (1533–1592) rejected the idea of native peoples as morally depraved and favorably compared the reported cannibalism of indigenous peoples with the savage brutality of the religious wars of Europe of his

Petroglyphs. These images had deep cultural and religious significance for the societies that created them. *(Field Mark Publications.)*

day. Baron de La Brède et de Montesquieu (1689–1755) in *The Spirit of the Laws* (1748) proposed that the spirit of native societies also resulted in laws, political structures, and social decorum.

By the early-twentieth century, the philosopher Lucien Levy-Bruhl (1857–1939) proposed that indigenous worldviews emerged from a prelogical mentality, intellectually different than the rational, logical Western mind, characterized by *mystical participation* in a pervasive life force (Levy-Bruhl 1923, 1985). His thesis is sharply questioned for projecting a universal mindset on very different peoples, but his emphasis on a cultural logic brought to descriptions of the world is now widely accepted. For native peoples, their perception, knowledge, and explanation of the world relates to their immediate technological-environmental circumstances as well as their linguistic and ideological heritage.

Franz Boas (1858–1942) emphasized *cultural relativity* and oriented a new generation of anthropologists to investigate the knowledge, technologies, and ethics of indigenous peoples as whole systems, or cultures. The anthropologist Claude Levi-Strauss (b. 1908), in *The Savage Mind* (1962), observed that the science and technology of native peoples follows from a mental structure evident in mythologies in which perception and attention to the natural world gradually lead to a cultural world. From a religious perspective, Mircea Eliade (1907–1986) proposed in the 1950s that indigenous peoples embodied technologies and ways of living that were based on seasonal and cosmological cycles rather than linear, historical understandings of reality.

Faced with the description of native North American peoples as the *first ecologists,* scientists in the 1980s questioned the roles of indigenous peoples in the extinction of large mammals, which occurred when native peoples were believed to have migrated to the American hemisphere (Martin and Klein 1984). The scientific understanding of indigenous knowledge continues into the present often including the voices of indigenous elders, artists, and intellectuals who seriously challenge the extinction theory. Acknowledging the roles of native hunters in mammoth and mastodon die-off evident in Clovis and Folsom spear-point technologies, they propose broader considerations of both anthropogenic and natural causes such as climatic change, disease pathogens, and fire (Deloria 1995, Wong 2001).

Indigenous Perspectives

Indigenous perspectives suggest that the art of knowing, or science, and the forces of production, or technology, as well as the sense of appropriate behavior, or ethics, weave together social and cosmological values. That is, knowledge of the world, tools for work, and reflection on one's behavior are properties of persons who are actively engaged with a living environment. Human persons interact with a world alive with dynamic forces that are powerful persons watchful of human behavior. Science, technology, and ethics are not transmitted in traditional thought as ways of controlling nature but primarily as modes of interaction with these other-than-human persons. Indigenous science results from maturing attention to nature as beings-in-the-world having capacities to interact with humans in person-to-person exchanges.

Technology is a way of creating the world, in relation to a task, that a person comes to gradually and internally as much as productively and externally. Ethics among indigenous peoples embodies a cultural relationship with specific places and forms of life in a local region that matures as the person ages. Through ritual and performance arts, such as rock art, basketry, canoe making, beading, and habitat construction, indigenous people express personal and social identity. These coherent, integrated activities place the human person in relation to powerful other-than-human spirit beings that inhabit the cosmos. Thus the personal subjectivity of humans, in indigenous perspectives, is brought to fruition through intersubjectivity with the world of animate forces. Paraphrasing the observations of Thomas Berry (1988), the weave of indigenous science, technology, and ethics is evident in their recognition that the universe is not a collection of objects, but a communion of subjects.

The social and cosmological basis of science, technology, and ethics within indigenous thought stands in sharp contrast to nonnative, European, Western, Marxist, capitalist, or other current globalization views. Broadly speaking, in modern standpoints technology has been identified as technical or mechanical manipulation of inert matter related to work as production. Ethics, following this paradigm, comes before action as intentional thought brought to fruition in activity. In all three acts, namely, science as knowing, technology as work, and ethics as intention, the human is central. The contemporary global ethos associated with urban, industrial societies is wholly anthropocentric. In the indigenous perspective the roles of science, technology, and ethics are integrated into the formation of persons and communities (Ingold 2000). Science, technology, and ethics are not simply anthropocentric acts that psychologically orient individuals and communities inward as the source of ultimate value. Rather indigenous perspectives foster an anthropocosmic orientation in which the living world is central, and the human seeks to balance inner identity and meaning in relation to a holistic outer world.

Indigenous intellectual knowledge exemplified in such inventions as the canoe, the bow and arrow, ritual ceremonies of seasonal renewal, and shamanistic therapies all involve complex interactions of place, spirit persons, and symbolic language. Coupled with the striking traditional environmental knowledge evident, for example, in the extraction and blending of plants to produce the ritual hallucinogen, ayahuasca, they affirm the prowess of science and technology among indigenous peoples. Rarely, however, have observers determined that material, human, and spiritual worlds are separated by the indigenous ethics implicate in those inventions. Becoming an authentic human in indigenous views involves relationship with and treatment of the natural world-as-person. Knowing and using the world implicates one's own body, social setting, and larger cosmological forces.

One Example from the Yekuana Peoples of South America

Among the Yekuana peoples of Venezuela traditional environmental knowledge gives rise to technical skills that foster an ethics, constructed in relation to mythological stories, for progressing gradually into mature personhood. Technical developments, such as the press for extracting yucca, the large circular community houses, as well as forms of social life are considered to have come from the culture hero, Wanadi; whereas all the troublesome, corruptible, dangerous aspects of nature and human life come from Odosha. The complex stories of the birth of Odosha from Wanadi's afterbirth, which was improperly buried, and the consequent yearnings and desires embedded within the natural world serve to teach Yekuana traditional environmental ethics. Each individual Yekuana participates in both the cosmic struggle of Wanadi and Odosha, as well as in the creative presence of Wanadi, for example, in the knowledge, skill, and intention of making yucca presses and especially baskets.

The Yekuana have developed a complex set of ethical teachings connecting the emergence of designs for baskets, the materials for making baskets, and limits on collecting those materials. Set within mythological stories of Wanadi and Odosha, the tense and ambiguous weave of the actual human condition is likened to those cosmological webs of relationships. Among the Yekuana the pragmatic use and location of grasses and roots for basket making are hedged with ethical warnings of the allure of those spirit beings who inhabit the grasses as well as the danger of inappropriate and unlimited use.

The knowledge of these grasses, the technical skills used in weaving them into baskets, and the complex of stories associated with their presence in the region are also directly related to personal maturing and social status (Guss 1989).

These complex cosmological stories braid cognitive-intellectual and affective-emotional realms of human experience into a learned and embodied practice of restraint. In effect, the weaving of baskets among the Yekuana is considered an aesthetic and contemplative skill in which individuals mature in their self-realization of society and bioregion. Thus Yekuana ethics springs from an inherent knowledge of limits with regard to natural consumption.

Conclusion

Indigenous knowledge is traditional in that it informs technical means not as a separate ethical mode but as the cosmological weave of storied knowledge, natural materials, and a respect for beings-in-the-world that limits consumption. No doubt ethical teachings emerged among indigenous peoples because there were those who overstepped cultural boundaries. The examples given here are not descriptive of all individuals within any one particular native community, nor of the diverse ways of knowing, embodying technical skills, and implementing ethical teachings among indigenous peoples. Yet there are shared indigenous perspectives, or *family resemblances*, embodied in science, technology, and ethics as ways of living that arise from the mutual dialogues of body, society, and place in the larger cosmological whole.

JOHN A. GRIM

SEE ALSO *Development Ethics; Globalism and Globalization; Modernization.*

BIBLIOGRAPHY

Basso, Keith. (1996). *Wisdom Sits in Places: Landscape and Language among the Western Apache*. Albuquerque: University of New Mexico Press.

Berry, Thomas. (1988). *The Dream of the Earth*. San Francisco: Sierra Club Books.

Bettinger, Robert. (1991). *Hunter-Gatherers: Archaeological and Evolutionary Theory*. New York: Plenum Press.

Boas, Franz. (1938). *The Mind of Primitive Man*. New York: Macmillan.

Boas, Franz. (2004). *Anthropology and Modern Life*. New Brunswick, NJ: Transaction Publishers.

Deloria, Vine, Jr. (1995). *Red Earth, White Lies: Native Americans and the Myth of Scientific Fact*. New York: Scribner.

Eliade, Mircea. (1985). *Cosmos and History: The Myth of the Eternal Return*. New York: Garland. Originally published in 1959.

French, Michael. (1988). *Invention and Evolution: Design in Nature and Engineering*. London: Longman.

Grim, John, ed. (2001). *Indigenous Traditions and Ecology: The Interbeing of Cosmology and Community*. Cambridge, MA: Harvard Divinity School Center for the Study of World Religions.

Guss, David. (1989). *To Weave and Sing: Art, Symbol, and Narrative in the South American Rain Forest*. Berkeley: University of California Press.

Harvey, Graham, ed. (2000). *Indigenous Religions: A Companion*. London, New York: Cassell.

Hutchins, Edwin. (1995). *Cognition in the Wild*. Cambridge, MA: MIT Press.

Ingold, Tim. (2000). *Perception of the Environment: Essays in Livelihood, Dwelling & Skill*. New York: Routledge.

Levi-Strauss, Claude. (1966). *The Savage Mind*. Chicago: The University of Chicago Press.

Levy-Bruhl, Lucien. (1923). *Primitive Mentality*, trans. Lilian A. Clare. New York: Macmillan.

Levy-Bruhl, Lucien. (1985). *How Natives Think*, trans. Lilian A. Clare. Princeton, N.J.: Princeton University Press. Originally published in 1910.

Martin, Paul, and Richard Klein, eds. (1984). *Quaternary Extinctions: A Prehistoric Revolution*. Tucson: University of Arizona Press.

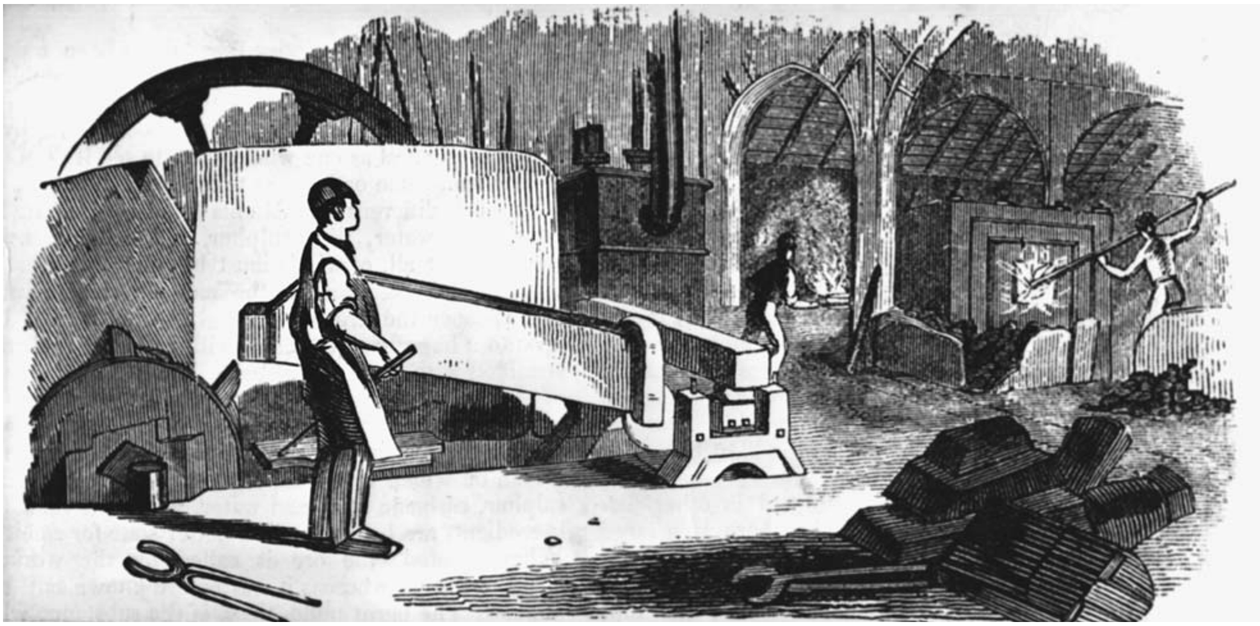
Montesquieu, Baron de La Brède et de. (1994). *The Spirit of the Laws*, trans. G. D. H. Cole. Chicago: Encyclopedia Britannica.

Sahlins, Marshall. (1972). *Stone Age Economics*. Chicago: Aldine-Atherton.

Wong, Kate. (2001) "Mammoth Kill." *Scientific American* 284(2): 22.

INDUSTRIAL REVOLUTION

The concept of an industrial revolution denotes an economic transition in which the means of production become increasingly specialized, mechanized, and organized. This process uses technology, in some association with science, to create large increases in the productive capacity of an economy, which in turn eventually transforms society as a whole. Industrial revolution is less violent or dramatic than political revolution and has roots that extend into the preindustrial agrarian past as well as consequences that continue to influence distant places and times. Great Britain inaugurated the Industrial Revolution in the late eighteenth century, and other nations have undergone similar revolutions in



A puddling furnace. Iron production was the first pillar of the Industrial Revolution. *(Hulton Archive/Getty Images.)*

subsequent years, continuing to the present. This process may be described as a single ongoing Industrial Revolution or as a series of separate revolutions that influence one another. Either way, the Industrial Revolution is without question one of the most important transformations in human history, and it is best understood through an appreciation of its complex origins, its evolution and spread, and its ethical and political influences.

Historical Origins

Most human societies have passed through several broadly defined stages marked by major turning points or revolutions. The transition from nomadic hunting and gathering to settled agriculture (farming and herding) that first occurred in the Near East is often called the Neolithic revolution. By enabling humans to live in one area, grow more numerous, and produce sufficient food surpluses to support nonfarming vocations such as artisanship and soldiery, the Neolithic revolution laid the groundwork for the next stage in societal evolution, the urban revolution. Human history is largely the history of cities and nations, and the gathering of populations into concentrated areas is responsible for many political, cultural, technological, scientific, and other developments. The Industrial Revolution is a third major societal transition point that follows and was made possible by the first two revolutions.

An industrial revolution requires a confluence of favorable labor, capital, technological, and ideological conditions. One vital component of industrialization is a populous labor supply that receives support from an agricultural sector capable of feeding it, and that possesses the necessary skills and discipline for manufacturing work. Capital is vital for covering the start-up and operating expenses that accompany new industrial endeavors, such as the purchase of land, facilities, and machinery; the preparation of stock on hand; the establishment of accounts receivable; and salary payments. Industrialization also depends on technological developments in manufacturing, power generation and transmission, transportation, and raw materials processing. Finally, an industrial revolution is facilitated by the development of political and philosophical ideologies that justify or mandate human organization and control over the natural environment. After many centuries of heterogeneous worldwide population growth, economic development, and technological advancement, all of these conditions converged for the first time in eighteenth-century Great Britain.

The Original Industrial Revolution

A variety of conditions caused Britain to experience moderate economic and manufacturing growth in the early eighteenth century, but these factors produced the greatest effects after 1760. By the 1780s, the British Empire's population, mechanization, and productive output were dramatically expanding. The term "Industrial Revolution" was first formulated by British historian Arnold Toynbee (1884), who considered this period of industrial and technological change more historically significant than political events such as the French Revolution.

Some of the preconditions of the British Industrial Revolution span or even predate the eighteenth century. New agricultural practices, such as the enclosures policies that brought more land under development, Jethro Tull's mechanical drill for sowing seed (c. 1701), Lord Townshend's four-year crop rotation system, advances in animal breeding, and the cultivation of the potato in Ireland, made possible a period of steady population growth. This population included a large supply of available laborers who started to concentrate in towns or cities.

Prior to the existence of large manufacturing establishments, Great Britain fostered a rich craft tradition that provided technological infrastructure and a substantial pool of skilled labor. Farmers comprised more than 90 percent of the preindustrial population, but artisans played a vital economic role. Indeed, while specialized artisans often congregated in cities, many farmers themselves practiced diverse craft trades or produced domestic manufactures in the evening or during winter months, serving as a vast pool of potential labor. This labor was increasingly tapped by enterprising merchants through the putting-out system, which involved the coordination of decentralized part-time laborers and led to regional specialization and the promotion of markets and towns. Early manufacturing networks introduced organizational, managerial, and business strategies that fostered the division of labor, specialization, and greater cooperation between workers or firms.

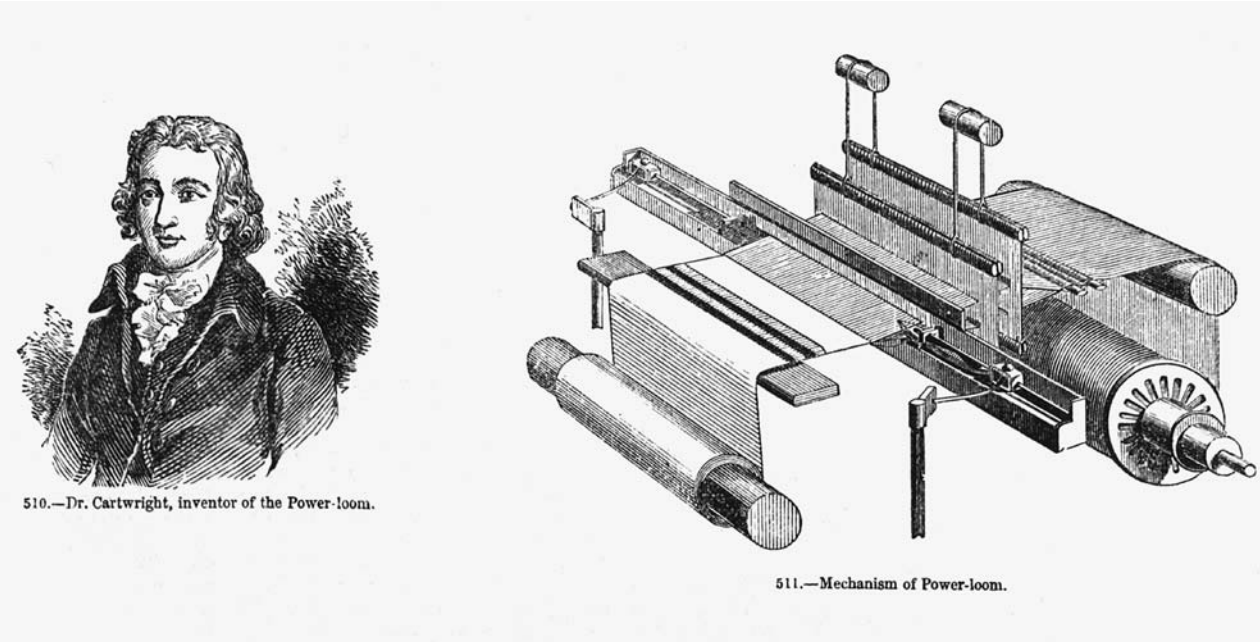
Great Britain also benefited from a convergence of advantageous economic, environmental, and technical factors. It possessed ample supplies of natural resources such as waterpower and coal, and its efficient transportation networks, including turnpike roads and water transport, further aided development. The commanding British navy and merchant network facilitated the shipment of raw materials to the mother country and carried British products to distant colonies or foreign markets. Described as a "nation of shopkeepers," Britain was founded on commerce, and its many merchants and middlemen fostered the spread of the market and funded manufacturing endeavors. Investment capital could also be raised and distributed through an advanced banking system and institutions such as the London Stock Exchange, and favorable regulatory policies (especially in comparison with European practices) enabled British manufacturers to practice their trades with a minimum of government interference. Two hundred years of British economic growth produced a relatively high level of prosperity, a widespread market economy, and a large potential demand for manufactured goods. And because the Industrial Revolution first took place within a capitalist economy, the pursuit of private profit drove the technological and industrial transformation.

What made it possible to take advantage of this confluence in material factors was the contemporary development of new ideals about how human beings could best realize their humanity. A sense of human beings as having the right to dominate the nonhuman world through technology, which had been emerging within a Christian theological framework in Europe, was given new secular articulation by, for instance, Francis Bacon (1561–1626) and his followers. Bacon's ethical vision of "the conquest of nature" for the "relief of man's estate" both justified and encouraged those activities that merged historical changes into a revolution in human industrial activity.

The takeoff of the British Industrial Revolution arose when several key productive sectors used new technologies to increase quantities of low-priced manufactured goods, change employment patterns, and expand technological networks that aided technical innovation and adoption. As the first nation to industrialize, Britain could not receive capital or technological aid from others. Fortunately, the technological challenges of the early Industrial Revolution were relatively simple and were certainly addressable via decentralized and informal experimentation and tinkering.

Iron production was the first technology to influence the British Industrial Revolution, in conjunction with developments in coal processing. Prior to the eighteenth century, British iron production had been increasingly limited by scarce supplies of wood, which was used to make charcoal. Coal was unusable in blast furnaces for various reasons, but in 1709 Abraham Darby discovered that coke, a burnable substance produced from coal, could be used. Technical barriers and quality control issues proved very limiting until 1760, at which point the British iron industry rapidly expanded.

Steam engines served as a second pillar of the Industrial Revolution and had close ties to coal mining and iron production. The Newcomen steam engine, invented by Thomas Newcomen in 1712, was a bulky and inefficient apparatus requiring enormous quantities of coal fuel. These limitations did not deter coal mine operators, who used it to pump water from deep mine shafts. Steam engines also became increasingly important for the iron industry, where they pumped water for water-powered bellows beginning in 1742, drove air



Dr. Edmund Cartwright (left), the inventor of the power loom (right). The textile industry was the third pillar of the Industrial Revolution. *(© Hulton Getty/Liaison Agency.)*

bellows a few years later, and then directly pumped air into furnaces after 1776 via the far more efficient Boulton-Watt steam engine (produced by James Watt and Matthew Boulton). Steam engines freed blast furnaces from the restrictions of water power and were used in different types of factories by the early 1780s.

The third and most visible British technology was the textile industry, which became increasingly mechanized throughout the eighteenth century as self-acting machinery replaced hand manufactures. The weaving process underwent steady productivity increases from early inventions such as the 1733 hand loom and flying shuttle, which caused weaving to outpace yarn production and create yarn shortages. The situation was corrected by subsequent inventions that automated the spinning process, such as James Hargreaves's spinning jenny (c. 1764) and Richard Arkwright's 1769 water frame. Samuel Crompton's 1779 spinning mule combined aspects of earlier spinning technologies and enabled yarn production to outpace weaving technology. This in turn inspired Edmund Cartwright to make a powered weaving loom in 1785. In addition to this technological escalation, the imposition of new organizational schemes in increasingly large textile factories greatly facilitated productivity increases as well as more exacting standards for the production of uniform thread and woven products.

As a result of these industrial developments, relatively high-quality and inexpensive British goods seized control of the home market and led to enormous increases in the demand for manufactured goods and in the standard of living. Mass production (a term first introduced to describe early-twentieth-century industrialization in the United States) helped inspire mass consumption. In addition to the large and steady domestic market, British goods also dominated many overseas markets, aided by Great Britain's colonization efforts, powerful navy, and aggressive merchant network. Great Britain also spurred industry through wartime purchases.

Britain appreciated the benefits it incurred from its sizable technological lead and attempted to guard and maintain this advantage through mercantile policies and the strict prohibition of technology transfer. Of course, other nations attempted to compete with Britain, which led to industrial espionage, the emigration of British technicians, and industrialization in other nations.

Waves of Industrialization

Although Britain led the world in industrial growth through the 1830s, the Industrial Revolution soon spread to other countries. A second wave of industrialization took place from the 1810s to the 1870s in Belgium, France, Germany, and the United States; and a third wave swept through Russia, Japan, Sweden, Italy, and other nations in the decades surrounding 1900. Latecomer nations have several advantages over industrial

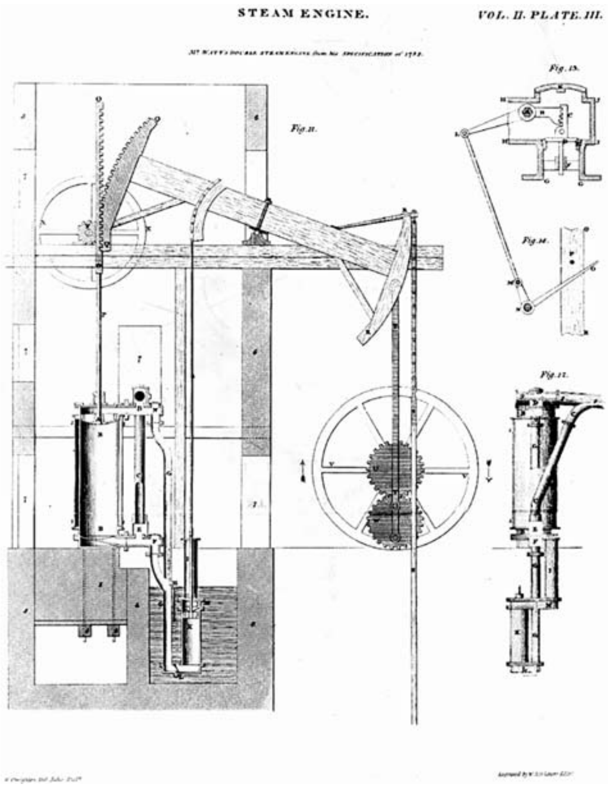


Diagram of the Watt steam engine. The steam engine is seen as the second pillar of the Industrial Revolution. *(The Library of Congress.)*

pioneers: Governments recognize the advantages of industrialization and develop supportive policies; investment capital is often available from individuals or institutions in more advanced economies; and technological expertise can often be borrowed or appropriated from the industrial powers. In addition to the iron, coal, and textile industries, railroads emerged as a fundamental technology of later industrialization. The Industrial Revolution continued to catalyze changes in technological development, managerial and labor organization strategies, economic policy, and consumer behavior.

As with the British example, the nations in the second wave of industrialization experienced long periods of gradual population growth fostered by agricultural improvements, economic and commercial expansion, and technological development that promoted a rapid industrial takeoff. Despite an overall manufacturing output that, as late as the 1780s, was not that far behind Britain, French industrialization was hindered by strong conservative craft and agrarian traditions and setbacks from the French Revolution and Napoleonic Era. France's mid-nineteenth-century growth was driven by widespread rural industry and thriving local markets, and was greatly aided by new government policies and the creation of institutions to collect and distribute investment capital.

Also in the mid-nineteenth century, the Prussian government took an active role in the sponsorship and funding of large-scale industry, and a close family of German banks offered capital and advice to support new industrial ventures. German industrialization truly began after the 1871 unification of the German states, but powerful agricultural interests successfully protected agrarian subsidies at the expense of the industrialists well into the 1890s. German industry also pioneered the inclusion of research laboratories as a well-funded and influential component of manufacturing endeavors, strengthening the link between science and technology.

Finally, industrialization in the United States was hampered by its small, sparse, and rural population; the lack of a strong economy or banking system; and competition from British goods. Many of these inhibiting factors had been reduced or removed by the mid-nineteenth century, and industrialization was aided in the United States by booming population growth, plentiful natural resources, increased access to investment capital, and the import and modification of technologies from Britain.

The end of the nineteenth century introduced an array of new technological products such as chemicals, bicycles, automobiles, and electrical networks; new methods of mass production and factory mechanization; dramatic increases in the quantity of capital required to launch new manufacturing endeavors; and the corresponding development of new capital-raising strategies such as large-scale stock subscriptions and direct government subsidies. Russia and Japan were the two largest economies to industrialize during this third wave of the Industrial Revolution, following Russia's abolition of serfdom and Japan's increasing degree of interaction with foreign nations. Both governments directly and unhesitatingly supported industrialization by running pilot companies, raising taxes or requesting foreign loans to produce investment capital, and establishing pro-industry policies. During the twentieth century the Industrial Revolution continued to evolve and spread to new regions such as China and India.

Indeed, as a result of post–World War II developments in automation, cybernation, and computerization, people began to speak of a second industrial revolution originating in the United States and spreading to other parts of the world. The phenomenon of globalization, which depends on advances in transportation and communication, could also be described as an extension of the industrialization that began in eighteenth-century Great Britain.

Ethics and Politics

The Industrial Revolution affected everyone and everything on the globe, starting with irrevocable alterations to societal development. Individuals and families increasingly left behind their rural agrarian life to gather in urban centers that offered increased access to a staggering variety of jobs, services, and goods, at the cost of health risks and a very different way of life. While the increased productivity of industrialization generally led to rising standards of living and increased consumption, societies became highly stratified and the newly created wealth and luxury items were not shared equally.

Industrial laborers often endured horrible working conditions, such as bad air quality, deafening noise, poor lighting, cramped conditions, lack of sanitation and resultant disease, repetitive work, and dangerous equipment that could cause mutilation and death. Industrialization also imposed a new system of managerial regulation, increased discipline, and the removal of skilled laborers' privileges. When laborers resented or resisted new workplace policies, employers considered them lazy and responded by structuring wages in a manner that forced employees to work long hours at a rapid pace in order to earn a living. This often resulted in the employment of entire families, especially in the textile industry. Unskilled workers frequently lived under the constant threat of unemployment, and even when they were employed their living conditions were often squalid.

The Industrial Revolution may have most affected the lives of women and children. Although advocates of industrialization asserted that contemporary children worked long hours on the farm, children working in factories routinely endured truly nightmarish work environments. Labor laws and other responses to unpleasant child labor conditions gradually shifted the focus of childhood from productivity to education. And although industrialization often forced women to work under horrible conditions for less pay than their male counterparts, this was sometimes mitigated by new opportunities for employed women, such as freedom from the toil or drudgery of farm labor, increased personal and economic freedom, and exposure to urban influences. The Industrial Revolution steadily pushed work out of the family setting and redefined gender and child roles.

These changes inspired extensive commentary from contemporary participants, particularly when the impacts were experienced for the first time in Great Britain. Romantic poets such as William Blake (1757–1827), Victorian novelists such as Charles Dickens (1812–1870), and socialist philosophers such as Friedrich Engels (1820–1895) approached this problem from different perspectives but were united in their association of industrialization with corruption, exploitation, poverty, and other social evils that primarily affected members of the laboring classes. Responses to industrialization included the Luddites' destruction of textile machinery as a means of protesting technological displacement of workers; the promotion of socialist ideals by philosophers such as Engels and Karl Marx (1818–1883); and efforts by Edwin Chadwick (1800–1890) to use the public health movement to establish scientific and technological principles for the improvement of housing and sanitation systems. But on balance, especially under the influence of such ameliorative initiatives, industrialization also clearly improved the material qualities of human life. Versions of these initiatives have been manifested and criticized in other industrializing nations, and debates over the positive and negative impacts continue into the present.

The Industrial Revolution also permanently altered the global power balance. The earliest industrializing nations exerted a substantial and lasting economic and military influence on the nonindustrial world. The growth of industrial economies and trade networks often promoted deindustrialization in less advanced countries that had previously benefited from the sale of handicrafts or other goods. Most nineteenth-century industrial powers practiced imperialism and colonialism, which yielded new supplies of raw materials and new markets and propagated capitalist and Western values throughout the world. In addition, the Industrial Revolution inspired many governments to shift their political philosophy from laissez-faire policies that favored traditional landed interests to proactive social and economic reforms.

Finally, the Industrial Revolution produced previously unimaginable effects on the human–environment relationship. The Industrial Revolution removed many barriers to population growth and accelerated the ability of farmers to produce food more efficiently, leading to an ever-increasing world population. And by increasing fuel use, the supply and demand of manufactured goods, and the scope of extractive tools and machinery, industrialization led to astronomical levels of raw material harvesting and ensuing environmental consequences such as deforestation and air and water pollution. At the same time, the Industrial Revolution firmly connected the scientific tradition to technological development, leading to increased industrial research and development, new standards of education, superior scientific equipment, government funding of science, and renewed support for the increase of human knowledge.

ROBERT MARTELLO

SEE ALSO *Affluence; Christian Perspectives; Colonialism and Postcolonialism; Modernization; Science, Technology, and Society Studies; Work; Urbanization.*

BIBLIOGRAPHY

Ashton, T. S. (1997). *The Industrial Revolution, 1760–1830,* rev. edition, with a new preface and bibliography by Pat Hudson. Oxford: Oxford University Press. This concise study focuses on the beneficial and progress-oriented aspects of the Industrial Revolution, with emphases upon innovation and the revolution's historical context.

Breunig, Charles, and Matthew Levinger. (2002). *The Revolutionary Era, 1789–1850,* 3rd edition. New York: Norton. Offers a general overview of the industrial revolution as well as a contextual study of relevant trends and events in contemporary Europe.

Diamond, Jared. (1999). *Guns, Germs, and Steel: The Fates of Human Societies.* New York: Norton. This expansive work explores the geographical, environmental, and demographic factors that caused human civilizations to develop differently. While it does not explicitly discuss the Industrial Revolution, its explanation of the Neolithic and urban revolutions provide interesting background and a global perspective.

Hobsbawm, Eric. (1962). *The Age of Revolution: Europe, 1789–1848.* London: Weidenfeld and Nicolson. This survey work adopts an economic approach to European history that is sympathetic to workers and the labor movement. Hobsbawm explores the causes and impacts of the industrial revolution at length and also discusses other European events in the same era.

Hobsbawm, Eric. (1999). *Industry and Empire: From 1750 to the Present Day,* revised and updated with Chris Wrigley. New York: New Press. This detailed study explores the political, social, and economic history of the industrial revolution (extending into the late twentieth century), primarily from a Western perspective.

Hughes, Thomas P. (1989). *The American Genesis: A Century of Invention and Technological Enthusiasm, 1870–1970.* New York: Viking. Praises the achievements of technological creativity in the United States during the second wave of industrialization as equivalent in significance to those of the Renaissance.

Landes, David S. (2003). *The Unbound Prometheus: Technical Change and Industrial Development in Western Europe from 1750 to the Present,* 2nd edition. Cambridge, UK: Cambridge University Press. Classic and detailed analysis of the economic and societal causes and impacts of the first industrial revolution, emphasizing the importance of technological enhancements to productive potential and the associated enrollment of natural, human, and financial resources.

Mokyr, Joel. (1990). *The Lever of Riches.* New York: Oxford University Press. A historical approach to technological creativity, exploring the many factors that give some nations innovative advantages over others, as well as the economic and social impacts of creativity.

Pacey, Arnold. (1990). *Technology in World Civilization: A Thousand-Year History.* Cambridge, MA: MIT Press. A global approach to the history of technology, concisely highlighting the impact of technology transfers and industrial development upon different civilizations' economies and societies.

Simon, Julian L., ed. (1995). *The State Of Humanity.* Oxford: Blackwell. Collects fifty-eight original articles arguing that industrialization has created across-the-board material benefits for all segments of society.

Toynbee, Arnold. (1884). *Lectures on The Industrial Revolution in England.* London: Rivingtons. First use of the phrase "industrial revolution" to describe the great industrial and economic changes faced by great Britain at the end of the eighteenth century.

INFORMATION

Science, technology, and ethics are all forms of information that depend *on* information to work. Furthermore there exist sciences, technologies, and ethics *of* information. To disentangle some of the main relations among these aspects of information, it is helpful to start with a simple example.

Monday morning. John turns the ignition key of his car, but nothing happens: The engine does not even cough. Not surprisingly the low-battery indicator is flashing. After a few more unsuccessful attempts, John calls the garage and explains that, last night, his wife had forgotten to turn off the car's lights—this is a lie, John did but is too ashamed to admit it—and now the battery is dead. John is told that the car's operation manual explains how to use jumper cables to start the engine. Luckily his neighbor has everything John needs. He follows the instructions, starts the car, and drives to the office.

This everyday example illustrates the many ways in which people understand one of their most important resources: information. The information galaxy is vast, and this entry will explore only two main areas: information as content and information as communication. The reader interested in knowing more about the philosophical analysis of the concept should consult the work of Jaakko Hintikka and Patrick Suppes (1970), Philip P. Hanson (1990), and Fred I. Dretske (1999).

Information as Content

It is common to think of information as consisting of *data* (Floridi 2005). An intuitive way of grasping the notion of data is to imagine an answer without a question. Ultimately data may be described as relational differences: a 0 instead of a 1; a red light flashing; a high or low charge in a battery.

To become information, data need to be *well-formed* and *meaningful*. Well-formed means that data are clustered together correctly, according to the rules (syntax) of the chosen language or code. For example, the operation manual from the example above shows the batteries of two cars placed one next to, not one on top of, the other. Meaningful indicates that the data must also comply with the meanings (semantics) of the chosen language or code. So the operation manual contains illustrations that are immediately recognizable.

When meaningful and well-formed data are used to talk about the world and describe it, the result is *semantic content* (Bar-Hillel and Carnap 1953, Bar-Hillel 1964). Semantic content has a twofold function. Like a pair of pincers, it picks up from or about a situation, a fact, or a state of affairs *f*, and models or describes *f*. *The battery is dead* carves and extracts this piece of information—that the battery of the car is dead—and uses it to model reality into a semantic world in which the battery is dead. Whether the work done by the specific pair of pincers is satisfactory depends on the resource *f* (realism) and on the purpose for which the pincers are being used (teleologism). Realistically *the battery is dead* is true. Teleologically it is successful given the goal of communicating to the garage the nature of the problem. *The battery is dead* would be realistically false and teleologically unsatisfactory if it were used, for instance, to provide an example of something being deceased.

INFORMATION AS TRUE SEMANTIC CONTENT. *True semantic content* is perhaps the most common sense in which information can be understood (Floridi 2005). It is also one of the most important ways, since information as true semantic content is a necessary condition for knowledge. Some elaboration of this concept is in order. First the data that constitute information allow or invite certain constructs and resist or impede others. Data in this respect work as *constraining affordances*. Second the data are never accessed and elaborated independently of a *level of abstraction* (LoA). An LoA is like an interface that establishes the scope and type of data that will be available as a resource for the generation of information (Floridi and Sanders 2004). *The battery is what provides electricity to the car* is a typical example of information elaborated at a driver's LoA. An engineer's LoA may output something like *a 12-volt lead-acid battery is made up of six cells, each cell producing approximately 2.1 volts*, and an economist's LoA may suggest that *a good quality car battery will cost between $50 and $100 and, if properly maintained, it should last five years or more*. Data as constraining affordances—answers waiting for the relevant questions—are transformed into information by being processed semantically at a given LoA (alternatively the right question is associated to the right data at a given LoA).

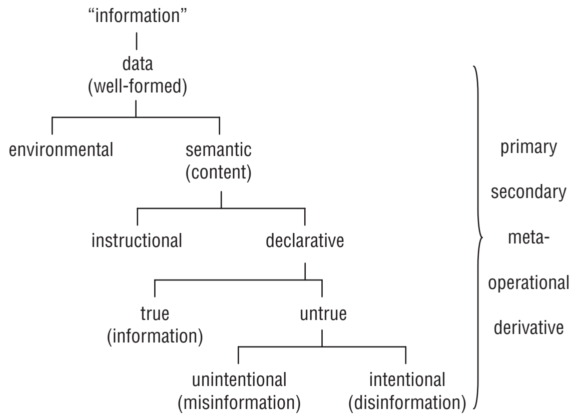
Once information is available, knowledge can be built in terms of *justified* or *explained information*, thus providing the basis of any further scientific investigation. One knows that the battery is dead not by merely guessing correctly, but because one sees the red light of the low-battery indicator flashing and perceives that the engine does not start. The fact that data count as *resources* for information, and hence for knowledge, rather than *sources*, provides a constructionist argument against any representationalist theory that interprets knowledge as a sort of picture of the world.

An instance of *misinformation* arises when some semantic content is false (untrue) (Fox 1983). If the source of the misinformation is aware that the semantic content is false, one may speak of *disinformation*, for example *my wife left the lights on*. Disinformation and misinformation are ethically censurable but may be successful teleologically: If one tells the mechanic that one's wife left the lights on last night, the mechanic will still be able to provide the right advice. Likewise information may fail to be teleologically successful; just imagine telling the mechanic that one's car is out of order.

INSTRUCTIONAL INFORMATION. True semantic content is not the only type of information. The operation manual, for example, also provides *instructional information*, either imperatively—in the form of a recipe: First do this, then do that—or conditionally—in the form of some inferential procedure: If such and such is the case do this, otherwise do that. Instructional information is not about *f* and does not model *f*: It constitutes or instantiates f, that is, it is supposed to make *f* happen. The printed score of a musical composition or the digital files of a program are typical cases of instructional information. The latter clearly has a semantic side. And semantic and instructional information may be joined in performative contexts, such as christening a vessel—for example, "this ship is now called *HMS The Informer*"—or programming—for example, when declaring the type of a variable. Finally the two types of information may come together in magic spells, where

FIGURE 1

The Taxonomy of Information



SOURCE: Courtesy of Luciano Floridi.

The figure illustrates how some of the main types of information may be related into a tree-like structure.

semantic modeling is confused with instructional power and control. Yet, as a test, one should recall that instructional information does not qualify alethically (from *aletheia,* the Greek word for truth). In the example, it would be silly to ask whether *only use batteries with the same-rated voltage* is true or false.

ENVIRONMENTAL INFORMATION. When John turned the ignition key, the low-battery indicator flashed. He translated the flashing into (a) semantic information: The battery is dead; and (b) instructional information: The battery needs to be charged or replaced. However the flashing of the indicator is actually an example of *environmental information*.

Environmental information may be described as *natural data:* It requires two systems *a* and *b* to be coupled in such a way that *a* being (of type, or in state) *F* is correlated to *b* being (of type, or in state) G, thus carrying to the observer the information that *b* is G (Jon Barwise and Jerry Seligman provide a similar analysis based on Dretske 1999). The correlation is usually *nomical* (it follows some law). It may be engineered—as in the case of the low-battery indicator (*a*) whose flashing (*F*) is triggered by, and hence is informative about, the battery (*b*) being dead (G). Or it may be natural, as when litmus—a coloring matter from lichens—is used as an acid-alkali indicator (litmus turns red in acid solutions and blue in alkaline solutions). Other typical examples include the correlation between fingerprints and personal identification, or between the age of a plant and its growth rings.

One may be so used to equating the low-battery indicator flashing with the information (that is, meaning) that the battery is dead as to find it hard to distinguish sufficiently between environmental and semantic information. However it is important to remember that environmental information may require or involve no semantics at all. It may consist of correlated data understood as mere differences or constraining affordances. Plants (e.g., a sunflower), animals (e.g., an amoeba) and mechanisms (e.g., a photocell) are certainly capable of making practical use of environmental information even in the absence of any (semantic processing of) meaningful data. Figure 1 summarizes the main distinctions introduced so far.

FIVE TYPES OF INFORMATION. More detail may now be added. First it should be emphasized that the actual *format, medium,* and *language* in which information is encoded is often irrelevant. The same semantic, instructional, and environmental information may be analog or digital, printed on paper or viewed on a screen, or in English or some other language. Second thus far it has been implicitly assumed that *primary* information is the central issue: things like the low-battery indicator flashing, or the words *the battery is dead* spoken over the phone. But remember how John discovered that the battery was dead. The engine failed to make any of the usual noises. Likewise in Sir Arthur Conan Doyle's *Silver Blaze* (1892), Sherlock Holmes solves the case by noting something that has escaped everybody else's attention, the unusual silence of the dog. Clearly silence may be very informative. This is a peculiarity of information: Its absence may also be informative. When it is, the difference may be explained by speaking of *secondary information*.

Apart from secondary information, three other typologies are worth some explanation since they are quite common (the terminology is still far from being standard or fixed, but see Floridi 1999b). *Metainformation* is information about the nature of information. "*The battery is dead is encoded in English'' is a simple example*. *Operational information* is information about the dynamics of information. Suppose the car has a yellow light that, when flashing, indicates the entire system that checks that the electronic components of the car is malfunctioning. The fact that the light is off indicates that the low-battery indicator is working properly, thus confirming that the battery is indeed dead. Finally *derivative information* is information that can be extracted from any form of information whenever the latter is used as a source in search of patterns, clues, or inferential evidence, namely for comparative and quantitative analyses. From a credit card bill concerning the purchase of gasoline, one may derive information about the cardholder's whereabouts at a given time.

Information as Communication

Also important is the concept of information as communication, as in the sense of a transmitted message (Cherry 1978). Some features of information are intuitively quantitative. Information can be *encoded, stored*, and *transmitted*. One also expects it to be *additive* (information *a* + information *b* = information *a* + *b*) and *non-negative*. Similar properties of information are investigated by the *mathematical theory of communication* (MTC, also known as *information theory;* for an accessible introduction, see Jones 1979).

MTC was developed by Claude E. Shannon (Shannon and Weaver 1998 [1949]) with the primary aim of devising efficient ways of encoding and transferring data. Its two fundamental problems are the ultimate level of data compression (how small can a message be, given the same amount of information to be encoded?) and the ultimate rate of data transmission (how fast can data be transmitted over a channel?). To understand this approach, consider the telephone call to the garage.

The telephone communication with the mechanic is a specific case of a general communication model. The model is described in Figure 2.

John is the *informer*, the mechanic is the *informee*, *the battery is dead* is the message (*the informant*), there is a coding and decoding procedure through a language (English), a channel of communication (the telephone system), and some possible noise. Informer and informee share the same background knowledge about the collection of usable symbols (the *alphabet*).

MTC treats information as only a selection of symbols from a set of possible symbols, so a simple way of grasping how MTC quantifies *raw information* is by considering the number of yes/no questions required to guess what the informer is communicating. When a fair coin is tossed, one question is sufficient to guess whether the outcome is heads (*h*) or tails (*t*). Therefore a binary source, like a coin, is said to produce one bit of information. A two-fair-coins system produces four ordered outputs: <*h*, *h*, *h*, *t*, *t*, *h*, *t*, *t*> and therefore requires two questions, each output containing two bits of information, and so on. In the example, the low-battery indicator is also a binary device: If it works properly, it either flashes or it does not, exactly like a tossed coin. And since it is more unlikely that it flashes, when it does, the red light is very informative. More generally the lower the probability of *p* the more informative the occurrence of *p* is (unfortunately this leads to the paradoxical view that a contradiction—which has probability 0—is the most informative of all contents, unless one maintains that, to qualify as information, *p* needs to be true [Floridi 2004]).

Before the coin is tossed, the informee does not *know* which symbol the device will actually produce, so it is in a state of *data deficit* equal to 1 (Shannon's *uncertainty*). Once the coin has been tossed, the system produces an amount of raw information that is a function of the possible outputs, in this case two equiprobable symbols, and equal to the data deficit that it removes. The reasoning applies equally well to the letters used in your telephone conversation with the mechanic.

The analysis can be generalized. Call the number of possible symbols *N*. For *N* = 1, the amount of information produced by a unary device is 0. For *N* = 2, by producing an equiprobable symbol, the device delivers one unit of information. And for *N* = 4, by producing an equiprobable symbol, the device delivers the sum of the amount of information provided by coin *A* plus the amount of information provided by coin *B*, that is two units of information. Given an alphabet of *N* equiprobable symbols, it is possible to rephrase some examples more precisely by using the following equation: log 2 (*N*) = bits of information per symbol.

Things are made more complicated by the fact that real coins are always *biased*, and so are low-battery indicators. Likewise in John's conversation with the mechanic a word like *batter* will make *y* as the next letter almost certain. To calculate how much information a biased device produces, one must rely on the frequency of the occurrences of symbols in a finite series of occurrences, or on their probabilities, if the occurrences are supposed to go on indefinitely. Once probabilities are taken into account, the previous equation becomes Shannon's formula (where *H* = uncertainty, what has been called above data deficit):

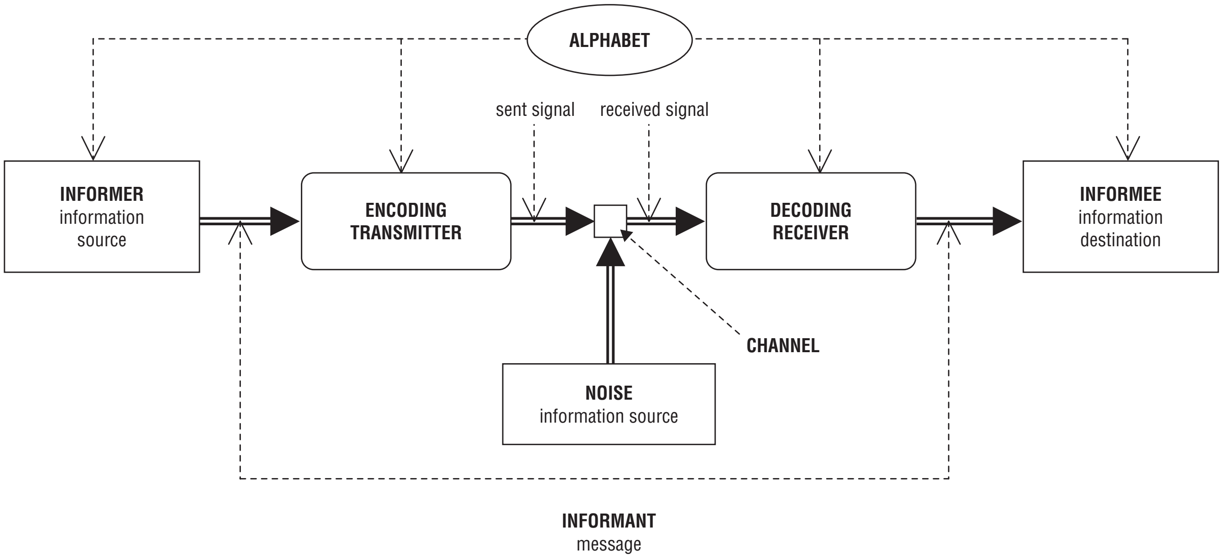
$$H = -\sum_{i=1}^{N} P_i \log P_i (\text{bits per symbol})$$

The quantitative approach just outlined plays a fundamental role in coding theory, hence in cryptography, and in data storage and transmission techniques, which are based on the same principles and concepts. Two of them are so important as to deserve a brief explanation: *redundancy* and noise.

Redundancy refers to the difference between the physical representation of a message and the mathematical representation of the same message that uses no more bits than necessary. It is basically what can be taken away from a message without loss in

FIGURE 2

The Communication Model



SOURCE: Courtesy of Luciano Floridi.

The figure illustrates the main elements and their relations in the communication model according to Shannon's approach.

communication. John's statement that his wife was responsible for the dead battery was redundant.

Compression procedures work by reducing data redundancy, but redundancy is not always a bad thing, for it can help to counteract *equivocation* (data sent but never received) and noise (received but unwanted data, like some interference). A message + noise contains more data than the original message by itself, but the aim of a communication process is *fidelity*, the accurate transfer of the original message from sender to receiver, not data increase. The informee is more likely to reconstruct a message correctly at the end of the transmission if some degree of redundancy counterbalances the inevitable noise and equivocation introduced by the physical process of communication and the environment. This is why, over the phone, John said that *the battery is dead* and that *the lights were left on last night*. It was the *by whom* that was uselessly redundant.

MTC is not a theory of information in the ordinary sense of the word. The term raw information has been used to stress the fact that in MTC information has an entirely technical meaning. Two equiprobable *yeses* contain the same quantity of raw information, regardless of whether their corresponding questions are *Is the battery dead?* or *Is your wife missing?* Likewise if one knows that a device could send with equal probabilities either this whole encyclopedia or just a quote for its price, by receiving one or the other message one would receive very different quantities of data bytes but only one bit of raw information. Since MTC is a theory of information without meaning, and since information – meaning = data, *mathematical theory of data communication* is a far more appropriate description than *information theory*.

MTC deals not with semantic information itself but with messages constituted by uninterpreted symbols encoded in well-formed strings of signals, so it is commonly described as a study of information at the *syntactic* level. This generates some confusion because one may think the syntactic versus semantic dichotomy to be exhaustive. Clearly MTC can be applied in information and communication technologies (ICT) successfully because computers are syntactical devices. It is often through MTC that information becomes a central concept and topic of research in disciplines like chemistry, biology, physics, cognitive science, neuroscience, the philosophy of information (Floridi 2002, Floridi 2004a), and computer ethics (Floridi 1999a).

LUCIANO FLORIDI

SEE ALSO *Computer Ethics; Cybernetics; Digital Libraries; Geographic Information Systems; Information Overload; Information Society; Internet; Wiener, Norbert.*

BIBLIOGRAPHY

Bar-Hillel, Yehoshua. (1964). *Language and Information: Selected Essays on Their Theory and Application*. Reading, MA; London: Addison-Wesley. Important collection of relevant essays by one of the philosophers who first tried to apply information theory to semantic information.

Bar-Hillel, Yehoshua, and Rudolf Carnap. (1953). "An Outline of a Theory of Semantic Information." In *Language and Information: Selected Essays on Their Theory and Application* Reading, MA; London: Addison-Wesley. Influential attempt to quantify semantic information.

Barwise, Jon, and Jerry Seligman. (1997). *Information Flow: The Logic of Distributed Systems*. Cambridge, UK: Cambridge University Press. Applies situation logic to the study of the dynamics of information.

Cherry, Colin. (1978). *On Human Communication: A Review, a Survey, and a Criticism*, 3rd edition. Cambridge, MA: MIT Press.

Dretske, Fred I. (1999). *Knowledge and the Flow of Information*. Stanford, CA: CSLI Publications. Originally published in 1981, Cambridge, MA: MIT Press. A simple and informative introduction to the mathematical theory of communication, even if no longer up-to-date.

Floridi, Luciano. (1999a). "Information Ethics: On the Theoretical Foundations of Computer Ethics." *Ethics and Information Technology* 1(1): 37–56. Provides a first foundation for an approach in computer ethics known as information ethics.

Floridi, Luciano. (1999b). *Philosophy and Computing: An Introduction*. London, New York: Routledge. Textbook introduction for philosophy students to computer science and its conceptual challenges.

Floridi, Luciano. (2002). "What Is the Philosophy of Information?" *Metaphilosophy* 33(1–2): 123–145. Provides a definition of the philosophy of information as a area of research.

Floridi, Luciano. (2004). "Outline of a Theory of Strongly Semantic Information." *Minds and Machines* 14(2): 197–222. Defends a theory of semantic information based on a veridical interpretation of information, in order to solve the Bar-Hillel-Carnap paradox.

Floridi, Luciano, and J. W. Sanders. (2004). "The Method of Abstraction" In *Yearbook of the Artificial: Nature, Culture and Technology: Models in Contemporary Sciences*, ed. Massimo Negrotti. Bern: Peter Lang. Develops the method of abstraction for philosophical analysis.

Floridi, Luciano. (2005). "Is Information Meaningful Data?" *Philosophy and Phenomenological Research* 70(2): 351–370. Defends the thesis that information encapsulates truth, hence that "false" in "false information" is to be understood as meaning "not authentic."

Fox, Christopher J. (1983). *Information and Misinformation: An Investigation of the Notions of Information, Misinformation, Informing, and Misinforming*. Westport, CT: Greenwood Press. Overview of the concepts mentioned in the title from an information science perspective.

Hanson, Philip P., ed. (1990). *Information, Language, and Cognition*. Vancouver: University of British Columbia Press. Proceedings of an influential conference on semantic information.

Hintikka, Jaakko, and Patrick Suppes, eds. (1970). *Information and Inference*. Dordrecht, The Netherlands: Reidel. Influential collection of essays on the philosohy of semantic information.

Jones, Douglas Samuel. (1979). *Elementary Information Theory*. Oxford: Clarendon Press. Excellent introduction to the mathematical theory of communication for the mathematically uninitiated.

Shannon, Claude E., and Warren Weaver. (1998 [1949]). *The Mathematical Theory of Communication*. Urbana: University of Illinois Press. Classic presentation of the fundamental results in the mathematical theory of communication.

INFORMATION ETHICS

Information ethics is a field of applied ethics that addresses the uses and abuses of information, information technology, and information systems for personal, professional, and public decision making. For example, is it okay to download someone else's intellectual property like pictures or music? Should librarians ever remove controversial books from the shelves or monitor users' Internet searching? Should a scientist post the genome for the Ebola virus on the Internet?

Information ethics provides a framework for critical reflection on the creation, control, and use of information. It raises questions about information ownership and access to intellectual property, the rights of people to read and to explore the World Wide Web as they choose. Information ethicists explore and evaluate the development of moral values, the creation of new power structures, information myths, and the resolution of ethical conflicts in the information society (Capurro 2001). If bioethics addresses living systems, then information ethics similarly covers information systems. Where bioethics evolved from medical ethics after World War II to engage the broader implications of societal changes such as informed consent and reproductive rights, information ethics grew out of the professional ethics traditions of librarians and early information professionals in order to describe and evaluate the competing interests that sought to control the information assets of a high-tech society (Smith 1997). Like other areas of applied ethics in science and technology, information ethics focuses on social responsibility and the meaning of humanity in relation to machines.

Built from the codes and commitments of professional librarians to protect the right to read, fight censorship, protect patron privacy, assure confidentiality of library records, and provide service for everyone, information ethics has extended these traditions into cyberspace. The term information ethics first appeared in the literature of library and information science in the late 1980's (Hauptman) alongside other terms such as information technology ethics, cataloging ethics, and archival ethics. In the next few years, information ethics grew to encompass dilemmas facing librarians and information professionals (Mason, Mason, and Culnan 1995) as they introduced new information and communications technologies (ICTs) to public, academic, and special libraries and also into publishing, healthcare, and the new information industry.

Today information ethics encompasses a wide range of issues involving the creation, acquisition, organization, management, translation, duplication, storage, retrieval, and any other processes involving printed or digital texts, graphics, voice, and video. Information ethics can address any issue relating to the *Information Society* or the *Knowledge Economy*. As a field of applied ethics, it draws upon historical and philosophical insights (Floridi 1999) in order to describe current problems such as bridging the digital divide and to craft normative solutions for personal and professional conduct and for public policy (Tavani 2003).

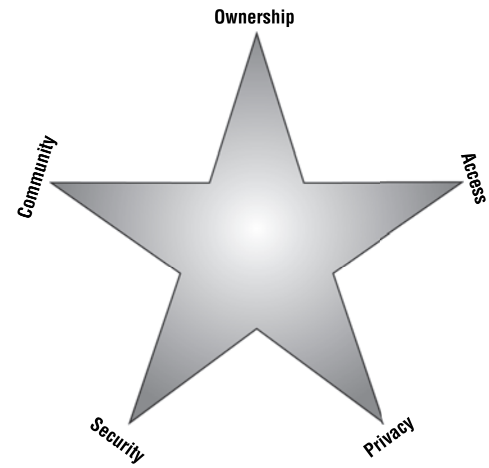
The Historical Context

In the mid-fifteenth century, Johannes Gutenberg's invention of the movable type printing press altered the parameters of information access and control and began to change the world. Widespread dissemination of printed information helped to change the balance of power in Europe, notably contributing to the sixteenth-century Protestant Reformation, disruptions to the political power of the Roman Catholic Church, and the rise of the nation-state.

In the mid-twentieth century, Claude Shannon (1948) and others developed elegant mathematical theories that made modern information technologies possible while other advances, such as the development of the atomic bomb, made the risks and rewards of widespread scientific and technological knowledge more significant and more visible in everyday life. Since then the increasing volume of digitized information and the exponential improvements in digital processing, storage, and communication have again altered the landscape of information access and control.

FIGURE 1

Five Themes in Information Ethics



SOURCE: Adapted from Smith, Martha. (2001). "Global Information Justice: Rights, Responsibilities, and Caring Connections." *Library Trends* 49 (3): 525, figure 6.

The COAPS star suggests the potential both for overlap and conflict amongst five infoethical themes.

Alongside the technological advances that have occurred since the mid-twentieth century, formal consideration of the uses and abuses of information began even before it was designated information ethics, or *infoethics*. The UN General Assembly raised many infoethical themes in the Universal Declaration of Human Rights (1948) including information access (Article 19), intellectual property (Article 27), privacy (Article 12), security (Articles 17 and 27), community (Article 27), and education (Article 26). Since then, the role of information in government, healthcare, and business, and concerns about the uses of that information, have continued to fuel public policy debates. The UN Educational, Scientific and Cultural Organization (UNESCO) uses the term information ethics to focus attention on global problems ranging from literacy, including cell phone access in the developing world, the need to protect local cultures and languages from the dominance of English on the Internet, and the ramifications of expanding databases of genetic information.

In the last fifteen years, information ethics has also evolved within and beyond its early professional and academic communities. Its academic vitality is evident in the formation of scholarly associations such as the International Society for Ethics and Information Technology (INSEIT), scholarly websites such as the International

TABLE 1

Most Challenged Books, 2002

Title and Author	Sexual Content	Offensive Language	Unsuitable to Age	Wizardry, Occult	Racism	Insensitivity	Violence	Disobedience
Harry Potter series, J.K. Rowling A young wizard studies magic and battles evil.				✓				
Alice series, Phyllis Reynolds Naylor Alice searches for a female role model.	✓	✓	✓					
The Chocolate War, Robert Cormier Jerry challenges the high school power structure.		✓	✓					
I Know Why the Caged Bird Sings, Maya Angelou Autobiography of an African American poet.	✓	✓	✓		✓		✓	
Taming the Star Runner, S. E. Hinton A talented, urban punk exiled to a farm.		✓						
Captain Underpants, Dav Pilkey Comic battles with Dr. Diaper and talking toilets.			✓			✓		✓
The Adventures of Huckleberry Finn, Mark Twain Classic novel of a boy's journey down the Mississippi.		✓			✓	✓		
Bridge to Terabithia, Katherine Paterson Friends reign in a fantasy kingdom in the woods.	✓	✓		✓				
Roll of Thunder, Hear My Cry, Mildred D. Taylor African-American family struggles to stay together in the 1930s South.		✓			✓	✓		
Julie of the Wolves, Jean Craighead George Can Julie/Miyax survive with wolves in the Alaskan wilderness?	✓	✓	✓				✓	

SOURCE: Adapted from ALA Office of Information Freedom. (2003). "Ten Most Frequently Challenged Books for 2002."Available from http://www.ala.org/ala/oif.

Book challenges illustrate the ethical tension between freedom of information and other values.

Center for Info Ethics (ICIE), and journals such as *The Information Society* (1981), *Journal of Information Ethics* (1992), *Science and Engineering Ethics* (1995), *Ethics and Information Technology* (1999), and *International Review of Information Ethics* (2004). The growing number of books and journal articles that address ethics in academic and professional literature indicates the expanding recognition of and participation in the field.

Key Ethical Themes

From the perspective of information ethics, there are five important themes to be considered: *community*, *ownership*, *access*, *privacy*, and *security* (COAPS; see Figure 1). As a framework, the COAPS themes help to guide ethical analysis and aid the discovery of underlying conflicts, as illustrated by ethical questions that have emerged since the mid-twentieth century.

Does the anonymity of the web encourage or detract from *community* formation online?

Who *owns* e-mail messages on a corporate e-mail server, and who can read them?

Do patients have a right of *access* to information about a terminal illness?

Do libraries and librarians have an obligation to protect the *privacy* of patron records?

Does personal *security* warrant the widespread use of surveillance cameras in public places?

Community

In an 1813 letter, Thomas Jefferson distinguished goods that are lessened and ideas that are multiplied when shared:

> He who receives an idea from me, receives instruction himself without lessening mine; as he who lights his taper at mine receives light without darkening me.

The distinction has become increasingly salient over time. Future creative work builds on past creative work. All branches of science have flourished since the Royal Society of London first published the *Philosophical Transactions* in 1765, establishing a creative commons of scientific work for scrutiny, criticism, and derivation.

TABLE 2

Post 9/11 U.S. Government Legislation and Programs

Legislation or Program Name	Summary
Terrorism Information Awareness Program (TIA)	.. "search[ing] for indications of terrorist activities in vast quantities of data."
Uniting and Strengthening America by Providing Appropriate Tools Required to Intercept and Obstruct Terrorism Act of 2001 (USA PATRIOT)	Grants law enforcement broad rights of search and surveillance with limited judicial oversight.
Computer Assisted Passenger Pre-screening System II (CAPPS II)	Focused on identifying and computing risk score for airline passengers.

SOURCE: Defense Advanced Research Program Agency (DARPA), http://www.darpa.mil; Electronic Privacy Information Center (EPIC), http://www.epic.org; American Civil Liberties Union (ACLU), http://www.aclu.org.

Legislation and government programs illustrate the ethical tensions that arise between the search for security and the desire for privacy.

While ideas on paper may be expensive to reproduce and awkward to distribute, they have demonstrated great power. Creativity requires a balance of access, to make future creative work possible, and control to make creative work worthwhile. The U.S. Constitution, Article 1, Section 8, establishes such a balance by granting inventors limited-term, exclusive rights to exploit their inventions, in exchange for full disclosure for the benefit of future inventors. Lawrence Lessig (2001) has written and spoken extensively about the intellectual and creative commons. In 2002, Lessig and others founded Creative Commons (http://www.creativecommons.org), "devoted to expanding the range of creative work available for others to build upon and share."

For software, the *open source* movement, described by Eric Raymond (1999), encourages community and collaboration by requiring programmers to share software source code and to allow the creation of derivative works. The widely deployed Linux operating system and Apache web server demonstrate the multiplicative benefits of a creative software commons.

Ownership

Modern technology, practice, and law allow tight control over the communication of and access to ideas, threatening the creative commons and future creative works. For example, while Charles Dickens's *Oliver Twist* (1837) exists in the public domain, *digital rights management technology* allows a publisher to prevent a buyer from sharing, copying, or printing the e-book version, a level of control that becomes more significant when fewer printed copies of a work exist. In practice, librarians balance owning paper journals against licensing electronic journals. Web-based, electronic journals offer economy and powerful access capabilities but also carry the risk of complete loss when the license expires. In law, the United States has extended the period of copyright protection, once fourteen years after publication, to seventy years after the author's death, seriously restricting the creation of derivative works.

The Internet hosts a dynamic evolution of morals, ethics, and laws related to information ownership and use. Freed from the limitations of identity, distance, and substance, Internet users have not always transplanted their behavioral norms directly from the *real* to the *virtual world*. Individuals and legislators face novel situations when the concept of theft is separated from both physical location and physical loss. Peer-to-peer file-sharing networks allow complete strangers to share perfect copies of digitized songs across vast distances while a presumed anonymity frees them from social constraints they might feel off-line.

Access

The First Amendment to the U.S. Constitution prohibits Congress from making laws "abridging the freedom of speech or of the press." The Universal Declaration of Human Rights, Article 19, begins "Everyone has the right to freedom of opinion and expression." These declarations codify ethical principles that recognize the value of expressing multiple points of view.

But freedom of speech, while widely recognized as a fundamental right, remains controversial in detail and execution. Because members of a pluralistic society may hold different values, there are frequent conflicts about what information should be publicly available and what information should not be. The American Library Association (ALA) Code of Ethics states, "We uphold the principles of intellectual freedom and resist all efforts to censor library resources." That commitment conflicts with the values of those who challenge the availability of some books in school and public libraries. The ALA Office for Intellectual Freedom reports over 6,000 book challenges (that is, " an attempt to remove or restrict materials, based upon the objections of a person or group") between 1990

TABLE 3

Information Ethics in Popular Culture

Film, Story, or Book	Dilemma
Frankenstein, Mary Shelley (fiction, 1818)	Ownership
1984, George Orwell (fiction, 1949)	Privacy
"The Enormous Radio," John Cheever (fiction, 1953)	Privacy
Fahrenheit 451, Ray Bradbury (fiction, 1954)	Access
The Gods Must Be Crazy (film, 1980)	Ownership
Blade Runner (film, 1982)	Security
The Electric Grandmother (film, 1982)	Community
"Melancholy Elephants," Spider Robinson (fiction, 1984)	Ownership
Neuromancer, William Gibson (fiction, 1984)	Access
The Handmaid'sTale, Margaret Atwood (fiction, 1986)	Community
Gattaca (film, 1997)	Privacy
AI: Artificial Intelligence (film, 2001)	Community
Minority Report (film, 2002)	Security

SOURCE: Courtesy of Ed Elrod and Martha Smith.

Popular books and films frequently draw on infoethical dilemmas for dramatic conflict.

and 2000. Table 1 lists the most frequently challenged books of 2002 and the reasons for the challenge.

Privacy and Security

Competing values and interests in public policy and government activities also lead to ethical tensions. Terrorist attacks, whether in Madrid, London, Tel Aviv, Kashmir, Tokyo, or New York, place governments in unfamiliar ethical territories as they develop responses in the form of new laws, policies, and programs that are in turn subject to the critical appraisal of civil liberties and human rights groups. James Moor (1998) describes such circumstances in terms of *conceptual muddles* and *policy vacuums* that arise when new situations (such as terrorism) and emerging capabilities (data mining) lead to new behaviors (widespread surveillance) with concomitant ethical questions of whether familiar concepts (privacy) apply and whether the new behaviors are acceptable. Table 2 presents a selection of U.S. government actions that have raised serious ethical dilemmas of privacy versus security and that illustrate an ongoing struggle between secrecy and accountability.

To the extent that such programs occur in secrecy, they leave their scope, policies, methods, activities, and even underlying data insulated from review and criticism. They leave the participants unaccountable outside their bailiwicks. As Joseph Pulitzer observed,

> There is not a crime, there is not a dodge, there is not a trick, there is not a swindle, there is not a vice which does not live by secrecy. (Brin 1998)

While secrecy does not presuppose malicious intent, it reduces the opportunity for accountability and opens the door for individual and institutional misuse of information.

Information professionals face dilemmas when balancing their ethical and legal obligations. For example, the USA PATRIOT Act grants law enforcement agencies broad rights to examine the records of library patrons. The ALA Privacy Toolkit describes privacy as "essential to the exercise of free speech, free thought, and free association" and urges libraries to adopt routine patron privacy and record retention policies in support of the library mission. At the same time, library policies may conflict with fulfilling the surveillance mission of law enforcement agencies.

Government responses to terrorism provide the opportunity for both practical and philosophical consideration. Practically it is reasonable to consider how much these actions enhance security, how much they impinge upon privacy, and what are the relative weights to be applied on either side of the equation. Philosophically it is valuable to ponder how government efforts to ensure security conflict with guaranteed civil rights.

Information Ethics in Popular Culture

Fiction and films frequently illustrate information ethical dilemmas, illuminating significant points that may not be apparent in everyday life. The entertainment value of emphasizing particular dilemmas and their consequences in fictional settings does not reduce the value of ethical exploration by way of popular culture.

Machines have long mimicked and extended human physical capabilities. But a physical aid such as a snow shovel presents few consequential dilemmas and appears only infrequently as the dramatic centerpiece of a film or book. At the other extreme, information technologies mimic and extend the human mind—popularly regarded as the essence of being human. The role of self-aware creations in fiction and film has increased as information and information technology permeate everyday life. Consider the Terminator (1984, 1991, 2003) and Matrix (1999, 2003, 2003) trilogies which project the ethical dilemmas that arise when the roles of information processing machines conflict with the needs, even the survival, of human society. Table 3 lists examples of films and fiction that highlight infoethical dilemmas drawn from the COAPS framework.

Professional Ethics

Ethical dilemmas also arise in the course of professional activities. When individuals adopt professional roles, they assume obligations beyond and sometimes in conflict with their personal beliefs. Librarians who order

TABLE 4

Professional Codes of Ethics—A Sample

Professional Organization	Of Particular Note
American Association of University Professors (CSEP)	Resolution on covert intelligence.
American Library Association (http://www.ala.org)	Explicit commitment to intellectual freedom, privacy, and service.
American Medical Association (CSEP)	Patient right to receive information.
American Society for Information Science and Technology (http://www.asist.org)	Multiple responsibilities to employers, clients, users, profession, and society.
American Society for Public Administration (CSEP)	*Whistle blower* policy statement.
Association for Computing Machinery (http://www.acm.org)	Identifies 24 imperatives as the elements of a personal commitment to ethical professional conduct. Supported by detailed guidelines.
Chartered Institute of Libraries and Information Professionals—UK (http://www.cilip.org.uk)	Statement of principles and multi-dimensioned responsibilities.
Dutch Association of Information Scientists (CSEP)	Multiple responsibilities to self, profession, employer, and society.
Institute of Electrical and Electronics Engineers (http://www.ieee.org)	Commitment "to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, …"
International Federation of Journalists (CSEP)	Primacy of respect for *truth.*

SOURCE: Courtesy of Ed Elrod and Martha Smith.

only books and materials supporting their political views about capital punishment are not exercising their professional obligations to build balanced collections and to provide services for a diverse, multicultural public. *Professional neutrality* refers to the commitment to separate professional obligations and personal beliefs.

Many professional groups have developed formal statements to guide decision making and behavior in situations common to their professions. These are often called *codes of ethics* to reflect their deliberate and conscious origins. Table 4 presents a sample of professional organizations with published ethical codes in fields related to the use of information.

Ethical decision making is neither straightforward nor predictable. Codes provide public statements of ideals and intentions. However they are only the starting point for decision making in professional activities. Codes cannot foresee every situation, yet professionalism often calls for decision making and action in unclear situations. Such ambiguity can require a delicate balancing act among stakeholder beliefs and priorities, the demands of professional obligations, and short-term, long-term, and unintended consequences.

Future Prospects for Information Ethics

The published literature of information ethics intertwines with other areas of applied ethics such as computer ethics, cyberethics, journalism, communications, and media ethics, image ethics, Internet ethics, engineering ethics, and business ethics, reflecting its broad philosophical underpinnings and practical applications far beyond academia. Information ethics contributes to society when it addresses problems that affect the quality of life. Looming ethical questions may seem to arise more from science fiction than science and technology, but science fiction quickly becomes everyday fact. For example, witness the confluence of technology, biology, and national security in the increasing use of biometric identification methods. Looking forward to future technologies and ethical debates:

Will single-issue, virtual *communities* focused on abortion or animal rights, for example, reduce the tolerance for other points of view?

What new business models will arise if intellectual property *ownership* withers in the face of unstoppable copying?

Who will have *access* to the research information about cloning a human?

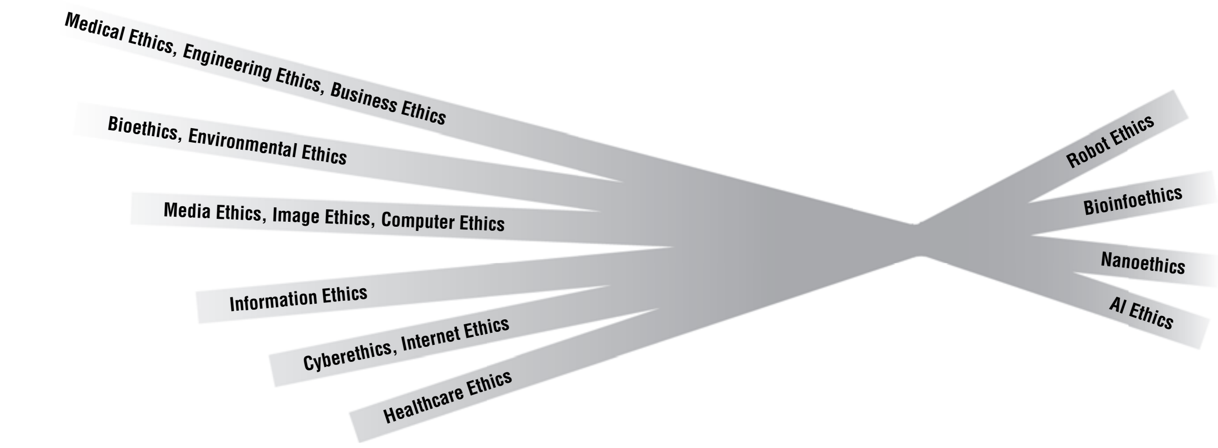
Will the *privacy* rights of consumers be renegotiable with every credit card transaction?

After the poliovirus has been successfully synthesized from its constituent chemical building blocks, does publishing the gene sequences for deadly viruses on the Internet pose a threat to worldwide *security?*

The future is arriving quickly in the emerging field of *bioinfoethics*. It signals a fresh arena for exploration using the combined insights of bioethics and information ethics. It encompasses recent discussions of reproductive ethics, genetics ethics, healthcare ethics, and computer ethics. Bioinfoethics promises to shape

FIGURE 2

Future Infoethics—Arising from Many Domains



SOURCE: Courtesy of Ed Elrod and Martha Smith.

Infoethics embraces many ethical domains. It provides a rich foundation for evaluating the ethics of emerging technologies and practices.

personal decisions, professional practice, and public policy. Beyond that, new infoethical domains will continue to emerge wherever new technologies and practices raise new dilemmas that might include applications of robots, nanotechnology, and artificial intelligence. Figure 2 illustrates the contributions of many, diverse domains of ethical analysis to bioinfoethics and to other emerging ethical domains in the future.

An Icelandic genetic mapping project illustrates such a bioinfoethical dilemma. With parliamentary approval, a private company has begun collecting and analyzing genealogical, medical, and genetic data about the people of Iceland in the hope of uncovering diseases with genetic bases and then developing profitable new drugs to treat those diseases. Such research holds the potential for immense medical benefit and immense privacy intrusion. Genetic mapping is likely to become more widespread, thereby expanding the relevance of the bioinfoethical debate.

The COAPS framework (Figure 1) suggests bioinfoethical questions about such a database. How should *communities* organize and negotiate to assure that the use and benefits of genetic databases best reflect the community interests? Should *ownership* of the genetic and medical data lie with the individuals or the company? What financial benefits accrue to the individuals if they do *own* the data? Should there be widespread *access* to the data to maximize the scientific benefit? Does one-way identity coding sufficiently protect individual *privacy* when the records carry other medically relevant but potentially traceable information? What *security* procedures are demanded for the centralized accumulation of immense amounts of personal and medical data? The Association of Icelanders for Ethics in Science and Medicine (Mannvernd) maintains a broad collection of information about genetic practices and the corresponding ethical considerations.

The Icelandic genetic database represents the leading edge of converging medical, social, government, and information technology practices. The associated bioinfoethical dilemmas explore frontiers of emerging ethical debates and demonstrate the relevance of information ethics to everyone.

EDWIN M. ELROD
MARTHA M. SMITH

SEE ALSO *Association for Computing Machinery; Communications Ethics; Computer Ethics; Cyberspace; Digital Divide; Geographic Information Systems; Hypertext; Information; Institute of Electrical and Electronics Engineers; Intellectual Property; Internet; Monitoring and Surveillance; Movies; Museums of Science and Technology; Popular Culture; Privacy; Science, Technology, and Law; Science, Technology, and Literature; Security; Terrorism; Virtual Reality.*

BIBLIOGRAPHY

Brin, David. (1998). *The Transparent Society*. Reading, MA: Perseus Books.

Floridi, Luciano. (1999). "Information Ethics: On the Theoretical Foundations of Computer Ethics." *Ethics and Information Technology* 1(1): 37–56.

Hauptman, Robert. (1988). *Ethical Challenges in Librarianship*. Phoenix, AZ: Oryx Press.

Hauptman, Robert, ed. (1992). *Journal of Information Ethics*. Jefferson, NC: MacFarland and Company.

Lessig, Lawrence. (2001). The Future of Ideas: The Fate of the Commons in a Connected World. New York: Random House.

Mason, Richard; Florence Mason; and Mary Culnan. (1995). *Ethics Of Information Management*. Thousand Oaks, CA: Sage Publications.

Moor, James. (1998). "Reason, Relativity, and Responsibility in Computer Ethics." *Computers and Society* 28(1): 14–21.

Raymond, Eric S. (1999). *The Cathedral and the Bazaar: Musings on Linux and Open Source by an Accidental Revolutionary*. Beijing; Sebastopol, CA: O'Reilly.

Shannon, Claude E. (1948). "A Mathematical Theory of Communication." *Bell System Technical Journal* 27: 379–423, 623–656.

Smith, Martha M. (1997). "Information Ethics." *Annual Review Of Information Science and Technology* 32: 339–366.

Smith, Martha M. (2001). "Information Ethics." In *Advances in Librarianship*, Vol. 25, ed. Frederick Lynden. New York: Academic Press.

Tavani, Herman T. (2003). *Ethics and Technology: Ethical Issues in an Age of Information and Communication Technology*. New York: John Wiley and Sons.

INTERNET RESOURCES

Capurro, Rafael. (2001). "The Field." Center for Information Ethics. Available from http://icie.zkm.de.

Center for the Study of Ethics in the Professions (CSEP). Illinois Institute of Technology (IIT). "Codes of Ethics Online." Available from http://ethics.iit.edu/codes.

Jefferson, Thomas. "No Patent on Ideas," Letter To Isaac McPherson, August 13, 1813. Available from HTTP://etext.lib.Virginia.edu.

Mannvernd, Association of Icelanders for Ethics in Science and Medicine. Available from http://www.mannvernd.is/english/index.html.

INFORMATION OVERLOAD

First comprehensively treated by the futurologist Alvin Toffler (1970), *information overload* refers to excessive flows and amounts of data or information that can lead to detrimental computational, physical, psychological, and social effects. For the vast majority of human history, information was scarce and its production, dissemination, and retrieval were nearly unqualified goods that could improve culture, develop commerce, and promote personal autonomy. The advance of information and communication technologies especially since World War II has transformed this scarcity into an abundance. For example, Peter Lyman and Hal Varian (2003) estimated that print, film, magnetic, and optical storage media produced roughly five exabytes of new information in 2002, equivalent to the information that could be stored in 37,000 libraries the size of the Library of Congress. This doubled the amount of new information that had been stored just three years earlier. The glut of information takes several forms and raises many concerns. Indeed it is ironic that information technologies, envisioned by many of their progenitors as devices for organizing information, improving understanding, and boosting productivity often also contribute to disorders, inefficiencies, and confusion.

Causes and Types

Technology, the free-market, and democracy have nearly erased the limits that once caused only the most important information to be published and distributed. Computers, cell phones, the Internet, optical cables, and wireless and satellite transmissions are just a few key technologies fueling the information age. People have become increasingly dependent on such technologies in both their professional and private lives, making information overload nearly unavoidable. The ease and low cost of online publishing and electronic mailing swells the amount of available information, including irrelevant and low quality information.

Information overload occurs in several forms. The term is frequently used in computer theory when so much information has entered an information-processing system that the system cannot easily, if at all, process it. This is usually due to hardware or software limitations, and the idea parallels findings by psychologists that cognitive constraints limit human capacities to process information. Information overload has also been utilized by cognitive scientists in their explanations of intelligent activity. One example is Herbert Simon's concept of *near decomposability* (where short-run behavior of components is independent of other components in the same system). An organism's visual subsystem, for example, can suffer from information overload, while the overall organism does not. In turn, the overall organism can suffer information overload, because it may lack the architectural structure to manage the information gathered and transmitted by each of its subsystems. Another more general concept useful in describing information overload is the decline in the *signal-to-noise* ratio, which denotes the proportion of useful information to all information present in some particular context.

Information overload is commonly experienced in the workplace, especially by managers and government officials who must synthesize growing streams of data. Academics and others who perform research are also negatively impacted by excessive flows of information that make it hard to discern high from low quality knowledge. Finally, information overload is a general experience shared by citizens in developed nations, where streams of information from a variety of media are unavoidable in daily life. Human beings have limited cognitive capacities to store and render information meaningful, and the blitz of information made available by modern technology can easily overwhelm these capacities. Spam, unsolicited commercial bulk E-mail, and its attendant aggravations and lawsuits highlight one specific instance of the personal and social ramifications of information overload.

Effects and Responses

Although information overload in computers can cause technical and social problems, its most detrimental effects usually occur when individual humans must cope with excess information. Indeed Toffler summarized one of the most pernicious effects with his term *information anxiety*. Richard Saul Wurman (1989) explains that, "Information anxiety is produced by the ever-widening gap between what we understand and what we think we should understand. Information anxiety is the black hole between data and knowledge. It happens when information doesn't tell us what we want or need to know" (p. 222). Showing the close connection between information overload and the overwhelming speed of modern social change, Wurman warns that information anxiety limits people to being only seekers of knowledge, because there is no time to reflect on the meaning of that knowledge for one's life. Many people become so obsessive in this quest that they experience what some have called an *information addiction* (Reuters 1997).

The printing press and its many unintended social consequences are often cited as precursors to such ethical implications of increased information. The sociologist Georg Simmel pointed to information overload in several of his studies. For example, he noted that some city dwellers developed the habit of hardly noticing individuals when moving through a crowd. In the 1960s, James G. Miller researched the psycho-pathological effects of information overload, and Karl Deutsch described information overload as a disease of cities that limits freedom as well as efficient communication and transport. In his 1986 *Overload and Boredom*, the sociologist Orrin E. Klapp argued that the second law of thermodynamics applies to information and culture as well as energy: The greater a social system's information and culture output the greater the system's disorganization in the form of information overload. This yields noise, banality, alienation, despair, anxiety, disenchantment, anomie, feelings of illegitimacy, and absurdity. Boredom results not from the absence of stimulation, but by its excess and repetition. Irrational or poor decisions can also result from information overload. Indeed, some researchers in choice behavior argue that too much choice can be a bad thing (Schwartz 2004).

Walter Kerr (1962) argued that modern societies erode pleasure because the information made available nearly anywhere (now via cell phones and portable computers) enables work to impinge on leisure time. On the positive side, this can improve work and enhance communication with loved ones. In a similar vein, some research suggests that children exposed to computer-enriched environments develop higher-order thinking abilities to a significantly greater degree than those not so exposed (Hopson 2001). Finally, recent philosophers (such as Braybrooke 1998) have conceptualized social information overload as a central element in the logic and processes of social change more generally.

A 1996 survey conducted by Reuters is just one of many reports investigating the effect of information overload. Surveying more than 1,000 managers, this report found that increasing numbers of people suffer ill health due to the stress of information overload and important decisions are delayed by excessive information. David Lewis proposed the term *Information Fatigue Syndrome* for the symptoms uncovered in this report, including poor decision making, difficulties in remembering, reduced attention span, and stress. Nearly half of those surveyed predicted that the Internet would play a primary role in aggravating the problem further. Yet in a follow-up report two years later, researchers at Reuters found that only 19 percent of respondents felt the Internet was making the situation worse, while nearly half felt it was improving the situation. More broadly, this report concluded that the age of information overload is waning, because although some economies were still struggling with it (for example, Southeast Asia), others (such as the United States, Japan, and Western Europe) were beginning to overcome it.

Timely, relevant, and accurate information is crucial for much of the government and many sectors of the economy (although opinions on the degree to which information is important for different tasks vary across the globe). So, if the solution is not to simply tune out, how are the problems posed by information overload resolved? Solutions can be categorized under the broad heading of information management. Entities implementing information management policies (according to the 1998 Reuters report) experienced marked increases in productivity and decision-making capability. Information management in this context connotes methods for evaluating, prioritizing, and processing information (for example, the ranking operations performed by many search engines). Technology (especially e-mail and the Internet) is increasingly regarded as enabling information management rather than exacerbating information overload. Work practices are being adapted to use information technologies more effectively and businesses increasingly rely on a single, trusted source of comprehensive information in order to improve efficiency.

Perhaps a computer-neural interface will be developed to improve cognitive abilities to process and store information, but will this necessarily enhance the capacity to understand and control nature and society? One conundrum raised by the issue of information overload is that infinitely increasing both information and the capacity to use that information does not guarantee better decisions leading to desired outcomes. After all, information is often irrelevant, either because people are simply set in their ways, or natural and social systems are too unpredictable, or people's ability to act is somehow restrained. What is required, then, is not just skill in prioritizing information, but an understanding of when information is not needed. These cases do not point to insoluble problems. Instead they raise a more appropriate question most eloquently stated by T. S. Eliot (1952) in *The Rock:* "Where is the wisdom lost in knowledge and where is the knowledge lost in information?"

A. PABLO IANNONE
ADAM BRIGGLE

SEE ALSO *Communication Systems; Cyberculture; Hardware and Software; Information; Information Society.*

BIBLIOGRAPHY

Braybrooke, David. (1998). *Moral Objectives, Rules, and the Forms of Social Change.* Toronto: University of Toronto Press.

Eliot, T. S. (1952). *Complete Poems and Plays.* New York: Harcourt and Brace.

Hopson, Michael H. (2001). "Using a Technology-Enriched Environment to Improve Higher-Order Thinking Skills." *Journal of Research on Technology and Education* 34(2): 109–119.

Klapp, Orrin Edgar. (1986). *Overload and Boredom: Essays on the Quality of Life in the Information Society.* New York: Greenwood Press.

Reuters. (1996). "Dying for Information? An Investigation into the Effects of Information Overload in the U.K. and Worldwide," news release.

Reuters. (1997). "Glued to the Screen: An Investigation into Information Addiction Worldwide," news release.

Reuters. (1998). "Out of the Abyss: Surviving the Information Age, news release.

Schwartz, Barry. (2004). *The Paradox of Choice: Why More is Less.* New York: Ecco. Challenges the view of humans as rational utility maximizers and argues that unlimited choice can lead to suffering.

Toffler, Alvin. (1970). *Future Shock.* New York: Random House. Argues that there can be too much change in too short of a time, and therefore people need to improve their ability to wisely regulate, moderate, and apply technology to serve human ends. Information overload is discussed on pages 311–315.

Wurman, Richard Saul. (1989). *Information Anxiety.* New York: Doubleday.

INFORMATION SOCIETY

The term *information society* refers to a set of developments in the global human environment that began during the last quarter of the twentieth century. These developments entailed increasingly intensive use of technologies of information and communication, from desktop computers and a plethora of sensing and "smart" devices to mobile telephony and portable handheld electronics, all progressively interconnected. In a cursory sense, an information society is simply one heavily dependent on these technologies for human interactions and transactions, though no clear threshold exists for classifying a society as informational at any particular stage of technological development. In a more important and complex sense, an information society is one in which use of various technologies has produced or is producing substantial change in the ways people live, learn, work, socialize, and govern themselves.

A New Context for Ethics

As societies around the globe integrate various technologies into economic, social, educational, personal, and governmental practices, the resulting changes create new contexts for ethics in the mundane sense of the customary guidelines for their engagement. The altered context involves new linkages among individuals and

A palm pilot. These hand-held computers are one of the products of the Information Society. (*© SIE Prouductions/Corbis.*)

organizations, along with transformations in the identity and structure of human collectivities. One hallmark is decentralization in some forms of control and decision making. In economic transactions, this involves reduced reliance on hierarchical structures in favor of more distributed, flexible, horizontal links among organizations able to communicate and coordinate with less centralization. At the same time that certain organizational structures are becoming less centralized, possibilities for the collection of highly centralized data about citizens and their activities are expanding. This means that increasingly centralized bodies of information about citizens are available both to government and to the new forms of decentralized organizations in economic and other realms.

In the social arena, such changes involve more flexible, complex patterns of association with decreased dependence on physical proximity or identification with well-bounded groups or communities. One extreme gives rise to self-organizing groups and associations that may be temporary in nature. Another is the direct exchange among individuals of digitized artifacts such as moving or still photography, music, books, or other narratives in the presence of little or no coordinating authorities and brokers.

The trend toward information societies is sometimes described in terms of the replacement of industrial-age human structures with *networks*. These networks involve adaptable, flexible, complex communication and interactions with many points of intersection. One of the classic descriptions of the information society is the trilogy of books by Manuel Castells collectively entitled *The Information Age: Economy, Society, and Culture* (1996, 1998, 1999). An earlier and widely influential statement that anticipated some of the developments of the information society is Daniel Bell's *The Coming of Post-Industrial Society* (1973).

Origins of the Information Society

Several factors contributed to the trend toward the information society. The intellectual threads of the information society can be traced back as far as Gottfried Wilhelm Leibnitz (1646–1716), who in the seventeenth century postulated a machine that might manipulate mathematical representations of human thought. More concretely, it was the rapid technological innovation by twentieth century corporations and universities that resulted in the production of a stream of fast, inexpensive, portable computing and communication technologies. These innovations began with the development of digital computers from the 1940s through the 1960s. Following establishment of digital computing as a field, progressive miniaturization from the 1970s through the 1990s promoted the design of smaller and more powerful information and communication devices.

Another interpretation traces the technological origins of the information society back to the industrial revolution. James Beniger (1986) argues that the demands for control and management of information associated with industrial activity and socioeconomic structure paved the way for the eventual rise of the information society.

A second economic factor contributing to information society trends was a wave of privatization of previously state-dominated media in many countries during the last two decades of the twentieth century. Both the technological developments and the restructuring of media-state relations fed economic globalization. Intensified economic and financial linkages among nations through corporate multinationalism and national trade policies created tighter interdependencies among societies and provided for means of cultural and social change. These developments were concentrated in the Americas, Europe, Australia, and non-authoritarian Asian nations. In many societies with authoritarian governments, such as Saudi Arabia and China, various government policies limited the deployment of information technologies.

Ethical Issues in the Information Society

Most technological innovations, beginning with the first use of tools made of stone or bone, have permitted humans to engage in new kinds of actions and to restructure relationships with one another. These altered actions and relationships raise important questions of ethics, social order, and governance. Which new possibilities for human agency and for restructuring of societies are desirable? How should such questions be decided—by individuals, by markets, by states, by religious institutions? Technologies of the information society precipitated many such questions. For instance, access to the technological infrastructure of the information society is highly unequal across nations and across groups and among individuals within nations, raising the possibility that information societies will be exclusionary. Additionally, the digitization and centralization of information and the density of interconnections among people allow for far greater possibilities of privacy violations by other individuals, corporations, and governments in information societies than in industrial ones. One of the most important ethical issues in information societies involves challenges to traditional conceptions of information ownership, which in earlier periods was defined partly by practical constraints on its replication and exchange.

Because cultures are sustained and altered by communication and the preservation of certain artifacts and information, information society changes create cultural mixing and shifts. Especially controversial is the transfer of Euro-American cultural norms and practices to non-Euro-American societies. Even within Euro-American societies, debates about the regulation of speech that were once largely settled matters have been revisited, due to the vastly increased capacity for people to communicate material or ideas that were previously limited by such simple constraints as cost.

It is difficult to predict how far trends toward information societies will extend. It is important to observe that the rise of industrial societies in the nineteenth and twentieth centuries did not bring about the cessation of agricultural activities or the end of agrarian ways of life. Instead they produced a shift in the locus of human activity for many people in many societies. Similarly, the rise of the information society will not entail the end of industrial activity or the termination of industrial-age social structures, cultural practices, and economics, but rather a transition to altered human arrangements across this spectrum.

BRUCE BIMBER

SEE ALSO *Bell, Daniel; Communication Ethics; Digital Divide; Information; Information Overload; Leibniz, G. W.; Networks; Privacy.*

BIBLIOGRAPHY

Bell, Daniel. (1973). *The Coming of Post-Industrial Society: A Venture in Social Forecasting.* New York: Basic Books.

Beniger, James R. (1986). *The Control Revolution: Technological and Economic Origins of the Information Society.* Cambridge, MA: Harvard University Press.

Castells, Manuel. (1996, rev. 2000). *The Rise of the Network Society—The Information Age: Economy, Society, and Culture, Vol. 1.* Malden, MA: Blackwell.

Castells, Manuel. (1997). *The Power of Identity—The Information Age: Economy, Society, and Culture, Vol. 2.* Malden, MA: Blackwell.

Castells, Manuel. (1998, rev. 2000). *End of Millennium—The Information Age: Economy, Society, and Culture, Vol. 3.* Malden, MA: Blackwell.

INFORMED CONSENT

Informed consent is an individual's voluntary agreement, based on adequate understanding of relevant facts, to permit some type of intervention by a second party. This term is most commonly used in medical contexts to refer to individuals' agreements to undergo medical treatment or to participate in research. In most cases, informed consent is required both ethically and legally prior to the commencement of treatment or enrollment in research.

Recent History

The ethical and legal mandate for informed consent as understood in the early twenty-first century was not established until the latter half of the twentieth century. Before that time, a paternalistic paradigm governed the relationship between patient and health care provider. However, driven by landmark cases, revelations of abuse, and a changing professional ethic, there has been a shift toward patient autonomy and away from physician paternalism. The establishment of a requirement for informed consent occurred independently but concurrently in the two contexts of medical treatment and research with human subjects.

MEDICAL TREATMENT. U.S. courts first recognized the need for patients to give consent for medical treatment in *Schloendorff* v. *Society of New York Hospital* in 1914. It was not until *Salgo* v. *Leland Stanford, Jr. University Board of Trustees* in 1957, however, that the additional provision requiring physicians to give patients information relevant to their treatment decisions was established. This requirement for physician disclosure was expanded, developed, and solidified by *Natanson* v. *Kline* (1960), *Mitchell* v. *Robinson* (1960) and *Canterbury* v. *Spence* (1972). These precedents were then incorporated into statements by the Judicial Council of the American Medical Association (AMA) in 1981 and the President's Commission for the Study of Ethical Problems in Medicine and Biomedical and Behavioral Research in 1982. The need to obtain patients' informed consent has since been incorporated into the medical practice guidelines of numerous national and international organizations of medical professionals.

RESEARCH SUBJECTS. The evolution of informed consent in research with human subjects was spurred not by legal decisions but by public and professional reaction to several cases in which people were used as research subjects without their knowledge or permission. The Nuremberg Code of 1947 established general guidelines for human subjects research in response to the revelation of the Nazi medical experiments, stating that the informed and voluntary consent of subjects was "absolutely essential." In an effort to create more specific ethical guidelines for research, the World Medical Association (WMA) adopted the first version of the Declaration of Helsinki in 1964, which also held the subjects' informed consent to be a necessary element of ethical research.

In 1966, Henry K. Beecher published an article in the *New England Journal of Medicine* identifying twenty-two ethically problematic studies involving human subjects, including studies at the Jewish Chronic Disease Hospital and Willowbrook State Hospital. Beecher concluded that patients must give informed and voluntary consent before participating in research. The uncovering of the Tuskegee syphilis study that took place between 1932 and 1972 brought widespread attention to violations of the rights of human subjects. In the Tuskegee case, poor and uneducated African American men were enrolled in a study of the progression of untreated syphilis without their knowledge or consent. At least partially in response to these abuses, The Belmont Report, published in 1978, and finally the federal Common Rule (45 CFR 46) in 1991 incorporated the requirement for informed consent into United States regulation.

PHILOSOPHICAL FOUNDATIONS. The moral requirement for informed consent can be grounded in both deontological and consequentialist ethical theory. Immanuel Kant (1724–1804) held that moral worth is based upon the ability to reason and that the ability to reason must be respected by others. Rational choices are expressions of the ability to reason and so have intrinsic value. As a result, people have obligations to make rational choices and others are obligated to respect those choices. Giving (or refusing to give) informed consent is a form of rational choice and so therefore has intrinsic value within a Kantian deontological framework.

The value of informed consent can also be derived from consequentialist ethical theory. Consequentialists hold that something is good if it produces good outcomes. In most cases, people know their own goals and values better than anyone else, and therefore are in the best position to decide how to promote their own good. Even though people may, on occasion, be mistaken about what is good for them, they benefit overall from exercising self-determination. As a result, the best outcomes are brought about when people make decisions for themselves. The requirement for informed consent is one way to protect and encourage self-determination and therefore to bring about good consequences.

Five Elements of Informed Consent

There are at least five necessary elements of informed consent: disclosure, understanding, capacity or competency, voluntariness, and assent. These elements can take different forms in research and treatment contexts and can entail various ethical and legal standards.

DISCLOSURE. Informed consent can only be given if the person consenting is adequately informed. The first part of this process involves the disclosure of information. The physician, researcher, or in some cases another individual, must make available to the patient or potential subject sufficient information to make a decision about treatment or participation in research.

What constitutes sufficient disclosure is ambiguous, but there are three plausible ways this can be interpreted. The *professional practice standard* of disclosure requires physicians to give patients as much information as is generally disclosed by other medical professionals about a particular procedure or research protocol. The *reasonable person standard* sets the disclosure requirement at whatever a reasonable person would want to know in a given situation. A final disclosure standard is the *subjective standard*, which states that a physician should tell a patient whatever that subject would want to know. Each of these views on disclosure has advantages and disadvantages.

There is no consensus on which standard best describes the ethical obligation of disclosure. Generally, however, disclosure must include at least a description of the treatment or procedure, the material risks and benefits, and the available alternatives. In research contexts, additional information must be provided to the individual considering participation. Examples of such additional information include: a statement about the experimental nature of the procedures, information about confidentiality of the subject's records, information about what to do in case of injury from the study, and a statement that participation in the research is voluntary.

Legally, state jurisdictions are approximately evenly split between using the professional practice standard and the reasonable person standard in treatment contexts. Only a few jurisdictions hold physicians to the subjective disclosure standard. The U.S. Common Rule provides an itemized list of the information that must be conveyed to potential subjects within research contexts.

UNDERSTANDING. In order for an individual to be informed in the ethically relevant sense, that individual must respond to the disclosure in an appropriate way. That is, the individual must internalize the information that has been made available though the disclosure process. If a patient or potential subject is unable to understand the provided information, informed consent is not possible. It is the responsibility of a physician or researcher to make an effort to maximize the understanding of the patient or potential subject. For example, a researcher should convey the relevant information in language that the potential subject can comprehend and should answer clearly any questions that the subject asks about the protocol. In practice, formal assessment of an individual's level of understanding is rare. Instead, patients or potential subjects may simply be asked if they understand the information they have been given or if they have any questions.

CAPACITY AND COMPETENCY. Capacity refers to an individual's ability to appropriately manipulate the information that has been understood. There are a number of different ways that decision-making capacity could be defined and by which the presence or absence of capacity could be assessed. The ability to appreciate the consequences of one's life options, to weigh the various considerations and come to a decision, to reason logically about one's situation, and to evaluate the situation in light of one's own values could all be used as indicators of capacity. There is no ethical or legal consensus on which of these definitions should be used.

Capacity is a task-specific concept, meaning that the level of decision-making capacity needed to make a given decision varies depending on the nature of the decision itself. As a result, at any given time one may have the capacity to make some decisions but not others. Generally, the higher the risk posed by a procedure, the more capacity one must have to make a decision to undergo that procedure. For example, a patient may have capacity to consent to having an IV inserted but not to having invasive surgery.

Individuals without the capacity to make a given decision about treatment or research cannot give informed consent to undergo that treatment or research. When a person lacks decision-making capacity, informed consent is solicited from a surrogate decision maker, that is, a family member or other individual appointed to made decisions on behalf of that person.

Competency is the legal analogue to capacity. Adults are presumed to have competency unless it has been demonstrated to a court that they are unable to make autonomous decisions, in which case the court declares the adult to be incompetent. At that time, a legally authorized representative is appointed for that individual. In contrast, children and adolescents under the age of eighteen do not have competency to make their own decisions unless a court decides otherwise.

VOLUNTARINESS. An individual's decision to undergo treatment or to participate in research must be voluntary. That is, the individual must not be coerced or unduly influenced by either external or internal factors. Threats of unwanted consequences such as physical harm or withdrawal of medical care are obvious examples of coercion. More subtle challenges to voluntariness include the provision of substantial incentives and the manipulation of an individual's decision-making process through the biased presentation of information. Because of the importance of voluntariness, informed consent is often denominated "free and informed consent" or just "free informed consent."

A physician or researcher may not coerce or unduly influence a patient or potential subject to make a desired decision. The conditions under which and the manner in which the physician or researcher solicits consent should be designed to minimize the possibility that voluntariness will be compromised.

ASSENT. The final element of informed consent is the decision made about undergoing treatment or participating in research. Inherent in the idea of informed consent is a positive decision—one gives informed consent to undergo a particular treatment or procedure. A negative decision—that is, a decision not to undergo the treatment or procedure—constitutes an informed refusal.

Generally, verbal agreement is sufficient for low-risk treatment decisions. When treatment methods involve higher levels of risk, however, the patient may be required to sign a consent form. The form summarizes the relevant information and states that the individual is voluntarily agreeing to the treatment or procedure. In research contexts, an individual's consent to participate in the research protocol must almost always be documented by the individual's signature on a consent form.

Exceptions to Informed Consent

There are a few exceptions to the requirement for informed consent for medical treatment. In emergency situations, treatment can be administered without the patient's consent because it is presumed the patient would consent if given the opportunity. Other exceptions include cases in which an individual poses a threat to public health. In such cases, treatment may be forced on that individual without consent. For example, a person with tuberculosis may be compelled to undergo treatment. Individuals may also waive their right to informed consent, stating that they do not wish to be informed of a diagnosis or to make decisions about their own treatment. Finally, children and incompetent adults do not give informed consent for treatment, although consent must be obtained from parents or guardians.

Informed consent is almost always required prior to enrollment in research. However, federal regulation allows individuals to be enrolled without their consent in research protocols in some emergency situations if obtaining consent would be impossible. It further allows emergent use of an investigational drug or procedure on a case-by-case basis if it is believed that doing so will have therapeutic value for the patient. A second exception to the requirement for informed consent in research contexts enables parents or guardians to give consent for the participation of children and incompetent adults. It has, however, been recommended that physicians and researchers seek the assent of these individuals when possible.

Informed Consent and Science and Technology

Although the concept of informed consent is most thoroughly developed within the contexts of medical treatment and biomedical research, it has ethical implications for the development and use of the products of science and technology more broadly defined. Research into and implementation of innovations in fields such as civil engineering, nuclear energy, genetic engineering, and nanotechnology have inherent risks. In many cases, the members of the community in which these innovations are being developed and put into use are exposed to these risks. The ethical requirement for informed consent, however, suggests that these individuals should not have to bear this burden without their knowledge and voluntary consent.

In most cases, the process of obtaining consent for medical treatment or for enrollment in biomedical research is dyadic, consisting of a dialogue between a physician or investigator and a subject. In non-medical contexts, however, this model of obtaining consent is often not feasible. Practically, it would be impossible to obtain individual consent from each member of the community that could be exposed to risk. Further, many of those who may be affected by these innovations could not even theoretically be asked for consent, such as members of future generations.

Despite these difficulties, the requirement for informed consent generates ethical obligations for those who develop and implement the products of science and technology. These obligations may be discharged through various community consent mechanisms, such as allowing public participation in the creation of policies that govern innovations, consultation with community leaders, and assessment of public opinion. The use of these and other community consent methods may help to ensure that science and technology move forward in an ethically appropriate way, and therefore that the goods that they produce are not achieved at too great a cost.

JANET MALEK

SEE ALSO *Bioethics; Human Subjects Research; Medical Ethics; Sociological Ethics.*

BIBLIOGRAPHY

Beauchamp, Tom L., and Ruth R. Faden. (2004). "Informed Consent: Meaning and Elements." In *Encyclopedia of Bioethics*, 3rd edition, ed. Stephen G. Post. New York: Macmillan. A concise and updated review of the elements of informed consent.

Beecher, Henry K. (1966). "Ethics and Clinical Research." *The New England Journal of Medicine* 274(24): 1354–1360. A landmark article identifying numerous ethically problematic research protocols.

Berg, Jessica W., et al. (2001). *Informed Consent: Legal Theory and Clinical Practice*, 2nd edition. Oxford, UK: Oxford University Press. Comprehensive review of the legal history and current practical applications of informed consent.

Committee on Bioethics, American Academy of Pediatrics. (1995). "Informed Consent, Parental Permission, and Assent in Pediatric Practice." *Pediatrics* 95(2): 314–317. Statement establishing the ethical requirement for children's assent for participation in research.

Faden, Ruth R.; Tom L. Beauchamp; and Nancy P. King. (1986). *A History and Theory of Informed Consent*. New York: Oxford University Press. Reviews the development of informed consent and provides a detailed analysis of its elements.

Grisso, Thomas, and Paul S. Appelbaum. (1995). "Comparison of Standards for Assessing Patients' Capacities to Make Treatment Decisions." *American Journal of Psychiatry* 152(7): 1033–1037. Discusses the possible standards and their implications for evaluating capacity.

Jones, James H. (1981). *Bad Blood: The Tuskegee Syphilis Experiment*. New York: Free Press. A historical report and analysis of the Tuskegee syphilis experiment.

Levine, Robert J. (1986). *Ethics and Regulation of Clinical Research*, 2nd edition. Baltimore, MD: Urban and Schwartenberg. Detailed review of the ethical requirements for clinical research.

Levine, Robert J. (2004). "Informed Consent: Consent Issues in Human Research." In *Encyclopedia of Bioethics*, 3rd edition, ed. Stephen G. Post. New York: Macmillan. Concise review of the concept of informed consent as it applies to research with human subjects.

Shrader-Frechette, Kristin. (1991). *Risk and Rationality*. Berkeley: University of California Press. Exploration of the conditions under which risks may be imposed on societies.

Shrader-Frechette, Kristin. (1994). *Ethics of Scientific Research*. Lanham, MD: Rowman & Littlefield. Discussion of scientific research emphasizing the importance of public welfare and public decision making.

United States Department of Health and Human Services. (1991). "Protection of Human Subjects." *Code of Federal Regulations*, Title 45, Part 46. United States federal regulation governing research involving human subjects; also known as the "common rule."

INNOVATION

SEE *Technological Innovation.*

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS

The Institute of Electrical and Electronics Engineers (IEEE) is the largest technical society in the world with more than 375,000 members in 150 nations; it publishes 30 percent of the global technical literature in electrical and computer engineering. The organization was formed in 1963 through a merger of the American Institute of Electrical Engineers (AIEE, founded in 1884) and the Institute of Radio Engineers (IRE, formed in 1912 when two local organizations founded in Boston and New York were merged).

In its early years the AIEE struggled to espouse professionalism in engineering despite strong pressure to the contrary from the businesses (mostly electric utilities) that employed the great majority of its members (Layton, 1986). Indeed, the famous engineer and socialist Charles Steinmetz served as president of the AIEE in 1901–1902. By the late twenties, however, business interests dominated the AIEE, evidenced by a lower membership standards that admitted business executives in the utility industry, restriction of the activities of local sections to purely technical matters, censorship of publications critical of business practices, stifling of dissent and public discussion of the profession through restrictions in the code of ethics, and abandonment of open elections in favor of a nominating committee. Many observers would argue that the AIEE's predisposition toward business interests was carried over to the IEEE and prevails to the present day (Herkert 2003).

The IRE was founded in part out of dissatisfaction with the growing dominance of business interests in the IEEE's affairs and in part due to the strong scientific basis and rapid growth of the field of radio engineering, which resulted in a higher sense of professionalism (McMahon 1984, Layton 1986). The IRE also aspired to become an international organization. Ironically, however, the IRE shied away from speaking for its members on professional and policy matters (Layton 1986). By the time of the merger the IRE had surpassed the AIEE in membership, buoyed by the explosive growth in electronics following World War II. The merger, an inevitable result of this development, resulted in a blending of the two institutional cultures that incorporated the IRE's decentralized management structure and professional groups, now known as technical societies (IEEE History Center 1984).

In 1973 the IEEE amended its constitution changing it from a strictly "learned" society to one that also represented the professional interests of its members. As a result, the United States Activities Board (USAB) was formed to represent the interests of U.S. members. (IEEE History Center 1984, McMahon 1984). The USAB and its successor organizations have played an important role in ethics activities of the IEEE and in promoting policy favorable to the U.S. engineering and business community. The affect of the USAB's presence on efforts to globalize the IEEE has been more controversial.

Codes of Ethics

The AIEE promulgated one of the earliest codes of engineering ethics in 1912. The code provided that the "first professional obligation" was to protect the interests of the engineer's clients or employers (Layton 1986). In 1950 the AIEE code was revised to incorporate the cannons of the code of ethics of the engineers' council for professional development, including a provision that the engineer "will have due regard for the safety of life and health of the public and employees who may be affected by the work for which he is responsible" (CSEP 2004). The first IEEE code of ethics was adopted in the 1970s (Unger 1994) following revisions in 1979 and 1987 (CSEP 2004). The current IEEE code of ethics (adopted 1990), in parallel with other contemporary engineering codes, pledges its members to protect the "safety, health and welfare of the public." Unlike others, however, the IEEE code also includes specific language regarding ethics support, committing its members "to assist colleagues and co-workers in their professional development and to support them in following this code of ethics."

Ethics Activities

The IEEE has long enjoyed a reputation as one of the more proactive professional engineering societies in the ethics area. This positive image derives primarily from ethics activity in the1970s, including preparation of a friend of the court brief supporting the three whistle-blowing engineers in the Bay Area Rapid Transit (BART) case. Much of this activity was encouraged by the formation of a Committee on Social Implications of Technology by Stephen Unger and other organizational activists, which evolved into the IEEE Society on Social Implications of Technology (SSIT). The SSIT, though only 2,000 members strong, has remained an important voice in the IEEE for ethical responsibility and concern for societal implications of technology. The SSIT publishes a quarterly journal, *IEEE Technology and Society Magazine*, hosts an annual conference, and periodically bestows its Carl Barus Award for Outstanding Service in the Public Interest on engineers who uphold the highest ethical standards of the profession. As noted earlier, the IEEE sub-unit that represents the interests of U.S. members has also been active in ethics issues. At the level of the parent organization, however, ethics activity was generally dormant between the late-1970s and mid-1990s (Unger 1994).

The IEEE reputation for promoting engineering ethics was, in the opinion of many observers, seriously tarnished by events that began to unfold in the late 1990s when a staff and volunteer leader backlash crushed gains in ethics support (Unger 1999, Herkert 2003). Prior to 1995, the only committee of the IEEE Board of Directors (BoD) charged with dealing with ethics was the Member Conduct Committee (MCC), founded in 1978. The MCC's purpose was twofold: to recommend disciplinary action for violation of the Code of Ethics and to recommend support for members who when following the Code encountered difficulties such as employer sanctions.

A BoD-level Ethics Committee, formed in 1995 as a result of efforts by members to elevate the prominence of ethics in the organization, was intended to provide information to members and advise the BoD on ethics-related policies and concerns. As one of its first actions, the Ethics Committee, whose membership included Stephen Unger, in 1996 established an Ethics Hotline designed to provide information and advice on ethical matters to professionals in IEEE fields of interest. Cases brought to the attention of the Ethics Hotline included falsification of quality tests, violations of intellectual property rights, and design and testing flaws that could result in threats to public safety. In some instances, such cases were referred to and acted on by the MCC (Unger 1999).

The Executive Committee of the BoD suspended the Ethics Hotline in 1997 after less than a year of operation. In 1998 the Executive Committee rejected and suppressed its own task force report, which recommended reactivation of the hotline. In the same year, the IEEE implemented bylaw changes that reduced the terms in office of members of the MCC and Ethics Committee, and, in apparent disregard of the IEEE Code of Ethics, prohibited the Ethics Committee from offering advice to any individuals including IEEE members. The cycle was complete in 2001 when the Ethics Committee and the MCC were merged. Like the old MCC, the combined committee has a dual-charge of member discipline and ethics support, but its activities are limited by IEEE Bylaw I-306.6: "Neither the Ethics and Member Conduct Committee nor any of its members shall solicit or otherwise invite complaints, nor shall they provide advice to individuals."

In another example of what one IEEE member describes as *ethical timidity*, in 2002 the IEEE denied membership benefits to its members in Iran and several other nations on the grounds that such action was required by U.S. trade restrictions, a position that was not shared by most other U.S.-based scientific and technical societies. Compounding the blow to the IEEE ethics profile, the IEEE leadership initially sought to conceal this action on a *need to know basis* (Gaffney 2003). Though the IEEE later claimed to be vindicated by a government exemption permitting editing and publication of papers submitted by Iranians, the ruling imposed restrictions on collaboration with Iranian scientists and left unchanged the IEEE's suspension of the membership benefits of residents of the sanctioned countries (Foster 2004)

JOSEPH R. HERKERT

SEE ALSO *Engineering Ethics; Professional Engineering Organizations.*

BIBLIOGRAPHY

Foster, Kenneth. (2004). "Call for Action to Protect Free Exchange of Ideas." *Nature* 429: 343. Letter to the editor calling for response of scientific and engineering community to U.S. government restrictions on publishing and other activities of scientific societies.

Gaffney, Owen. (2003). "IEEE Under Fire for Withdrawing Iranian Members' Benefits." *Science* 301: 1646. News article regarding the IEEE's controversial actions with respect to the U.S. Treasury's Office of Foreign Assets Control.

Herkert, Joseph. (2003). "Biting the Apple (But Not Inhaling): Lessons from Engineering Ethics for Alternative Dispute Resolution Ethics." *Penn State Law Review* 108: 119–136. Review of recent developments in the field of engineering ethics including discussion of the IEEE's changing stance on ethics support.

Layton, Edwin. (1986). *The Revolt of the Engineers*, 2nd edition. Baltimore: Johns Hopkins. Seminal history of the development of the engineering profession in the first half of the nineteenth century that focuses on the continuing conflict between business and professional values.

Mcmahon, A. Michael. (1984). *The Making of a Profession: A Century of Electrical Engineering in America*. New York: IEEE Press. History of the electrical engineering profession commissioned by the IEEE for its centennial.

Unger, Stephen. (1994). *Controlling Technology: Ethics and the Responsible Engineer*, 2nd edition. New York: Wiley. Well-known text on engineering ethics that gives extensive coverage to the IEEE's activities in the ethics arena from the perspective of a long-time participant in many of them.

Unger, Stephen. (1999). "The Assault on IEEE Ethics Support." *IEEE Technology and Society Magazine* 18(1): 36–40. Review of the IEEE backlash to ethics committee activities in mid-1990s by a prominent member of the ethics committee.

INTERNET RESOURCES

Center for the Study of Ethics in the Professions (CSEP). (2004). "Codes Of Ethics Online." Available from http://www.iit.edu/departments/csep/PublicWWW/codes/. Archive of more than 850 codes of professional ethics and other material on codes.

IEEE History Center. (1984). "Origins of the IEEE." Available from http://www.ieee.org/organizations/history_center/history_of_ieee.html. Brief history of the AIEE and the IRE and their merger to form the IEEE.

IEEE Society on Social Implications of Technology. (2004). Available from http://ieee.org/ssit. Internet site of the IEEE "technical" society concerned with social, ethical, and policy implications of technology; publisher of the *IEEE Technology and Society Magazine* and sponsor of the international symposium on technology and society.

Institute of Electrical and Electronics Engineers. (1990). "IEEE Code of Ethics." Available from http://www.ieee.org/about/whatis/code.html. The IEEE's current Code of Ethics; this code has a somewhat different format from other contemporary codes of engineering ethics.

Institute of Electrical and Electronics Engineers. (2001). "Bylaw I-306." Available from http://www.ieee.org/about/whatis/bylaws/i-306.html. Bylaw describing functions and membership of IEEE standing committees and boards; Section 7 applies to the Ethics and Member Conduct Committee.

INSTITUTE OF PROFESSIONAL ENGINEERS NEW ZEALAND

• • •

The first engineering society in New Zealand was the Institute of Local Government Engineers, which was founded in 1912. In 1914 it merged with the New Zealand Society of Civil Engineers, founded in 1913, which in 1982 became the Institute of Professional Engineers New Zealand (IPENZ). IPENZ is open to all engineering professionals.

The terms *engineering profession*, *professional engineer*, and *professional engineering* are used by IPENZ in the most general possible manner, to include all those who use a systematic process of analysis, design/synthesis, and implementation; strive to operate in a responsible way; are governed by a code of ethics set by their peers; and engage in continuing professional development to maintain the currency of their competence. IPENZ publishes the peer-reviewed print journals *e.nz* and *Engineering treNz* as well as the member newsletter, *engineering dimension*. Membership is currently about 9,000.

Because of New Zealand's unique geology—it is prone to floods, earthquakes, and volcanic eruptions—IPENZ has a strong focus on natural hazard and risk management. It also supports a heritage project, whose goal is described on its web site as "To inspire and teach present and future generations by preserving the legacy of the past through the identification, maintenance and promotion of New Zealand's engineering heritage."

The IPENZ code of ethics, perhaps under the influence of Engineers for Social Responsibility, gives high priority to social and environmental responsibility; along with the Australian Institution of Professional Engineers, IPENZ was one of the first engineering societies to do so. While it would be incorrect to describe it as an activist organization, IPENZ has on occasion taken strong public stands on issues such as dam safety.

ALISTAIR GUNN

SEE ALSO *Australian and New Zealand Perspectives; Professional Engineering Organizations.*

BIBLIOGRAPHY

INTERNET RESOURCE

Institute for Professional Engineers New Zealand. Available from www.ipenz.org.nz.

INSTITUTIONAL BIOSAFETY COMMITTEES

• • •

Institutional Biosafety Committees (IBCs) are review boards appointed by an institution to evaluate and approve potentially biohazardous lines of research. IBCs were established in 1976 by the National Institutes of Health (NIH) Guidelines for Research Involving Recombinant DNA Molecules (Guidelines). Their function is to provide local institutional oversight and approval of nearly all forms of NIH-sponsored research utilizing recombinant DNA (rDNA) in order to ensure that such research is in compliance with the Guidelines. IBCs were developed in response to fears about the risks posed by genetic engineering and guided by principles considered at the Asilomar Conference on recombinant DNA molecules.

Although IBCs still serve as the cornerstone for oversight of this research, their role has also been expanded to include review and supervision of a variety of experiments involving biological materials and other potentially hazardous agents. The potential threats posed by "dual use research" has prompted the National Science Advisory Board for Biosecurity (NSABB) to consider further expanding the role of IBCs to monitor research that may have implications for bioterrorism. There are doubts, however, about the ability of some IBCs to perform this expanded function. Furthermore, controversy exists not only about the performance of certain IBCs in their main role of ensuring safety, but also about how transparent their work should be. Judging the validity of these concerns is hampered by a general paucity of evaluations and assessments of individual IBCs and the system as a whole.

Background, Development, and Institutionalization

The risks presented by emerging techniques in rDNA research during the early 1970s led scientists to implement a brief self-imposed moratorium on this work. Research with rDNA eventually continued under the principles and guidelines established at the 1975 Asilomar Conference. A mechanism for institutionalizing review and approval of proposed research was considered but not formally adopted at Asilomar. However, in 1976 such a mechanism was created by the NIH Guidelines in the form of IBCs. The model of local, decentralized review committees created and guided by a mandate at the federal level already existed in the form of Institutional Review Boards (IRBs), formalized by the 1974 National Research Act, to monitor human subjects research. Like IRBs, IBCs serve as a mechanism for delegating oversight and approval responsibilities to the local institutions performing research supported by federal grants.

The 1976 Guidelines created Institutional Biohazards Committees, but in 1978 there was a formal shift in focus from "biohazards" to "biosafety." The same year also brought other changes, including more emphasis on ensuring appropriate review, the appointment of a Biological Safety Officer (BSO) at each institution, and improved training protocols and implementation procedures. In 1984 IBCs became responsible for oversight and approval of human gene transfer research. Two years later, the IBC system formally incorporated the "points to consider" developed by the Recombinant DNA Advisory Committee (RAC) Working Group on Human Gene Therapy, and in 1990 the emphasis was shifted to gene transfer rather than gene therapy. The NIH Guidelines were further expanded with additional appendices during the 1980s and 1990s as emerging techniques presented novel regulatory requirements. In 2000 the gene transfer protocols were amended to require RAC review prior to IBC approval (Grilley and Gee 2003).

Although the core responsibilities (review and oversight of rDNA research) of IBCs have remained stable throughout these changes, they have also been expanded to include oversight of other potentially hazardous research, including work on such materials as infectious agents and carcinogens. In March 2004, the U.S. government announced plans to create a National Science Advisory Board for Biosecurity (NSABB), which would identify possible "dual use research" (legitimate scientific work that could be misused to threaten public health or national security) and develop guidelines and recommendations for oversight. The task of implementing the board's recommendations will fall mostly on the roughly 400 IBCs (Couzin 2004).

Each IBC must be composed of no fewer than five members, and at least two members must be unaffiliated with the institution and represent the environmental and public health interests of the surrounding community. Members must be selected in a manner that ensures adequate expertise in rDNA technology and competence in assessing potential risks of proposed research. The functions and responsibilities of IBCs include: assessing containment levels required by the Guidelines for the proposed research; implementing contingency plans; maintaining proper facilities; ensuring adequate training of personnel; ensuring compliance with all surveillance, data reporting, and adverse event reporting; and additional responsibilities for human gene transfer experiments in accordance with Appendix M of the Guidelines. The NIH Office of Biotechnology Activities (OBA) manages and evaluates the conduct of the IBCs as part of its broader mandate to implement oversight mechanisms and information resources to promote the science, safety, and ethics of rDNA research (Shipp and Patterson 2003).

Criticisms and Assessments

Transparency, or openness to public review, is the most contentious issue surrounding both the conduct of individual IBCs and the system as a whole. Proprietary rights and privacy issues often conflict with demands for information about research that could threaten public health. IBCs have been targeted by several watchdog organizations, including the Sunshine Project, which investigates activities that could undermine the 1972 Biological and Toxin Weapons Convention and the 1993 Chemical Weapons Convention. The question of transparency is especially contentious when it involves biodefense research. Such activities require secrecy, yet in the absence of public oversight they could cross over into offensive research or generate new risks (Enserink 2004). The increasing awareness that terrorists could misuse some of the research regulated by IBCs only intensifies the conflict as some call for tighter controls on information and others demand increased public involvement.

There are additional concerns that several IBCs are not only reluctant to publicize information but may be lax in their oversight responsibilities. The Sunshine Project (Enserink 2004) and Diana Dutton and John Hochheimer (1982) accused some IBCs of meeting too infrequently or informally to adequately fulfill their duties. This raises further doubts about the ability of certain IBCs to take on the additional responsibilities of monitoring dual use research. The charge could also be made that a more neutral body should be responsible for oversight and evaluation of IBCs, because the OBA is housed within the NIH, which may raise conflict-of-interest issues.

Dutton and Hochheimer (1982) and Philip Bereano (1984) carried out detailed evaluations of IBCs. Both sets of researchers agreed that IBCs represent novel and promising experiments in the joint regulation of technology by lay and technical communities. However, both also argued that several shortcomings in the IBC system have severely limited its potential to forge consensual judgments about the acceptable risks of scientific research. Bereano argued that the Guidelines were developed primarily by the group being regulated, which narrowed their scope and unduly constrained the purpose of the IBC system. In a related critique, he claimed that IBCs are often dominated by rDNA scientists, which leads to a narrow perception of risk and a general hostility toward regulation. Dutton and Hochheimer argued that IBCs rarely realize their potential for genuine public participation, both for the reasons Bereano outlined and because IBCs often lack adequate resources.

Follow-up on these evaluations has been relatively sparse, which may reflect the difficulty in assessing a decentralized system designed to tailor oversight responsibilities to specific project proposals. The paucity of neutral, comprehensive evaluations, however, also means that many criticisms of IBCs are difficult to substantiate and operationalize into reforms that could improve the regulatory system.

ADAM BRIGGLE

SEE ALSO *Bioethics Commissions and Committees; Biological Weapons; Biosecurity; Institutional Review Boards.*

BIBLIOGRAPHY

Bereano, Philip. (1984). "Institutional Biosafety Committees and the Inadequacy of Risk Regulation." *Science, Technology, and Human Values* 9(4): 16–34. Provides a thorough critique of IBCs and argues that they are still primarily a self-serving mechanism for science rather than a genuine opportunity to involve the public in the process of broadly judging the risks of science from political, social, and environmental angles.

Couzin, Jennifer. (2004). "U.S. Agencies Unveil Plan for Biosecurity Peer Review." *Science* 303(5664): 1595. Discusses the formation of the NSABB as a mechanism for regulating dual use research and the impacts it may have on IBCs.

Dutton, Diana, and John Hochheimer. (1982). "Institutional Biosafety Committees and Public Participation: Assessing an Experiment." *Nature* 297: 11–15. Study of twenty IBCs in California as experiments in local participation in the regulation of science. Revealed great diversity in performance, but concluded that IBCs do little to support public participation.

Enserink, Martin. (2004). "Activist Throws a Bright Light on Institutes' Biosafety Panels." *Science* 305(5685): 768–769. Examines the efforts of Edward Hammond and the Sunshine Project to ensure that IBCs are transparent.

Grilley, B.J., and A.P. Gee. (2003). "Gene Transfer: Regulatory Issues and their Impact on the Clinical Investigator and the Good Manufacturing Production Facility." *Cytotherapy* 5(3): 197–207. Discusses regulatory oversight of human gene-transfer studies and comments on good manufacturing practice issues.

Shipp, Allan, and Amy Patterson. (2003). "The National Institutes of Health System for Enhancing the Science, Safety, and Ethics of Recombinant DNA Research." *Comparative Medicine* 53(2): 159–164. An overview of the NIH Guidelines, IBCs, and RACs, with a commentary on their relationship to animal research.

INTERNET RESOURCE

National Institutes of Health. "Guidelines for Research Involving Recombinant DNA Molecules." Available from: http://www.nih.gov.

INSTITUTIONAL REVIEW BOARDS

Established by Congress in the 1974 National Research Act, institutional review boards (IRBs) are decentralized committees that review and monitor nearly all federally funded research projects involving human subjects in the United States. In most other nations these groups are called research ethics committees (RECs). The purpose of IRBs is to ensure that research conforms to ethical standards and protects the rights and welfare of the people who participate as research subjects. This is accomplished through the IRB Review of Research process, which involves the review of protocols, informed consent documents, and related materials for proposed research. Although flawed and contentious, the IRB regulatory framework is improving in its ability to assure the upholding of ethical standards in a rapidly evolving research context.

Background

The unethical practices of Nazi doctors at concentration camps spurred several attempts to formulate ethical principles for the conduct of research involving human subjects and institutionalize political mechanisms capable of upholding those principles. The most notable international efforts include the 1948 Nuremberg Code and the 1964 Declaration of Helsinki made by the World Medical Association. In 1975 the Helsinki Declaration was revised to include a statement recommending that independent committees review research proposals. The declaration has been revised five more times (1983, 1989, 1996, 2000, and 2002), but the role of ethical review committees has remained central.

In the United States the first federal document requiring committee review was issued in 1953, but it applied only to research conducted at one National Institutes of Health (NIH) facility. In 1966 the U.S. Public Health Service required recipients of its grants to establish committees to review the ethical merits of proposed research involving human subjects. In the early 1970s the U.S. Food and Drug Administration (FDA) and the U.S. Department of Health, Education, and Welfare (DHEW) (forerunner to the Department of Health and Human Services [DHHS]) both promulgated regulations that required committee review of research conducted in institutions.

In 1974, one year after the unethical Tuskegee syphilis study was discontinued, the National Research Act established a statutory requirement for review of FDA- and DHEW-funded research by a committee to which it called an institutional review board (IRB National Research Act 1976). That act also created the National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research (hereafter the Commission) to identify the basic ethical principles that should underlie the conduct of research involving human subjects and to develop guidelines to assure that that research is conducted in accordance with those principles. In 1978 the Commission added a requirement to ensure the equitable selection of research subjects.

In the next year the Commission issued its basic ethical principles and guidelines in the Belmont Report, which resulted from a four-day period of discussions held in February 1976 at the Smithsonian Institution's Belmont Conference Center. The three basic ethical principles identified in the report are justice, beneficence, and respect for persons. The Belmont Report did not make specific recommendations for administrative action by the Secretary of DHEW. Instead, the Commission recommended that the report be adopted in its entirety as a statement of the department's policy. The subsequent adoption of the Belmont Report represents a rare instance of the federal government formally accepting a moral theory as the foundation for legislation (Callahan 2003).

Each of the three principles outlined in the Belmont Report has engendered specific regulations for the practice of research involving human subjects. The principle of justice focuses on the question of who should receive the benefits and bear the burdens of research. It has given rise to both federal and NIH regulations that ensure that the selection of research subjects is equitable (that is, no discrimination against such groups as women, children, and minorities) and that research subjects not be coerced or manipulated in any way. The principle of beneficence entails producing the greatest good while minimizing harm. This principle is reflected in federal regulations that require risk-benefit assessments. The principle of respect for persons highlights researchers' responsibility to treat autonomous persons as such and to protect those with diminished autonomy. The first aspect of that principle is reflected in the regulation requiring informed consent from potential participants. The second is embodied in special regulations designed to protect vulnerable populations, including children, fetuses, and prisoners.

Institutionalization and Criticism

In 1981 the FDA and the U.S. Department of Health and Human Services issued regulations in reaction to the Belmont Report. In that year the FDA created noninstitutional review boards (NRBs) to accommodate the increased scope of the review process. In 1991 more than a dozen federal departments and agencies adopted the IRB process as the official Federal Policy for the Protection of Human Subjects, or "Common Rule." The Common Rule includes requirements for (1) assessing compliance; (2) informed consent; (3) IRB membership, function, operations, review of research, and record keeping; and (4) protection for vulnerable research subjects.

The IRB system has improved research practices by making researchers aware of ethical norms and exercising the power to withhold approval for substandard proposals. It is essential for the protection of human subjects and "is an important structural innovation in the social control of science" (Robertson 1979, p. 29). Nonetheless, the IRB system is "under strain" and "in need of reform," and "significant doubt exists regarding [its] capacity to meet its core objectives" (Federman et al. 2003, p. 5).

Central to this debate is whether the regulations unduly inhibit scientific output and progress. Before this question can be answered, however, more data about the impacts of IRBs must be collected. Frustrating this task is the absence of a national registry of all subjects participating in biomedical or social science research. Also, many people claim that the system is too strict in regard to less invasive social science projects and too lenient in regard to more risky research. A failure to balance risk-benefit ratios often hurts the credibility of the IRB system, and this weakens its capacities to achieve its goals (Levine 1986).

A third contentious issue is the decentralized structure of the system and the difficulty of applying general guidelines to specific research projects. Although the decentralized system allows IRBs to remain close to ongoing research, there may be too much local discretion and inadequate oversight of both researchers and individual IRBs. Without adequate assurance of compliance, research institutions may utilize IRBs to protect themselves and researchers rather than to protect subjects.

A fourth area of debate concerns the proper scope of IRB authority. An example from this set of issues is the question of whether IRBs should have the authority to approve or disapprove the scientific design of research protocols.

Assessment

IRBs have been the subject of intense scrutiny, and in 1979 the Hastings Center established a journal, *IRB: A Review of Human Subject Research,* devoted exclusively to issues raised by and within the system. As with any regulatory framework, the IRB system has had a host of administrative and structural challenges, yet it has proved to be resilient and adaptable. One example is the membership structure of IRBs. Early review committees were limited to immediate peer groups within the research community, but subsequent reforms have led to the requirements of gender diversity, the presence of at least one nonscientist, and the inclusion of at least one member not affiliated with the institution. Further reform efforts are improving the ethics education and certification requirements for IRB members.

The charge that the IRB system may impede scientific output is dubious in light of the rapid development of new drugs and other products and the fact that very few research proposals are rejected by IRBs. Daniel Callahan states that current scientific practice is motivated more and more by the imperative to do research and less and less by the quest for meaningful, life-enhancing knowledge and products (Callahan 2003).

RECs in other countries may offer lessons for reform of the U.S. IRB system. One example is the use of regional, national, and even international committees in other parts of the world. For example, in contrast to the U.S. commitment to local IRBs, many European RECs are regional (McNeill 1989). One issue that will always plague RECs and IRBs, however, is the difficulty of establishing objective criteria by which to evaluate their effectiveness. Most likely, assessment will remain a contested topic that is as much philosophical as it is empirical in nature.

ADAM BRIGGLE

SEE ALSO *Bioethics; Bioethics Commissions and Committees; Institutional Biosafety Committees.*

BIBLIOGRAPHY

Callahan, Daniel. (2003). *What Price Better Health? Hazards of the Research Imperative.* Berkeley, CA: University of California Press. Examines the "research imperative" in the United States and the ways in which it can be distorted into harmful practices.

Curran, William J. (1970). "Governmental Regulation of the Use of Human Subjects in Medical Research: The Approach of Two Federal Agencies." In *Experimentation with Human Subjects,* ed. Paul Freund. New York: George Braziller. Compares the FDA and the NIH review protocols and argues that their differences stem from the fact that they are different types of agencies: One is regulatory, and the other funds exogenous research.

Federman, Daniel D.; Kathi E. Hanna; and Laura L. Rodriguez, eds. (2003). *Responsible Research: A Systems Approach to Protecting Research Participants.* Washington DC: National Academies Press. An Institute of Medicine study commissioned by the DHHS to assess the national system for providing protection for research subjects. An excellent overview with insightful recommendations.

IRB National Research Act. (1976). *Code of Federal Regulations,* Title 45, Pt. 46.

Levine, Robert J. (1986). *Ethics and Regulation of Clinical Research,* 2nd edition. New Haven, CT: Yale University Press.

MacKay, Charles R. (1995). "The Evolution of the Institutional Review Board: A Brief Overview." *Clinical Research and Regulatory Affairs* 12(2): 65–94.

McNeill, Paul M. (1989). "Research Ethics Committees in Australia, Europe, and North America." *IRB: A Review of Human Subjects Research* 11(3): 4–7. A look at RECs worldwide.

Robertson, John A. (1979). "Ten Ways to Improve IRBs." *Hastings Center Report* 9(1): 29–33. A brief summary of the performance of IRBs followed by ten recommendations for improvement. Categorizes defects into two types: administrative and structural.

Sherman, Max, and John D. Van Vleet. (1991). "The History of Institutional Review Boards." *Regulatory Affairs Journal* 3: 615–27.

U.S. National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research. (1978). *Report and Recommendations: Institutional Review Boards.* Washington, DC: U.S. Government Printing Office.

Williams, Peter C. (1984). "Success in Spite of Failure: Why IRBs Falter in Reviewing Risks and Benefits." *IRB: A Review of Human Subjects Research* 6(3): 1–4. An assessment of inherent defects in the IRB system.

INSTRUMENTATION

Instrumentation refers to the use or application of instruments or specialized technologies for observation, measurement, control, or production. In the last sense one even speaks of the instrumentation of a piece of music, meaning its adaptation to being produced or played by a particular set of musical instruments. Technologies in the form of instrumentation have also played a crucial role in the production of human knowledge science prehistory. In all these senses, instrumentation calls for general philosophical reflection, including ethical reflection.

Instrumentation, Ancient and Modern

The usual story about the origins of science cite ancient Greek philosophical speculations such as the prescient hypothesis of Democritus (460–370 B.C.E.) that there must be ultimate small bits of matter, which he termed "atoms," that constitute the most basic things of the world. Plato (428–347 B.C.E.), in opposition, developed an alternative hypothesis of a finite set of ideal geometrical forms into which the universe fits, a finite number of polyhedron shapes or Platonic solids at the base of things. Yet neither Democritus nor Plato produced any concrete, verifiable knowledge about the physical universe through their speculations. It was not until the later Hellenic period of Greek antiquity that heirs to the intellectual tradition initiated by Democritus and Plato began to produce lasting scientific knowledge of physical phenomena by developing measuring instrumentation.

When Robert Crease (2003) asked physicists to identify what ten experiments in the history of science were the most "beautiful," number seven turned out to be the measurement of the circumference of the Earth by Eratosthenes of Cyrene (c. 276–c. 194 B.C.E.). Combining a shrewd set of assumptions with a simple instrument, a gnomon or variation on a sundial, and mathematical measurements, Eratosthenes made a reasonable estimate of planetary size. Assuming a spherical Earth and a Sun at great distance, when the shadow of a gnomon was vertical at Syene he instrumentally measured its angle some 800 kilometers away at Alexandria; then using angular geometry he calculated the curvature necessary to account for such a difference, and extended this to reach an estimate of the circumference that remains respectable to the present day.

The vote that confirmed this as a "beautiful experiment" should come as no surprise, because it simultaneously validates popular belief in the genius of the Greeks, confirms human nostalgia for this particular history, and emphasizes the geometrical thinking that characterizes what later became modern science. But this experiment neither stands alone, nor is it even close to being the most ancient example of knowledge production embodied in technological instrumentation. A multicultural survey of almost any pre-historic set of peoples would show that instrumentation played a role in the knowledge of natural processes that in the early twenty-first century would be called *astronomy* or even *cosmology*. Virtually all larger cultures of the past were sky-watchers and developed often deep knowledge of celestial motions, solstices, seasons, moon cycles, eclipses, sometimes parallax, and other complex astronomical phenomena. These were recorded upon calendars, some of which were superior to calendars within Western traditions until very recent times. Moreover, although sometimes simple, most such observations were made through instrumental mediations. Indeed, *archeoastronomy*, the study of ancient astronomies, has led to the recognition that many of the stone circles of antiquity and prehistory had instrumental uses for establishing solstices, moon and sun cycles, and the like. Examples include Stonehenge, Mesoamerican equivalents, and even ancient North American sites in the Mississippian cultures. Calendar signs of moon cycles can be recognized on antler markings that go back to the last Ice Ages of more than ten millennia ago. Thus technologies have been incorporated into the production of what would now be called "scientific" knowledge from pre-history and within multiple cultures, all using instruments.

Within what some would term the Western master narrative, much is made of a seventeenth century "scientific revolution" as the turning point of early modern science. Yet it is possible to reframe this episode in the accelerated production of scientific knowledge as a second high point in the crucial development of instrumentation as well. Its predecessors were the Renaissance, itself a revival of ancient knowledge, much of it developed and conveyed by Islamic cultures that had perfected instruments and preserved ancient texts, thus creating an instrument-saturated and instrument-fascinated epoch.

Instrumental Perception

Instruments embody *measuring perceptions*. Those previously mentioned entail *visual* sightings, using some stable feature (the instrument) to make repeated observations. Of course the motivation and human contexts for performing such practices differed across cultures. Edmund Husserl (1970) recognized that a simple geometry arose out of the *lifeworld* practices of re-measuring agricultural fields after the annual floods of the Nile in Egypt. In other contexts, the annual renewal of kingships (as in ancient Sumeria) called for accurate dates and times. Islamic cultures needed accurate instruments to identify directions to Mecca, instruments such as the astrolabe and world maps with mathematical grids allowed such measurements, but later were also applied to navigation in the age of exploration. In the early 2000s, with space exploration such as that of the Cassini spacecraft orbiting Saturn, much more precise instrumentation is called for.

Measuring perceptions are not restricted to visual perceptions. Auditory perception has also been mediated through a variety of instruments. Listening tubes, later stethoscopes, amplify the capacity of auditory perception to determine interiors, including voids and shapes. More complex and later acoustic devices, including early sonar, remained auditory but gave way to a preference for visualization in scientific culture. Contemporary radar and sonar produces visual imagery on screens.

Further, various animal-analogues became technologically produced, one example being the development of thermal imaging. Thermal perception is common with reptiles, particularly snakes, which can even sense the shapes of prey through thermal awareness. Thermal awareness in the human case does have a moment in Western science. William Herschel (1792–1871), experimenting with a prism, detected warmth beyond the edge of the red end of the spectrum and correctly inferred the radiation that became known as *infrared*. Thermal imaging in military instruments has become highly sophisticated. But again, the tendency is to translate the thermal image into a visual one, such as obtains with certain types of night-vision instruments (other night vision instrumentation amplifies ambient light).

Tactile instrumentation plays especially important roles in medical practices. The setting of broken bones traditionally employed direct physical, bodily manipulations, and even with early instrumentation, the trained surgeon could "feel" what he was doing through the instrument. In dentistry, for example, the tools used to examine teeth reveal the cracks, soft areas, and cavities that are of dental interest. These perceptual experiences are *mediated* through the instruments, or the instruments are embodied by the practitioner. Contemporary instruments, however, often change previous practice. For example, laparoscopy, or even more extremely, distance surgery, entails practices that more resemble video games than earlier forms of surgery. Here miniscule tubes outfitted with imaging devices and connected to microsurgical tools are operated by the surgeon through skilled eye-hand coordination to perform the operation (sometimes called "Nintendo surgery").

Instrumental Hermeneutics

To this point, instrumentation has been described in relation to the way in which bodily-perceptual capacities are amplified or magnified. A different set of instrumentations, again going back to antiquity, relates more obviously to the human capacities for making and reading *inscriptions*, that is, instrumentation that engages interpretive or *hermeneutic* practices. Inscriptions found on reindeer antlers, dated as much as 30,000 years ago, have been found with twenty-eight cycle patterns, thus likely signifying a lunar cycle. Abstract hatch marks and other inscriptions have been found alongside the highly isomorphic or "realistic" depictions of animals in the cave regions of France and Spain have also been found (18,000 to 15,000 years ago). With early modernity, calculating machinery began to be employed, usually with counters inscribed with numbers or letters and driven by complex gearing. Dials, gauges, readable panels, all are forms of instrumentation engaging "reading" or hermeneutic skills.

The recognition of perceptual patterns, particularly as *images*, and the recognition of inscriptions in number-like (counting) or letter-like (reading) form, are both instrumental. The philosopher of science Peter Galison (1997) calls these the *image and logic* traditions that dominate late modern physics. But the data-to-image-to-data inversions are also a newly dominant form of instrumentation in contemporary science.

Technoscientific Instrumentation

Contemporary science is *technoscience*—that is, a science thoroughly embodied in its technologies and instruments. Only since the middle of the twentieth century has astronomy broken the bounds of both ancient "eyeball" and then early modern optical instrumentation. First, with the breakthrough provided by radio astronomy (associated with the development of radar), then through forms of spectroscopy that range from very short gamma-waves to very long radio-waves, has the limitation of optical wave frequencies been exceeded. In the early twenty-first century, slices of the microwave spectrum, such as x-ray imaging, can show pulsars in action, or map the dark emissions of the radio spectrum. In a parallel fashion, medical imaging, ranging from photography through the x-ray devices from 1895, to MRI and PET scans since the 1970s, perform the same function with respect to imaging the human body.

These processes are made possible through: (a) the data-image conversions possible through computer tomography and computer-aided technology (CAT) processes, (b) modeling and simulation techniques again employing computations, and (c) the algorithmic projection of imagery such as may be instanced in fractal patterning. Thus contemporary imaging may be either processed as data (numbers, counting, calculational) or as imaging (picture-like), and each form is transposable to the other. More important, however, is that the range of phenomena detectable through contemporary forms of sensing may not only be remote, but it exceeds all ordinary bodily perceivability, as has been analyzed at length by Ernesto Mayz Vallenilla (1990).

Yet, indirectly or in the form of new mediations, such instrumentation *translates* its results into countable/readable ones. Contemporary Mars and Saturn missions image the surface of Mars or the rings of Saturn, close up, and return these to the earth-bound observer for perceivable, close-up results. Or in the case of the Chandra X-ray source, images of the explosive nebulae through "false color" depictions can be perceptually grasped in human visual form. Instrumentation provides science with its own sensorium.

Popular Instrumentation

While the above overview of instrumentation has been focused upon various science practices, the same or similar types of instrumentation have more common manifestations. Some have said that the twenty-first century will be the century of one big and one little technology. The big technology is the home entertainment and work center, containing a high-definition screen for television, computing, and communicating, and a multimedia, multi-tasking station that incorporates the Internet, word processing, communications, and entertainment. The small, mobile technology that incorporates digital photography, mini-screen, for everything from cell phoning to email to reading barcodes for purchases is the other extreme of the big/little technofantasy. This is a not unrealistic extrapolation from extant technologies that are also social-cultural-economic instruments.

In one sense, these technologies are the same as those noted in science. Each transforms the texture of human experience. If contemporary astronomy produces near-distance with its images of multi-billion-year-old galaxies, so does electronic communication make near-distance of every electronically accessible spot on the globe. If the technologies are state-of-the-art audio-video ones, then any online place can produce conference interchanges. Or if lapsed time is used, as in videos, cinemas, or Internet technologies, then the result is even more like the galaxy example, and lapsed-time phenomena are made into present-time phenomena. Academic experience is illustrative: Many first time contacts are electronic, by email, or telephone. Arrangements for conferences, lectures, travels, are almost always arranged electronically—including air tickets. First person contact may or may not follow, and when it does, the follow-up reverts to the electronic instrumentation. Academic globalization is already electronically embodied and actual.

Ethics of Instrumentation

This communication-entertainment-information instrumentation also entails complex ethical-political, cultural-economic dimensions. Especially in the area of medical instrumentation, a primary question concerns safety. In the area of communications instrumentation more generally, a primary issue is privacy.

But more generally still one can examine the social justice of who has access to the whole communication-entertainment-information instrumentation complex. Is the globally interconnected world merely another elite? Is the trajectory centralist or decentralist? Many have noticed the extreme irony of the Internet—originally designed to be a fail-safe mode of communication for a military-university elite, it has become a diffuse, world-connecting instrument for everything from spam, electronic scams, and virtual romances to instant political dissemination of news and politics—and a new mode of campaign financing. No one knows if the outcome will be more democratic or more totalitarian. Yet by virtue of both the unpredictability and the indeterminacy (or, better, underdetermined) qualities produced by these new instruments, new opportunities have clearly come into being.

While prognosis is ambiguous, in part because all technologies display multiple possible developments and uses, the human-instrument relationship exhibits its own multiple dimensions. Many contemporary instruments are complex and characterized as "high tech" machines, implying the need for a highly skilled, technically informed set of users—technocrats and technically trained individuals. But although some subset of technically proficient persons is needed for the infrastructure of such technologies, a different set of skills is required for instrumental uses. For example, generational differences are often remarked upon in that young children quickly become computer literate whereas older people often display reluctance or "technophobias" regarding these technologies. Yet the child is not so much a technician as a skilled user. One need not know computer programming to play a video game, any more than one needs to know physics to ride a bicycle. Yet it is also interesting that the emergence of both many software developments and the location of much worldwide hacking and virus development is associated with countries once thought to be underdeveloped or under-technologized.

Instrumentation, whether in knowledge production, communication, commerce, entertainment, and much of the full range of human activity, is a means by which human perceptual and interpretive activity is embodied. As the above examples show, instrumentation may be very simple (a gnomon) or very complex (Internet), but the diffusion, adaptability, and spread of instrumentation technologies is more dependent upon the easy adaptability into human use practices—which then change—than the degree or type of complexity built into the technology. Historically, photography, radio, cinema, and television all were rapidly diffused, whereas modern agricultural and transportation technologies were not, or took much longer to be adapted. One possible reason for this may be the ease with which bodily-perceptual actions are quickly and without much technical training brought into play. To hear a radio and recognize a voice, to see a movie, to recognize a photograph is an almost immediate phenomenon. Contrarily, to transfer a set of agricultural practices or ship building skills is much more complex. Instrumentation, in the very contemporary sense, entails both kinds of complexity. The evening news, or the Cassini image of Saturn's rings, both involve large, complex infrastructures and global or even interplanetary connections—but both yield perceivable results as focal outcomes of instrumentation.

DON IHDE

SEE ALSO *Body; Experimentation; Scientific Review.*

BIBLIOGRAPHY

Crease, Robert P. (2003). *The Prism and the Pendulum: The Ten Most Beautiful Experiments in Science*. New York: Random House. Robert Crease, philosopher of science and historian for the Brookhaven National Laboratory, discusses the history and science of ten historical experiments in Western science.

Galison, Peter. (1997). *Image and Logic: A Material Culture of Microphysics*. Chicago: University of Chicago Press. Mallinckrodt Professor of the History of Science at Harvard University, Peter Galison is particularly noted for his philosophical style which more deeply incorporates the role of technologies into science practice. This book shows that two traditions, imagers and counters, pervade late modern physics.

Husserl, Edmund. (1970). *The Crisis of European Sciences and Transcendental Phenomenology*, trans. David Carr. Evanston, IL: Northwestern University Press. This "classic" of phenomenology, the last major book published by Husserl, introduces the notions of *Lifeworld* and science arising from practices now more common in science studies.

Ihde, Don. (1990). *Technology and the Lifeworld: From Garden to Earth*. Bloomington: Indiana University Press. This systematic philosophy of technology introduces the roles of different human-technology relations, cultural hermeneutics and contemporary trajectories to philosophy of technology.

Ihde, Don. (1991). *Instrumental Realism: The Interface Between Philosophy of Science and Philosophy of Technology*. Bloomington: Indiana University Press. The first English language book to relate philosophy of technology to the "newer" technologically sensitive philosophers of science.

Mayz Vallenilla, Ernesto. (1990). *Fundamentos de la meta-técnica*. Caracas: Monte Avila. A Spanish language philosopher of technology is one of the few to deeply appreciate and work with contemporary instrumentation in science. English translation: *The Foundations of Meta-Technics*, trans. C. Mitcham, Lanham, MD: University Press of America, 2004.

INTEGRITY

SEE *Research Integrity*.

INTELLECTUAL PROPERTY

The concept of *property* is as old as civilization. As people acquired possessions or inhabited land or shelters, they sought to secure these items for personal or collective use. Customs and rules evolved to define ownership and specify the rights and responsibilities that attached to ownership. In conjunction especially with developments in science and technology, property has taken on intellectual forms that embody ethical stances and have policy implications.

From Property to Intellectual Property

The definition of property evolved as society invented or identified new things that can be owned. *Property rights* began with the physical or concrete, such as land, and eventually expanded to include more intangible or abstract phenomena (Horwitz 1992). Interference with such rights shifted from a physical invasion to interference with a proprietary right or a decrease in market value.

Property rights are a series of formal and informal rules governing what owners are allowed to do with their property and the degree to which they can exclude others from its use. Such rights describe relations "not between an owner and a thing, but between the owner and other individuals in reference to things. Property rights reflect societal values of how wealth should be distributed and protected.

Intellectual property is abstract and refers to the products of human intellect such as inventions, literary works, music, and art. Many societies historically have not recognized ownership in intellectual property. Others have associated names with achievements but have not provided serious protection. As societies industrialized, they found a need to protect intellectual property, especially the valuable products of science and technology. Intellectual property rights (IPRs) describe a bundle of rights or privileges that, like other property rights, allow the owner to use, derive income from, and transfer the ownership of the property.

Intellectual Property Rights

IPRs define the rights and privileges attached to ownership of intellectual property. Such rights allow owners to exercise a temporary monopoly over the use of their creations; they have exclusive rights, for a limited time, to decide who may use a product or work and under what conditions. Such rights define ownership and specify the degree to which inventors and creators may profit from their work, the access others may have to the works themselves or to information about them, and how others may use or improve upon existing works.

IPRs involve issues of wealth distribution, incentives for innovation and creativity, access to information, and basic human rights. Ethical issues attach to questions of what should be publicly or privately owned, how ownership is established, how much and how long the owner can control the property, and whether public policy should create exceptions to intellectual property rules to serve social interests.

IPRs encourage innovation by protecting new work from appropriation by others and allows people and institutions to profit from their work. Such rights promote the communication of information; as long as the right is in place, information can be published without fear of loss. IPRs also define public rights by indicating when private protections expire.

Rationales for IPRs fall into two categories, "instrumental rationales, which view intellectual property in terms of its benefits to society as a whole, and natural rights which stresses the inherent authority of innovators to control works they have created" (Schecter and Thomas 2003, p. 7). *Instrumental* rationales focus on the need for protection to promote societal goals, such as economic growth or technological innovation. *Natural rights* arguments, grounded in the philosophy of John Locke, assert that people are entitled to protection for the products of their minds, regardless of whether the protections serve other societal goals. The two rationales may lead to different policy decisions about the appropriate type and level of intellectual property protection.

Intellectual property protection is regarded as a basic human right. According to Article 27 of the Universal Declaration of Human Rights (1948), "Everyone has the right to the protection of the moral and material interests resulting from any scientific, literary or artistic production of which he is the author." The reach of the right differs across nations, with industrial nations generally providing higher levels of protection than developing nations.

Constructing an IPRs system requires the balancing of often conflicting societal values and needs, such as the need to promote innovation; concerns for equitable distributions of wealth, information, and other benefits; and the desire to allow authors or inventors to profit from the fruits of their labor and imagination. Increasing protection in one area often detracts from another.

Types of Intellectual Property Law

The international system recognizes two types of intellectual property: industrial property, including but not limited to inventions, trade secrets, and trademarks; and copyright. Systems of IPRs laws differ across nations but often include the following.

Copyrights protect works of creativity and authorship such as literary, musical, and visual art, as well as audio recordings, choreography, and computer software. Laws specifying such protection must consider issues such as fair balance between private and public use, the need for public access to information, when protection should begin and how it can be triggered, and how to enforce protections.

Patents protect innovative products and processes by allowing the patent holder to control use of the invention for a limited period of time. In exchange for patent protection, inventors generally must agree to disclose information about their inventions to the public. Patents are generally restricted to inventions, including both products and processes, although the restrictions on patents have narrowed in recent years. Products of nature have generally not been patentable but improvements in biotechnology have challenged definitions of what is natural.

Trademarks identify the origin of products or services and are used to promote them. Trademark protection prevents others from using a trademark to promote a product or service of a different origin. Such protection prevents the appropriation of the competitive advantage trademarks are intended to provide.

Trade secret law protects proprietary business information from misappropriation. Some information, such as an industrial process, might be eligible for protection either under patent law or trade secret law but not both. Trade secrets must be protected from disclosure, while the patent process generally requires making information public.

Science, Technology, and Intellectual Property

Science and technology provide many societal benefits, such as the enhancement of economic growth or quality of life. They also can produce negative, unintended consequences. Most societies promote science and technology, but this can be costly. Establishment of IPRs that protect new works and give innovators the right to profit from their creations provides incentives for expensive innovation without the need for direct government subsidies (Posner 2004). At the same time, IPRs may maintain or aggravate wealth inequities.

Rights have little meaning unless they can be enforced and modern technology has made IPRs enforcement increasingly difficult. Photocopiers make it possible for anyone with access to a machine to reproduce works entitled to copyright protection and the Internet allows anyone to make literary or musical works available to the world.

Science and technology challenge intellectual property systems, particularly patent laws. New fields such as information technology and genetic engineering force courts to decide how to apply laws made before such technologies were contemplated. As knowledge itself becomes more valuable, people and institutions seek additional protection for control of the knowledge and its profits. At the same time, society has an increasing need for access to some kinds of knowledge and protection from the use of others.

Abstract ideas cannot be patented but their applications can qualify for patent protection. For example, "Einstein could not patent his celebrated law that $E = MC^2$; nor could Newton have patented the law of gravity. Such discoveries are 'manifestations of Nature, free to all men and reserved exclusively to none.'" (Diamond v. Chakrabarty, p. 309, quoting Funk Brothers Seed Co. v. Kalo Inoculant Co., 333 U.S. 127, 130, 1948). General ideas remain in the public domain but their applications may be privatized through the patenting process.

Biotechnology, perhaps more than any other field, has challenged courts and lawmakers to reconsider intellectual property laws. In 1972 Ananda Chakrabarty, a microbiologist, sought a U.S. patent for a genetically engineered bacterium. The U.S. Patent Office denied the application because bacteria are products of nature, and living things cannot be patented under U.S. law. The case was appealed and eventually reached the U.S. Supreme Court. The Court restated the principle that natural phenomena cannot be patented, but found that Chakrabarty's bacterium was "a product of human ingenuity," and therefore was patentable under U.S. law.

So many biotechnology patents have been issued for such small innovations that some fear the creation of a *tragedy of the anti-commons* in which new innovations involve so many existing patents that innovation is discouraged. At least one study has found the anti-commons is not yet a significant deterrent to innovation, but that the situation should be monitored.

IPRs can be attached to writings or products regarded as dangerous or immoral, and IPRs tend to legitimize such works by implying social approval. Societies must decide whether to provide protection for harmful or otherwise objectionable work. New technologies, particularly those that create or replicate life, often trigger debate over whether the work should be done at all, much less be protected by law. IPRs also establish ownership of particular innovations, which may help to determine liability if a product causes harm. This raises questions of whether innovators should be held responsible for their products, particularly when the products are used in unintended ways.

Public funding for science and technology further complicate intellectual property issues. Who should benefit from works developed under public funding, the creator or the public? What balance of public/private benefits best serves societal goals?

Academics build their reputations by producing intellectual works. They seek recognition for their accomplishments, control over any economic benefits, and protection against plagiarism. IPRs promote release of information to the public by assuring the author of protection for the work, even after it is made public. IPRs protect authors from possible appropriation of ideas by others, including peer reviewers, before the work has actually been published.

Ownership can be a major IPRs issue. Who owns the product of collaborative work? At what point does a contribution by a supervisor, graduate student, or coworker deserve coauthorship? When the creator works for a corporation or a university, does ownership lie with the creator or the institution? What about funding agencies? In many cases, ownership or authorship is established by disciplinary customs or by agreements among the parties (Kennedy 1997).

Plagiarism is professionally unacceptable and sometimes illegal, but timing is critical to determining whether plagiarism has occurred. According to Donald Kennedy, "To take someone else's idea and use it before it has been placed in the public domain is a form of theft . . . [t]o make further use of someone else's idea after it has been published is scholarship" (1997, p. 212). Of course attribution is critical even, or especially, in scholarship, whether or not a work is protected.

International Intellectual Property Rights

The absence of an international sovereign makes a global IPRs system problematic. Every nation has different intellectual property laws, making cooperation difficult, although many international IPRs agreements have been developed. Which nation's standards should apply? Most international agreements take a national approach in which a country agrees to provide foreign innovators with the same protection provided to its domestic citizens. Creators of intellectual property generally must seek protection separately in each jurisdiction, a cumbersome process.

The United Nations World Intellectual Property Organisation (WIPO) provides support for the international intellectual property system. Its mission is "to promote through international cooperation the creation, dissemination, use and protection of works of the human mind for the economic, cultural and social progress of all mankind."

Globalization has increased the need for more international IPRs coordination. Multinational organizations seek consistent laws across borders and inventors want universal protection for their inventions. The World Trade Organization Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS Agreement) attempts to provide a more standard IPRs system and sets minimum protection that must be provided by all member states.

Ethical issues become particularly important at the international level (Rischard 2002). Some fear that increasing IPRs protection will increase inequities between the developed and the developing world. Others are concerned that IPRs deny access to products desperately needed by the poor or powerless. Still others believe adequate IPRs standards are critical to promoting technology transfer and foreign investment.

IPRs can deny access to essential products and information to those who need them most, particularly in developing countries. Drug research and development is extremely expensive, and pharmaceutical countries price drugs to recoup expenses and make a profit. No one else is allowed to manufacture drugs protected under patents. Those who need the drugs often have little money. Is it fair to allow people to die because they cannot afford drugs that could prolong their lives?

The TRIPS Agreement allows for compulsory licenses, an exception to IPRs in special cases such as emergencies, that give developing countries access to essential drugs for major health problems such as HIV/AIDS or malaria. Such policies may have a boomerang effect; pharmaceutical companies may be less likely to invest in research to develop drugs for conditions found primarily in poor countries if there is no profit to be made. The answer to the drug access problem may be better addressed by turning to solutions unrelated to intellectual property rights, such as foreign aid. Some pharmaceutical companies have made drugs available at drastically reduced rates to those who cannot afford them.

Inspiration for new products often comes from local or traditional knowledge. Who should benefit when a drug company develops a new drug based on knowledge about the properties of a plant gained from an indigenous tribe in a remote region? Is the company that developed a commercial drug entitled to all the profits or should it share revenues with the people who supplied the information or with the country from which the plants are harvested?

Conclusion

Consensus exists over the need for IPRs but not over the content of such rights. Countries that produce more science and technology and other intellectual property support more protection than other nations. Globalization requires more consistency in IPRs than has traditionally been available. IPRs help to promote innovation and the communication of information, but questions remain about the appropriate balance between public and private rights, the nature of ownership, and the equitable provision of access to products and information. Debates continue over the types of intellectual property that should be protected by law. New technologies intensify such debates, particularly technologies that create new or duplicate old life forms.

MARILYN AVERILL

SEE ALSO *Human Rights; International Relations; Property; Science, Technology, and Law.*

BIBLIOGRAPHY

Horwitz, Morton J. (1992). *The Transformation of American Law: 1870–1960*. Oxford: Oxford University Press. General property rights are addressed throughout this treatment of the development of American law over a ninety-year period. IPRs are not specifically treated.

Kennedy, Donald. (1997). *Academic Duty*. Cambridge, MA: Harvard University Press.

North, Douglass C. (1990). *Institution, Institutional Change and Economic Performance*. Cambridge, England: Cambridge University Press. This book discusses how formal rules develop, including property rights; it does not specifically discuss IPRs.

Posner, Richard A. (2004). *Catastrophe: Risk and Response*. Oxford: Oxford University Press.

Rischard, Jean-François. (2002). *High Noon: 20 Global Problems, 20 Years to Solve Them*. New York: Basic Books.

Schechter, Roger E., and John R Thomas. (2003). *Intellectual Property: The Law of Copyrights, Patents and Trademarks*. St. Paul: West. This comprehensive reference covers American intellectual property law in great detail, including the history of, rationales for, and elements of each right.

Walsh, John P.; Ashish Arora; and Wesley M. Cohen. (2003). "Effects of Research Tool Patents and Licensing on Biomedical Innovation." In *Patents in the Knowledge-based Economy*, ed. Wesley M. Cohen and Stephen A. Merrill. Washington, DC: National Academies Press.

INTERNET RESOURCES

World Intellectual Property Organization. (2005). *WIPO Intellectual Property Handbook: Policy, Law and Use*. Available from http://www.wipo.int/about-ip/en/iprm/. General organization site can be found at http://www.wipo.int/. This site provides a wealth of materials on intellectual property rights.

World Trade Organization. TRIPS Material on the WTO Website. Available from http://www.wto.org/english/tratop_e/trips_e/trips_e.htm.

INTERDISCIPLINARITY

Any attempt to consider relations among science, technology, and ethics is by definition interdisciplinary. This entry distinguishes among basic approaches to terminology, reflects on the intersection of interdisciplinarity and ethics, and assesses future prospects. Because it provides an existing model, with both strengths and weaknesses, for examining science, technology, and ethics interactions, references will often be made to the existing interdisciplinary field of science, technology, and society (STS) studies.

Forms of Interdisciplinarity

Interdisciplinarity has both broad and more restricted meanings. In the broad sense it includes a number of different forms, one of which is interdisciplinarity in a more narrow sense. There are three forms of interdisciplinarity in the broad sense that are important to distinguish, and that provide a framework for discussions of types of interdisciplinary interactions.

Multidisciplinarity juxtaposes separate disciplinary approaches around a common interest, adding breadth of knowledge and approaches. But the disciplines continue to speak as separate voices in encyclopedic alignment. Underlying assumptions are not examined, and the status quo remains intact.

The major disciplines in STS multidisciplinarity have traditionally been history, philosophy, and sociology of science (Cozzens 2001). Studies of science in literature and scientific literature also received attention, and anthropology became prominent in the 1990s. Although disciplinary identities remain strong, there are specialized interdisciplinary bridges, such as alliances of economists of scientific research and technological development with historians and sociologists of technology interested in technological innovations. Gary Bowden (1995) distinguishes three methods of explanation in STS: topic-, issue-, and combined-focus. Topic-focus is the most common, using methods and techniques of one discipline to study an aspect of science or technology. The result is an amalgamation of contextualist approaches. Both Bowden and Susan Cozzens characterize STS as a multidisciplinary array of activities.

Interdisciplinarity integrates separate data, methods, tools, concepts, theories, and perspectives in order to answer a question, solve a problem, or address a topic that is too broad or complex to be dealt with by one discipline (Klein and Newell 1997). In education, content is revised and the curriculum is restructured around a theme, problem, or issue. In research, the task at hand becomes the primary focus, and in interdisciplinary fields a new body of knowledge emerges.

Several added distinctions appear. *Instrumental, strategic, pragmatic,* or *opportunistic* forms tend to focus on economic and technological problems. During the 1980s, interdisciplinarity gained heightened visibility in science-based areas of intense economic competition such as computers, biotechnology, and manufacturing. In this instance, interdisciplinarity served the political economy of the market and national needs.

Critical and *reflexive* interdisciplinarities differ. They interrogate the existing structure of knowledge and education, raising questions of value and purpose that are silent in instrumentalist forms (Weingart 2001, Klein 2001). Bowden also aligns interdisciplinarity with *combined focus methods,* marked by a common culture of investigation and a coherently integrated package of analytic resources and, often, new concepts. Insofar as STS becomes interdisciplinary, Cozzens adds, it ceases to be anchored in constituent disciplines.

Transdisciplinarity was initially defined as an overarching synthesis that transcends the narrow scope of disciplinary worldviews. General systems theory, structuralism, Marxism, the policy sciences, feminism, and complexity theory are leading examples. Likewise, sustainability and science, technology, and society reorganize and further develop knowledge and education around new synthetic frameworks. The term has also been a descriptor for broad fields (for example area studies, cultural studies), and synoptic disciplines (philosophy, geography). Recently in humanities it has been aligned with new critical paradigms, and it is a label on web sites in areas as varied as education, health care, and engineering sciences. In the 1980s and 1990s, three new connotations appeared: a new structure of unity informed by the worldview of complexity in science (Nicolescu 1996); a new mode of knowledge production that fosters synthetic reconfiguration and recontextualization by drawing on expertise from a wide range of organizations; and collaborative partnerships for sustainability that cross the boundaries of social sectors as well (Klein et al. 2001). Bowden also associates transdisciplinarity in STS with analytic *issue-focused methods* that emphasize a particular theoretical issue. They are not limited to the particulars of a specific substantive topic. The problem of reflexivity, for instance, is not unique to social studies of science and technology. Postmodernism also appears across a wide range of subjects.

Relation to Science, Technology, and Ethics

These basic distinctions are apparent in science, technology, and ethics (STE). In multidisciplinary STE, science, engineering, and ethics all retain their distinctive superdisciplinary features. Science is a superdiscipline that includes physics, chemistry, biology, geology, and other kindred disciplines. Comparably, engineering encompasses mechanical, chemical, electrical, and other fields of engineering. Ethics, in turn, encompasses distinctive forms that range from consequentialism and deontologism to virtue ethics. Applied ethics in its first incarnation took ethics as is and put it to work in and for science and engineering. In interdisciplinary STE, new fields emerged that combined a science and ethics. Applied ethics in its second incarnation appeared as fields of computer ethics, engineering ethics, environmental ethics, bioethics, and so on. In an instance of transdisciplinary STE, some philosophers also attempted to create a general ethics of technology that transcends any one type of science or engineering while subsuming other forms of ethics. Examples include Hans Jonas's argument in *The Imperative of Responsibility* for an overarching ethical obligation to protect the future of human and all life. Other examples include proposals for sustainability as a moral obligation and the precautionary principle as a general guideline for scientific research and technological innovation.

Interdisciplinarity intersects with ethics in science and technology in many ways. During the 1960s and 1970s, a renewal of ethics occurred in philosophy, driven by new problems of justice, fairness, and values in professional practice. In the ensuing decades, new categories of moral thought and action emerged, the moral and ethical dimensions of every field began to be explored and, in general education, related issues were incorporated into disciplinary and interdisciplinary core courses. As David Edge (1995) observes, it is not accidental that new critical approaches evolved hand in hand with new developments in training technical experts. Such developments were part of a broad shift from positivist models and programmed research on applied problems toward critical scrutiny of their implications. The distinction is not absolute though. Research on problems of the environment and health, for instance, often combines programmed problem solving with critique of current practices and institutional structures.

The interdisciplinary character of STS also fostered greater attention to implications and consequences. Before the 1980s, Bowden recounts, social science and humanities research in the field was primarily historical, philosophical, and, to a lesser degree, sociological. Science and technology were treated as autonomous entities separate from social context. Philosophers examined the logic of the scientific method, historians documented the evolution of ideas and technological artifacts, and sociologists looked at the institutional structure and internal patterns of science. In the mid 1960s, especially among historians of technology and some in engineering education, notions of autonomous technology and the neutrality of technology were challenged by new understandings of technology as a complex enterprise in specific contexts that are shaped by, and in turn shape, human values.

This development generated a sizable literature on ethics and values in relation to technology. The new discourse of problem understanding and political choice placed greater emphasis on social impacts and policy as well. In the mid-1970s, developments in philosophy and history of science opened up the content of scientific knowledge to sociological scrutiny, fostering empirical examination of social bases of scientific knowledge and challenging the authority and epistemological privileging of science. In the late 1980s, a turn toward technology occurred. The first two developments involved conceptual reformulations that contextualized science and technology and the manner in which context affects creation of scientific knowledge and the impact of science and technology on society.

Analogously multidisciplinarity, science, engineering, and ethics retain their distinctive features. *Applied* ethics takes ethics as it is and puts it to work in and for science and engineering. In science-technology-ethics (STE) interdisciplinarity, new fields that combine a science and ethics emerge, producing areas such as computer ethics, engineering ethics, environmental ethics, and bioethics. In STE transdisciplinarity, some philosophers and ethicists have created a general ethics of technology that transcends any one type of science or engineering and subsumes other forms of ethics.

Assessment

Interdisciplinarity and STS are both conflicted discourses, marked by unresolved questions and differing positions. Disagreements center on key issues and problems, the role of disciplines, and priorities of integration versus critique. Moreover, the full range of options exists simultaneously, from multidisciplinary juxtapositions to interdisciplinary integrations to transdisciplinary frameworks. Both interdisciplinarity and STS are also maturing movements. Knowledge is widely considered to be increasingly interdisciplinary and, Bowden observes, the scholarly endeavor of STS has come of age. Nonetheless the widely touted interdisciplinary transformation of the university has not occurred. Multidisciplinary approaches are more common, institutional impediments retain their force, and Cozzens concludes, the integrated whole of STS thought is more of an ideal than a pervasive reality. The practice of STS often remains discipline-bound and removed from the world of practice. Edge concurs, asking whether "the heady sense of interdisciplinary adventure" and "seductive combination of academic priority and practice urgency" has disappeared (Edge 1995, p. 3).

There is also a constant tension between the particular and the general. Interdisciplinary STE is often criticized for trying to be too general: for instance in comments that "there is no such thing as 'technology' but only 'technologies'" and "all general principles are vacuous." At the same time, applied ethics fields such as computer ethics and biomedical ethics are criticized for reinventing the wheel: for instance in talk about risk analysis or informed consent and in their failure to synergize achievements from different applications.

In existence only since the early-1970s, STS has attained an expanding presence and established a platform for greater interdisciplinarity. An identifiable group of scholars and teachers has formal affiliations with the field, and an infrastructure for communication is in place. Cozzens highlights, in particular, the generation emerging from interdisciplinary STS programs in the early-twenty-first century. They are less bound to disciplinary identities than their professors and more prepared to move in the direction of *postdisciplinary* research that goes beyond narrowly circumscribed conceptual categories and analytical practices while often critiquing underlying premises of disciplinarity as well. Yet much work remains. The gains that have been made must be secured and the field must continue to develop on its own terms, not as the cumulative sum of its disciplinary parts. Doing so will require diligence to insure sufficient economic and symbolic capital; inclusion in funding categories of research agencies; an adequate number and scale of programs; full-time appointments in STS programs and departments; secure locations in organizational hierarchies; and autonomy in decisions about curriculum, budget, and staffing.

In both STS and STE, there is constant tension between the particular and the general. Both, moreover, raise the same question that all interdisciplinary fields raise. Where do they *fit?* The problem of fit, Lynton Caldwell (1983) advises from the experience of environmental studies, prejudges the epistemological problem at stake. Interdisciplinary categories arose because of a perceived misfit among need, experience, information, and the prevailing structure of knowledge. If the structure must be changed to accommodate the new field, perhaps the structure itself is part of the problem.

JULIE THOMPSON KLEIN

SEE ALSO *Two Cultures; Science, Technology, and Society Studies.*

BIBLIOGRAPHY

Bowden, Gary. (1995). "Coming of Age in STS." In *Handbook of Science and Technology Studies*, eds. Sheila Jasanoff, Gerald E. Markle, James Petersen and Trevor Pinch. A diagnosis of three distinct methods of explanation in STS (topic-, issue-, and combined focus), the visions of the field they imply, formative experiences that defined STS's identity, and assessment of the appropriateness of the methods.

Caldwell, Lynton K. (1983). "Environmental Studies: Discipline or Metadiscipline?" *Environmental Professional* 5: 247–259. A genealogy of the field that accounts for its rise and historical shifts, structural and curricular forms, intellectual and practical affiliations, and multidisciplinary versus interdisciplinary dimensions.

Cozzens, Susan E. (2001). "Making Disciplines Disappear in STS." In *Visions of STS: Counterpoints in Science, Technology, and Society Studies*, eds. Stephen H. Cutcliffe and Carl Mitcham. Albany: State University of New York Press. A mapping of STS as a movement and multidisciplinary network of discipline-bound theory and practice that also calls for a more integrated and interconnected body of knowledge responsive to the interdisciplinarity of STS problems.

Edge, David. (1995). "Reinventing The Wheel." In *Handbook of Science and Technology Studies*, eds. Sheila Jasanoff, Gerald E. Markle, James Petersen, et al. Newbury Park, CA; London: Sage. An overview recalling the field's origin in the mid-1960s, early research and educational considerations, the democratic impulse of the field, subsequent growth and differentiation, and current possibilities for a creative reconciliation of tensions.

Jasonoff, Sheila; Gerald E. Markle; James C. Petersen; and Trevor Pinch, eds. (1995). *Handbook of Science and Technology Studies*. Thousand Oaks, CA: Sage. A comprehensive collection of essays on the field by leading scholars that defines, summarizes, and synthesizes the literature and provides theoretical, historical, and policy essays plus case studies on the cutting edge of STS.

Klein, Julie Thompson. (2001). "A Conceptual Vocabulary of Interdisciplinary Science." In *Practicing Interdisciplinarity*, eds. Peter Weingart and Nico Stehr. Toronto: University of Toronto Press. An overview of definitions and related forms of discourse, patterns of activity, the role of complexity and hybridity, practices of borrowing and problem solving, and the conflicted status of disciplines and integration.

Klein, Julie Thompson, ed. (2002). *Interdisciplinary Education in K-12 and College: A Foundation for K-16 Dialogue*. New York: College Board. A collection of essays on the history and forms of interdisciplinary approaches, use of technology in teaching, integrative processes, political stakes in curriculum reform, and strategies of course design, team teaching, administration, and evaluation.

Klein, Julie Thompson, and William H. Newell. (1997). "Advancing Interdisciplinary Studies." In *Handbook of the Undergraduate Curriculum: A Comprehensive Guide to Purposes, Structures, Practices, and Change*, eds. Jerry Gaff and James Ratcliff. San Francisco, CA: Jossey-Bass. An overview of the history, motivations, structures, and forms of interdisciplinary study with analysis of the core concept of integration and its implications for course design, approaches to teaching and learning, and assessment.

Klein, Julie Thompson, et al., eds. (2001). *Transdisciplinarity: Joint Problem Solving among Science, Technology, and Society*. Basel, Switzerland: Birkhauser.

Newell, William H., ed. (1998). *Interdisciplinarity: Essays from the Literature*. New York: College Board. An anthology of essays on the nature of interdisciplinary study, its administration, disciplinary contexts, lessons from interdisciplinary fields, and theory and practice in social sciences, humanities and fine arts, and natural sciences.

Nicolescu, Basarab. (1996). *La transdisciplinarité: manifeste* [Manifesto of interdisciplinarity]. Paris: Editions du Rocher. English edition, Albany: State University of New York Press, 2001; trans. K. C. Voss. Also available from the web site of the Centre International de Recherches et Etudes Transdisciplinaires at http://perso.club-internet.fr/nicol/ciret/. A defining proposal for a new scientific and cultural approach informed by the new worldview of complexity in science and based on the three pillars of: complexity, multiple levels of reality, and the logic of the included middle.

Weingart, Peter. (2001). "Interdisciplinarity: The Paradoxical Discourse." In *Practicing Interdisciplinarity*, eds. Peter Weingart and Nico Stehr. Toronto: University of Toronto Press. An analysis of the apparent paradox of the intensified discourse of interdisciplinarity in the face of increasing specialization, links with innovation, and the realities of funding agencies and research institutions in Germany.

Weingart, Peter, and Nico Stehr, eds. (2001). *Practicing Interdisciplinarity*. Toronto: University of Toronto Press. A collection of essays on changes in the traditional order of knowledge in Europe, North America, and Australia that includes the role of funding bodies, current social and economic contexts, and case examples of practices.

INTERNATIONAL AFFAIRS

SEE *International Relations*.

INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION

The International Commission on Radiological Protection (ICRP) is a non-governmental organization that issues recommendations for radiation protection from ionizing radiation. With Wilhelm Roentgen's 1895 discovery of x-rays that, unlike the rays of visible light or of radio transmissions, tend to break down or ionize atomic structures, a new phenomenon was added to human experience. As this phenomenon became increasingly utilized especially in medical work, its dangers were likewise progressively recognized. The recommendations issued by the ICRP are used by many national and international radiation protection agencies to deal with such dangers and have a profound influence on radiation protection all over the world.

History and Activities

The ICRP was established in 1928 by the Second International Congress of Radiology, in order to address health and safety issues concerning radiation used for medical purposes. Until 1950 it was called the International X-ray and Radium Protection Committee. The new name reflected a widened scope to include all aspects of protection against ionizing radiation.

The ICRP functions as an advisory body to national and international agencies in the field of radiation protection. According to its constitution, the ICRP shall provide recommendations and guidance on all aspects of radiation protection and consider the fundamental principles and quantitative bases for radiation protection, while leaving to national bodies the responsibility of formulating specific advice, codes of practice, or regulations best suited for each country. No country or international organization is obliged to follow the recommendations of the ICRP. International organizations that use the ICRP recommendations include the International Atomic Energy Agency (IAEA), the World Health Organization (WHO), the International Labor Organization (ILO), and the Nuclear Energy Agency of the Organization for Economic Cooperation and Development (OECD).

The ICRP is registered as an independent charity in the United Kingdom and is mainly financed by voluntary contributions from international and national bodies with an interest in radiation protection. The organization consists of the Main Commission and five standing committees. The Main Commission has twelve members and a chair. The Main Commission elects itself, and three to five members of the Main Commission are replaced after each four-year period. According to the constitution of the ICRP, members shall be chosen on the basis of their recognized activity within professional fields of relevance to radiation protection. The standing committees are chaired by members of the Main Commission and consist of fifteen to twenty experts (mostly biologists, physicians, and physicists) appointed by the Main Commission. The committees are Committee 1 (radiation effects), Committee 2 (doses from radiation exposure), Committee 3 (protection in medicine), Committee 4 (application of ICRP recommendations), and Committee 5 (protection of non-human organisms). In addition to these committees, the ICRP also appoints task groups comprised of radiation protection experts outside the ICRP. At any given time, about 100 scientists are involved in ICRP work.

The ICRP publishes reports containing guidelines on a variety of topics related to radiation protection. Examples of such reports include: "Radiological Protection in Biomedical Research" ICRP Publication 62, 1993), "Radiological Protection Policy for the Disposal of Radioactive Waste" (ICRP Publication 77, 1998) and "Principles for Intervention for the Protection of the Public in a Radiological Emergency" (ICRP Publication 63, 1993). The *ICRP Recommendations* are special reports containing fundamental principles for radiation protection advocated by the ICRP. The main objective of these recommendations is "to provide an appropriate standard of protection for man without unduly limiting the beneficial practices giving rise to radiation exposure" (ICRP 1991, p. 3). The ICRP recognizes that this objective cannot be achieved solely on the basis of scientific data, but must also include value judgments and ethical considerations.

ICRP Recommendations

The basic principles of the ICRP recommendations for radiation protection have evolved considerably over time. In 1928 the first ICRP report on health effects concerned primarily damage to the skin and the destruction of blood forming tissues, that is, injuries caused by massive cell death following exposure to high levels of ionizing radiation. There is a *threshold dose* for these effects, which means that they occur only when sufficient numbers of cells are destroyed. The first ICRP report aimed to prevent these kinds of effects by providing recommendations on working practices and guidelines for use, but due to problems of defining a relevant dose measure, a dose limit was not included. In a subsequent 1934 report, however, the ICRP did recommend a dose limit, called a *tolerable dose,* which added a margin of safety to the threshold dose.

The system of tolerable doses was retained into the 1950s when a new appreciation of the risks from ionizing radiation altered the foundation for radiation protection. Previously it had been assumed that in the absence of no immediate negative health effects below a threshold level, there were also no long-term effects. But evidence had accumulated that ionizing radiation could also cause cancer and hereditary defects. Such longer-term results are called *stochastic effects* and are caused by modification, rather than the destruction, of cells, and occur with a certain probability, which was taken to be proportional to the dose. It was argued likely that no threshold existed for these kinds of effects. This meant that every dose implied a risk—that there was no completely safe level for ionizing radiation. Ever since, radiation protection has had to deal with the implications.

In 1950 the ICRP recognized the potential for cancer and hereditary effects from ionizing radiation, and recommended new, lower dose limits, called maximum *permissible doses.* But if there is no wholly safe dose, the concept of permissible dose becomes problematic. What is permissible or not? The ICRP based its judgments on a comparison with other hazards in life. The ICRP also recommended that exposure to ionizing radiation should be reduced to the lowest possible level, meaning that doses should be kept as low as practicable and that any unnecessary exposure should be avoided. Eventually this evolved into the principle that doses should be kept *as low as reasonably achievable* (ALARA), which became known as the *ALARA-principle.*

The next major step was taken in 1977 when ICRP introduced a protection system consisting of three BASIC principles. No practice involving exposure to radiation should be adopted unless it produces a positive net benefit (the *justification principle*). All exposures should be kept as low as reasonably achievable, economic and social factors being taken into account (the *optimization* or ALARA-principle). Doses to individuals should not exceed specified dose-limits (the *dose-limitation principle*). The emphasis was no longer on permissible doses, but on the requirement that doses should be kept as low as reasonably achievable (optimization). Mere compliance with dose limits was not sufficient—exposure must also be justified and optimized. The ICRP recommended that the optimization procedure should operate on the *collective dose,* defined as the product of the number of exposed individuals and their average dose.

Subsequent recommendations were adopted in 1990 (ICRP 1991) retaining the overall structure from the recommendations of 1977. The emphasis was still on the optimization principle, but in order to limit inequities that could follow from application of its three principles, the ICRP introduced a restriction on the optimization process. The reason for this was to prevent situations where the optimization principle would advocate a protection alternative (that is, the lowest collective dose) where, although all individuals would be below the dose limits, a few individuals would also be exposed to much higher doses than the rest of the exposed population. This is obviously a problem if there is no threshold for the risk from exposure to ionizing radiation. To avoid this the ICRP recommended additional individual limits, usually much lower than the old dose limits, called *dose constraints.* The concept of dose limits was retained but the definition was changed in order to define a boundary above which individual risk was considered unacceptable. Another difference was that the dose constraints were *source-related,* while the dose limits included exposure from all relevant sources.

The recommendations from the ICRP have been updated at intervals of ten to fifteen years, and the ICRP plans to deliver the next general recommendations in 2005. The proposed recommendations (ICRP 2003) involve further emphasis on the concept of dose constraints. The new system is based on the idea that constraints should be applied for each individual. The starting point for selecting the level of these constraints should, according to the proposal, be the *concern that can reasonably be felt* about the annual dose from natural sources. After applying the dose constraints there will still be a requirement to reduce doses even further. The proposal also suggests less emphasis than previously on the application of the collective dose and that individual doses below a fraction of the average annual dose from natural sources should be excluded from the system of protection.

The proposal for the new recommendations has been publicly discussed by the ICRP since 1999. Critics claim that the 1990 recommendations work well and that no substantial change to the basic system is needed. It has also been argued that the previous application of the collective dose ought to be retained, and that the introduction of a general exclusion level for very small doses has not been satisfactory justified.

PER WIKMAN

SEE ALSO *Radiation; Regulatory Toxicology.*

BIBLIOGRAPHY

International Commission on Radiological Protection. (1991). *1990 Recommendations of the International Commission on Radiological Protection–ICRP Publication 60*. Oxford: Pergamon Press. Contains the basic principles of the ICRP 1990 recommendations, which have had a profound influence on radiation protection internationally.

International Commission on Radiological Protection. (1998). *International Commission on Radiological Protection: History, Policies, Procedures*. Oxford: Elsevier Science. A comprehensive work on the history and operations of the ICRP.

International Commission on Radiological Protection. (2003). "The Evolution of the System of Radiological Protection: The Justification for the New ICRP Recommendations." *Journal of Radiological Protection* 23: 129–142. Describes the proposed ICRP 2005 recommendations.

Mould, Richard F. (1993). *A Century of X-rays and Radioactivity in Medicine: with Emphasis on Photographic Records of the Early Years*. Bristol, PA: Institute of Physics Publishing. A thorough description of the history and development of radiation protection.

Sowby, David, and Jack Valentin. (2003). "Forty Years On: How Radiological Protection Has Evolved Internationally." *Journal of Radiological Protection* 23: 151–157. Gives an overview of international organizations in radiation protection and describes the development of the ICRP recommendations since 1950.

Taylor, Lauriston S. (1979). *Organization for Radiation Protection: The Operations of the ICRP and NCRP 1928–1974*. Springfield, VA: National Technical Information Service. Provides a detailed account of the early relations between the ICRP and the U.S. organization NCRP (National Council on Radiation Protection and Measurements).

Wikman, Per. (2004). "Trivial Risks and the New Radiation Protection System." *Journal of Radiological Protection* 24: 3–11. Contains a review of the proposed ICRP 2005 recommendations from an ethical and philosophical perspective.

INTERNET RESOURCE

International Commission on Radiological Protection. Available from www.icrp.org.

INTERNATIONAL COUNCIL FOR SCIENCE

The International Council for Science, still known by the initials of its former name, International Council of Scientific Unions or ICSU, is a nongovernmental organization (NGO) that includes more than one hundred national scientific bodies and close to thirty international scientific unions. The ICSU mission is to:

- Identify and address major issues of importance to science and society.
- Facilitate interaction among scientists across all disciplines and from all countries.
- Promote the participation of all scientists—regardless of race, citizenship, language, political stance, or gender—in the international scientific endeavor.
- Provide independent, authoritative advice to stimulate constructive dialogue between the scientific community and governments, civil society, and the private sector.

The main philosophy of the organization is perhaps best reflected in section 5 of its statutes, where the principle of the universality of science is expressed:

> This principle entails freedom of association and expression, access to data and information, and freedom of communication and movement in connection with international scientific activities, without any discrimination on the basis of such factors as citizenship, religion, creed, political stance, ethnic origin, race, colour, language, age or sex. ICSU shall recognize and respect the independence of the internal science policies of its National Scientific Members. ICSU shall not permit any of its activities to be disturbed by statements or actions of a political nature.

History

ICSU was founded in Brussels in 1931, originally under the name International Council of Scientific Unions. It emerged as an extension of two earlier bodies, the International Association of Academies (1899–1914) and the International Research Council (1919–1931). The main change brought about through the founding of ICSU was the dual membership: Both national scientific bodies (initially forty) and international scientific unions (initially eight) make up the membership, and the unions received a more prominent and independent role.

World War II marked an interruption in ICSU activities. But after the war ICSU was the first NGO with which the newly founded United Nations Educational, Scientific and Cultural Organization (UNESCO) signed an agreement.

In light of wartime experiences and the new political prominence of science and technology, Joseph Needham (1900–1995), then Head of the Natural Sciences Division of the Preparatory Commission of UNESCO, addressed the ICSU Committee on Science and Its Social Relations, outlining the prospects of postwar scientific cooperation. This was discussed during ICSU's London General Assembly of 1946, and the first agreement between UNESCO and a non-governmental organization, i.e. ICSU, was signed shortly thereafter. Topics discussed included a plea for the elimination of military secrecy, a hope for increased international collaboration in applied science especially with regard to atomic power, a request for scientific "frankness, openness and integrity" so as to promote the common good, and advancement of the public understanding of science.

During the ensuing cold war period a new challenge emerged within the ICSU structure, namely the free circulation of scientists across national borders. Prewar ICSU statements already expressed the universality of science. For instance, in 1934, ICSU president George Ellery Hale proclaimed: "We welcome to our meetings the man of science in all countries and we appreciate the opportunity to join with them in the pursuit of our common object" (Greenaway 1996, p. 93). With the creation of the North Atlantic Treaty Organization (NATO) in 1949, however, realities became very different. For instance, East German scientists were refused visas for entry into NATO countries thus effectively blocking their participation in scientific meetings in these countries.

In 1963 ICSU formed the Standing Committee on the Free Circulation of Scientists (SCFCS), which in 1993 was renamed the Standing Committee on Freedom in the Conduct of Science and given an expanded mandate. The work of this committee became increasingly important as political tensions increased. The SCFCS worked primarily by correspondence contact with key persons in countries that either prevented entry or exit of individual scientists. The balance between safeguarding free scientific communication and keeping a politically neutral position was always a delicate one, and necessitated low-key action. By and large, the SCFCS managed to fill its watchdog role. In 1976 the SCFCS published its first edition of the "blue book," which is currently entitled "Universality of Science" and contains the principles pertaining to the rights of scientists and their freedom of movement.

Structure

The main decision-making body within ICSU is the General Assembly, which convenes every three years at various locations around the world upon invitation from a host country. Currently the General Assembly is assisted by an Executive Board, which consists of six executive officers and eight ordinary members, four from the unions and four from national members. The Executive Board is assisted by a permanent Secretariat, headed by an executive director.

Since 1972 the ICSU Secretariat has been based in Paris with French government support. A small structure was built up under the leadership of Julia Marton-Lefèvre (1978–1997) and has become a cornerstone in ICSU activities. Since 2002 ICSU has been headed by Thomas Rosswall as executive director. Compared to other international bodies or to its national members, the ICSU Secretariat of twelve people is strikingly small in size.

Activities

ICSU activities are varied and have changed character over the years. Some of its activities serve as examples of international scientific cooperation, despite political situations that at times seem to render them impossible. One such example was the International Geophysical Year (IGY), 1957–1958, which involved sixty-seven nations. The IGY established the principle that "expeditions and explorations in the remoter parts of the earth are now geophysical in intention" (Greenaway 1996, p. 156). An International Polar Year is planned for 2007–2008.

ICSU also engaged in other areas of common concern for international science. ICSU in 1966 set up its interdisciplinary Committee on Data for Science and Technology (CODATA) aimed at making scientific data of various kinds accessible to scientists beyond their origin. In 1969 the Scientific Committee on Problems of the Environment (SCOPE) was established to plan and facilitate, among other things, a global monitoring network and a training program for future environmental managers. SCOPE contributed to the Untied Nations (UN) Conference on the Human Environment in Stockholm, Sweden, in 1972 and the International Geosphere-Biosphere Programme (IGBP), which was initiated in 1986.

Such activities strengthened the ICSU role in the area of global environment and development, and led to close collaboration with various UN bodies. The International Conference on an Agenda of Science for Environment and Development into the 21st Century (ASCEND 21), held in Vienna in 1991, contributed to "Agenda 21: Science for Sustainable Development," the major document to emerge from the United Nations Conference on Environment and Development in Rio de Janeiro in 1992 (commonly called the Earth Summit). When the follow-up World Summit on Sustainable Development was held in Johannesburg in 2002, ICSU was again among the key NGOs addressing scientific issues.

ICSU now sponsors three global observing systems (GOS)—the Global Ocean Observing System, the Global Climate Observing System, and the Global Terrestrial Observing System—in collaboration with partner organizations such as UNESCO, the World Meteorological Organization, the Food and Agriculture Organization of the United Nations, and the United Nations Environment Programme. The goal of the GOS is improved monitoring of the global Earth system.

ICSU links with the social sciences and engineering remain relatively weak. Of the member unions in ICSU, four can be counted as belonging to the social sciences, among them the International Union of the History and Philosophy of Science (IUHPS). Already during the 1980s and early 1990s it was recognized that the global problems facing humankind required cooperative efforts from scientists, social scientists, and engineers. Efforts were made to bring these various fields together through closer cooperation between ICSU and the International Social Science Council (ISCC). In 1996, then, ICSU, ISCC, and other organizations became cosponsors of the International Human Dimensions Programme on Global Environmental Change (IHDP), originally established in 1990. In the early 2000s the IHDP, IGBP, and related programs were brought together under the banner of the Earth System Science Partnership (ESSP) to promote international and interdisciplinary research within four focal areas: carbon, food, water, and human health. It remains to be seen how the challenge of multi- and interdisciplinarity across the various fields will be met in practice.

Standing Committee on Responsibility and Ethics of Science (SCRES)

At the end of the 1980s and the beginning of the 1990s under the presidency of M. G. K. Menon the ICSU Executive Board took up issues of the ethics of science. Two observations spurred this discussion. First, previous views that simply identified progress in science with social progress were more and more difficult to uphold. In the light of environmental and developmental issues, science was seen as not only part of the solution but to some extent as part of the problem. Second, scientific activities need to be guided by a sense of social responsibility. While ICSU already had established a mechanism to deal with the rights (freedom) of scientists, it lacked a platform to deal effectively with scientific responsibilities.

Following these discussions IUHPS was contacted for further suggestions on how to deal with this challenge. L. Jonathan Cohen (Oxford University), then secretary-general of ICSU and member of IUHPS, and Jens Erik Fenstad (University of Oslo), member of the Executive Board and former president of IUHPS, were among the driving forces in this effort. In collaboration with ICSU a workshop in London on ethical issues in science was arranged by Philip Kitcher (Columbia University) and Nancy Cartwright (London School of Economics and Political Science) in 1994 on behalf of the Philosophy of Science section of IUHPS (with contributions eventually published in *Perspectives on Science*, 1996). IUHPS then focused its activities on ethics of science, leading to a special session on this topic during the 1995 International Congress on Logic, Methodology, and Philosophy of Science in Florence, Italy (see Dalla Chiara et al. 1997). As a general outcome of these activities ICSU set up an informal working group that proposed a Standing Committee on Responsibility and Ethics of Science (SCRES). This proposal was endorsed by the General Assembly in Washington, DC, in 1996.

The remit of SCRES included:

- to act as a focus within ICSU and with outside partners for questions pertaining to scientific responsibility and ethics;
- to clarify issues of moral principle which affect the choice of policies for scientific research . . .;
- to raise awareness of important ethical issues among scientists, policy makers and the general public . . . (ICSU documents GA 1996)

An offer from the Norwegian Academy of Science and Letters led to SCRES being based in Oslo and sharing offices with the National Committees for Research Ethics.

SCRES was a small committee, compared with the more established Standing Committee on Freedom in the Conduct of Science, and it struggled to define its agenda. This took a new turn in the planning of the

World Conference on Science (WCS) that was jointly hosted by ICSU and UNESCO in Budapest, Hungary, in 1999. Cooperation with the UNESCO World Commission on the Ethics of Scientific Knowledge and Technology (COMEST) led to a special WCS session on "Science, Ethics and Responsibility." Indeed, SCRES prepared a WCS background document that was one of only two such documents distributed to all speakers, chairs, and rapporteurs (ICSU-SCRES 2000).

The WCS also placed a new topic on the SCRES agenda. The WCS keynote speech of Joseph Rotblat (b. 1908), the Polish-born physicist and international activist, called for a universal oath or pledge to be taken by scientists when receiving a degree in science. Such a "Hippocratic oath" would make explicit the commitment to social responsibility in science. This proposal spurred intense discussions, and while it proved impossible to include Rotblat's suggestion in the final endorsed documents of the WCS, section 3.2 of the "Science Agenda—Framework for Action" calls for COMEST and SCRES to follow up with a view to encourage young scientists to "respect and adhere to the basic ethical principles and responsibilities of science."

In response, SCRES produced a study of 115 ethical guidelines and codes of ethics that was presented to the ICSU General Assembly at its Rio de Janeiro meeting in 2002. At the same time SCRES presented an evaluation of its own activities and suggested that ICSU reconsider how best to place the ethics of science within its structure. SCRES pointed out that a body of its kind and structure could not meet the expectations expressed in its remit, especially regarding public awareness of science and society issues. Its impact remained peripheral, perhaps with the exception of China where SCRES activities spurred a major influence at the national level.

SCRES furthermore suggested that a better balance be found for ad hoc activities directed at special areas of wide ethical interest and addressed through cooperation with other partners, while retaining the continuity and identity that a standing committee can provide. ICSU was asked to consider whether a revised and renewed SCFCS with an explicit mandate for ethics might not be a better framework. As a result SCRES was dissolved in 2002, and ICSU established a strategic review committee to work out suggestions for the future of ethics within ICSU. While the importance of ethics of science is widely recognized by many of the ICSU members and by the Executive Board, ICSU still needs to find its own profile in this area that would not duplicate activities of other bodies, but at the same time provide a voice for global and international concerns.

MATTHIAS KAISER

SEE ALSO *American Association for the Advancement of Science; Nongovernmental Organizations; Pugwash Conferences; Royal Society.*

BIBLIOGRAPHY

Cetto, Ana María, ed. (2000). *World Conference on Science: Science for the Twenty-First Century, A New Commitment.* Paris: United Nations Educational, Scientific and Cultural Organization.

Dalla Chiara, Maria Luisa; Kees Doets; Daniele Mundici; and Johan van Benthem, eds. (1997). *The Tenth International Congress of Logic, Methodology, and Philosophy of Science, Florence, August 1995*, Vol. 2: *Structures and Norms in Science*. Dordrecht, Netherlands: Kluwer Academic.

Greenaway, Frank. (1996). *Science International: A History of the International Council of Scientific Unions*. Cambridge, UK: Cambridge University Press.

International Council for Science. (1996). ICSU documents GA 1996: ICSU Report 25th General Assembly of ICSU (26GA/99/3.1, point 9.c), and Resolutions of the 25th General Assembly of ICSU, 25GA/99/3.1.i, point 11, and Recommendation to establish a standing Committee on Responsibility and ethics in science, 25/GA/96/9.3.

International Council for Science (ICSU). Standing Committee on Responsibility and Ethics in Science (SCRES). (2000). "Ethics and the Responsibility of Science: Background Paper for the World Science Conference." *Science and Engineering Ethics* 6(1): 131–142.

Kitcher, Philip, and Nancy Cartwright. "Science and Ethics: Reclaiming Some Neglected Questions." *Perspectives on Science* 4(2).

INTERNET RESOURCES

International Council for Science. Available from http://www.icsu.org/.

"Science Agenda—Framework for Action." United Nations Educational, Scientific and Cultural Organization. Available from http://www.unesco.org/science/wcs/eng/framework.htm.

INTERNATIONAL RELATIONS

The term "international relations"—subsuming "international affairs" and "foreign affairs"—refers to interactions among nation states, and includes such diverse topics as international law, international trade, and the international monetary system. Although international corporations and non-governmental organizations influence these interactions, and international bodies such as the United Nations help manage them, the primary actors remain nation states. Insofar as nations carry and articulate values, and find their powers conditioned by changes in science and technology (from military effectiveness and productivity to means of communication and bureaucratic organization), international relations also function as an important site for science, technology, and ethics interactions.

Historical Transformations

Following the Peace of Wespthalia (1648) and acceptance of the nation state as the sovereign arbiter of values and power within its borders, questions arose about how to manage interstate relations. The assumption, shared more by theorists than political leaders, from the seventeenth through the nineteenth centuries was that all nations desired peace, which was to be achieved through international law, which laid out the rules of the game for managing the balance of power through international treaties. The failure of this system in World War I, in which technological destructiveness exceeded civilized control, and the subsequent rise of state actors empowered by new techniques of organization, driven by aggressive ideologies in Russia and especially in Germany committed to the marshaling of science and technology for violent conquest, challenged the classic consensus. As Hans J. Morgenthau (1948) observed, peace and security is the ideology of satisfied powers.

The study of international relations grew after World War II into a major focus of social science to encompass these new realities, new states, and new issues, and developed in two directions. In the first case, social scientific studies endeavor to understand why state actors behave as they do, including how technology helps to determine their capabilities. In the second case, advances in science and technology became integral aspects of the relations between and among states including, among others, their role in war and peace, in the management of conflict, in the promotion of economic development, and in the analysis of decision marking.

Other less spectacular but equally far-reaching changes have been the ability to reach any telephone instantaneously and inexpensively worldwide, increased dependence of weapons systems on competitive technological innovation, the relevance of scientific competence to national economies, and the immediacy and global reach of television. Advances in the technologies of transportation, communication, and information thus contributed measurably to such phenomena as the fall of Soviet Communism and the end of the Cold War (1990), public demands for international humanitarian action, the increased unification of Europe, and economic globalization. Still others underline causal connections between local actions and global consequences, such as destruction of stratospheric ozone as a result of the widespread use of chlorofluorocarbons (CFCs), the far-reaching consequences of a disruption in energy supplies or a failure of information systems, and the climatic effects of the accumulation in the atmosphere of waste gases. (International response to the CFC problem in the form of the Montreal Protocol for their elimination has become one of the success stories of multi-state cooperation in response to issues both engendered and identified by science and technology.) The transnational impacts of space exploration and environmental issues, plus the post-Cold War rise of non-state actors adapting technologies for terrorism are further examples of new science and technology-related issues altering international affairs.

Yet the international significance of science and technology goes beyond physical power. The intellectual currents of the Enlightenment, which was largely a product of the experimentation and rationality of the scientific revolution, have stimulated massive forces for change in the West—and have been interpreted as forces involved in a post-Cold War "clash of civilizations" (Huntington 1996).

Moreover, science and technology are not static. By 2003 worldwide investment in research and development (R&D) had risen to $750-800 billion per year, leading to rates of innovation that defy accurate forecasting, let alone estimation of their social effects. There is now in place a formidable and growing system for dedicating human ingenuity to the rapid expansion of knowledge and the production of new technologies to serve perceived or speculative needs. Not only do the results of this system have significant international implications, its very operation favors the creation of global markets. Science and technology may not *cause* changes in international affairs, but their interaction with a mosaic of social, economic, and political factors clearly does so.

The present and future implications for the international system may be summed up in a cliché: Advances in science and technology and their application have led to an unprecedented degree of interaction and mutual dependence among nations in their economies, social structures, and security relationships. The result has moved nations to a new level of interdependence. Nevertheless, the fundamental principles and organization of the international system have *not* been altered substantially. Although multilateral and transnational organizations have increasingly important roles to play across the spectrum of issues from security to economies, this does not imply the end of nation-states. The world is still organized as a system that retains the basic structure of states, each jealous of its independence, seeing itself in competition with others, attempting to maintain maximum freedom of action, and committed to enhancing national welfare and influence. At the same time the state capacity to act as an independent unit increasingly depends on the breadth and depth of its links to other states. Indeed, degrees to which states are intertwined with others may affect internal matters as well. And the frequency with which domestic and foreign policies related to science and technology are confronted with ethical issues concerning the effect of policies on other states and peoples is a product of such intensive linkages.

Ethical and Political Issues

Changes in international relations resulting from interactions with science and technology have raised ethical and political issues that range in scale and consequence from minor inconveniences in travel or communication to decisions that may dictate the immediate violent deaths of thousands of people or choices that have long-term, potentially large, but uncertain effects.

WEAPONS SYSTEMS. Perhaps the most obvious instance arises from the development of weapons systems that directly or inadvertently target civilian populations as well as military forces. The most dramatic are the nuclear weapons used by the United States against Japan to end World War II but not used since. In 1945 there was some debate in government circles and the scientific community about using a weapon with such destructive power and unleashing a means of warfare that would have a profound effect on international relations.

That decision remains controversial, but at the time the imperative to end the war and avoid large losses of American lives in an invasion of Japan was irresistible to the U.S. president. Moreover, a different technological weapon—incendiary bombs—had already been used against both Germany and Japan with equivalent loss of life; the atomic bomb did not appear radically different in terms of the number of lives at risk. There are other arguments about the moral use of this weapon, but these were decisive at the time (Alperovitz 1996).

The decision to proceed with development of the hydrogen (fusion) bomb in 1950 was likewise fraught with moral and political consequences because of the extent of the destruction it could unleash (Bundy 1988).

The policy of nuclear deterrence that is based on the destructive power of nuclear weapons—that is, the paradoxical threat of use in order to avoid use—has been highly controversial. Conventional weapons systems that cause considerable "collateral" damage—the death and destruction of noncombatants—raise moral issues as well, though on a smaller scale.

Other weapons-related programs and policies that have been proposed and questioned on ethical grounds include nuclear test ban treaties and ballistic missile defense. The Limited Nuclear Test Ban Treaty (1963) and subsequent proposals to limit testing in space and underground have necessarily involved politicians working closely with scientists and engineers on programs that had wide moral support. In the case of President Reagan's Strategic Defense Initiative or "Star Wars" program to create a shield against nuclear armed ballistics missiles, a program revived by President George W. Bush as the National Missile Defense, there have been important questions about feasibility and functionality in which science, technology, and ethics are intimately intertwined.

GLOBAL CLIMATE CHANGE. A major environment-related ethical issue of international significance is the threat of global climate change or warming, which (like CFC emissions) became an issue only as a result of theoretical calculations made by scientists, not evidence of actual damage. Based on computer models and solid evidence of the accumulation of carbon dioxide and other atmospheric greenhouse gases, scientists have warned that more solar radiation will lead to a growing heat burden for the planet. Depending on the timing and magnitude of the effects, the impact could be very large, with a major effect on low-lying nations (because of sea-level rise) and on agricultural production, especially in developing countries. The calculations of the scientists are controversial, but the relevant scientific community has accepted the validity of the threat. The Intergovernmental Panel on Climate Change (IPCC), an international panel of scientists from many countries charged by governments to assess the danger, increasingly accepts the existence of the phenomenon and in its last assessment predicted a temperature rise between 1.4 and 5.8 degrees Centigrade by the end of the twenty-first century (Intergovernmental Panel on Climate Change 2001).

International negotiations have been proceeding since the "Earth Summit" in Rio in 1992, itself a major science and technology related international event, with a Framework Convention on Climate Change that was negotiated that same year and entered into force in 1994; in 1997 the Kyoto Protocol was accepted for ratification (Skolnikoff 1999, O'Riordan and Jager 1996). The United States under President Clinton signed the protocol, but President George W. Bush withdrew the signature and has refused to consider ratification. The U.S. Administration argument is that the science is not proven, the developing countries that eventually will be major producers of carbon dioxide have no obligations under the protocol, and the costs to the American economy would be too great. Modest alternative policies, largely voluntary, have been pursued instead by the Administration. Regardless of the merits of the general arguments, the ethical issue is stark: Does the United States, which is by far the major producer of greenhouse gases (25 percent or more of global emissions), have the right to ignore an issue that could have a catastrophic effect on other countries and peoples? The United States will suffer from global warming, but its wealth will make it relatively easy to adapt to the effects of changes in climate. That is not true for other countries, especially the poorer ones.

GENETICALLY MODIFIED ORGANISMS. Genetically modified organisms (GMOs) raise significant ethical questions. These organisms, which so far have been used largely in the agriculture domain, are familiar crop strains (corn, soybeans, wheat, cotton) modified by biotechnological techniques to have valuable new characteristics, such as reduced sensitivity to herbicides and better cold-weather stamina (Thompson 2002). The new strains have been introduced widely in the United States but have been resisted in some other countries, particularly in Europe.

Companies that market GMO products in the United States assert that the resultant food is indistinguishable at the consumer level from unmodified food; Europeans respond that the evidence is inconclusive. Moreover, consumers in Europe insist that food should be labeled so that they have a choice about whether to buy modified food. The United States takes the position that labeling would destroy the market for the American-produced food, that there is no scientific evidence of danger, and that the European position is a ploy to protect European agriculture from less expensive imports. Some African countries, desperately in need of food aid such as Zambia, Zimbabwe, Malawi, Mozambique, and Angola have refused U.S. food on the grounds that their crops would become "contaminated" and thus unable to be exported to Europe (Bohannon 2002). The United States is taking the issue to the World Trade Organization (WTO) on the grounds that the E.U. policy is a form of protectionism. Yet Europeans argue that the United States is attempting to impose its values in an area that will be irreversible once the modified crop strains are in widespread use. Does one nation have the right to make such a decision regardless of the validity of the political and economic arguments?

FOREIGN WORKERS. An issue that is a perennial focus of criticism of multinational corporations is variance in the standards of treatment of workers in different countries. Is it ethically appropriate for corporations to follow identical standards regardless of local wages or living and employment conditions, or should there be differences that take account of variations in income or environment? U.S. corporations often have been the focus of protest, especially when they pay workers in developing countries wages much below American scales or do not provide equivalent working conditions.

The subcommission for protecting and promoting human rights of the United Nations Commission on Human Rights has been drafting a code on norms of responsibility for multinational corporations, the draft of which was approved in August 2003 (*Draft Norms on the Responsibilities of Transnational Corporations and Other Business Enterprises with Regard to Human Rights* 2003). If the draft ultimately is approved by the full commission and accepted by the member states, it will for the first time create a standard for the ethical behavior of multinational corporations. Final approval will not create an enforcement mechanism but should have considerable influence, particularly on larger corporations that are vulnerable to public pressure and protest.

INTELLECTUAL PROPERTY RIGHTS. An issue with similar characteristics is the general subject of intellectual property rights (IPR). Patents, including those in the pharmaceutical industry, copyrights, and trademarks are issued to provide a protected monetary return for an inventor or artist and thus to encourage innovation and performance. Ethical issues arise when intellectual property is pirated or when royalties or fees are too high for developing countries.

Often new technologies are not available in developing countries because of the cost. When copying of intellectual property is easy and low-cost, as in the case of copying videos or music records without paying the copyright fee, the result has been wholesale reproduction and sale at a fraction of the original price. This would seem to be clearly unethical. Many argue, however, that it is the IPR regime that is unethical and that intellectual property should be considered a public good, freely available or available at a low cost, to anyone. That position is not likely to be accepted in countries that produce most of the intellectual property, which argue that without a chance to recoup costs, innovation and artistry would dry up. It is particularly important for the United States, which is increasingly dependent on high-technology and innovation-intensive goods. The Trade Related Intellectual Property Rights Agreement (TRIPS) of the WTO represents an attempt to reach international agreement on this issue, so far with limited success.

Another IPR debate focuses on the patenting of genetically engineered organisms and of products found in the wild for use in pharmaceutical research and development. In the case of genetically engineered organisms, the European Union is much more restrictive on this practice than the United States, thus raising an IPR issue that requires international harmonization. The patenting of biological discoveries in what are sometimes called "gene-rich" poor countries by corporations based in so-called "gene-poor" rich countries has been criticized as a form of "biopiracy" that fails adequately to compensate the country from which these new resources are derived.

TERRORISM. A more recent issue has arisen from the fear of terrorists' use of scientific data. Since September 11, 2001, the U.S. government has sought to limit the publication of the results of research that might benefit terrorists. This has revived issues of the proper boundaries of government imposed scientific secrecy that were prominent during the Cold War but had abated since, and is particularly relevant in the case of fast-moving biological research but also affects other areas with weapons potential, particularly in the nuclear and chemical fields. Scientists are resisting such regulations on the grounds that they would degrade the scientific enterprise and make it difficult to counter possible weapons development or acquisition by terrorists. Should it be possible to publish in a journal or on the Internet any information, such as the methodology for producing biological agents or the design of a nuclear weapon, that could be misused even though the information is otherwise available and is not classified? What is the ethical (and political) judgment? The issue has not been settled (Skolnikoff 2002), although a number of biology journals have agreed to institute a review process to flag potentially dangerous articles and consider how the suspect material might be reduced or eliminated. No recent cases of "prior" censorship outside classified areas have reached the courts.

Other Issues

Weapons systems, global climate change, genetically modified organisms, foreign workers, intellectual property rights, and terrorism constitute six representative international relations issues intimately engaged with science and technology. Many others might be mentioned, from population growth, economic development (the rich/poor divide and the proper parameters of foreign aid), and world health, to biodiversity loss, the allocation of resources in international waters (as provided for in the Law of the Sea Treaty, 1982) and space (including communication satellite orbits), and remote sensing of countries and individuals from space without their permission.

Issues of these kinds arise ubiquitously and are a natural product of advances in science and technology and the use of those advances in national and international policies. In recognition of this fact, the U.S. National Research Council (1999) argued strongly for major innovations in the department of state to more effectively deal with these issues. Improved education and personnel policies for regular foreign service officers, creation of a new post of science adviser to the Secretary, and recruitment of more scientists and engineers to the department's ranks were advocated and most of the recommendations approved by the then Secretary. Additionally, all sciences and technologies are "dual use" in the sense that they can be used for benign or malevolent purposes. Inevitably, they will often pose choices that raise ethical as well as social, political, and economic considerations. Some of those choices will be minor and insignificant, but others will require careful thought and almost surely will be controversial.

EUGENE B. SKOLNIKOFF

SEE ALSO *Atomic Bomb; Baruch Plan; Global Climate Change; Genetically Modified Food; Globalism and Globalization; Intellectual Property; Limited Nuclear Test Ban Treaty; Montreal Protocol; Terrorism.*

BIBLIOGRAPHY

Alperovitz, Gar. (1996). *The Decision to Use the Atomic Bomb*. New York: Vintage. A controversial analysis of the decision to drop the a-bomb that argues the primary purpose was to influence future negotiations with the Soviet Union.

Bohannon, John. (2002). "Zambia Rejects GM Corn on Scientists' Advice." *Science* 298(8): 1153–1154.

Bundy, McGeorge. (1988). *Danger and Survival: Choices about the Bomb in the First Fifty Years*. New York: Random House. Superb account of the policy process and decisions surrounding nuclear weapons by the special assistant for national security affairs to Presidents Kennedy and Johnson.

Intergovernmental Panel on Climate Change. (2001). *Climate Change 2001: The Scientific Basis*. Cambridge, UK: Author. The third assessment report to the international community from scientists appointed by some fifty governments. The most authoritative single voice, though controversial among a minority of scientists.

Keatley, Anne G., ed. (1985). *Technological Frontiers and Foreign Relations*. Washington, DC: National Academy Press. Of special interest are Simon Ramo's "The Foreign Dimensions of National Technology Policy," Richard N. Cooper and Ann L. Hollick's "International Relations in a Technologically Advanced Future," and C. W. Robinson's "Technological Advances—Their Impact on U.S. Foreign Policy Relative to the Developing Nations."

Lee, Thomas H., and Proctor P. Reid. (1991). *National Interests in an Age of Global Technology*. Washington, DC: National Academy Press. The emerging global technical enterprise is altering relations among nations.

Morgenthau, Hans J. (1948). *Politics among Nations: The Struggle for Power and Peace*. New York: Knopf.

O'Riordan, Tim, and Jill Jager. (1996). *Politics of Climate Change: A European Perspective*. London: Routledge. An analysis of European views by two knowledgeable environmentalists.

Skolnikoff, Eugene B. (1993). *The Elusive Transformation: Science, Technology and the Evolution of International Politics*. A Council of Foreign Relations Book. Princeton, NJ: Princeton University Press. On how international politics has been changed by science and technology advance since World War II. For an earlier, more restricted overview: *Science, Technology, and American Foreign Policy* (Cambridge, MA: MIT Press, 1967).

Skolnikoff, Eugene B. (1999). "The Role of Science in Policy: The Climate Change Debate in the United States." *Environment* 41(5): 42–44. A political analysis of the climate change debate in the U.S. that shows how and why the scientific evidence plays a much lesser role than would be expected in this quintessential science-related subject.

Skolnikoff, Eugene B. (2002). "Research Universities and National Security: Can Traditional Values Survive?" In *Science and Technology in a Vulnerable World*, ed. Albert H. Teich, Stephen D. Nelson, and Stephen J. Lita. Washington, DC: Association for the Advancement of Science. On threats to American research universities posed by the attempts to keep potentially dangerous scientific information out of the hands of terrorists.

Thomson, Jennifer A. (2002). *Genes for Africa: Genetically Modified Crops in the Developing World*. Landsdowne, South Africa: University of Capetown Press.

United Nations Commission on Human Rights. (2003). *Draft Norms on the Responsibilities of Transnational Corporations and Other Business Enterprises with Regard to Human Rights*. E/CN.4/Sub.2/2003/12 Minneapolis: Human Rights Library, University of Minnesota.

U.S. National Research Council. (1999). *The Pervasive Role of Science, Technology, and Health in Foreign Policy: Imperatives for the Department of State*. Washington, DC: National Academy Press.

Wines, Michael. (2004). "Angola's Plan To Turn Away Altered Food Imperils Aid." *New York Times:* March 30, p. A3.

INTERNET

Emerging from the integration of computer and communications technologies, the Internet is a text- and graphics-based communications system that supports people and organizations in the performance of multiple activities. As such it has the potential to transform the worlds of work in industry, government, education, and entertainment as well as everyday life. A variety of ethical issues arise with this technology, involving not only individual users, but also corporations and governments.

There are two basic meanings associated with the word Internet. In a narrow sense, the Internet is a global network *inter*-connecting computer *net*works, from which the word derives. Hence it is a complex network connecting large numbers of devices such as computers, file servers, and video cameras, by means of telephone lines, satellites, and wireless networks. In a broad sense, the Internet also includes that which such technological infrastructure makes possible, which some refer to as *cyberspace*.

For present purposes the Internet will be characterized as constituting a *digital habitat* where people increasingly live. Habitat denotes here an environment in which people carry out activities, possibly in interaction with other people, involving specific actions and things. Because the kinds of things people interact with in the Internet are not *material* in the usual sense of the term, but rather electronic and digital, the Internet may be termed a digital habitat (Stefik 1996).

Emergence and Development of the Internet

Initial development of Internet technology was supported in the 1960s by the Advanced Research Projects Agency (ARPA) of the U.S. Department of Defense in the context of the Cold War between the United States and the former Soviet Union. ARPA's task was to establish the technological and military superiority of the United States. But the agency gave considerable freedom of action to researchers and the development of Internet technology was carried out mainly at university research laboratories by academics whose primary agenda was to develop technologies to allow computers to communicate with each other (Castells 2001).

In 1969 the first nodes of the ARPANET, a packet-switching network, became operational. Subsequently, to deal with the proliferation of computer networks that had appeared in the United States and other countries, additional technology was developed during the 1970s and 1980s to interconnect any kind of network, as long as certain preestablished rules of communication were followed. It is in this context that the Internet, as a network of computer networks, was born (Abbate 1999).

Initially the Internet was used primarily at universities, for the purposes of exchanging electronic mail and for transferring files. It was not until the 1990s, with the development of the World Wide Web—a particular kind of Internet application (Berners-Lee and Fischetti 1999)—that a massive use of the Internet became possible. By mutually reinforcing each other, factors such as an increasing number of users, a growing number of services provided through the Internet, and increasing investment in technologies led to an explosive growth of the Internet. What had started as the ARPANET with four nodes in 1969, had become the Internet with millions of users by the end of the twentieth century.

Ethical Issues

Some have suggested that the ethical issues of the Internet are the same ones that arise in preexisting practices. Another position maintains that although these issues have a correspondence with well known, preexisting dilemmas they nonetheless constitute novel and significant variations (Johnson 2000). Their novelty arises from the very special properties of the entities that populate the Internet.

Because the Internet is composed of digital representations of text, data, music, and software, it can be characterized as a digital habitat. Because of the powerful capabilities of computers and networks, these entities can be *reproduced* and *transferred* with minimal effort and delay. One consequence of these properties is a notable characteristic of the Internet that can be called *virtual nearness*. Every public entity embedded in the Internet, within certain limits, is immediately available to the user—is *near* in a virtual way. This characteristic makes the emergence of virtual communities possible.

People perform activities in the Internet by means of *digital actions* carried out by digital programs. The specific steps programs perform can be easily recorded to leave a trace of the actions. In addition, because actions are carried out by programs, there is a question as to who is ultimately behind them, leading to certain forms of anonymity.

Privacy Issues

People carry out an increasing number of activities on the Internet, including exchanging email messages, visiting Internet sites, and buying goods. Transactions with government are increasingly done through the Internet. Medical records are created and made available online. In all of these activities sensitive information about people is gathered and stored. Because of its interconnectivity, the Internet makes it possible to transfer, combine, and cross-reference personal information at a much higher level than was previously achievable. The existence of multiple databases containing information on individuals about health, education, tax, and police matters, as well as on shopping patterns, enables the development of detailed profiles of individuals. Such profiles can be used for making decisions about them, for example, to grant or deny loans, to grant or deny medical insurance, to hire or not to hire, possibly leading to certain forms of discrimination.

Personal information is routinely used for purposes other than those originally intended, in most cases without the knowledge of the people involved. This situation constitutes a significant erosion of privacy.

Although there is a wide consensus that privacy—in particular, medical privacy—has been negatively affected by Internet technology (for example, Etzioni 1999; Johnson 2000; Parenti 2003), there is less agreement on how to confront the situation. Corporations claim they need personal information on their customers in order to be more efficient and profitable. Government agencies claim they need access to personal information for law enforcement purposes. For some theorists, then, the issue is to find a balance between the desires of individuals to keep information about themselves private and the desires of corporations and government to freely access that information. For others this perspective is too narrow because it transforms privacy issues into the balancing of competing claims. In a broader sense, privacy refers to a fundamental aspect of the human condition. Etymologically it is related to the Latin word *privus*, meaning single, alone. While human beings cannot be understood apart from the communities they belong to, they cannot be understood, either, unless it is recognized that they are unique individuals and have the potential to become increasingly autonomous.

By autonomy is meant the capacity to understand the sources, meanings, and consequences of actions and to exercise that understanding in deciding what actions to take. When information is collected and processed by others, autonomy is endangered in the sense that others can openly or surreptitiously attempt to influence actions on the basis of that information. In this respect, an important consequence of the availability of large amounts of personal information to corporations and government is that it increases their relative power with respect to that of individuals, possibly upsetting a delicate societal balance. For this reason, privacy is not only relevant to individuals but it should also be considered a social good, relevant to society as a whole.

Further discrepancies exist on how to deal with the erosion of privacy. Those who assign an intrinsic value to privacy tend to favor an approach in which individuals must provide explicit consent for the exchange of personal information among corporations, coupled with legislation enforcing such procedures. They claim that existing legislation—such as the Fair Credit Reporting Act, the Driver's Privacy Protection Act, and the Electronic Communications Privacy Act—has been developed piecemeal, and propose stronger forms of regulation similar to those existing in some European countries. Others favor a mixture of self-regulation by companies, use of technology to control access to information, and institutional changes leading to practices where information is less exposed to misuse.

An approach increasingly followed by companies is to develop privacy policies that are made available to their customers, indicating how information about them is used and with what other organizations it will be shared, and offering certain privacy options to customers. But without appropriate legislation many are skeptical that corporations can truly police themselves.

Two factors will exacerbate the erosion of privacy in the future. First, given the pace of technological development it is likely that increasing amounts of personal information will be available online. Second, the fight against terrorism triggered by the attacks that destroyed the World Trade Center on September 11, 2001, will put significant pressure on government agencies to acquire and make use of that information, by wiretapping or other means, to detect terrorism-related activities. The Patriot Act enacted by Congress in October 2001 points strongly in this direction (Hentoff 2003). To conclude, a significant, multi-pronged effort will be required to deal with the erosion of privacy underway at the beginning of the twenty first century and to a large extent catalyzed by Internet technology.

Intellectual Property Issues

Intellectual property differs from tangible forms of property, such as cars and other goods, in that it is easily reproducible. Given that in the context of the Internet intellectual property, such as software and music, is stored in electronic files, people can reproduce and transfer it with minimal effort. It is precisely this notable characteristic of the Internet that is at the source of contentious issues regarding intellectual property. The case of Napster—a company that facilitated the global sharing of music files over the Internet and was shut down in 2001 as a consequence of a lawsuit brought against it by the recording industry—is important because it brought to light subtle issues, both at the core of the notion of intellectual property and on why and how the law protects it.

Ideas, literary works, and music are forms of speech. Freedom of speech, in one sense, implies the freedom to formulate and propagate ideas, as well as to have unfettered access to ideas and forms of speech produced by others. In the latter case, the authors of these works regard them as property and would like to be fairly compensated for their use. In addition, the free flow of ideas, for example of those that emerge in the context of science and technology, is regarded as beneficial to society as a whole. How can the tension between freedom of speech and *progress*, on one hand, and ownership of intellectual works, on the other, be resolved?

The Constitution itself lays out a basic framework for dealing with these issues, and gives Congress the power to enact legislation. Copyright law emerged in this context. An important distinction is established between ideas and expression of ideas, such that only the latter can be owned, and for a limited time.

Copyright law grants exclusive rights of copy to owners of intellectual property or to those whom owners grant permission, but through the notion of *fair use* it also establishes limits on this exclusivity. If a person buys a compact disk containing music, it is considered fair use to make extra copies of the disk for use in a car and for backup purposes. This is also true with regard to software. The law imposes additional restrictions on what can be copyrighted, including that the expression of ideas be novel and developed independently by its author.

Given these subtle distinctions, limits and restrictions imposed on intellectual property, the determination of whether copyrights have been infringed, and the enforcement of these rights are very difficult matters. The advent of the Internet has complicated the issues. The Napster case illustrated how the Internet made the copy and dissemination of music possible on a grand scale. While the recording industry considered it a form of electronic thievery, for some the exchange of files may have been an extreme case of fair use.

Supplemental Ethical Issues

Because the Internet makes it easy for people and groups to publish electronically, and given the potentially large audience that can be reached, the issue of what can be expressed on and accessed through the Internet arises. Again conflicting demands come into play. For example, freedom of access to public information conflicts with the desire to limit the availability of material that many regard as unacceptable.

Specifically impeding access to pornography by children in public libraries through the Internet could interfere with access to those same materials by adults. The Communications Decency Act passed by Congress in 1996 addressed that issue. A year later, the Supreme Court declared the act unconstitutional, siding with freedom of access and against censorship.

As already discussed, virtual nearness makes the emergence of virtual communities in the Internet possible, giving rise to virtual community (Turkle 1995). Some communities, in which people are represented by icons and fictitious names, provide opportunities for socializing in novel ways. In particular anonymity allows for the possibility of altering important elements of one's identity including gender, age, and race. What range of behavior is permissible in these situations? What would count as *violence*, as being too *close* to another person, as an attempted *rape* (Johnson 2000)?

Global Issues

A more global view raises two sociopolitical questions. First, given that the Internet facilitates the association of people with shared views, in particular, political views, and that it allows for the communication of those views to large numbers of people, does the Internet promote democracy as some have suggested? Second, considering that geographical barriers have little or no effect on the Internet, could the Internet contribute to undermine nation-states?

To a large extent, the answer to these questions depends on what the Internet becomes in the future. The Internet could remain as it is in the early-twenty-first century, except that almost everybody, everywhere, would have access to it and more activities would be carried out with its support. Or the Internet could become primarily a *global entertainment machine* by the convergence of radio, television, and the film, recording, and computer game industries. Or finally the reach of the Internet could be extended by ubiquity, wirelessness, and wearable computers.

In the context of these scenarios, the question of promotion of democracy answers itself: Although the possibility of performing political actions through the Internet would continue to exist, in the last two scenarios—the most likely—given the amount of noise that a global entertainment machine and the various extensions to the Internet would put into circulation, anything else would become barely audible and visible, including political action. In addition, the erosion of privacy mentioned earlier could contribute to undermining autonomy with, possibly, negative consequences for democracy.

With respect to the second question, about nation-states, the pressure to have common rules and laws, for electronic commerce, intellectual property, and privacy, that would facilitate the migration of activities to the Internet could undermine the sovereignty of less powerful countries. Although nation-states could try to control what regions of the Internet are accessible to its citizens (Hamelink 2000), given the connectivity of the Internet the effort would fail.

Finally the third scenario posed above leads to a fundamental philosophical question that can only be set out in this entry. Is it possible that the pervasive and substantial intermediation of human activities by the Internet—which would amount to a massive migration from material habitats to a global digital habitat—could invite essential transformations of the way human beings *are?* And what kinds of transformations would they be? But importantly, do people still have the ability to actually ask this question, or will the increasing noise make such questioning impossible?

AGUSTIN A. ARAYA

SEE ALSO *Computer Ethics; Computer Virusus; Cyberspace; Digital Divide; Hypertext; Networks.*

BIBLIOGRAPHY

Abbate, Janet. (1999). *Inventing the Internet.* Cambridge, MA: The MIT Press.

Berners-Lee, Tim, and Mark Fischetti. (1999). *Weaving the Web: The Original Design and Ultimate Destiny of the World Wide Web.* San Francisco: Harper.

Castells, Manuel. (2001). *The Internet Galaxy: Reflections on the Internet, Business, and Society.* Oxford: Oxford University Press.

Dreyfus, Hubert. (2001). *On the Internet.* New York: Routledge. The author presents a critique of the Internet reminiscent of his previous critique of Artificial Intelligence. Focusing on possibilities opened up by the Internet such as navigation with hyper-links, distance learning, disembodied telepresence, and anonymity the author shows them to give rise to weaker forms of experience when compared with the way in which people deal with the world without the intermediation of the Internet.

Etzioni, Amitai. (1999). *The Limits of Privacy.* New York, NY: Basic Books.

Halbert, Terry, and Elaine Ingulli, eds. (2002). *CyberEthics.* Cincinnati, OH: West-Thomson Learning. See especially in this collection John Perry Barlow's "The Economy of Ideas: A Framework for Patents and Copyrights in the Digital Age."

Hamelink, Cees J. (2000). *The Ethics of Cyberspace.* London: SAGE Publications.

Hentoff, Nat. (2003). *The War on the Bill of Rights and the Gathering Resistance.* New York: Seven Stories Press.

Johnson, Deborah G. (2000). *Computer Ethics,* 3rd edition. Upper Saddle River, NJ: Prentice Hall.

Parenti, Christian. (2003). *The Soft Cage: Surveillance in America from Slavery to the War on Terror.* Cambridge, MA: Basic Books.

Poster, Mark. (2001). *What's the Matter with the Internet?* Minneapolis: University of Minnesota Press. In this ambitious work, the Internet and its transformative power is examined from a variety of perspectives ranging from Heideggerian meditations on technology to Foucauldian considerations of subjectivity to post-Marxian analyses of capitalism and the nation-state. By juxtaposing these perspectives a rich understanding of the Internet emerges.

Stefik, Mark. (1999). *The Internet Edge: Social, Legal, and Technological Challenges for a Networked World.* Cambridge, MA: The MIT Press.

Stefik, Mark, ed. (1996). *Internet Dreams: Archetypes, Myths, and Metaphors.* Cambridge, MA: The MIT Press.

Turkle, Sherry. (1995). *Life on the Screen: Identity in the Age of the Internet.* New York: Simon & Schuster.

INVENTION

Invention (from the Latin *invenire,* to find or to discover) in a broad sense refers to any novel idea or the process of its creation. In the technological sense it means the identification of a science or technology potential matching a specific human need or the result of this process: a novel technical product.

Because any invention implies a use, it is intrinsically value-laden and thus of ethical interest. This applies to the intended purpose as well as to the unintended side effects of production or use, the possibilities of misuse, and of so-called dual use (when the function of a product may be employed for either good or bad use). The social promotion or regulation of the inventive process also has ethical dimensions.

Basic Distinctions

Originally there was no distinction between invention and discovery. Invention could refer to theoretical cognition as well as to technical designing. However, beginning with the twentieth century, these concepts usually are distinguished. To discover is to recognize an existing but previously unknown phenomenon. To invent is to conceive of a novel and previously not existing phenomenon.

Invention is the starting point for a new technical development. An innovative cognition in science or technology may precede invention but not necessarily. What is decisive is the notion that some natural or technical effect might function as an artifact that could replace or enhance some human activity or operation. Any invention creates a new means for some human end.

According to the German engineer and writer Max Eyth (1905), there are four types of invention. One is a new means for a new end; an example would be television. Second is a new means for a preexisting end; an example is the transistor as replacement for the electronic vacuum tube. Third is an existing means put to a new end; an example is the telephone to transmit written materials, as in the documents in a telefax. Finally fourth is an existing means for an existing end; an example is when music CDs are used to store data. Completely new inventions are rare; frequently, an invention is a mere combination of elements already in existence. The distinction between these different types of invention naturally raises questions about whether some types might present more serious ethical challenges than others, and whether ethics might be differentially related to different types of invention.

Inventors may apply for patents, which will protect the idea against illegal imitation. Usually, however, the invention by itself is not immediately ready for everyday use. Lengthy designing, testing, and improving are required before a properly functioning form is achieved.

This part of development is called the *innovation process*, and results, if technically and economically successful, in an *innovation* (in the narrow sense). The period between invention and innovation may take years or even decades. The question concerning whether in modern technology this period tends to progressively shorten, is highly debated.

Where Inventions Come From

At one time, the ability to invent was ascribed to the ingenious talent of gifted engineers who were regarded more as artists than as skilled experts. The art of inventing was explained by so-called creativity, an ability limited to only a few exceptional persons. Traditional histories of technology glorified the uniqueness of the inventor by drawing up long lists, in which important inventions were assigned to specific dates and famous names. The phenomenon of multiple inventions, however, disturbed this individualistic view. When both a technological potential and human need are in existence, the idea of bringing them together in an invention readily occurs to several persons at the same time. Although the aura of the individual ingenious creator may be shaken by this phenomenon, the process of inventing itself acquires a more solid explication.

According to John Guilford (1950), cognitive psychology explains creativity as a specific mixture of individual mental activities, partly conscious and partly subconscious. In the conscious stage, a person collects all knowledge available regarding certain problems and possible solutions (*preparation*). This knowledge sinks down to the subconscious, where it is stored, processed, and accidentally combined with additional tacit knowledge, without any explicit awareness on the person's part (*incubation*). Suddenly a new combination of knowledge and imagination emerges from the subconscious, and is identified as the perfect solution to a problem (*illumination*). In a final stage this new idea has to be tested and elaborated explicitly by rational thinking (*verification*).

In design theory, a modern branch of engineering research, the art of inventing is methodologically reconstructed. Instead of accumulating technical knowledge in an accidental and unsystematic way, design theory suggests systematic patterns arranging all the elements of possible solutions according to basic functional and structural features. This procedure, design theory claims, results in the totality of possible solutions to a given problem, and the only remaining difficulty is to choose the optimal solution among hundreds or even thousands of feasible combinations. Thus the associating and combining process, originally hidden in the subconscious, is objectified and rationalized, and is even accessible to computer programming.

Whether this rational strategy of inventing is actually feasible is debatable. Some observers hold that on principle the role of intuition and tacit knowledge in inventing is indispensable. For others the rationalistic approach seems promising for social interaction in teamwork, because individual intuitions from the subconscious are hard to communicate. Also invention cannot be reduced to personal performance alone, but obviously has social implications. Often it depends on the sociocultural context, which technical potentials an individual inventor takes into account, and which human needs and purposes are being realized. Furthermore the inventing activity depends on an innovative social climate and on economic incentives to motivate persons and corporations. Some hold that in the early twenty-first century the majority of inventions are made by large corporations, but there remain many individuals who also perfect basic inventions.

Ethical Issues

Recognizing that numerous inventions are ambiguous or even harmful to environment and society, several critics have considered whether an effective assessment and approval of the innovation process might be instituted. Some of them refer to historic examples, when certain inventions, in ancient Greece or medieval eastern Asia, had been suppressed systematically on ethical grounds, either by the very inventor or by political forces. The German economist Werner Sombart (1934) made the radical suggestion that every invention ought to be submitted to a National Council of Culture, which would release only such inventions as prove beneficial without question. Less radical approaches to improve the ecological and social quality of inventions are discussed at present in *engineering ethics*, which focuses on the professional responsibility of individual inventors, and in *technology assessment*, which concentrates on industrial strategies and political regulations.

Individual refusal—like that of the father of cybernetics, Norbert Wiener, who in 1947 rebelled against doing any further work for the military—usually is not very effective, because nearly always there will be found others to continue a questionable project. Therefore, moral sensitivity of the individuals has to be supported by corporate and political institutions such as those of technology assessment, which proves to be the social organization of teleological ethics.

Some commentators question the ever growing rate of inventions and innovations, mostly driven by economic forces, which possibly threaten natural environment, the stability of cultural traditions, and personal self-fulfillment. Such views are, of course, at odds with the dominant innovation tendencies in modern industrial and information society.

GÜNTER ROPOHL

SEE ALSO *Political Economy of Science and Technology; Technological Innovation.*

BIBLIOGRAPHY

Eyth, Max. (1905). "Zur Philosophie des Erfindens." In *Lebendige Kraefte*. Berlin: Springer, 249–284.

Gilfillan, S. Colum. (1935). *The Sociology of Invention*. Cambridge, MA: MIT Press. Analyzes social conditions and consequences of inventions.

Guilford, John P. (1950). "Creativity." *American Psychologist* 5: 444–454.

Hubka, Vladimir, and W. Ernst Eder. (1988). *Theory of Technical Systems: A Total Concept Theory for Engineering Design*. Berlin: Springer.

Porter, Alan L.; Frederick A. Rossini; Stanley R. Carpenter, et al. (1980). *A Guidebook for Technology Assessment and Impact Analysis*. New York and Oxford: North Holland.

Ropohl, Guenter. (1999). *Allgemeine Technologie*. Munich and Vienna: Hanser. Provides a comprehensive understanding of technology and analyzes thoroughly the process of technological development.

Schumpeter, Joseph A. (1939). *Business Cycles*. New York and London: McGraw Hill. Introduces the fundamental notions of invention and innovation from an economic point of view.

Sombart, Werner. (1934). *Deutscher Sozialismus*. Berlin: Buchholz & Weisswange. A peculiar attempt to suggest leftist ideas to German "national socialism", but important because of the perspicacious criticism of technological development.

Wiener, Norbert. (1993). *Invention: The Care and Feeding of Ideas*. Cambridge, MA: MIT Press. A book found in manuscript and published forty years after it was written, which provides a broad analysis of invention in relation to most of the themes touched on in this article.

IN VITRO FERTILIZATION AND GENETIC SCREENING

The first birth following in vitro fertilization (IVF) took place in the United Kingdom in 1978, and the number of IVF births per year has increased steadily since then. More than 35,000 infants were born with the help of IVF in 2000 in the United States alone, and more than 1 million infants have been born worldwide following IVF. Although IVF has become an integral part of fertility medicine, ethical and policy issues continue to be debated as technologies change and IVF becomes more common. Among the topics debated are those relating to the moral status of embryos, disposition of frozen embryos, use of genetic testing of embryos to detect the presence of moderate rather than serious genetic disorders, and the adequacy of regulation.

Technologies

For an IVF cycle, physicians stimulate a female patient with hormones to induce the release of more than one egg. When tests show the eggs are ready to be released, physicians remove the eggs in an office procedure, fertilize them in vitro (in glass) with spermatozoa from the male partner or a donor, culture the fertilized eggs for two to three days to at least the stage of a four-cell embryo, and transfer the embryos to the woman's uterus for possible pregnancy.

Although IVF was primarily designed for women with blocked fallopian tubes who could benefit from the way IVF bypasses these tubes, advances over the years have extended the versatility of IVF as a method for circumventing infertility. For example women who do not ovulate can use donated eggs, and men with extremely low sperm counts can be aided by the manual injection of a single spermatozoan into an egg in a technique known as intracytoplasmic sperm injection (ICSI).

Another technique used in conjunction with IVF is pre-implantation genetic diagnosis (PGD), which is available for couples at risk for passing serious genetic diseases, such as Tay-Sachs disease and cystic fibrosis, to their offspring. In one form of PGD, the embryo biopsy, technicians remove a single cell from an embryo created through IVF and amplify the DNA to detect the presence of the disease-linked gene in question. Physicians then selectively transfer only those embryos without the anomaly to the woman's uterus. PGD is also used to detect chromosomal abnormalities that cause serious disorders in offspring or that interfere with conception. The first birth following IVF/PGD occurred in 1990. More than 1,000 infants had been born worldwide by 2002, with a pregnancy rate of about 24 percent (Robertson 2003).

Moral Status of Embryos

Perspectives about the moral status of embryos differ significantly among individuals. Some believe that early

In vitro fertilization. Many ethical questions surround the process, in which egg cells are fertilized outside the mother's body in cases where conception is impossible through normal intercourse. (*© Owen Franken/Corbis.*)

stage embryos are human beings with the moral status of persons that must be protected from injury or destruction. Others believe embryos are potential human beings warranting special respect but not the moral status of persons. Policy advisory groups in the United States have generally adopted the latter perspective (Ethics Advisory Board 1979). Due to a lack of consensus about the status of embryos, however, as of 2004 federal funds cannot under law be used to finance research in which human embryos are injured or destroyed. To the extent that investigators study human embryos, they do so with private research funds.

Disposition of Frozen Embryos

When couples undergo IVF or IVF/PGD, extra embryos are often created and frozen for later thaw and transfer. More than 100,000 embryos were frozen in the United States alone in 2002. Couples who no longer want or need their spare embryos can direct that the embryos be discarded, donated for research and eventual destruction, or donated to other couples. Difficulties can arise, however, if a couple divorces and has no prior written agreement about what should be done with the embryos or if one party seeks to nullify the agreement. The first appellate court to rule on this matter held that the person who wants to avoid parenthood (by not transferring the embryos) generally ought to prevail over the person who wants to achieve parenthood (by transferring the embryos) (*Davis* v. *Davis* 1992). Judges rely on case-by-case rule making in frozen embryo cases. In general they accept the principle established in *Davis* v. *Davis*, but differ on whether they will enforce prior agreements (Elster 2002).

Extending PGD

PGD is generally regarded as an ethically acceptable way of preventing human suffering when the disease in question is serious or fatal. Some have voiced reservations, however, about the potential for tests that can be used to detect less serious diseases such as deafness or predispositions to diseases such as Alzheimer's disease or breast cancer. The concern is that this will discourage tolerance for imperfections and devalue the inherent worth of individuals. Another concern is that negative selection (discarding affected embryos) will, when technologies allow it, set the stage for positive selection (seeking embryos with socially desirable traits), which would magnify differences between the rich and the less well-off; have eugenic overtones; and contribute to the mindset that people can be made to order, like commodities.

Those who do not share these concerns argue that IVF/PGD is so costly and intrusive that only a small number of people will use it. They point out that PGD is an alternative to prenatal testing for at-risk couples who know they will not terminate the pregnancy of a fetus with serious disorders and who welcome the opportunity to transfer only unaffected embryos for a potential pregnancy. In addition supporters of PGD question the wisdom of interfering with a technique that could prevent the birth of babies with serious disorders now on the basis of speculative concerns about possible future uses of PGD.

Policy Issues

IVF and other reproductive technologies are governed in a decentralized manner in the United States. Debates continue about whether more oversight is needed and, if so, what forms it should take. One point of view is that the system of oversight, which is based on state laws, medical licensing requirements, tort law, self-regulation by professional associations, administrative rule making, and the power of the marketplace, is thorough and effective (Adamson 2002). One federal law directs the government, in conjunction with professional associations, to collect and publicize data from fertility clinics to educate patients and the public about clinic performance. Those who believe that the oversight system is sufficient point to statistics on healthy children and improved birth rates for IVF as indicators of effective regulation and professional caution. They argue that concerns, such as those questioning the sizeable number of twin, triplet, and higher order births following IVF, can be addressed by professional self-management and improved technologies.

From another point of view, the government should take a more active role in monitoring IVF/PGD practice by developing a centralized oversight system and taking other steps to protect the health of patients and offspring. According to this view, the government should develop a centralized data gathering system or, at least, a national level forum for debating issues relating to infertility treatment. It should also enact laws to address specific concerns; for example, to limit the number of multiple births, and regulate by law the number of embryos that can be transferred per IVF cycle (International Society for Law and Technology [ISLAT] Working Group 1998).

The ability of the federal government to regulate IVF is limited by constitutional protections of reproductive liberty. In addition political controversies over the status of embryos make legislation difficult to enact. The likelihood of enacting in the United States a central oversight board for assisted reproductive technologies, as exists in the United Kingdom, is slim. In the meantime researchers are engaged in data gathering to assess the long-term safety of IVF, state legislatures are considering various forms of regulation, and practitioners are continuing to produce practice guidelines as part of self-regulatory policies.

Conclusion

IVF has led to the birth of more than 1 million children who may not otherwise have been born to couples experiencing various infertility problems. Issues about the status of embryos, disposition of frozen embryos, proper reach of PGD, and optimal forms of oversight have recurred in the years since 1978. New ethical issues arise as the technologies and applications change. For example what payment is appropriate for egg donors? Should practitioners accept single persons as patients? What should be done with embryos abandoned by couples? What issues are raised when egg or sperm donors are related to the recipients? Should PGD be used to determine predisposition to disease? Should children conceived with donor eggs, sperm, or embryos be told how they were conceived?

Although no central forum exists for debating these issues in the United States, the public fascination with IVF ensures that the issues are aired and discussed. While it is tempting to call for governmental controls, the issues raised by rapidly changing technologies are not easily amenable to preemptive legislation, which can be rigid and easily dated. Moreover government policy precludes funding research in which embryos are injured or destroyed, which removes the *power of the purse* as a vehicle for oversight. Consequently, robust discussion, public education, regulations of medical facilities in general, and self-regulation by professional associations all contribute to oversight. Though complex and decentralized, this system allows monitoring while also respecting the reproductive liberty of couples seeking the services of fertility clinics.

ANDREA L. BONNICKSEN

SEE ALSO *Assisted Reproduction Technology; Embryonic Stem Cells; Eugenics; Fetal Research; Genethics; Genetic Counseling; Playing God.*

BIBLIOGRAPHY

Adamson, David. (2002). "Regulation of Assisted Reproductive Technologies in the United States." *Fertility and Sterility* 78: 932–940. An overview of numerous professional guidelines and government laws and policies that make up the regulatory framework for assisted reproductive technologies in the United States.

Davis v. *Davis*, 842 S.W.2d 588 (Tenn. 1992). First court case involving a dispute between male and female partners over the disposition of their frozen and stored embroyos.

Elster, Nanette R. (2002). "ARTistic Licence: Should Assisted Reproductive Technologies Be Regulated?" In *Assisted Reproductive Technology: Accomplishments and New Horizons*, eds. Susan M. Avery and Peter R. Brinsden. New York: Cambridge University Press. Review of court decisions, state and federal laws, and self-regulation of assisted reproductive technologies, including what Elster considers to be regulatory gaps.

Ethics Advisory Board. U.S. Department of Health, Education, and Welfare. (1979). *Report and Conclusions: HEW Support of Research Involving Human In Vitro Fertilization and Embryo Transfer*. Washington, DC: Government Printing Office. First report by a governmental advisory body on the ethics of in vitro fertilization; report concluded that research into IVF was ethically acceptable, with limits.

International Society for Law and Technology (ISLAT) Working Group. (1998). "ART into Science: Regulation of Fertility Techniques." *Science* 281: 65–66. Brief review of regulation of assisted reproductive technologies with recommendations for increased governmetnal oversight.

Robertson, John A. (2003). "Extending Preimplantation Genetic Diagnosis: The Ethical Debate." *Human Reproduction* 18: 1–7. Review of situations in which pre-implantation genetic diagnosis can be used; discussion of ethical and legal issues relating to these uses.

Society for Assisted Reproductive Technology and the American Society for Reproductive Medicine. (2002). "Assisted Reproductive Technology in the United States: 1999 Results Generated from the American Society for Reproductive Medicine/Society for Assisted Reproductive Technology Registry." *Fertility and Sterility* 78: 918–931.

IQ DEBATE

In 1905 two Frenchmen, Alfred Binet (1857–1911) and Theophil Simon (1873–1961), invented the IQ (Intelligence Quotient) test to distinguish between mentally retarded and normal school children. They set tasks that normal children could do; for example, five-year-olds were asked to compare two weights, copy a square, repeat a sentence of ten syllables, count four pennies, and unite the halves of a divided rectangle.

By 2005 there were thousands of tests but two have special significance. The first, Raven's Progressive Matrices, measures on-the-spot problem solving where no previously learned method is applicable. It presents a pattern of shapes from which one piece is missing, offers six alternative missing pieces, and then asks the examinee to choose the correct one (Raven 2000). The second, the Wechsler Intelligence Scale for Children (WISC), supplements Raven's by using ten to twelve subtests to measure a variety of cognitive skills. These tests constitute technologies that raise significant ethical issues.

What IQ Tests Measure

Various cognitive skills go into problem solving. One such skill is mental acuity, which involves both solving problems without a previously learned method and the active creation of alternative solutions. The WISC subtest called Similarities measures mental acuity: The subject must decide what certain things, such as dawn and dusk, have in common. Similar subtests include Block Design, Picture Concepts, and of course Matrices. Another set of subtests are quite different. Clearly, a wide range of basic knowledge and a large vocabulary enhance problem-solving ability. These are measured by the Vocabulary and Verbal Comprehension subtests and, until recently, by the Information and Arithmetic subtests that were dropped in the fourth edition of the WISC. Although there is learned content in these subtests, it is the kind of learning that intelligent people will master more easily and more thoroughly. A third kind of relevant skill is speed of information processing—which is measured by the Coding and Symbol Search subtests. Finally, that ability called memory, which allows individuals to access accumulated knowledge, is tested by the Digit Span (the number of digits a person can repeat after they are read out —and the ability to repeat them in reverse order) and the Letter-Number Sequences subtests.

Given that the WISC tests cover the cognitive skills that go into problem solving, it may seem surprising that there is so much debate about whether IQ tests measure intelligence. There are several reasons why the controversy endures.

Attitudes affect cognitive skills because people invest mental energy into problems only if they feel they are significant. Attitude shifts over time have enhanced performance on some subtests more than on others (Flynn 2003). Members of a street gang may see little point in problems that appear to lack practical significance. Lots of noncognitive skills contribute to problem solving such as empathy, tact, setting people at ease, and being a good listener. In addition, IQ tests do not measure a host of attributes regarded as important, such as artistic and musical ability, honesty, and generosity.

Most debate about what IQ tests measure consists in endless repetition of these points and inventing a host of intelligences, such as emotional intelligence, social intelligence, surviving-in-a-wilderness intelligence, and musical intelligence, among others (Jensen 1998). This sterile debate can perhaps be circumvented by a modest claim: IQ tests measure *cognitive* skills relevant to problems encountered in the *mainstream of industrial societies;* and test the *basic knowledge* needed to function in those societies. However, there is a caveat: IQ tests cannot determine when a person scores better than others because of *attitudes* friendlier toward the kind of problems that are to be solved.

Uses of IQ Tests

IQ tests perform three main roles: comparing individuals for cognitive skills; comparing groups; and measuring cognitive skill trends over time, this last being a special case of comparing groups because it entails comparing one generation with another.

IQ scores give each person a percentile rank using Standard Deviations (SDs) as the link. An IQ of 100 is average for any particular age and is at the 50th percentile. An IQ of 130 is two SDs above the mean (an SD = 15) and is at the 98th percentile (only 2.3% of the subject's peers have a higher score); an IQ of 110 is 0.67 SDs above the mean and is at the 75th percentile; an IQ of 70 is two SDs below the mean and equals the 2nd percentile (only 2.3% of the subject's peers have a lower score). Certain IQ scores set the threshold for performing certain social roles. Few people with IQs below 130 will receive a Ph.D. from an academically superior university; few with IQs below 110 will enter the elite professions, that is, medicine, law, accounting, natural science, and engineering; and few with IQs below 100 will hold a professional, managerial, or technical post of any kind. Those with IQs below 70 are often regarded as being unable to cope with normal life and are labeled mentally retarded.

Race Differences

The existence of IQ thresholds for occupations generates group comparisons unfavorable to blacks. The mean IQ of white Americans is 100, while black Americans have a mean IQ of 85 or one SD below whites. The pool of potential professionals, managers, and technicians has a threshold of 100. Therefore, 50 per cent of whites would qualify but only the highest scoring 16 per cent of blacks (a score of 100 is at their 84th percentile). The Berkeley psychologist Arthur Jensen suggests that even if environments were equalized, blacks would still have a mean IQ of only 90 (Jensen 1973, p. 363). If he is correct, even then, only 25 percent of blacks would qualify.

Some believe scholars should not debate whether ethnic groups show genetic differences for intelligence. This moral advice will fail and should fail. Those who read Jensen will quickly find that he has an argument that must be answered, high professional standards, and no trace of racial bias. Thus the only reason not to test his hypothesis is that it would be unpleasant if it were true. In addition, if those who have offered evidence in favor of genetic equality were to opt out of the debate, Jensen's hypothesis would remain undisputed, a sort of unilateral disarmament. The debate should proceed and be conducted purely along evidential lines. The strongest evidence supporting a genetic hypothesis is the under performance, both on IQ tests and academically, of children of the black middle and upper classes—who do fall at least 10 IQ points short of their white counterparts (Herrnstein and Murray 1994, p. 288). The strongest evidence in favor of an environmental hypothesis was obtained as the result of an historical event: the U.S. military occupation of Germany after World War II, which removed thousands of black males from the American environment. The U.S. army left behind many illegitimate children. The mean IQs of those with black fathers and those with white fathers were the same (Flynn 1999).

Whatever the causes of the IQ gap between black and white Americans, it exists. When standardized tests are used as screening devices, the lesser representation of blacks leaves the realm of theory and becomes fact. The debate as to whether affirmative action should be used to redress the balance is complex. Opponents point to cases of underprivileged whites who are rejected in favor of the child of a black professional, lower performance in key areas such as police protection, and the fact that blacks may actually suffer harm, for example, by being admitted to universities where they are doomed to fail (Herrnstein and Murray 1994).

Proponents argue that black Americans suffer from their group membership in many ways, ranging from police behavior toward them, higher consumer prices in the ghetto, discrimination in housing and employment, and an unfavorable marriage market. White men very rarely marry black women. Therefore, black women are restricted to marrying black men and many are unlikely to find permanent partners—because too many black men die young, are imprisoned, or are not regularly employed. Therefore, more than one-half of black children are raised in solo-mother homes, often below the poverty line (Flynn 2000, pp. 148–149). Supporters of affirmative action also contend that most efficiency gains would accrue if standardized tests were only used to disqualify those without essential skills and if job-related criteria were substituted to rank applicants above that level. They cite data showing that when blacks admitted to elite universities (for which they would not normally qualify) are matched with blacks who went to other universities, the graduation rates are similar—and that the former profit by earning higher incomes (Kane 1998).

Genes and Environment

Studies of identical twins separated at birth and raised apart show that, at adulthood, twin and co-twin are far more alike in IQ than randomly selected individuals. This appears to be because of their identical genes—and does that not mean that genes are far more potent than environment? Jensen calculated that if environment were in fact this weak, no plausible environmental difference within a society such as America could account for a one SD IQ gap—which is the gap between the IQs of blacks and whites (Jensen 1973, pp. 166–169).

In 1987 James R. Flynn, a moral philosopher at the University of Otago, challenged this reasoning with evidence showing the existence of massive IQ gains over time. For example, the Dutch gained fully 20 IQ points on Raven's Matrices from one generation to the next, that is, from 1952 to 1982, a result replicated in several nations. Since there can be little genetic upgrading in a single generation, Flynn contended that these huge gains must have been due to environment (Flynn 2003). Thus, a paradox arose that baffled the discipline for many years: How can twin studies show environment to be so weak, while IQ gains over time show environment to be so enormously potent?

In 2001 William T. Dickens, an economist at the Brookings Institution, and Flynn offered *reciprocal causation* as a possible solution. Imagine identical twins who were separated at birth and raised apart in a basketball-mad state such as Indiana. Their identical genes dictate that they are born both a bit taller and quicker than average. Thus, although raised in different cities, both tend to be picked for informal basketball games at school. The extra play upgrades their skill advantage and they both get picked for the school team. They then play a rigorous schedule and get professional coaching, which upgrades their skill advantage further. At adulthood, they end up with basketball skills that are remarkably similar and well above average—and their identical genes get all the credit. But that assumption is a mistake. It overlooks the fact that these identical twins also had atypically similar basketball environments—their genes are getting credit for shared factors like more practice, playing on a team, and professional coaching. The kinship studies mask the potency of environment.

Skill gains over time show the true strength of environment. In 1950 TV brought basketball into American homes and basketball put baseball into the shadows—those close-ups look so good even on the small screen. Suddenly everyone was playing basketball and skills escalated. At first, to be better than average, a player needed merely to pass and shoot well. However, the rising quality of the average performance became a powerful factor in its own right. To excel, a few people learned to shoot with both hands. Then everyone who wanted to compete had to try to do the same, which pushed the mean up further. Soon a few people learned to pass with both hands and then, everyone had to try to do that. Every rise in the average performance encouraged a further rise.

So now this has resolved the gene-environment paradox: The key is reciprocal causation as a potent multiplier of skill differences. Within a generation, genes drive the feedback process and get credit for the environmental input—which gives the illusion of environmental weakness. Between generations, a persistent environmental factor (the rising popularity of basketball) drives the feedback process—and shows how environment can produce huge skill differences between groups separated by only a few years of time.

New Spectacles

The concept of reciprocal causation provides spectacles that improve our perception of what may cause group IQ differences. Do blacks start with what may be a modest but significant genetic disadvantage, one that gets multiplied into a 15-point IQ deficit? Or are there persistent environmental factors that divide black and white, analogous to belonging to the pre-TV and post-TV generations? Some have attempted to identify the kind of factors that might inhibit black academic achievement and IQ test performance: that they feel threatened by intellectual competition with whites; that black males are ambivalent about intellectual success and may even strive to fall below the class mean (so blacks would have negative multipliers!); and, as has been seen, that the problems of black males affect black children, so that a majority of them are raised by solo-mothers struggling to avoid poverty.

The brute fact that average IQ scores increase over time adds a new dimension to another debate: whether IQ tests should be used to classify people as mentally retarded. IQ gains mean that subjects will get higher IQs on an out-of-date test. If someone was average when compared to the test performance of their peers today (and therefore gets an IQ of 100), they would automatically be better than average compared to their peers of 20 years ago (and therefore get an IQ well above 100). After all, the fact that the average performance was worse in the past is what constitutes IQ gains over time. There is no doubt that people have been denied special education or have been executed on death row because taking obsolete tests inflated their IQs above 70, the usual cut-off point for mental retardation (Kanaya et al. 2003). These facts strengthen the argument of those who believe in purely behavioral criteria for mental retardation: School children should be classified as such if they cannot understand the rules of games they play frequently; prisoners should be executed only if their life histories show they can cope with the usual activities of everyday life, for example, by qualifying for a driver's license.

Are IQ Gains Real?

The United States and other nations have been making massive IQ gains for at least as far back as the 1930s. Are these really intelligence gains? The answer is that they are piecemeal cognitive skill gains that affect the real world—but they are not gains in terms of the kind of general intelligence IQ tests are designed to measure.

When an IQ test measures individuals competing with one another, certain people tend to do better than average on all or most of the WISC subtests—which is to say part of what is being measured is a better functioning brain that gives someone an advantage for most cognitive skills. Society does not upgrade average brain quality from one generation to another because it does not run radical experiments in selective breeding. What it does do is manipulate environmental factors that have a differential effect on various cognitive skills. If Americans fill more leisure time with cognitively demanding games, and fill more professional positions in which they must make decisions rather than simply following rules, scores on the Similarities subtest should rise—and they have enormously. If efforts to improve reading in the United States have not made people love books, and if visual entertainment of a largely escapist sort tempts people away from books, one would not expect better ability to read serious literature, or bigger non-specialized vocabularies, or the command of more general information—and the relevant WISC subtests show that this is indeed the case (Flynn 2003).

In sum, IQ tests are good tools for comparing the cognitive skills of individuals and alerting researchers to group differences. However, finding causes and solutions for those differences involves the totality of social science. The general intelligence factor that IQ tests are designed to measure may indicate which mind competes best with other minds at a certain time and place. But it is a crude measure of what society is doing to a wide variety of cognitive skills over time. We must free our minds of it and look at trends on the various WISC subtests. They reveal the intellectual history of these times.

JAMES R. FLYNN

SEE ALSO *Emotional Intelligence; Eugenics; Race.*

BIBLIOGRAPHY

Deary, Ian J. (2001). *Intelligence: A Very Short Introduction*. New York: Oxford University Press. A good introduction to IQ tests and their significance.

Dickens, William T., and James R. Flynn. (2001). "Great Leap Forward." *New Scientist* 170(2287): 44–47. Spells out the concept of multipliers and how they clarify the roles of genes and environment.

Flynn, James R. (1999). "Searching for Justice: The Discovery of IQ Gains Over Time." *American Psychologist* 54: 5–20. Discusses the social issues that IQ tests raise.

Flynn, James R. (2000). *How to Defend Humane Ideals: Substitutes for Objectivity*. Lincoln: University of Nebraska Press. Makes a case for affirmative action as necessary even in the absence of racism.

Flynn, James R. (2003). "Movies about Intelligence: The Limitations of *g*." *Current Directions in Psychological Science* 12: 95–99. Argues that IQ gains represent real gains in certain cognitive skills even if they are not general intelligence gains.

Herrnstein, Richard J., and Charles Murray. (1994). *The Bell Curve: Intelligence and Class in American Life*. New York: Free Press. A case that social progress is producing an underclass without the genetic potential to contribute to society; for a rebuttal, see Flynn (2000).

Jensen, Arthur R. (1973). *Educability and Group Differences*. New York: Harper and Row. A case that blacks on average have a lower potential for intelligence than whites; for a rebuttal, see Flynn (1999).

Jensen, Arthur R. (1998). *The g Factor: The Science of Mental Ability*. Westport, CT: Praeger. A case that the concept of general intelligence, *g*, is central to the study of human cognition—for reservations, see Flynn (2003).

Kanaya, Tomoe; Matthew H. Scullen; and Stephen J. Ceci. (2003). "The Flynn Effect and U.S. Policies: The Impact of Rising IQ Scores on American Society via Mental Retardation Diagnoses." *American Psychologist* 58: 778–790. Spells out how IQ gains over time have made a lottery out of classifying people as mentally retarded.

Kane, Thomas J. (1998). "Racial and Ethnic Preferences in College Admissions." In *The Black-White Test Score Gap*, eds. Christopher Jencks and Meredith Phillips. Washington, DC: Brookings Institution Press. Presents data that show that blacks profit from affirmative action at the university level.

Raven, John. (2000). "The Raven's Progressive Matrices: Change and Stability over Culture and Time." *Cognitive Psychology* 41: 1–48. The "architect" of Raven's Progressive Matrices describes its role in measuring cognitive trends throughout the world.

ISLAMIC PERSPECTIVES

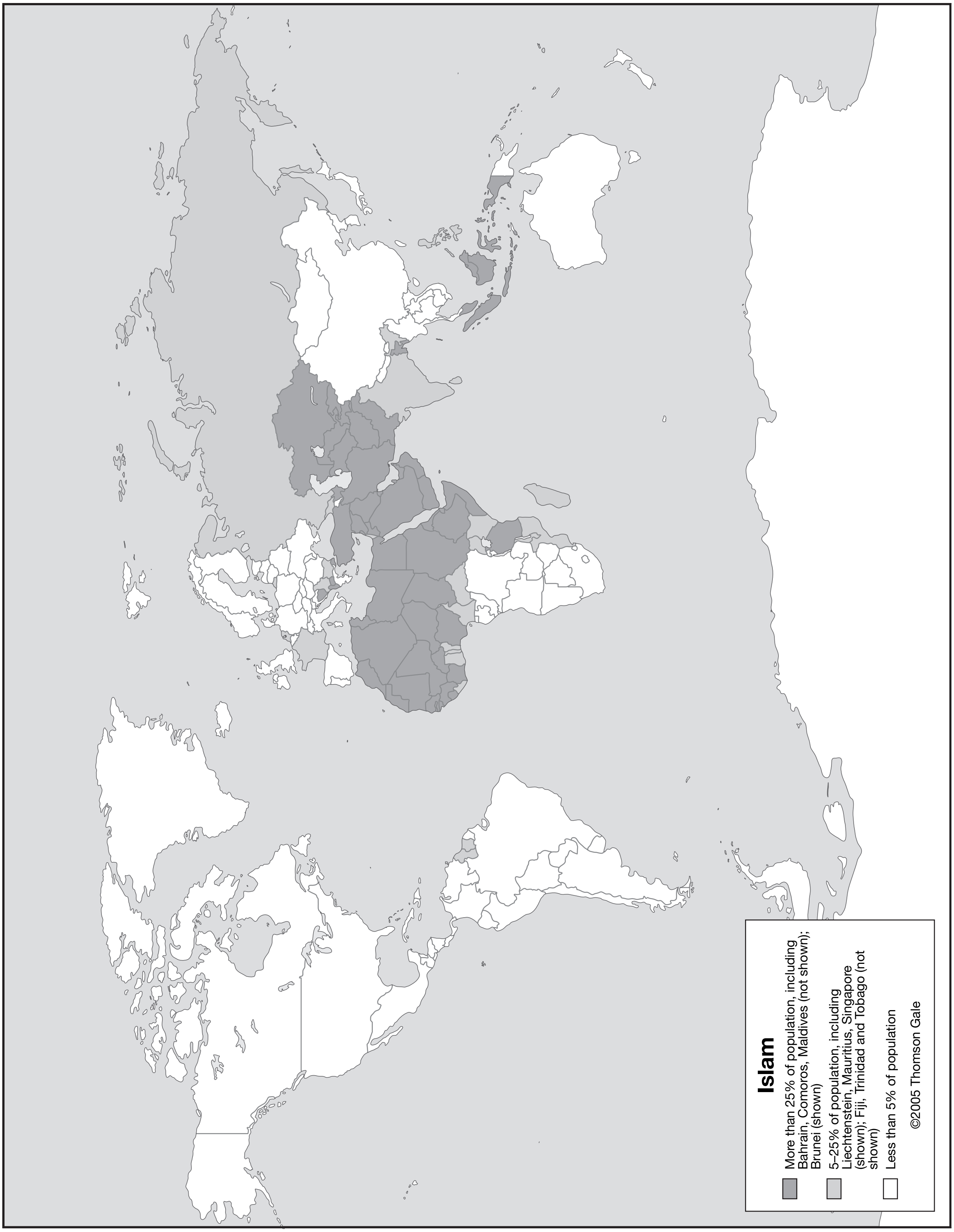
Islam is at once a religion, a community, and a civilization. In all three senses, Islam is a source of unique perspectives on relations between science, technology, and ethics. As a religion, Islam upholds knowledge as the key to both individual and societal salvation. With the idea of unity of reality and knowledge as a guiding principle it refuses to entertain any distinction between the religious and the secular in the realm of knowledge. Science and technology are as relevant as the so-called religious sciences to the human pursuit of the divine. As a community, Islam stresses on the divine law as the most important source of ethics to guide human actions in all sectors of personal and public life and as the most visible expression of Muslim cultural identity. This law is generally viewed as not only all-embracing in the scope of its applications but also as dynamic enough to be adaptable to the changing needs of space and time. Science and technology are to be regulated by ethics embodied in this law. As a civilization, Islam seeks to promote the interests of all humanity by standing up for the perspectives of universalism, the common good and inter-faith understanding. As so many of Islam's thinkers have asserted over the centuries science and technology are the most powerful and the most enduring universal elements in human civilization and should be pursued for the sake of the common good and inter-faith peace, Islam places strict limits on technology and subordinates scientific rationality to revelation. As a community, Islam is more concerned to adapt science and technology for practical benefit.

Historical Background

Islam was born in Mecca, Arabia, in 610 C.E. when Muhammad, an illiterate but highly respected member of Arabia's most powerful tribe, the Quraysh, claimed he had received revelations from God. During one of his regular spiritual retreats in a cave on the outskirts of Mecca, the archangel Gabriel appeared before him instructing him to recite a few verses in Arabic and proclaiming him God's new messenger to humankind. That initial revelation was essentially about the true spirit of human learning: Seeking knowledge is to be done in the name of God who is humanity's best teacher, and the best human instrument of knowledge is the intellect as symbolized by the pen. This tenet supported the new religion's claim to be essentially *a way of knowledge*.

The Prophet, as every generation of Muhammad's followers call him, received further revelations intermittently over a period of twenty-three years until just before his death in 632 C.E. These revelations were systematically compiled into a book known as the *Qur'ān* (literally meaning *The Recitation*). The precise arrangement of the *Qur'ān* itself is traditionally thought to be divinely inspired. This book, believed sacred both in text and meaning, is the most authentic and the most important source of Islamic teachings. The names Islam for the religion and Muslims for its followers are set out in the *Qur'ān*. Islam means both *submission to God's will* and *peace*, while Muslim means *one who submits to the divine will*. More than anything else the *Qur'ān* is a source of guidance in the domain of knowledge. Muslims believe that the *Qur'ān* contains the principles of all sciences. Islam claims to revive the pure monotheism of Abraham while presenting itself as the synthesis of all previously revealed religions, which has helped foster a positive attitude among Muslims toward the intellectual and cultural legacies of other civilizations.

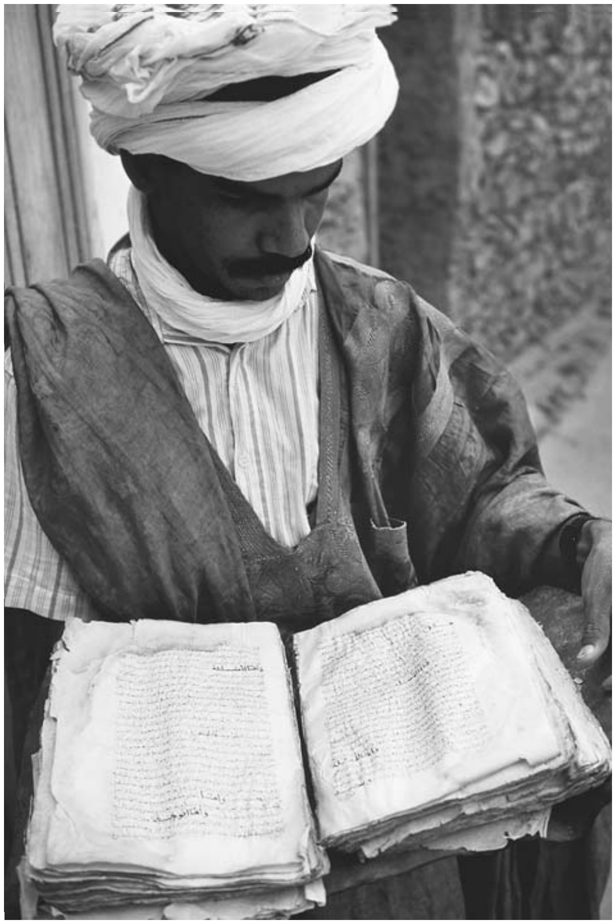
As a full-fledged religious community (*ummah*) with distinctive characteristics as envisioned in the *Qur'ān*, Islam was founded in Medina, formerly known as Yathrib, in 622 C.E. (although the nucleus of the community had formed earlier in Mecca). The Prophet and his followers migrated to Medina to escape persecution following his uncompromising stand on idol worship. This flight, known as the *hijrah*, marked a major turning point in the history of Islam. The original group grew to become a worldwide community that is estimated at 1.2 billion followers in the early-twenty-first century. As an extension of his community, the Prophet established a city-state that he named *Madinat al-Nabiy* (City of the Prophet) or simply *al-Madinah* (The City). This pluralistic city-state, multiethnic and multireligious, reflected


Islam
More than 25% of population, including Bahrain, Comoros, Maldives (not shown); Brunei (shown)
5–25% of population, including Liechtenstein, Mauritius, Singapore (shown); Fiji, Trinidad and Tobago (not shown)
Less than 5% of population
©2005 Thomson Gale

the moral and ethical basis of the sociopolitical teachings of Islam. In postprophetic Muslim history, Medina is an enduring model of Islamic polity.

As a civilization (*tamaddun*), Islam manifested itself when the community organized all aspects of daily life in accordance with the spiritual and ethical values set out in the *Qur'ān* and as interpreted by the Prophet. The cultural identity of Muslims became easily visible in the way they cultivated *a knowledge culture* that did not separate the religious and the secular, envisioned and practiced moderation in religious life, merged temporal life with the spiritual, championed social justice, permeated ethical concern in all individual and societal activities, engaged pluralism, and approached relations with other faiths. But the happenings in Medina merely lay the foundation of Islam. Fuller development of the civilization occurred after the religion spread throughout the world, encountering other civilizations, and the *ummah* grew into a more ethnically and culturally diverse circle of believers.

Islam and the world did not have to wait long to see the realization of a civilization that was innovative, unique, and unrivaled in brilliance for its times. The spread of Islam to distant places was astoundingly swift. Within a century from the death of the Prophet, Islam swept through North Africa reaching Spain in the west and central Asia in the east, and even became a minority religion in China. With a generally positive attitude toward the cultural and scientific legacies of past and contemporary civilizations, Islam tried to create a new civilization by merging the best of these traditions with its own resources. The hallmark of Islam, the civilization, is *the grand synthesis*. Islam, the religion, inspires the Muslim mind to create a human civilization that is basically *synthetic* in nature.



Man holding an ancient copy of the Koran. Muslims believe that the Koran is the literal word of God and culmination of God's revelation to mankind, revealed to the Prophet Muhammad over a period of 22 years by the archangel Gabriel. *(© Nik Wheeler/Corbis.)*

Islam, Science, and Technology

This historical background provides a context to understand science, technology, and ethics in Muslim culture and civilization. Muslims believe the *Qur'ān* affirms the supreme role of knowledge in ordering human life and thought and delivering success. Knowledge is regarded as the key to human salvation and to human happiness in this world and in the afterlife. But knowledge that saves must be sacred in nature. Sacredness is not defined in terms of primacy of revelation over reason. Among Muslim philosophers and scientists the distinction between revelation and reason is rather blurred. This is because reason is regarded as a minor revelation given to every human individual and as such is itself sacred in nature even if many humans are not aware of it. By sacred knowledge the *Qur'ān* means knowledge that is related in some way to God, pursued in the name of God, and used and applied in the name of God. As Muslims see it, human knowledge, including science, possesses a sacred character because God is the ultimate source of all knowledge regardless of whether humans acquire it empirically or otherwise. The *Qur'ān* speaks of God as the All-Knower and the giver of knowledge to humans through various avenues ranging from physical senses to intellectual reflection, dream interpretation to divine revelation. The Muslim idea of sacred knowledge is contained in the very first revelation Muhammad received.

The *Qur'ān* also maintains that the ultimate purpose of human knowledge is to know God. This objective is attainable because human knowledge of creation will lead to knowledge of the divine reality, which is considered to be the highest form of knowledge possible. The *Qur'ān* is emphatic in acknowledging that God is knowable. Muslims approach the study of different branches of knowledge, including science and technology, with this spiritual objective in mind. Scientists view their study of the natural world as a form of religious worship, but the lesser objectives of knowledge are duly recognized. Knowledge helps humans to fulfill their rational and mental needs, such as clarity of mind, certitude of thought, and rational explanations of both natural and social phenomena, as well as those material needs that can be met by technology. In the traditional Muslim pursuit of knowledge, the deepest theoretical understanding of things goes hand in hand with an earnest appreciation of their practical utility.

It was the Prophet who inspired Muslims to pursue knowledge of things for both their theoretical and practical considerations. He encouraged his followers to reflect and contemplate natural phenomena pursuant to the *Qur'ān* with a view toward deepening understanding of divine power and wisdom in creation. But the Prophet also compared knowledge that had no practical benefits to a tree without fruit. He often prayed to God seeking protection from *useless knowledge*. On the basis of this tradition, Muslim scholars progressively sought to articulate ideas, concepts, and theories on the broader issue of the ethics of knowledge as activities of knowledge production and applications in the new civilization expanded and became more complex. Major issues included clarifying the meanings of beneficial and harmful knowledge in the perspective of Islamic law and determining the general criteria for each type of knowledge. Muslim preoccupation with the knowledge culture took many different forms. One was classification of knowledge, which proved to be a good way of keeping track of the state of knowledge at any given time. Classification of knowledge divided the sciences into thematic groups of well-defined disciplines, and preserved their hierarchy.

The Arab philosopher al-Kindi (c. 801–873) authored the first Muslim classification of the sciences in the ninth century. Since then many scholars have devoted considerable effort to expositions of this theme. The last significant work on the subject is the classification written by the Indian theologian Shah Waliallah of Delhi (1703–1762) in the eighteenth century. The importance and popularity of classification of the sciences was evident not only from the number of books written on the subject but also from the diverse nature of the scholarly community that produced them. Theologians, philosophers, scientists, historians, and jurists, among both Sunnis and Shiites, were represented in this unique enterprise. Classifications had been particularly useful to the organization of educational curricula. Interestingly there appeared to be a correlation between the rate of production of classifications of knowledge and the intensity of knowledge expansion. The interest in classifications was at its height during the era when Muslims were the most productive in terms of adding new scientific disciplines to the existing body of human knowledge. After the sixteenth century when intellectual and scientific innovations began to decline in most parts of the Muslim world, work on classifications dropped sharply. The fact that hardly any work has appeared on the subject since the eighteenth century testifies to the reduced importance of the role of knowledge among Muslims in the early-twenty-first century world.

It is clear from past classifications that Muslims were concerned with the need for a balanced approach to both theoretical and practical knowledge. In addition, Muslims accord relative importance to each science in the context of human knowledge as a whole. Generally scholars use three criteria to determine the epistemic position of each science in what is traditionally called the hierarchy of knowledge. The criteria are defined in terms of the relative excellence of the objects of study, methods of study, and benefits of study. Some sciences may be viewed as more laudable than others on the basis of one or more of these criteria. The greatest science in light of the three criteria is the science of God or theology in the true sense of the word.

Islamic Culture, Science, and Technology

As clearly reflected in classifications over the centuries, Muslims do not consider science and technology to be the most important branch of knowledge, as do many people in Europe and North America who view science as the sole basis for reliable knowledge and technology as the best means to solve human problems. From the Muslim perspective, science could never take the place of metaphysics and theology in either temporal or moral importance because the latter have God and the divine realities as their *object of study* whereas science and technology focus on natural objects created by God. Additionally technology could never replace divine law (*shari'ah*) as the best provider of efficacious solutions to human individual and societal problems. Despite these beliefs, at the apex of their cultural influence, Muslims demonstrated a degree of appreciation of science and technology unseen in earlier times. Such appreciation was contextual, as dictated by the *shari'ah* itself.

Muslims distinguish between two types of obligatory knowledge. The first type is *fard 'ayn,* meaning obligatory for everyone to have as, for example, in the case of knowledge of canonical prayer. The second type is *fard kifayah,* meaning obligatory for society to possess, though the task of acquiring it may be left to certain individuals or groups. Implicit in the meaning of this category of knowledge is that without it a society would lack something that is important to its well being. *Shari'ah* confers the status of *fard kifayah* knowledge to science and technology on the basis of their immense benefits to human society. A society without a level of science and technology proportionate to its problems is considered unhealthy. Political philosophers like al-Farabi (870–950) went so far as to claim that science and technology are necessary ingredients in the pursuit of human happiness. But to Muslims, science and technology serve society best when pursued and employed in the light of ethical-legal principles of *shari'ah.*

Muslims believe both *shari'ah* and science and technology are necessary to societal salvation, and that the two should be joined within the ethical and legal framework of *shari'ah. Shari'ah,* which is primarily based on the teachings of the *Qur'ān* and the prophetic *hadiths,* is considered by Muslims to be the most important source of ethical values and principles to guide human actions and conduct. In the case of the Shiites, the *hadiths* extend to embrace the teachings of their supreme spiritual leaders known as *Imams. Shari'ah* refuses to separate between ethical and legal thought. What is legal has to be ethical, and vice versa. The religious significance of scientific and technological activities resides in the fact that the *shari'ah* divides all human actions into five categories. These categories are the obligatory (*wajib*), the meritorious or the recommended, the indifferent (*mubah*), the forbidden (*haram*), and the reprehensible (*makruh*). The main significance of these ethical categorizations for science and technology in Muslim culture is that society and the state are in broad agreement on what ought to be the priorities in scientific and technological pursuits. Obviously scientific and technological products and activities in the obligatory and meritorious categories are given the greatest priority. At the same time *shari'ah* is ever present to remind society and the state of the need to refrain from indulging in scientific and technological activities belonging to the forbidden category because *haram* would be harmful to society. *Shari'ah's* general objectives, namely to protect religion, reason, life, progeny and property, and its specific exhortations pertaining to both worship and social duties determine the types and scopes of scientific and technological activities to be encouraged or shunned. Muslim science and technology over the centuries had more or less developed along the ethical track that *shari'ah* provided. Muslims emphasized sciences like mathematics, astronomy, geography, medicine, botany, and agriculture because of their practical relevance to *shari'ah.* For the same reason, Muslims developed civil engineering and medical, agricultural, and navigational technology to new heights in the medieval period. But on the whole, harmony between science, technology and ethics was rarely shattered.

Contemporary Issues

In many early-twenty-first century Muslim societies worldwide, the traditional bond between divine law and technology has been severed. For various reasons, *shari'ah* is no longer seen as relevant to the shaping of technological pursuits. Muslims face the ethical challenge of dealing with science and technology issues that are largely not of their own making, and that pose numerous challenges to traditional Islamic ethics.

Perhaps the most serious challenge derives from military technology and biotechnology including medical technology that enables humans to, literally, determine life and death. Modern military technology in the form of weapons of mass destruction, such as nuclear and biological weapons, clearly transgresses the limits of traditional Islamic war ethics. Some Muslim states are defending the right to acquire such weapons on what they claim to be *Islamic grounds,* although it seems clear that their motive is primarily political. Many scholars in Sunni Pakistan defend that country's *Islamic bomb* on the basis of geopolitical considerations. In Shiite Iran clerics are divided on the issue of possessing nuclear weapons with President Seyed Mohamed Khatami (elected 1997) taking the stand that such weapons are contrary to Islamic ethical teachings. Muslims throughout the world are divided on the issue not along theological or jurisprudential grounds but by political, ideological perspectives. However one thing is clear: Pronuclear weapons advocates have been able to sustain their views largely by appealing to political considerations rather than to the more fundamental Islamic ethics on the conduct of war. Proponents of the supremacy of Islamic political power are likely to endorse such weapons.

Biomedical technology has impacted the social fabric of Europe and North America in an unprecedented way and has sent shock waves into the Muslim world. The range of biomedical technology currently employed in Muslim countries is still limited. But that limited use is apparently dictated far more by economics than by perceptions of ethical incompatibility with Islam. But the few richer ones as well as Muslim minorities in the west have helped Muslims to keep abreast with ethical issues arising from modern biomedical practice. In countries such as Nalaysia, Indonesia, Turkey, and Kuwait issues in biomedical ethics such as debated in the west are likewise discussed in the medical profession and the academia. The Islamic Organization for Medical Sciences based in Kuwait is exceptionally active in organizing international meetings of Muslim medical doctors to discuss implications of contemporary biomedical technology for Islamic societal values. Quite often experts in Islamic law are invited to these meetings for religious consultation. This meeting of Muslim scientific and religious minds has been successful in coming up with well-defined criteria for Muslim acceptance of biomedical technology. There is a particular concern for the impact of biomedical technology on traditional family values and institutions. The general Muslim view is that while that technology is not the cause of the breakdown in traditional family and marriage institutions, it nonetheless has created new possibilities that allow the viability of alternative lifestyles. Life-support machines that call into question the traditional definition of death, technology that uncovers information about babies still in the womb, sperm banks, and artificial insemination are major examples of modern-day scientific and technological innovations that have attracted the attention of Muslim ethicists. Debates on those issues had hardly settled when the more serious ethical issue of cloning emerged.

On some issues such as the technology associated with prenatal information and artificial insemination the Muslim debate has been fairly brief as religious experts and political authorities quickly find satisfactory answers to initial Muslim grievances on the possible misuse of the technology. On other issues such as the life-supporting machines the debate rages on. The majority view is that as traditionally held the community of believers should help to facilitate "easy and peaceful" death of the dying and not to prolong agony and suffering such as through the use of the life-supporting machine. The traditional belief is that death, a passage to afterlife, is itself a suffering. To be in a state of neither life nor death is viewed as being in a state of suffering. The traditional way of facilitating peaceful death is recitation of verses from the *Qur'ān*. The minority view is that use of the machine is permissible because religion also teaches the saving of every human life through every possible means. While debates on such issues rage on the more serious ethical issue of cloning emerged. Muslims are unanimous in rejecting human cloning. But they are deeply divided on the use of stem cells for research. The overwhelming majority oppose using human embryonic stem cells for research. But many Muslim groups consider use of adult stem cells as religiously permissible.

The following patterns emerge in the still-fluid Muslim response to bioethical issues. First Muslims are increasingly turning to Islam's inner resources as found in the *Qur'ān*, prophetic traditions, and traditional ethics in looking for answers to dilemmas posed by new technologies. Second Muslims are evaluating the potential value of new technologies while remaining committed to defending *shari'ah*-sanctioned social institutions. They are likely to adopt new technologies within the constraints of *shari'ah* as they have already done in many cases. For example, Muslim jurists have permitted artificial insemination as long as the couple is legally married according to Islamic law and the semen is that of the husband. Third Muslims are questioning whether humanity needs to have better and more encompassing ethical ideas than just those that appeal to *research interests* or *search for medical cures* in order to justify controversial, new scientific research and biomedical technology. As Muslims become more immersed in technological matters they more often find the need to consult the ethics of *shari'ah*.

A deep interest in ethical issues in science and technology presupposes a certain level of scientific and technological progress. As things are, most Muslim countries have hardly attained that level of progress. Many factors ranging from the religious and the political have contributed to the present Muslim lack of progress in science and technology. One of these is the neglect in Muslim education of that dimension of Islamic teachings favorable to scientific and technological progress. The current lack of interest in the ethics of science and technology in Muslim societies is thus understandable. But this lack of interest does not at all reflect the intellectual richness that characterizes the traditional treasury of Islamic ethical wisdom. Students of the *shari'ah* and the ethical dimension of Islamic science and technology when it was at its best are quite aware that Islamic ethical thought remains largely relevant to many of the contemporary ethical issues. There is nothing more glaring than the example of environmental ethics to illustrate the wide discrepancy between Islam's actual teachings and the current index of Muslim environmental awareness. The *Qur'ān* is replete with verses of environmental significance. Traditional Islamic architecture and urban planning has been one of the best Muslim attempts to embody the ideals of Islamic environmentalism as taught by the *Qur'ān*. Yet in the early twenty-first century Muslim countries are plagued with environmental pollution and urban degradation.

A promising Muslim country is Malaysia. It is one of the most advanced Muslim countries in science and technology. While seeking to reap the benefits of modern western science and technology Malaysia has also shown much interest in Islamic values as a contributing factor to scientific and technological progress in the twenty-first century. There is a visible attempt in the country to create a new synthesis of tradition and modernity not only in science and technology but also in other fields of civilization. The Malaysian government has created several institutions with that goal in mind. The most well known is perhaps the Malaysian Institute of Islamic Understanding, which has organized many programs on ethical issues in science and technology. Malaysia is quite advanced in genetic engineering. For a country noted for its Islamic fervor it is rather interesting that Islam does not appear to be a hindrance to the progress of genetic engineering. The new Badawi administration (succeeding that of Mahathir in 2003) has unveiled an agricultural policy that places great emphasis on genetic engineering and biotechnology. Interestingly, Badawi views this agricultural policy as an integral part of his Islam policy now known as civilizational Islam.

The case of Malaysia is important. It is not Arab but predominantly Malay like its neighbor Indonesia, which is the largest Muslim nation on earth. And yet in the early 2000s Malaysia appears to be more vocal than all the Arab states in championing modern Islamic issues. And many Muslims do make a careful distinction between *Islamic* and *Arabic*' while acknowledging the Arabic coloring of Islam by virtue of the Muslim belief that God has revealed the *Qur'ān* in Arabic. Islamic issues as distinct from Arabic are those that concern all Muslims transcending ethnic barriers. The Islamic organization in Kuwait may be led by Arabs but the ethical issues they discuss are Islamic issues of importance to all Muslims. Similarly the Malaysian institute of Islamic understanding is led by Malays who are non-Arabs but its programs on ethics in science and technology have the participation of Muslims from various parts of the world including Arabs.

Muslim attitudes toward modern science and technology are far more positive in the early twenty-first century than in the colonial period when they generally equated modernization with Westernization. From Morocco in the western wing of the Muslim world to Indonesia in its eastern most part colonial attempts at modernization such as in education, agriculture, and business often found stiff resistance from the Muslim populace. Such attitudes became the legacy of post-independence leaders in the Muslim world. But in the last several decades Islam has also emerged as an important source of positive influence on the Muslim thinking on science and technology. Many Muslims now see the possibility of merging the best of modern scientific and technological culture with the best of Islamic intellectual and cultural tradition.

OSMAN BAKAR

SEE ALSO *Christian Perspectives: Historical Traditions; Jewish Perspectives; Scientific Revolution.*

BIBLIOGRAPHY

Anees, M. A. (1989). *Islam and Biological Futures: Ethics, Gender, and Technology.* London: Mansell. One of the few Muslim discussions of biomedical ethical issues in an Islamic context. It gives a good treatment of the implications of advances in biomedical technology for Muslim beliefs and practices including approaches to issues of gender.

Anees, M. A. (1994). "Human Clones and God's Trust: An Islamic View." *New Perspectives Quarterly* 2: 1. A pioneering treatment on the subject of human clones by a Muslim writer. It has also been published as part of a chapter entitled "God and the Clone" in the book *The Human Cloning Debate,* ed. Glenn McGee and Arthur Caplan, Berkeley, CA: Berkeley Hills Books (2004).

Bakar, Osman. (1986). "Islam and Bioethics." *Greek Orthodox Theological Review* 31(2): 157–179. A detailed discussion of the relevance of Islamic law (*shari'ah*) to Muslim understanding of bioethical issues.

Bakar, Osman. (1997). *History and Philosophy of Islamic Science.* Cambridge, UK: Islamic Texts Society. A good introduction to the relations between science and religion according to Islamic perspectives.

Bakar, Osman. (1998). *Classification of Knowledge in Islam.* Cambridge, England: Islamic Texts Society. Perhaps the most comprehensive study of Muslim classifications of the sciences ever taken. It is a useful source of information on the place of science and technology in Muslim intellectual culture in different periods of Islamic history.

Hill, Donald, R. (1996). *Islamic Science and Engineering.* Chicago: Kazi Publications. Provides an insightful account of various branches of medieval Islamic engineering and its contribution to the development of Western technology.

Hill, Donald R, and Ahmed Yusef al-Hasan. (1992). *Islamic Technology: An Illustrated Study.* Lanham, MD: Cambridge University Press. Impressive illustrated study of medieval Islamic technology providing readers with invaluable manuscripts and artifacts illustrations.

King, David. (1995). *Islamic Astronomical Instruments.* London: Variorum Reprints. Collection of papers the author has published in various journals on astronomical instruments originating or widely used in medieval Islam such as the astrolabe, quadrant and sundial.

McClellan, James E., and Harold Dorn. (1999). *Science and Technology in World History: An Introduction*. Baltimore, MD: Johns Hopkins University Press. Good introduction for lay readers and undergraduate students to the history of science and technology in different civilizations in the East and in the West.

Nasr, Seyyed Hossein. (1976). *Islam Science: An Illustrated Study*. London: World of Islam Festival Publishing. The first illustrated study of the whole of Islamic science ever undertaken and thus provides a good companion to *Science and Civilization in Islam* (see below). The book combines an account of the morphology and brief history of the various sciences with illustrations drawn from sources spread throughout the Islamic world.

Nasr, Seyyed Hossein. (1987). *Science and Civilization in Islam*. Cambridge, England: Islamic Texts Society. Excellent overview of the theory and practice of Islamic science. It provides a useful context for understanding Muslim appreciation of science when Islam was at its best.

Sayili, Aydin. (1981). *The Observatory in Islam*. New York: Arno Press. One of the best historical studies of an important scientific institution in Islam, namely the observatory, which initiated a clear inter-dependence between scientific research and technological innovations in the field of astronomy.

ITALIAN PERSPECTIVES

The Italian cultural tradition has historically belittled the cultural, ethical, and social roles of science and technology. This is surprising given that an Italian, Galileo Galilei (1564–1642), was one of the founders of modern science, and that his *Dialogues Concerning Two New Sciences* (1638) praised the cultural role of technology and the philosophical importance of science. In the last half of the twentieth century, Italian appreciation of Galileo's theories increased, especially in relation to ethical discussions of science and technology, along with recognition of the philosophical importance due to technics and scientific thought.

Historical Background

Italian tradition was biased by the circumstances of Galileo's 1633 trial by the Holy Office of the Catholic Church. Despite his defense of science and technology, the trial ended with the Pisan scientist recanting his beliefs and being sentenced to house arrest for life. This condemnation long hindered the free development of scientific research and, together with the Counter-Reformation climate and Italy's difficult economic and political evolution, effectively sidelined the development of science and technology. Even though a few thinkers continued to maintain the importance of scientific knowledge and technological innovation, as a whole Italian intellectual culture became centered around literary, artistic, historical, and political activities.

This attitude was reinforced, in the first half of the twentieth century, by the hegemony of the neo-Hegelian idealism of Benedetto Croce (1866–1952) and Giovanni Gentile (1875–1944), who saw science as possessing no philosophical significance. Croce contended that science produces only *pseudo-concepts* of practical utility. Such concepts were subordinate to truth, which was, in his opinion, the exclusive province of the *sciences of the Spirit* (namely art, literature, philosophy, and history), of which philosophy was the crown jewel. *True* knowledge rises above science, which is irremediably tied to a practical horizon. Giovanni Gentile similarly devalued science, which he saw as oscillating between art and religion, unable to unify the two in a higher synthesis such as that achieved by philosophy. For Gentile, science combined the defects of art, objectivity and universality, with those of religion, subjectivity and rationality, and was thus the fruit of multiple errors and devoid of any autonomous historical development.

This negation of science by Croce and Gentile proved widely influential, both because it was set in a traditionally antiscientific culture and because these two neo-idealists played leading roles in the opposing political movements of liberalism and fascism. Their thinking exerted an almost dictatorial authority and aggravated the general cultural devaluation of science and technology.

Post World War II

Following World War II, the social and economic crisis in Italy contributed to the decline of the theories of Croce and Gentile. A new generation of intellectuals rejected neo-idealism, attacking its ambiguous cultural categories and sterile antinaturalistic, antiscientific polemics. In this climate, a dialog emerged among proponents of various ideologies including neopositivist philosophy, developed in Vienna by Moritz Schlich and Rudolf Carnap, the early ideas of Ludwig Wittgenstein, and the mathematical logic of Bertrand Russell. This led to the formation of a neo-enlightenment movement (Dal Pra and Minazzi 1992), with the participation most notably of Ludovico Geymonat (1908–1991) and Giulio Preti (1911–1972). Geymonat and Preti—through numerous studies, books, translations, and reviews—

critically introduced neopositive issues into Italian thinking, arguing both the cultural value of science and the importance of technology.

Geymonat, beginning with his *Studies for a New Rationalism* (1945), delineated a neo-enlightenment philosophy centered in the philosophy of science, logic, and the history of science and technology, arguing for replacement of *static* with *dynamic* studies of scientific theories. Geymonat became, in 1956, the first Italian to hold a chair in philosophy of science (at the University of Milan) and, in 1974, to win the *Médaille Koyré* for history of science, awarded by the Académie Internationale d'Histoire des Sciences in Paris. He also was mentor to a group of young scholars working in these fields. Geymonat's own work culminated in the publication of the highly regarded, seven-volume *History of Philosophical and Scientific Thought* (1970–1976) and *Science and Realism* (1977). In these works, he developed a materialistic-dialectic perspective and placed the fundamental role of the *scientific-technical legacy* at the heart of critical comprehension of knowledge and of the historical development of society. Preti, in a series of books including *Idealism and Realism* (1943), *The History of Scientific Thought* (1957), and especially *Praxis and Empirism* (1957), related neopositivist themes to both the pragmatism of John Dewey and the philosophy of the young Karl Marx.

Parallel with work conducted by the neo-enlightenment thinkers was that of Valerio Tonini (1901–1992), a Catholic engineer and philosophy of science scholar. After working in the field of engineering for many years, Tonini turned to information theory, epistemology, the sociology of work, and bioethics. A member of the *Académie Internationale de Philosophie des Sciences* (International Academy of Philosophy of Science), in 1950 Tonini founded the *Società Italiana di Logica e di Filosofia della Scienza* (Italian Society of Logic and Philosophy of Science) and, in 1955, started a review of human sciences and philosophy of science called *La Nuova Critica* (The New Critic), which he edited until his death. Tonini also raised important issues regarding the philosophy of technology, to which he devoted a book titled *Structures of Technology* (1968). In the ambit of what was described as his *long march to scientific realism,* Tonini defined technology as the *science of praxis.* He argued that technology implemented processes that modify the environment and, as a *new science,* was capable of achieving semantic precision, synthetic rigor, and verification of its theories. It created a direct link to communication theory, information theory, cybernetics, control theory, process theory, and systems theory.

Contemporary Contributions

In the last quarter of the twentieth century, Italian scholars became particularly interested in science, technology, and ethics. Discussion of biomedical ethics, not only from a Catholic perspective, broadened, with reflections on nuclear weapons and environmental ethics. In 2001, the Council of Genetic Rights was founded in Rome by Mario Capanna.

In the early-twenty-first century, two of Italy's most influential thinkers in the area of science, technology, and ethics are Evandro Agazzi and Luciano Floridi. Agazzi especially has made important contributions to the critical study of these issues. Born in Bergamo in 1934, Agazzi studied philosophy at the Catholic University in Milan, and continued his education, in physics and philosophy, at Marburg, Oxford, and Münster. Agazzi was part of the logical-mathematical team founded by Geymonat in the 1960s. He thereafter became a professor at universities in both Genoa and Fribourg (Switzerland), and published a number of studies on mathematical logic, including *Introduction to Axiomatic Problems* (1961), *Symbolic Logic* (1964), and *Themes and Problems of the Philosophy of Physics* (1969), in which he outlined an original objectivist and realistic epistemological perspective.

Agazzi's positive philosophical revaluation of technology is rooted in the antitheoreticism with which he reacted to the epistemology of the neopositivists and Karl Popper (cf., his philosophical dialogue with Geymonat in *Philosophy, Science, and Truth* [1989]). He developed his own interpretation of the hermeneutic dimension of science, embodied in *Wisdom the Technique* (1986) and most influentially in *Right, Wrong and Science: The Ethical Dimensions of the Techno-Scientific Enterprise* (1992).

The merits of Agazzi's analysis rest with his arguments regarding the ethical dimensions of the scientific-technological undertaking. Agazzi proposed to distinguish between technics (know-how that works without an awareness of its purpose), technology (which he used to denote, by contrast, effective action that has an awareness of its purpose), and science (knowledge capable of explaining empirical facts by adducing reasons that explain *why* reality is configured in a given way). Technology represents the result of the development of science, and Agazzi stresses the subtlety of the interconnections between science, technics, and technology, analyzing the scientific ideology, technological system, and complex encounter between ethics, norms, and values within human action. By defending a dynamic model of knowledge, Agazzi opts for a systemic approach in which the regulation of research is configured as a projection of responsibility. From this perspective, his science and technic studies are closely entwined with those devoted to bioethics, fostering a debate between Catholic and secular thinking that has contributed to the development of a freer and more responsible society.

Luciano Floridi, a professor of philosophy (at the University of Bari in 2004), has done influential work on the relationship between philosophy and computing from an ethical perspective. For Floridi Information Ethics represents the philosophical foundational counterpart of Computer Ethics which is thought as a non-standard, object-oriented and ontocentric theory.

FABIO MINAZZI

SEE ALSO *Axiology; Galilei, Galileo; Pareto, Vilfredo.*

BIBLIOGRAPHY

Agamben, Giorgio. (1998). *Homo Sacer: Sovereign Power and Bare Life*, tr. Daniel Heller-Roazen. Stanford, CA: Stanford University Press. Original Italian publication, 1995.

Agazzi, Evandro. (1961). *Introduzione ai problemi dell'assiomatica* [Introduction to the problem of axiomatics]. Milan: Vita e Pensiero.

Agazzi, Evandro. (1964). *La logica simbolica* [The symbolic logic]. Brescia: La Scuola.

Agazzi, Evandro. (1969). *Temi e problemi di filosofia della fisica* [Themes and problems of the philosophy of physics]. Milan: Manfredi.

Agazzi, Evandro. (1986). *Weisheit im Technischen* [Wisdom in the technique]. Luszern: Verlag Hans Erni-Stiftung.

Agazzi, Evandro. (1992). *Il bene, il male e la scienza* Milan: Rusconi. English Translation: *Right, Wrong and Science: The Ethical Dimension of the Techno-Scientific Enterprise*, ed. Craig Dilworth. Amsterdam and New York: Rodopi (2004).

Agazzi, Evandro, Fabio Minazzi, and Ludovico Geymonat. (1989). *Filosofia, scienza e verità* [Philosophy, science, and truth]. Milan: Rusconi.

Dal Pra, Mario, and Fabio Minazzi. (1992). *Ragione e storia: Mezzo secolo di filosofia italiana* [Reason and history: a half-century of Italian philosophy]. Milan: Rusconi.

Floridi, Luciano. (1999). *Philosophy and Computing. An Introduction*. London, New York: Routledge.

Geymonat, Ludovico. (1970–1976). *Storia del pensiero filosofico e scientifico* [History of philosophical and scientific thought], 7 vols. Milan: Garzanti.

Geymonat, Ludovico. (1977). *Scienza e realismo* [Science and realism]. Milan: Feltrinelli.

Preti, Giulio. (1943). *Idealismo e positivismo* [Idealism and positivism]. Milan: V. Bompiani

Preti, Giulio. (1957). *Storia del pensiero scientifico* [History of scientific thought]. Milan: Mondadori.

Preti, Giulio. (1975). *Praxis ed empirismo* [Praxis and empiricism]. Turin: Einaudi.

Tonini, Valerio. (1968). *Strutture della tecnologia* [Structures of technology]. Rome: Armando Editore.

Tonini, Valerio, and Minazzi, Fabio. (1989). *La realtà della natura e la storia dell'uomo* [The reality of nature and the history of man]. Milan: Franco Angeli.

J

JAPANESE PERSPECTIVES

In the early years of the twenty-first century ethical concerns related to scientific and technological developments are receiving a great deal of attention in Japan. A focus on globalization has resulted in a renewed concern with the impact of traditional values on technology, as well as in the adaptation of some western perspectives on ethical issues. Currently evolving discussions, in areas ranging from bioethics to nuclear power, make an excellent case study of how a society's ethical considerations both arise out of a given historical context and interact with a wider global context.

Japan is an ancient nation of 127 million people (2003) living mostly on four mountainous islands in the Northern Pacific off the coast of Asia. Records of inhabitance date back to the early centuries of the Common Era. After a long history of isolation followed by tentative openings, during the period of the Tokugawa Shogunate (1603–1868), Japan almost totally closed itself off from the outside world and consequently also from the influences of Western scientific and technological developments. It even successfully abolished the production and use of firearms, thus becoming one of the few examples where a more advanced technology, after having been widely utilized, was suppressed for an extended period of time. Toward the end of the Shogunate, however, it became clear that Japan would have to adopt Western technology in order to survive as an independent state, as was made evident in 1853 by the arrival of Commodore Matthew C. Perry in his black ships with their superior firepower, demanding an opening of trade. The subsequent Meiji Restoration of the emperor in 1868 accelerated a period of change in Japan, during which Western science and technology were rapidly integrated into an agrarian social system in flux. The slogan for the process of adoption was *wakon yōsai* or *Japanese soul with Western technology*, indicating an unwillingness to identify modernization with a transformation of the national cultural characteristics.

Historical Evolution of Ethical Issues

An initial movement to bring in experts from throughout the world and send students abroad, while adapting foreign learning to the Japanese cultural context and improving on it, set the pattern for much of the twentieth century. Japan became known as a society that emphasized incremental improvements on revolutionary innovations developed elsewhere. This reflected a societal objective of catching up to European and North American powers in economic and military strength, where the national government assumed the primary leadership role in building up the infrastructure necessary for scientific and technological growth. In this process, Japan became the first country to establish a college of engineering within a university system. As early as the 1870s, the Imperial University (later the University of Tokyo) established a Faculty of Engineering with its own service departments in the sciences. Ever since, the university system has produced many more engineering graduates than ones in the sciences. Under this system relatively less attention was given to basic or pure scientific research; the dominant focus was on applied science and technology for industrial development. As a result, the demarcation between science and technology has not been as evident in Japan as in the Western tradition. Neither has been the close cooperation between corporations and universities typical in the United States.

To understand how the historical evolution of science and engineering is connected to ethics in Japan, it is necessary to gain some insight into Japanese social values, which are influenced both by the general Asian traditions of Buddhism, Daoism, and Confucianism, and by the native Shintō religious perspective. As a unified value system, these social values have resulted in an emphasis on the group over the individual; a focus on family and clan, with priority being given to loyalty and hierarchy; sacredness associated with the elements of nature, and an integrated perspective on body and spirit. In addition, there are still religious connotations associated with the emperor and the land of Japan itself as having divine origins. All of these values, in turn, have influenced Japanese conceptions of ethics, which in general are dominated by relativistic and situational group norms.

During the late-nineteenth and early-twentieth centuries, a large percentage of engineers and scientists came from the samurai class. Thus, as Nitobe Inazo pointed out in his influential *Bushido: The Soul of Japan* (1900), the heritage of science and engineering ethics in Meiji Japan was associated with Japanese ideals of *chivalry*. However, perhaps as a result of Japan's ethnic and linguistic homogeneity, a written code of ethics for engineers and scientists was not introduced until 1938, when the Japan Society of Civil Engineers adopted the first one. This code, based upon its U.S. counterpart, was a pioneering work largely authored by Aoyama Akira (1878–1963), a leading engineer of the time, who had worked on the construction of the Panama Canal and had a well-developed international perspective, reflected in his humanitarian philosophy and his Christian beliefs. As Imperial Japan was hastening toward World War II, however, his work must be considered to have been well ahead of its time.

Ethical Concerns in the Postwar Recovery Period

In the postwar recovery period, during which first priority was given to materialistic goals, Japan experienced a tremendous turmoil in thought as Western idealism and democracy rapidly replaced prewar ultranationalistic values and the associated ethical framework. These were denied in large part because they were identified in the minds of the people with the political stand of Imperial Japan. In particular, the memories of Hiroshima and Nagasaki had a critical impact on how Japanese scientists, especially physicists, viewed their role in society. The Science Council of Japan (SCJ) declared at its first assembly after its establishment in 1949 that the aim of scientific research should be to contribute to the welfare of humankind and to world peace. When the government officially made budgetary arrangements for utilizing nuclear power in 1954, the SCJ demanded that research on and the use of nuclear energy be conducted on the principles of "openness, democracy, and independence." The first Japanese Nobel Laureate, the theoretical physicist Yukawa Hideki (1907–1981), was one of the signatories of the Russell-Einstein Manifesto (1955). After recommending to the government in 1962 and 1976 that it establish the Basic Act on Scientific Research, the SCJ proposed a Charter for Scientific Researchers, reemphasizing basic values such as human welfare, world peace, freedom of scientific research, safety, and internationalism. SCJ efforts to emphasize the social responsibility of scientists were important historically; however, because most members of the organization are senior scholars and researchers, its statements appear to have had limited influence on young scientists and engineers with career ambitions.

Changes in engineering ethics had a similarly limited impact. Modeled after the American system of consulting and professional engineers, and the British system of chartered engineers, the Japanese version of engineering licensing was legally institutionalized in 1957, and the Institution of Professional Engineers, Japan (IPEJ), formed in 1951. IPEJ adopted a code of ethics in 1961. However because of the limited number of licensed engineers (approximately 40,000 since 1958) and the general lack of interest in engineering ethics, this code was not widely promoted. In addition, the concept of *engineering as a profession* is unequivocally absent in Japan, most likely because the development of engineering was dominated by the state and industry, rather than by public forces. The Japanese employment system has also encouraged engineers to develop identities with their company rather than as part of a professional association.

Aside from such attempts to formalize ethical concerns, the postwar period could well be characterized as an *ethical vacuum,* in which traditional values dominated, but without an underlying ethical framework. The situation in bioethics perhaps best illustrates the difference between traditional and Western perspectives. The medical establishment is quite paternalistic in its approach. Informed consent has been recognized, but is not well institutionalized, with physicians sometimes using patients in experimental procedures without their knowledge. Truth-telling and patient autonomy are only slowly being recognized as significant values. Traditionally concealing the truth from patients, and more rarely from their families, has been seen as protecting the health of even dying patients. The assumption has been that physicians are authority figures, so that explanations to patients are not necessary. Only recently, for example, have physicians been held to account for practicing involuntary euthanasia.

On the societal level the impact of Japanese values has also been influential in the medical field. Despite legalization, religious and social norms have prevented any significant use of organ transplants. Conceptions of human nature have resulted in a hesitancy to adopt Western standards of brain death, further inhibiting both transplants and a widespread *death with dignity* movement. At the same time, abortion is commonly practiced in Japan without social stigma, both because the woman and fetus are considered to be one entity and because contraceptive pills are not generally available.

However any assessment of the state of scientific and engineering ethics in Japan must recognize that the society is entering a period of structural change, which has already begun to influence discussion about a variety of ethical issues. During the entire postwar period developments in technology were considered issues of national security and survival. National interests took priority over popular consumer desires. In order to spur economic development, the government took a central role in technological planning activities and in guiding research. Major corporations adopted systems of lifetime employment and seniority-based pay to foster workforce loyalty. Japan quickly became an economic juggernaut based on the total commitment of its workers and on the innovative use of management and production strategies such as quality circles and just-in-time supply procurement.

A New Emphasis on Ethics for the Twenty-First Century

Then came the decade-long recession of the 1990s, resulting in fundamental changes in corporate life and public attitudes. Japanese increasingly accepted the need for more global approaches, a move away from governmental direction, and more attention being given to the public. The impacts of these changes are evident in a variety of new discussions of ethical issues. In the area of bioethics, for example, there is a burgeoning patient rights movement and an increased emphasis on physician accountability.

Many of the cutting edge technological innovations in Japan have come from corporations rather than out of the university system. Consequently any changes in the corporate environment tend to influence discussions of research ethics. For example, notions of intellectual property are undergoing testing. Traditionally researchers received little monetary reward. However as Japan is moving toward more mobility in its professional class, with the weakening of lifetime employment and seniority-based pay, researchers are increasingly seeking a greater ownership stake in their work. University researchers are likewise being granted greater independence with a shift away from government direction of the university system as a whole. University science departments, operating on the chair system, in the past have been awarded a set amount of research funding rather than operating on a competitive grant basis. With change to a more merit based system, it can be expected that research priorities will be different and that increased coordination between university and corporate researchers will be established, in turn resulting in new discussions about ethical issues.

Another area that is undergoing change is concern about the natural environment. Although respect for nature is a dominant factor in the Japanese value system, during the period of economic expansion environmental preservation was considered secondary to economic growth. Since the late-twentieth century, especially after the signing of the Kyoto protocol in Japan, a renewed concern with the environment has been in evidence. Japanese are moving away from an ethics that emphasizes disposal to a recycling culture. There is also increased recognition of the global nature of environmental issues such as the heavy use of wood products in Japan and the lack of suitable disposal opportunities for refuse.

The 1990s was also a decade of awakening for engineering ethics. Various incidents and accidents having to do with engineering practice occurred, including a major sodium leak at the Monju fast-breeder reactor in 1995, the sarin gas attack in the Tokyo subway system that same year (by members of a religious cult who were educated as engineers and scientists), and the disastrous nuclear criticality accident in Tokaimura in 1999. These prompted increased interest in engineering ethics and major engineering societies established codes of ethics one after the other, starting with the Information Processing Society of Japan in 1996. The Japan Society of Civil Engineers revised its code honoring the spirit of Aoyama's contribution in 1999. By 2003 most of the major engineering societies had adopted codes, which in general include fundamental values such as giving first priority to the safety of the public, in common with their North American counterparts.

The process of globalization has had great impact on engineering ethics. In 1999 the Japan Accreditation Board for Engineering Education (JABEE) was established to harmonize engineering education with international standards, to enable participation in mutual recognition of engineering qualifications. This required ethics education as one of its components and set in motion a flurry of activity, ranging from short courses on the subject, to conferences, to modification of engineering curricula to include required courses on engineering ethics. All of this activity is financially well supported by the government, so that large numbers of people are involved in what is essentially a new area of inquiry in Japan. In this work there is a twofold emphasis on application to specific ethical problems and on theoretical philosophical analysis. Given the scientific-technological heritage of Japan, the emphasis in the discussions tends to be broader than it has been in the United States, leaning more toward a science, technology, and society (STS) perspective than one that emphasizes strictly professional responsibilities. This is in part because Japan has an existing tradition of STS studies and lacks a tradition of professional identification. The JABEE accreditation criteria therefore require the study of engineering ethics conceptualized as "understanding of the effects and impact of technology on society and nature, and of engineers' social responsibilities," as opposed to the U.S. standards that emphasize "professional and ethical responsibility" and put these in a separate category from the need to "understand the impact of engineering solutions in a global and societal context."

Given the attention to engineering ethics present in Japan, it can be expected that the discussion will increasingly impact the overall consideration of ethical concerns in Japanese society and its scientific community. The population as a whole appears to be seeking new standards of accountability in many areas of life, including business, government, and universities, and in relation to the environment. These discussions will be influenced by both local traditions and a more global outlook.

HEINZ C. LUEGENBIEHL
JUN FUDANO

SEE ALSO *Buddhist Perspectives; Engineering Ethics.*

BIBLIOGRAPHY

Fudano, Jun; Heinz C. Luegenbiehl; et al. (2004). *Gijyutusha Rinri* [Introduction to engineering ethics]. Tokyo: Society for the Promotion of the University of the Air. Textbook written for the first Japanese television course on engineering ethics, which is offered by the National Broadcasting University. Codes of ethics are given special attention.

Low, Morris Fraser; Shigeru Nakayama; and Hitoshi Yoshioka. (1999). *Science, Technology and Society in Contemporary Japan.* Cambridge and New York: Cambridge University Press. Discusses a variety of technological issues from the perspective of various stakeholders.

Morishima Michio. (1982). *Why Has Japan 'Succeeded'?: Western Technology and the Japanese Ethos.* Cambridge, UK, and New York: Cambridge University Press. Relates the Japanese value system to contemporary emphases in technological development.

Morris-Suzuki, Tessa. (1994). *The Technological Transformation of Japan: From the Seventeenth to the Twenty-First Century.* Cambridge, UK, and New York: Cambridge University Press, 1994. Provides an introduction to the evolution of technology in the Japanese societal context.

Nitobe, Inazo. (1900). *Bushido, the Soul of Japan.* Philadelphia: Leeds and Biddle Company. The major exposition of the code of ethics of the Samurai class. It was the foundation of much of the ethical perspective of scientists and engineers, most of whom came from that class.

JASPERS, KARL

Psychiatrist and philosopher Karl Jaspers (1883–1969), who was born in Oldenburg, Germany on February 23, became one of the most important representatives of existential philosophy. He died in Basel, Switzerland on February 26.

Jaspers developed an existential analysis of technology in two distinct phases. His early conception of technology, which he put forth in *Man in the Modern Age* (1931), revolved around the transformation of human society into a mass, mechanized culture. His initial assessment of this transformation was negative. He wrote of the *demonism of technology,* describing technology as an independent power that had been summoned into existence by human beings but that now has turned against them. According to Jaspers, technology transforms human society into a mass culture, alienating human beings from themselves and from the world around them.

Jaspers considered mass-rule a byproduct of the close interaction between technological development and population growth, which results in a vast number of human beings whose existence becomes utterly dependent on technology. This dependency requires a quite specific social and cultural formation. Besides a mechanization of labor, society needs a smoothly operating bureaucratic organization in order to keep functioning. Society becomes a machine itself, described by Jaspers as *The Apparatus.*

This apparatus of workers, machines, and bureaucracy increasingly determines how human beings carry out their daily lives. It has two different but related effects. First its system of mass production fosters a homogenization of the material environment in which human beings live. No attachment is possible to mass produced objects, which only exist as exemplars of a general form and are primarily present in terms of their functionality. Second the apparatus approaches human beings not as unique individuals, but as fulfillers of functions who are in principle interchangeable. Both effects of the technological transformation of society impede human beings from being present as authentic existences, and from living their lives authentically and in existential proximity to the world around them. From an existential point of view, therefore, technology deprives human beings of their highest possibilities.

After World War II, Jaspers's analysis of technology changed course. Rather than viewing technology as a threat to authentic human existence, in *The Origin and Goal of History* (1949) and *The Atom Bomb and the Future of Man* (1958), Jaspers saw technology as what was *at stake* in it. He concluded that technology is ultimately neutral or no more than a means for human goals, because it is incapable of generating its own goals. This neutrality makes human beings responsible for what they make of technology: Technology requires human guidance.

Jaspers no longer considered demonism to be an intrinsic property of technology, but a result of the fact that humans have handled it as an end in itself, rather than a means for human ends. To overcome this demonism, therefore, humanity needs to ask itself the question of what it wants to do with technology. The task for human beings is to reassert sovereignty over technology.

This sovereignty, according to Jaspers, requires a reversal in thinking in which technological thought, or *intellect* (*Verstand*), is transformed into an existential way of thinking that he calls *reason* (*Vernunft*), and in which individuals are present authentically as themselves. Only this way of thinking will allow humans to experience the situation in which they find themselves as *their* situation, for which they are *responsible*. Reason can turn the contemporary situation into a task, and allow humanity to seek new goals for applying technology.

Jaspers's later perspective allowed him to discern not only a threatening side of technology but also ways in which it opened up new existential possibilities. These include new proximity to reality, by understanding the laws of nature lying behind the functioning of technology; recognition of the beauty of technological constructs; and making use of the possibilities opened up by media and transportation technologies, which allow humans to experience the Earth as one whole for which they can feel responsible.

Karl Jaspers, 1883–1969. The German philosopher wrote important works on psychopathology, systematic philosophy, and historical interpretation. *(David E. Scherman/Getty Images.)*

Jaspers's analysis is important as an existential philosophy of technology. Yet in light of later understandings, his separation of technology and society—with autonomous technology dominating society or a sovereign society guiding technology—has become problematic. An existential analysis of technology should take as a starting point the interrelationship of human existence and technology, and investigate how technologies mediate the ways in which human beings realize their existence, by impeding specific aspects of human existence and creating space for new ones.

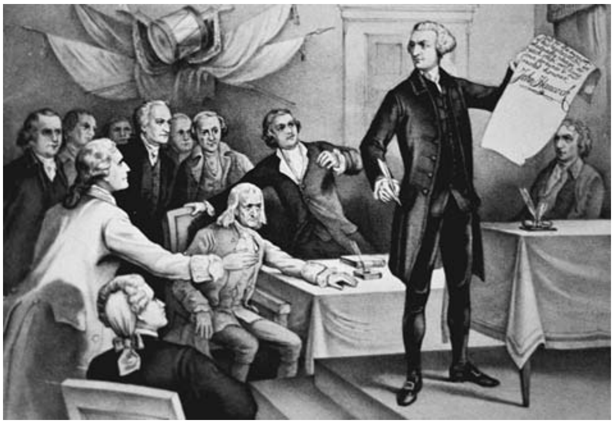
PETER-PAUL VERBEEK

SEE ALSO *Existentialism; German Perspectives.*

BIBLIOGRAPHY

Jaspers, Karl. (1931). *Die geistige Situation der Zeit.* Berlin: Göschen (Band 1000). Published in *English as Man in the Modern Age,* trans. Eden and Cedar Paul. (1973). New York: AMS Press.

Jaspers, Karl. (1932). *Philosophie.* Berlin: Springer (3 volumes). Published in English as *Philosophy,* trans. E. B. Ashton (1969–1971). Chicago: University of Chicago Press (3 volumes).



Thomas Jefferson, 1743–1826. The American philosopher and statesman was the third president of the United States. A man of broad interests and activity, he exerted an immense influence on the political and intellectual life of the new nation. *(The Library of Congress.)*

Jaspers, Karl. (1949). *Vom Ursprung und Ziel der Geschichte*. Zurich: Artemis. Published in English as *The Origin and Goal of History*, trans. Michael Bullock (1953). London: Routledge; New Haven, Conn.: Yale University Press.

Jaspers, Karl. (1958). *Die Atombombe und die Zukunft des Menschen*. Munich: Piper. Published in English as *The Future of Mankind*; also as *The Atom Bomb and the Future of Man*, trans. E. B. Ashton. (1961). Chicago: University of Chicago Press.

Jaspers, Karl. (1994). *Basic Philosophical Writings*, 2nd edition. Atlantic Highlands, NJ: Humanities Press.

JEFFERSON, THOMAS

The early American political philosopher and politician Thomas Jefferson (1743–1826), was born in Albemarle Country, Virginia on April 13. By the time of his death at his home of Monticello just outside Charlottesville, Virginia on July 4, Jefferson considered his three greatest achievements to be writing the Declaration of Independence, writing the Statute of Virginia for Religious Freedom, and founding the University of Virginia. It is nevertheless also the case that Jefferson's views on science, politics, and ethics present a uniquely American perspective on technological progress as flowing from individual liberty, economic freedom, and personal Christian morality.

This "American System" of viewing advances in scientific knowledge as part of political freedom and moral development, remains a distinctive approach to the social issues of economic development, education, crime, religious freedom, and personal happiness. Its confidence in technological and scientific progress tempered by religious and ethical considerations is the basis for American concerns with problems of medical/genetic ethics, environmentalism versus economic development, and private rights versus social responsibility. Its enthusiasm for the free individual and for relatively unrestrained international expansion of these American values has, at times, caused it to be accused of imperialism, hegemony, and disregard for traditional nontechnological and more hierarchical societies (including Islamic, African, and Asian societies) and for socialist economics. Much of contemporary world conflict, such as terrorism, is to some extent an extension of the debate over this "Jeffersonian" worldview of progress, knowledge, religious liberty, democracy, and individual freedom.

Jefferson as Scientist and Inventor

Jefferson's scientific and technological interests were wide ranging. He investigated every branch of science, from botany to biology, meteorology, archaeology, astronomy, chemistry, geology, mathematics, paleontology, and ethnology. He designed the curriculum at the new University of Virginia (1819) to revolve around a core of natural philosophy (science), including physics, engineering, and mineralogy, when most American colleges still focused exclusively on the liberal arts and divinity. He wished to develop as a discipline "the science of the mind" (contemporary psychology), calling it "moral zoology." Throughout his life, Jefferson conducted scientific studies and collected data. He studied new methods for determining the heights of mountains (using mathematical calculations with barometer measurements), tested atmospheric moisture with a hygrometer, and used double-refraction optical instruments to measure small angles, eclipses, lunar movement, and Earth's longitude. Jefferson was a close observer of nature, recording the appearance of many plants, animals, and birds on his Monticello estate and wherever his travels took him. He kept weather data all his life and shared it with other meteorological observers around the country.

Not confining his scientific interests to observation alone, Jefferson invented several useful products. His most famous invention was a new design for a moldboard plow, the simple and efficient design of which drew attention throughout the Association of Agricultural Societies in America and within England's Board of Agriculture. He also invented a swivel chair, a writing desk that could be placed on one's lap, a walking cane that converted to a chair, and a copying machine that duplicated letters as they were being written. He enthusiastically supported other inventions, including the hot-air balloon, dry docks for ships, the submarine, fireproofing for houses, telescopes, the camera obscura, carriage odometers, and personal pedometers. He was an advocate of the decimal system of American currency.

While U.S. minister to France (1785–1789), Jefferson consulted with European scientists on new inventions and the natural environment of the Old World. When he moved to Philadelphia as vice president in 1797, Jefferson brought a box of prehistoric bones for the American Philosophical Society museum. As U.S. President (1801–1809), Jefferson conducted botanical expeditions around the Washington, DC, area and distributed European seeds to the local vegetable markets. In the White House, he displayed scientific instruments, globes, charts, a dry-dock model, a mockingbird, and a grizzly bear (in the garden) brought back by the Lewis and Clark expedition (1803–1806), which he had commissioned. He led discussions on the serious cowpox disease and presented an evening slide show on "The Natural History of French Parrots."

Jefferson's Science Policy

Jefferson's main interest in science was as technology, or for its *usefulness*. The practical benefits to humanity, economic development, and individual happiness were always foremost in his mind. This explains his special devotion to agriculture, because food production was, for him, the basis of all other social wealth. For the same reason, he believed in the free sharing of scientific knowledge: that it would enhance the prosperity of all people in the world. He gave every new discovery to his neighbors without charge, showing that such shared knowledge "is the great parent of science and of virtue; . . . a nation will be great in both, always in proportion as it is free" (Letter to Joseph Willard, March 14, 1789). Therefore, the advance of science and technology, for Jefferson, necessitated economic freedom (capitalism, free markets) and intellectual freedom (freedom of speech, press, and academic inquiry), including religious freedom. Thus, political democracy is integral to technological advances.

Jefferson's intellectual attitudes and scientific interests sometimes earned him ridicule, especially from his political opponents (who caricatured them as "philosophical fogs"). But his own international reputation for scientific inquiry raised the prestige of American science throughout the world. Jefferson was elected to the Institut de France, the Dutch Royal Institute of Sciences, the Board of Agriculture in England, the Agronomic Society of Bavaria, and the Linnaean Society of Paris. His comparative study of European and North American animals refuted the French naturalist Buffon's claim of New World degeneracy (proving, for example, that North American otters weigh more than their European counterparts).

The cosmological foundations of Jefferson's scientific ethics may be described as "deistic science." That is, he believed (after Aristotle, Thomas Aquinas, Isaac Newton, and John Locke) that a divinity created the universe, rather than that the world emerged out of itself randomly. "[I]t is impossible for the human mind," Jefferson wrote, "not to perceive and feel a conviction of design, consummate skill, and infinite power in every atom . . . up to an ultimate cause, a Fabricator of all things from matter and motion, their Preserver and Regulator . . . an eternal pre-existence of a Creator" (Letter to John Adams, April 11, 1823). Such Creationist ethics for Jefferson implied that all of nature, including humankind, exists within God's laws. This commends, for him, a humble, reverent appreciation of the universe and shows the limits of human knowledge. Such divine, moral limitations serve as checks on scientific presumption and hubris, or human pride. Ethical concerns regarding genetic engineering, embryonic research, euthanasia, and nuclear power in the early twenty-first century reflect such Jeffersonian ethical sensibilities.

Jefferson's ethical philosophy reflected his scientific empiricism by placing values in a human "moral sense" (akin to other physical senses such as sight and hearing). Though of divine origin, this moral sense provides for Jefferson a biological basis for ethics, or knowledge of good and evil, justice and injustice. As with Aristotle's teleological ethics, however, this human capacity is innate but undeveloped. Society must educate and refine this ethical faculty, especially through religion, politics, and law. "I consider ethics, as well as religion, as supplements to law in the government of man," Jefferson wrote (Letter to Judge Augustus B. Woodward, March 24, 1824). The highest ethics for him was "the ethics of Jesus," or what he called "the most sublime and benevolent code of morals which has ever been offered to man" (Letter to John Adams, October 12, 1813). This consisted of a simple Christian ethics, such as that presented in Jesus' Sermon on the Mount. But the best means of learning these ethics, for Jefferson, was freedom of religion—the liberty of every individual to investigate, proclaim, and believe religious truth, and the freedom to change religious faiths on the basis of personal conscience. Jefferson believed that such religious freedom, like freedom of intellectual inquiry, economic activity, and scientific advancement, would produce the most prosperous, happy people.

GARRETT WARD SHELDON

SEE ALSO *Agrarianism; Democracy.*

BIBLIOGRAPHY

Bedini, Silvio A. (1990). *Thomas Jefferson: Statesman of Science*. New York: Macmillan.

Bedini, Silvio A. (2002). *Jefferson and Science*. Charlottesville, VA: Thomas Jefferson Foundation.

Sheldon, Garrett Ward. (1993). *The Political Philosopy of Thomas Jefferson*. Baltimore: Johns Hopkins University Press.

JEWISH PERSPECTIVES

Judaism is the most ancient of three Abrahamic religions (the other two being Christianity and Islam) that are distinct from other world religions in at least three respects: they are all strongly monotheistic; they claim divine or supernatural intervention (revelation) into the world through their historical founders in ways that are in tension with natural reason; and they place special authority on one or more written texts. Judaism (like Christianity) also has a close historical relation with modern science and technology; historians of science have argued that in its origins science was dependent on a view of the world as well ordered and subject to human investigation and control precisely in the ways presented by the Jewish revelation, and certainly Jewish scientists especially are disproportionately represented in the technical community. At the same time, science and technology have presented specific challenges to Jewish tradition and identity, the responses to which offer special contributions to more general discussions of science, technology, and ethics.

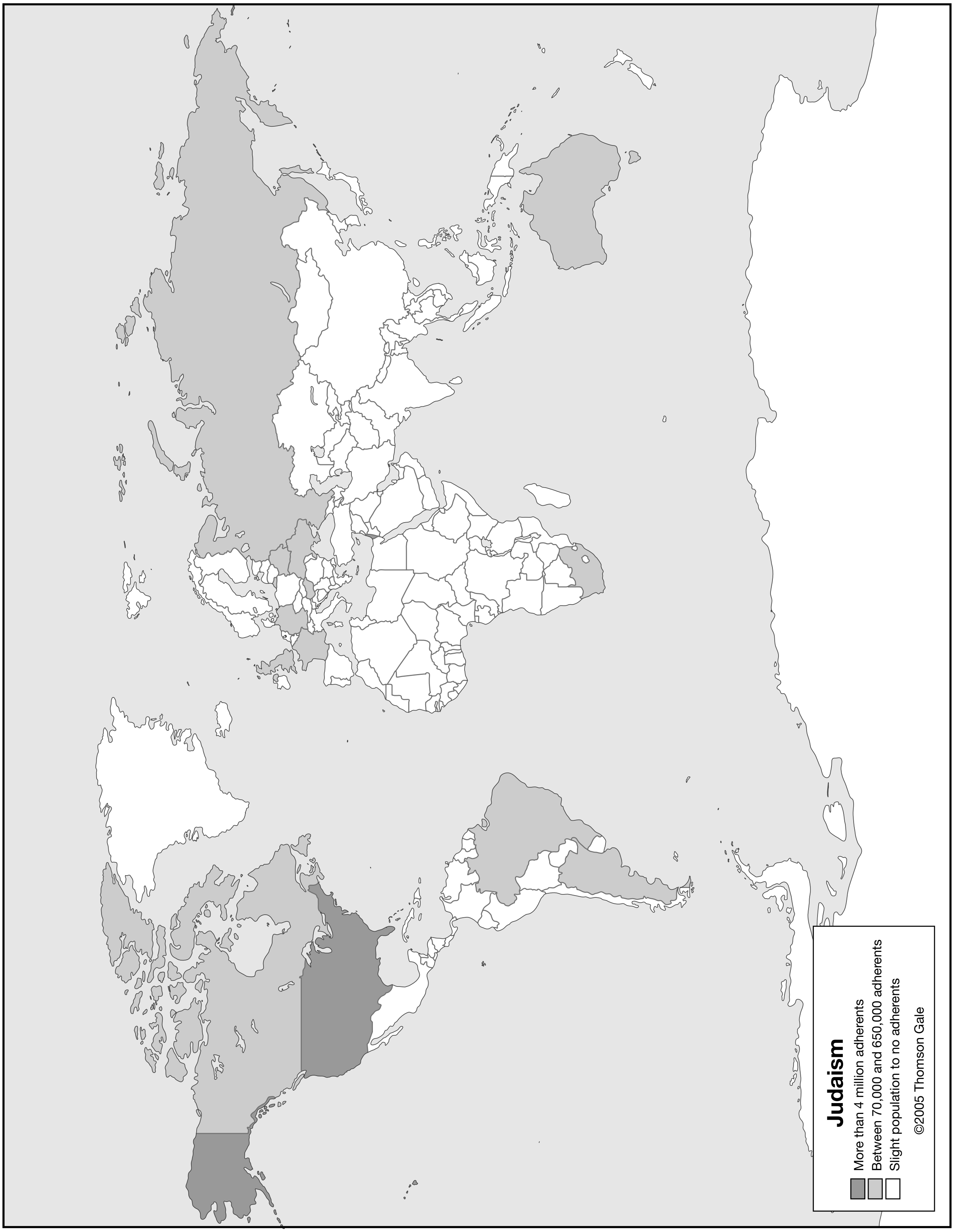
Approaches to Judaism

Individuals explain their adoption of a Jewish designation by their adherence in various degrees to one or more facets of the "Jewish way of life." Among the most important aspects are the beliefs that there is only one God; that the first five books of the Hebrew Scriptures (known as the Torah, containing 613 commandments and canonized between 700 and 200 B.C.E.) were handed down from God to Moses around 1500 B.C.E.; and that Jews should follow both the oral and written laws that have been handed down through the generations. These laws, which number in the thousands and whose varied selection or adoption accounts for the varieties of Judaism, are found in a number of tracts:

- The Mishnah (the oral law handed down from Moses and put into writing in six volumes about 1800 years ago).
- The Gemara, comprising commentaries on the Mishnah and other aspects of Jewish life and stories, found as part of the Talmud.
- The Talmud (of which there are at least two versions: Babylonian, with about 2.5 million words, and Jerusalem, about one-eighth the size), which is a commentary on the Mishnah and Gemara; it was compiled and redacted (canonized) between 300 and 500 C.E.
- The Midrash (also considered a part of the Talmud), a commentary on the first five books of the Old Testament.
- The Kabala, a book that emphasizes the mystical relationships between humans, God, heaven and its inhabitants, and hell with its entourage.
- The remaining thirty-four books of the English Old Testament, referred to as the Prophets and the Writings.
- The Apocrypha, which contains the books that were left out of the Bible when the latter was canonized to include additional sections on the prophets and writings (a process that began with Ezra in 530 B.C.E. and continued until the fall of the second temple in 70 C.E.).
- The Shulchan Auruch, a summary of the laws drawn up in the sixteenth century.
- The Haggadah, a story of the Exodus of the Jews from Egypt in about 1450 B.C.E., whose formulation began in pre-temple times (1000 B.C.E.); put into its conventional form in the thirteenth century but still provides the basis of numerous modern variants.

In addition to belief in the holiness of the above writings and the requirement to follow all or a selection of the laws, Jews may also define themselves in relation to:

- their descent from other Jews (in particular a Jewish mother, although in biblical times it is clear that patrilineal descent also pertained);
- their conversion;


Judaism
More than 4 million adherents
Between 70,000 and 650,000 adherents
Slight population to no adherents
©2005 Thomson Gale

- Jewish traditions such as those that pertain at rites of passage such as birth (plus penile circumcision in the event of a male child), confirmation as in a bar mitzvah for boys at thirteen and recently bat mitzvah for girls at twelve or thirteen, marriage, and death;
- the annual calendar of religious events such as the New Year (Rosh Hashanah), Day of Atonement (Yom Kippur), Passover (Pesach), Festival of Lots (Purim), Festival of the Lights (Chanukah), and others;
- culture defined in terms of types of food, cooking methods, respect for learning and education, charity, style of clothing, and modesty;
- the acceptance of the rulings of a court of Rabbis referred to as a Beth Din;
- the need to have at least ten men (a minyan—and recently, may count women) in order to have a fully competent prayer meeting;
- the State of Israel, which is the country in the world where a persecuted Jew may seek succor without further fear of the pogroms or selective legislation that has been a characteristic of the history of most other countries;
- or a membership in an internationally dispersed community that has a common history or treatment in the hands of a variety of host communities.

In structural terms, a Jew who seeks to follow the laws may refer to the literature cited above or consult a rabbi. There is an extensive correspondence extant that consists of individuals or communities asking for guidance from the most eminent rabbis of the day. The *responsa* that result constitute the norm for the behavior of the respondent. This worked well for ghettoized communities living in relatively static circumstances, but history since the mid-eighteenth century has been anything but static.

On the basis of which tenets an individual Jew adopts, he or she will associate (or not) with one or more of the recognized religious groups. These range from the ultra-orthodox (themselves divided into sects such as the Lubavich, Satmars, Aish, Chasidim, and Chaderim) who reject the opportunities of the modern world and generally do not permit their children to view television (although they may make use of the Internet for Midrashic discussions, with Web sites such as http://www.vbm-torah.org), to the Liberal Progressives with whom virtually anything goes. In between there are the Orthodox, Masorti, Conservative, Reform, and Liberal groupings.

Science, Technology, and Judaism

The European Enlightenment of the seventeenth and eighteenth centuries sowed the seeds of the modern world in which science and technology have changed both the way people think and the way they live. Beginning with the works of Francis Bacon (1561–1626), René Descartes (1596–1650), Isaac Newton (1642–1727), and others, the Enlightenment challenged the Jewish community as it did other religious groups. Those who were in occupations that brought them into contact with prominent business people, politicians, or royalty rapidly learned the language of the host country and became both educated and secular to differing degrees. In the late 1700s and early 1800s, Jews in Germany, Poland, Russia, Holland, France, and Austria set up schools where the medium of education was the national language and where Yiddish (or Jewish German) was in some cases outlawed for education and business transactions. At this time science was beginning to make a showing in these curricula, especially at the secondary level. As time advanced, science began to provide secular explanations of the biblical miracles, of the creation of the universe, of the creation of life, and of the creation and nature of humans and their relationships to the rest of the living world. Not only did science provide challenges to the intellect and belief system, but technology and engineering offered new ways of working, of traveling, of writing, and of doing business. How did Judaism and the Jews respond to these changes?

In the contemporary world, the Jewish people live either in Israel or outside Israel in the so-called Diaspora. In the early twenty-first century in Israel about one third of the Israelis are secular, another third are religious and follow the dictates of the laws with varying degrees of observance, while a middle third would acknowledge a belief in God and do not follow many of the laws in their day-to-day lives, but observe them during rites of passage or special occasions such as the reading of the Haggadah at Passover. Nevertheless, the secular government of Israel does not generally legislate on matters of a religious nature. While the government allows Jews a right of return to Israel, it has not so far made a legal definition of who is a Jew. The government does, however, require a religious marriage for official dealings; nevertheless, foreign civil marriages are recognized. Local authorities, however, may choose to operate transport systems on the Sabbath or may ban them as being contrary to religious laws that forbid travel on the Sabbath. Similarly, erotically suggestive advertisements may be banned by some localities while accepted in others. Work on the Sabbath is generally banned nationally, although particular industries may obtain special dispensations from the government. Those industries that are essential to the economy such as defense, food, and health care find it easy to obtain licenses to operate, as do industries that rely on continuous processes, an interruption to which will disrupt production with considerable economic loss.

The introduction of new technology has presented religiously disposed Israelis and Diaspora Jews with many concerns. This is because the laws as defined by that body of literature that is accepted as the Halakhah expressly forbid many of the applications that are made possible by contemporary machines and devices. There are four main areas where such concerns are expressed. The first relates to the observance of the laws pertaining to work on the Sabbath. A second concerns determinations as to whether certain food preparations are in compliance with the religious laws of kashruth—that is whether they are, or are not, *kosher*. This latter term derives from the biblical laws of what foods are allowable (Lev. 11:2–47); for example, it is allowable to eat meat from cloven hoofed animals that chew the cud but not shellfish, a calf may not be cooked in its mother's milk, and creatures that crawl on their bellies are forbidden. A third set of issues relate to health care and medicine. Finally, a fourth area of concern focuses on changes occurring in agriculture.

The fourth commandment requires Jews to keep the Sabbath holy and to do no work on that day. But what is work? This is often held to be activities of a constructive nature such as preparing food, making a tool or object, giving professional advice, teaching (but learning is acceptable), and doing anything that creates fire, such as making a spark whenever an electrical contact is made. Similar laws apply on holy days.

These prohibitions are managed in a number of ways. First, one may appeal to an overriding statement by God in the Torah (*Deut.* 30:19): *Therefore choose life* . . .''; if work is effected in an effort to save life, it would be acceptable. Secondly, it is possible to employ a non-Jew to do the constructive work on the Sabbath, such as to make the fire, heat food, or run a factory. A third option is to use an automatic device such as an electrical timer switch. A battery of these switches may be programmed and used to effect the daily routine jobs that require electrical equipment (heating, lighting, cooking, communicating, elevators, and alarms). It is moot as to whether a modern computer can be used as part of this automation process or whether its use is proscribed because it is an instrument of writing.

To engage in more detail with those issues where a technological fix can obviate a religious prohibition, the Institute for Science and Halakhah was founded in Jerusalem. This body seeks to use sensor systems, robotics, computers, and information devices to loop around the traditional laws and accomplish ends that would otherwise have been forbidden. Its work is proving so successful that this independently-funded body has been adopted as an element of the national government.

Whether or not food is kosher is defined by the rabbis of the local jurisdiction or on appeal to a more respected rabbi with international stature. Clearly, because food is now purchased as pre-prepared items or is made as a composition in tins, it is difficult to know whether or not such material is kosher. While many food producers act under the supervision of the rabbinate, it is possible to produce kosher foods outside this restriction. A food ingredients list is helpful, but it does not specify the way the ingredients are produced in sufficient detail to satisfy a rabbi that non-kosher material was not been prepared with the same equipment and the washing process was effected with sufficient (and often excessive) thoroughness that it could be used for kosher manufacture.

In addition to pig insulin, pig heart valves are generally deemed acceptable for transplantation into observant Jews. As and when pigs are reared that are immunologically compatible with human immune systems, the transplantation of pig hearts, livers, lungs, kidneys, and other organs might also be deemed acceptable by the orthodox Jew.

However, there are medical issues in the area of abortion and *in vitro* fertilization that exercise the minds of those seeking ethical acceptance from a Judaic standpoint. Facing infertility, an orthodox Jewish couple could receive a dispensation from a rabbi for *in vitro* fertilization, even if this means creating extra embryos that are eventually killed. Abortion, however is generally forbidden unless the health of the mother is threatened. There are other issues that raise concern, such as blood transfusion: many religious people believe that a person's life is in the blood, and to accept another person's life (albeit in part) is not allowable (*Lev.* 17:13–15).

The relevant agricultural restriction is that it is forbidden to plant two different kinds of seed in the same field. From this standpoint, genetically manipulated seeds do not present a problem nor do trees that are grafted because the stock and the plant are of the same type. However, the production of hybrid plants that derive from clearly different stocks does cause difficulty and some religious kibbutzim (Israeli agricultural settlements) do not permit themselves the advantages that hybrid vigor provides.

Where science challenges religion most is in those areas that have to do with origins and miracles. Judaism seems to be able to ride the resulting intellectual issues with aplomb. It takes evolution in its stride by asserting that Darwin's ideas are but hypotheses; they have not been, nor can they be, proven. The account of creation in the Torah, however, is a truth as it was given to Moses by God and this constitutes the "gold standard" of knowledge. A mere hypothesis cannot seriously challenge such a truth. The miracles may be treated similarly. There may well be scientific explanations for some of the miracles. For example, the turning of the river Nile into blood by Moses may be explained by the emergence of a bloom of a euglenoid alga that has lost its chlorophyll and appears red by virtue of its red carotenoids. It yet remains possible that God performed the event to provide Pharaoh with evidence of his powers to effect miracles.

When it comes to metaphysical considerations such as the nature and origin of matter, Judaism relies on a belief in an all-powerful God who created all things. Theories of the big bang still leave dangling the origin of the matter that made the "bang" possible, or the process whereby all the matter in the universe was made in an unimaginably short time. The possibility of God creating other universes is not considered, although there is no reason to uphold the claim that humans (and maybe others) inhabit the only universe. Since the beginning of the twentieth century, humans have come close to understanding how an abiotic (lifeless) world some four billion years ago gave rise to a molecule that evidenced the properties of life. The story of the evolution of this notional entity to humans, is also well thought out. Nevertheless, those who profess a strict adherence to the literature and the codes of Judaism will not brook such thinkings because they adhere to the letters and words of Genesis.

R.E. SPIER

SEE ALSO *Arendt, Hannah; Holocaust; Virtue Ethics.*

BIBLIOGRAPHY

Ausubel, Nathan. (1964). *The Book of Jewish Knowledge.* New York: Crown Publishers.

Rohl, David M. (2002). *The Lost Testament: From Eden to Exile: The Five-Thousand Year History of the People of the Bible.* London: Century; New York: Random House.

Wigoder, Geoffrey, et al, ed. (1997). *Encyclopedia Judaica,* CD-ROM edition. Jerusalem: Keter Publishing House

INTERNET RESOURCES

Bible Gateway. Available at http://www.biblegateway.com. Contains fourteen searchable versions of the Bible.

Internet Sacred Text Archive. Available at http://www.sacred-texts.com/jud/. Contains an English translation of the Babylonian Talmud and other texts as referred to in the article.

The Jewish Chronicle. Available at http://www.thejc.com. Weekly UK newspaper available internationally and on the Internet.

JONAS, HANS

The intellectual heritage of Hans Jonas (1903–1993) spans and reflects the twentieth century. Born in Mönchengladbach, Germany, on October 4, he died in New Rochelle, New York, on February 5, having become one of the most important contributors to philosophical reflection on science, technology, and ethics. For more than half a century, Jonas worked consistently to develop a persuasive alternative to modern nihilism in its diverse existentialist, positivist, scientific, and technological manifestations.

Life and Works

In Germany Jonas studied with the major figures of philosophy such as Edmund Husserl (1859–1938), Martin Heidegger (1889–1976), and the Protestant theologian Rudolf Bultmann (1884–1976). His doctoral dissertation adapted Heidegger's Dasein analysis from *Time and Being* (1927) to demythologize Gnostic texts from the early centuries of the Common Era, revealing the extreme dualism and world estrangement of this ancient religious literature. Increasingly aware of the social estrangement of Jews in Europe (his mother would be murdered in Auschwitz), Jonas joined the Zionist movement and, as the Nazi's came to power, left Germany for Palestine. During World War II he joined the Jewish Brigade of the British forces in Italy as an artillery soldier; in 1948 he fought in the Israeli War of Independence.

During this period Jonas also began to reflect on the philosophical problems of modern science, especially biology, distancing himself from Heidegger and Gnosticism by noting the parallels between the inimical cosmos of Gnostic belief and the conception of an indifferent nature found in science. In 1949 he left Israel for Canada, and after a few years moved to New York, where he taught at the New School for Social Research until his retirement. From the 1960s on, Jonas made a number of visits to Germany and as a result published frequently in the German language. He became influential in the land of his birth, especially in the Green movement. He received European recognition for his work, beginning with the *Friedenspreis,* the peace prize awarded by the German Book Trade, in 1987.

Jonas first major book was *The Phenomenon of Life* (1966), his initial foray into a phenomenological interpretation of biology that might disclose the metaphysical significance of organic phenomena. *Philosophical Essays: From Ancient Creed to Technological Man* (1974) contains his first essays on the ethics of technology. His single most important book, *The Imperative of Responsibility: In Search of an Ethics for the Technological Age* (1979), brings together these two lines in an attempt to ground his ethics of technology in a philosophy of nature. Over the last two decades of his life, Jonas sought to extend the practical applications of his thinking while deepening its cosmological and theological foundations in such works as *Technik, Medizin und Ethik* (Technology, medicine, and ethic) (1985) and *Mortality and Morality* (1996). *Errinnerungen* (Recollections) (2003) is a collection of autobiographical interviews.

Hans Jonas, 1903–1993. The German-born philosopher is best known for his influential work, *The Imperative of Responsibility*. His work centers on social and ethical problems created by technology. (*© Bettmann/Corbis.*)

Responsibility for Integrity and Sustainability

In his central work, *The Imperative of Responsibility,* Jonas spells out the need for an early formulation of the precautionary principle that he calls the *heuristics of fear,* which gives "prevalence to the bad over the good prognosis" in case of unforeseeable and irreversible technological risks to the future of humankind (Jonas 1984, p. 31). For Jonas, such a procedure is justified by the ontological idea of humanity as that being which is able to bear responsibility. Because of this capacity, Jonas argues that humans have an unlimited responsibility to preserve life on Earth, in which they, as those who bear responsibility, may be primary, but which encompasses all of nature. This responsibility is total, continuous, and future oriented. Parental responsibility for children is archetypical, although in this case there is a terminus: Children grow up and become adult bearers of responsibility themselves. But with regard to nature, responsibility does not cease. The imperative of that responsibility associated with technology is to pass on responsibility, or more generally, to safeguard conditions for the continual existence of responsibility on Earth. Indeed, for Jonas, "The presence of [human beings] in the world is demanded to ensure the very premise of responsibility—the existence of mere candidates for a moral order" (Jonas 1984, p. 10).

Until the modern period, responsibility for the integrity of life on Earth was not a human imperative, because nature took adequate care of itself. But the human relation to nature has decisively changed. Human responsibility is disclosed in its new intensity by the vulnerability of nature to human destruction and to the potential mutilation of the human genetic heritage by long-range effects of modern science and technology. The world now needs human care to a degree previously unexperienced in the history of humankind. This theory holds insofar as one accepts Jonas's argument that a striving, teleological nature, revealed in the attempts at self-preservation among even the most primitive forms of organic life, constitutes an objective affirmation of good that is infinitely superior to a cold and indifferent universe.

Criticisms

Four main criticisms have been leveled against Jonas's ethics of technological responsibility. A first is that his responsibility is too general or formal. Who is responsible for what? Jonas maintains that humanity ought to exist. But Richard Bernstein (1995) replies that even if one accepts the general goodness of organic nature as a whole, no obligation to exist follows for humanity, nor does obligatory human existence imply any specific moral guidance for medical or environmental practices.

But the imperative of responsibility is not meant to be part of a deductive system. Instead the heuristics of fear and criticism of utopianism offer more practical counsel. According to Jonas, utopianism is a form of idolatry that the heuristics of fear counters by pointing out how in the technological pursuit of utopian goals the integrity of natural species or even of human existence may itself be at stake. Categorical responsibility functions as the overriding argument for preservation.

A second criticism asks whether Jonas's ethics is compatible with democracy and personal autonomy. Jonas has little faith that democratic politics works beyond short-term interests. Eventually a noble tyrant might have to avert the apocalypse. There is a parallel in medical ethics in which Jonas treats the requirement of informed consent as a problem instead of a solution. In both cases, Jonas seems to hold the view that fallible autonomous subjects need to be protected from themselves.

This reflects the asymmetry of the concept of responsibility. For Jonas, morality is not based on a social contract made up by self-reliant individuals, but originates with the call for protection from vulnerable beings. Human beings have to work to ensure the welfare of future generations because those generations cannot do it for themselves. In medical experiments, the sick should be the last to be recruited as subjects because they are the most vulnerable and dependent. Nevertheless the implied paternalism, though restricted to negative injunctions (*Do not* or *Refrain from doing*) represents an unpopular and therefore important perspective.

Third is whether the restoration of a metaphysical ethics is necessary to answer questions posed by modern technology. Karl Otto Apel (1994) strongly rejects Jonas's metaphysical principle of responsibility as incompatible with justice. The survival of humanity might entail the starvation of many people in developing countries, which Apel refers to as a social Darwinist solution.

But as in the case of democracy and autonomy, Jonas is well aware of the dilemma. Moreover he does not dismiss the demands of justice but relates their obligating force to the still higher duty of sustainability. Whereas Apel argues that there is no meaning in survival without justice, Jonas replies that there is no meaning in justice without survival. According to Jonas, sustainability is finally a metaphysical issue. Prevailing attempts in the ethics of technology based on nonmetaphysical, symmetrical rationality seem unable to enter substantive discussion on topics involving individual liberties. Therefore it becomes impossible to put a hold on the insatiable demands of the modern individual for justice, safety, health, and welfare. Jonas meets this vacuum with his *first rule:* that no future condition should be accepted that would affect the integrity of humanity.

Finally the boldest aspect of Jonas's ethical theory, involving the move from *is* to *ought*, is his claim that living nature objectively appeals to human responsibility to heed its integrity. Lawrence Vogel, however, criticizes such *cosmic deontology* as unnecessary in his 1996 introduction to Jonas's *Mortality and Morality*. Jonas clearly aims to replace Kantian deontology with an equally categorical imperative in which nature serves as a good in itself. If this were not the case, human obligation might be illusory. But perhaps it is not cosmology that teaches people to be responsible for living nature and the future. Maybe the reverse is the case: A basically self-evident responsibility teaches respect for a cosmos that brought forth life in its manifold of species and in its depth of subjective intensity. Yet while others argue for an ethics rooted solely in the social world, Jonas deliberately invokes an argument that overarches both the social and the natural domains. When considerations of the limits of progress lead to discussions of the limits of the human condition, people have to proceed from ethics to metaphysics in a new attempt to answer eternal questions regarding poverty, illness, and evil, in both natural and human forms.

TON VAN DER VALK

SEE ALSO *Deontology; Freedom; Future Generations; German Persepctives.*

BIBLIOGRAPHY

Apel, Karl Otto. (1994). "Die ökologische Krise als Herausforderung für die Diskursethik" [The ecological crisis as a challenge to discourse ethics]. In *Ethik für die Zukunft: Im Diskurs mit Hans Jonas*, ed. Dietrich Böhler. Munich: Beck.

Bernstein, Richard. (1995). "Rethinking Responsibility." In *The Legacy of Hans Jonas*, ed. Strachan Donnelley. *Hastings Center Report* 25(7). A special issue of the journal.

Jonas, Hans. (1963). *The Gnostic Religion: The Message of the Alien God and the Beginnings of Christianity*. Boston: Beacon Press. A translation of Jonas's doctoral dissertation from 1934.

Jonas, Hans. (1966). *The Phenomenon of Life: Toward a Philosophical Biology*. New York: Dell.

Jonas, Hans. (1974). *Philosophical Essays: From Ancient Creed to Technological Man*. Englewood Cliffs, NJ: Prentice Hall.

Jonas, Hans. (1984). *The Imperative of Responsibility: In Search of an Ethics for the Technological Age*. Chicago: University of Chicago Press. Unites two volumes first published in German: *Das Prinzip Verantwortung* [The imperative of responsibility] (1979) and *Macht oder Ohnmacht der Subjektivität* [Power or importance of subjectivity] (1981).

Jonas, Hans. (1985). *Technik, Medizin und Ethik: Zur Praxis des Prinzips Verantwortung* [Technology, medicine, and ethic: On the practice of the principle of responsibility]. Frankfurt: Suhrkamp.

Jonas, Hans. (1992). *Philosophische Untersuchungen und metaphysische Vermutungen* [Philosophical investigations and metaphysical suppositions]. Frankfurt: Insel.

Jonas, Hans. (1996). *Mortality and Morality: A Search for the Good after Auschwitz,* ed. Lawrence Vogel. Evanston, IL: Northwestern University Press.

Jonas, Hans. (2003). *Erinnerungen* [Recollections], ed. Christian Wiese. Frankfurt: Insel.

Levy, David J. (2002). *Hans Jonas: The Integrity of Thinking*. Columbia: University of Missouri Press.

JOURNALISM ETHICS

Journalism is the profession of writing, editing, and publishing high-frequency periodicals that aim to report and comment on events of public interest, commonly called *news*, with its frontline practitioners those who gather the data—reporters, photographers, videographers—and those who approve the data and prepare the collection of text and visuals for presentation—editors and producers. The unique role-related responsibility of journalists, which includes all of these practitioners, in democracy is to communicate to citizens information needed for self-governance. Self-governance includes the most mundane of decisions, such as what weather to prepare for when driving to work, and the most complex of choices, such as voting on referendums or candidates for public office.

As a profession journalism is dependent on certain ethical standards to maintain the credibility needed to perform its role-related responsibilities. The professional acts of discovering, reporting, and disseminating the news is dependent on various technologies. Thus insofar as both changes in science and technology alter the practice of journalism and journalists report on scientific and technological news, journalism ethics is of relevance to science, technology, and ethics, and vice versa.

Origins and Ethics

Journalism has emerged parallel with the development of technologies for the rapid, mass dissemination of written texts and broadcast messages. Although anticipations can be found in serial official announcements such as the *Acta diurnal* (Daily proceedings) of the Roman Empire or the *Tching-pao* (Palace news) of the Chinese T'ang dynasty, the first modern news sheets appeared in Germany in the 1450s, where Johann Guttenberg invented the printing press. The first true newspaper was probably the *Gazette de France*, which began publication in Paris in 1631. Since then both Germany and France have maintained strong journalistic traditions, which after World War II exhibited special expertise in reporting on science and technology in relation to, for instance, nuclear weapons and environmental issues. Indeed one can argue that the strength of the environmental movement in Europe rests in part on such reporting.

The early 1700s is sometimes described as the golden age of English journalism, with what are now classified as more literary journalist-publishers such as Joseph Addison (1672–1719) and Richard Steele (1672–1729), among others, developing the occasional general interest essay in the *Spectator* and the *Tatler*. Such essays are no doubt ancestors of the personal columns and op-ed perspective pieces of the present. In another development, when the London *Times,* founded initially in 1785 as the *Daily Universal Register*, published dispatches from correspondents at the front during the Napoleonic Wars (1793–1815), it was the first time the public was able to read about the results of military battles from other than government sources.

In the United States the rise of the journalism profession is strongly associated with the writing and publishing of early patriots such as James Franklin's *New England Courant* and his younger brother Benjamin Franklin's *Pennsylvania Gazette*. In part because of the contributions of the press to successful revolutionary politics, the first amendment of the U.S. Constitution (1791) guaranteed freedom of the press to a historically unprecedented degree. The development of this freedom during the mid-1800s drew on new technologies to create a pluralistic, mass circulation *penny press,* which in the late-1800s began to be consolidated into a set of newspaper chains that themselves drew on new means of communication such as the telegraph. These major newspapers subsequently separated themselves into the high-standards press (*New York Times*, *Washington Post*, among others) and more popular publications that practiced what was criticized as *yellow journalism*.

Reaction to the distortion and sensationalism of yellow journalism, with its power to influence events through muckraking exposes and jingoistic politics, led to efforts to professionalize the field. In 1892 Joseph Pulitzer proposed the creation of a school of journalism at Columbia University (which did not happen, however, until twenty years later). At virtually the same time, in 1909, reporters themselves established their first professional association (the Sigma Delta Chi fraternity, which in 1988 changed its name to the Society of Professional Journalists). It was in these two contexts that ethics began a process of explicit development, with the first code of ethics for professional journalism written by members of Sigma Delta Chi in 1926. Two organizations focused on science writing emerged at about the same time. The American Medical Writers Association traces its origins to 1924, with the development of its own code of ethics in 1976. The National Association of Science Writers was formed in 1934 to promote the dissemination of accurate information regarding science.

Following from the interdependence of technical and professional growth, wire services contributed to the development of common journalistic standards. Wire services, which sent a single story or photograph to multiple outlets via telegraph, then telephone lines, then satellite, both reflected and influenced subscriber news organization standards. The service had to meet the professional demands of its subscribers, but it also served as a model for local news organizations.

Journalism ethics at the macro level describes and criticizes the practices of news organizations and the role journalism plays in society. Drawing on the disciplines of history, sociology, philosophy, and political theory, scholars work to distinguish those practices that are ethically obligatory, desirable, and proscribed. At the micro level journalism ethics both describes and argues for normative behaviors of individual practitioners and the profession.

In a democracy, journalists play a central role in providing citizens with the information they need to practice self-governance. In a highly scientific and technological democracy this responsibility extends to accurate reporting on science, technology, and engineering. This role-related responsibility in journalism to present informative accounts of issues and events, including of science and technology, serves as the basis for a cornucopia of ethical issues.

At the macro level such issues include critical assessment of (a) domination of media attention and story spin by the most powerful; (b) the presence of less powerful individuals and groups often not considered immediately newsworthy; and (c) the determination of events, issues, and people as newsworthy based on audience interest, government promotion, or corporate influence. These macro issues are apparent in which scientific actions get reported and which get ignored. The science that finds its way into the public press is that most easily distilled, most eagerly promoted by articulate spokespersons, and which attracts funding or policy discussions.

At the micro level issues include (a) conflicts between media exposure and individual desires to limit such exposure; and (b) conflicts between professional journalist responsibilities and recognized or unrecognized bias by reporters.

Scientific and Technological Change

While the Internet has made it possible for all people with computer access to broadcast their messages, recognized news outlets remain in the hands of a few corporate owners. "In Britain now, 85% of the national daily press is in the hands of four groups . . . In the United States . . . six companies control most of the media" (Bertrand 2003, p. 5). Technology has offered the tools for true participatory democracy, but technology has also limited the countries and corporations that can reach the world through satellites in geostationary orbit.

Since the early-1800s, technology has influenced how journalism is practiced, produced, and presented. Technological advances that have affected journalism include methods of recording events as well as methods of data transmission from the field to the news organization and from the news organization to its audiences. The challenge for the profession is to use evolving technology to meet the institution's unique role-related responsibilities. Technology also makes some unethical acts, such as fabricating photos or recorded quotes, easier to perform and more difficult to detect.

The standard of *objective reporting*, for example, finds its origins in the development of the wire service in the early-twentieth century. For the first time, it was possible for reporters, and then photographers, to be present at a distant scene and disseminate coverage of the event to large numbers of news organizations at the same time. What sold best to audiences in a variety of markets was journalism that appealed to the broadest possible interests. Journalists covering the story could not make assumptions about the political, religious, or cultural beliefs of readers and viewers as they might have when reporting for a specific hometown audience. Thus the reporting that worked best for the most general audience became the standard. Generations of students in journalism schools learned to report the five W's and an H—who, what, when, where, why and how—with the importance of each obvious in its order of appearance in the news product. The technology of precomputer pagination dictated an inverted pyramid style of reporting that put the most important facts at the top of the story so that the layout staff could lop off from the bottom of an account material that did not fit into limited space.

While these technologically influenced norms served as standards for the field of journalism, they did not necessarily assist in meeting role-related responsibilities. For example, one general interpretation of objective balancing of facts is the myth that each story has two sides that must be accurately presented. Complicated stories involving policy decisions have many sides. When a story is reported as a two-sided issue, the reporting itself creates a polarized debate rather than a nuanced public discussion. The attempts to establish a national healthcare system in the United States in 1994, for example, was reported as a political debate between the Clinton White House and the Republican-controlled Congress. The story of the need for uninsured citizens to access needed healthcare was overpowered by the win-lose style of its presentation. It took another decade before the public issue of developing a new healthcare policy could be discussed without the goal being lost in the reporting. Technological advances during the 1990s added to technology-accommodating norms, such as photo-transmitting cell phones. Digital cameras and satellite transmission made the delivery of information from the field to the news organization instantaneous. In homes the introduction of cable and satellite television and the World Wide Web (WWW) allowed for multichannel broadcast, 24-hour news channels, and instantaneous transmission of material from the news organization to the audience. Indeed, in an era of live coverage, the news organization itself is bypassed by journalists and nonjournalists who are on the scene, broadcasting and making their own decisions about what to reveal and what is and is not news.

The resulting norms, as questionable as the striving for two-sided objective news coverage, include the following:

1. an assumption that on-the-scene coverage is the best;
2. accessible information is synonymous with news;
3. news is a never-ending evolution of first impressions or viewable dramatic events—while interpretation and context building may get viewers and broadcasters through quiet periods, it is access to new and dramatic pictures that creates *breaking news;*
4. mediated reality is reality.

The first news team on the scene is more likely to report speculation than fact. Turning a camera to a scene and flooding viewers' homes with dramatic images creates mediated events, not news.

News stories developed for print dissemination or electronic news packages are more than recordings of slices of reality. If information is to be useful to citizens for self-governance, they need to understand the context and meaning behind events. Citizens are dependent on journalism to know what is happening in the world, but it is easy to confuse mediated reality with reality.

Experiencing the events of September 11, 2001 in New York City, or at the Pentagon, was far different from watching the scenes played out on television. Yet most viewers felt they *experienced* the terrorist attacks through the media. *Watching* the second plane hit the South Tower, *watching* the towers tumble, *watching* those on the scene scramble for safety was possible for everyone with access to a television screen, what one author calls *mass interpersonal communication*. (Newton 2001, p. 153). But making sense of a mediated event is limited by what the videographer, story producer, and news organization has chosen to show the audience.

American journalism has cultural domination of broadcast media in that it serves as primary source material for historians and others who create records of contemporary events (Winch 1997, p. 4). The importance of these accounts create the ethical necessity for journalists to use technology to enhance their ability to meet role responsibilities rather than allowing technology to create standards that interfere with meeting those responsibilities. The technological worldwide domination of American journalism also creates the ethical necessity for journalists to perceive of themselves as representing global, not national, interests. Reality, if left unrecorded, is not available for public consideration or discussion.

According to communication scholar Paul Ansah, a problem with the domination of technology and news is "the paucity of the horizontal flow of news among developing countries in the South, thus compelling people in those countries to see one another from the perspective of foreign correspondents whose value systems, ideological options and even prejudices are reflected in the reports" (Ansah 1986, p. 66).

The Internet gives every person with access to that technology the opportunity for free expression and access to a world of ideas. In twenty-first century university life in the United States, where professors expect students and colleagues to exist in a wired world, it is easy to forget that such access actually exists only for the privileged few. According to a 2003 UN report, 91 percent of Internet users represent 19 percent of the world's population.

Yet in a world in which anyone with access can find an audience—what might be called information anarchy—credible journalism is more necessary than ever to sustain democracy. Citizens "need a guarantee of authenticity. . . . There is an ever greater need for competent, honest journalists to filter, check, and comment upon the information available" (Bertrand 2003, p. 4).

Specific Ethical Concerns of Reporting on Science, Technology, and Engineering

Science coverage rose steadily from the mid-twentieth century into the early-twenty-first century. The explosive growth in technology and in medical knowledge fueled a steady stream of science news. The need for average citizens to achieve a higher degree of science literacy so that they could understand and operate new technological equipment and so that they could understand and access advanced medical technology created a greater and sustained need for mediation between experts and general public.

Increasing awareness and concern for environmental impact on the part of scientists, policy makers, and the public created the same need for the development of environmental journalism as a specialization. Journalism education responded with the development of science writing courses and curriculum.

A 1978 directory (Friedman, Goodell and Verbit) found fifty-nine colleges and universities teaching 104 science communication courses including those in general science, technical writing, environmental journalism, and agricultural journalism. A mid-1990s update of Sharon Dunwoody's directory found an increase in the number of programs, courses, and specializations. For example, specialized communication courses were offered in risk, engineering, cyberspace, marine science, and earth sciences, in addition to general science, and technical, environmental, and medical writing.

Journalists and scientists continue to recognize the need for collaboration between the professions and to understand the different professional conventions that make such collaboration difficult. Professional societies, web resources, and workshops for scientists and journalists are necessary to create a communication bridge between science and the public it affects.

DENI ELLIOTT

SEE ALSO *Communications Ethics.*

BIBLIOGRAPHY

Ansah, Paul A. V. (1986). "The Struggle for Rights and Values in Communication." In *The Myth of the Information Revolution*, ed. Michael Traber. Beverly Hills, CA: SAGE Publications.

Bertrand, Claude-Jean. (2003). *An Arsenal for Democracy*. Cresskill, NJ: Hampton Press.

Bucchi, Massimiano. (1998). *Science and the Media: Alternative Routes in Science Communication*. New York: Routledge.

Dunwoody, Sharon. (1993). *Reconstructing Science for Public Consumption: Journalism as Science Education*. New York: Hyperion Books.

Dunwoody, Sharon, and Ellen Wartella. (1979). "A Survey of the Structure of Science and Environmental Writing Courses." *Journal of Environmental Education* 10(3): 29–39.

Friedman, Sharon M.; Rae Goodell; and Lawrence Verbit. (1978). *Directory of Science Communication Courses and Programs*. Binghamton: Science Communication Directory, Department of Chemistry, State University of New York at Binghamton.

Friedman, Sharon M.; Sharon Dunwoody; and Carol. L. Rogers, eds. (1999). *Communicating Uncertainty: Media Coverage of New and Controversial Science*. Mahwah, NJ: Erlbaum.

Friedman, Sharon M.; Sharon Dunwoody; and Carol L. Rogers, eds. (1986). *Scientists and Journalists: Reporting Science as News*. New York: Free Press.

Levi, Ragnar. (2001). *Medical Journalism: Exposing Fact, Fiction, Fraud*. Ames: Iowa State University Press.

Nelkin, Dorothy. (1995). *Selling Science: How the Press Covers Science and Technology*. New York: W. H. Freedman.

Newton, Julianne H. (2001). *The Burden of Visual Truth*. Mahwah, NJ: Lawrence Erlbaum Associates.

Paradis, James G., and Muriel L. Zimmerman. (2002). *The MIT Guide to Science and Engineering Communication*. Cambridge, MA: MIT Press.

Street, John. (1992). *Politics and Technology*. New York: Guilford Press.

Winch, Samuel P. (1997). *Mapping the Cultural Space of Journalism*. Westport, CT: Praeger Press.

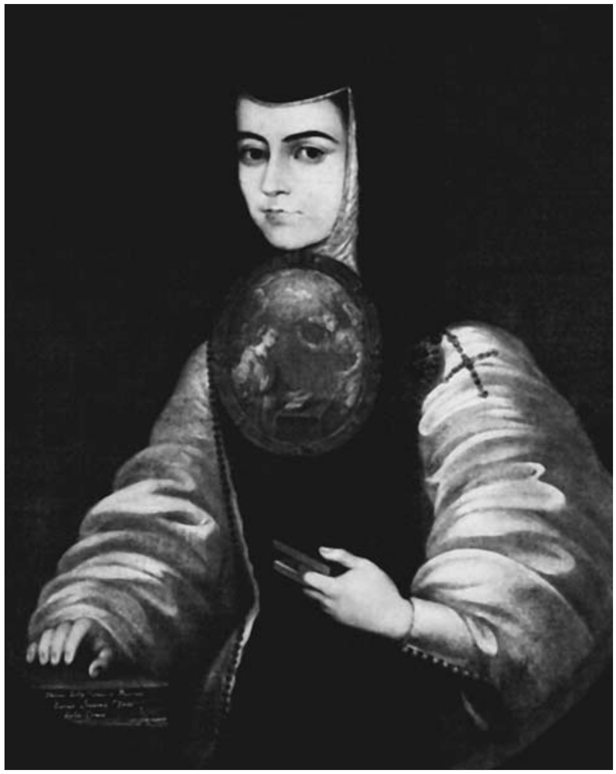
JUANA INÉS DE LA CRUZ

Born in Nepantla, near Mexico City, Sor Juana Inés de la Cruz (1648 or 1651–1695) is best known as one of the greatest Baroque poets and as the iconic forerunner of Hispanic feminism. However, the significance of her work and life in studies of the relationships among gender, science, and society in New Spain (Mexico) and colonial Spanish America has been gaining greater recognition.

In 1662 Sor Juana, then known by her birth name, Juana de Asbaje y Ramírez, was admitted into the service of the viceroy's wife, the marquise of Mancera, who became her protector, a role later filled by the wife of the succeeding viceroy, the countess of Paredes. Believing that a religious life was most compatible with her intellectual pursuits, Sor Juana entered a Carmelite convent in 1667 but left after three months, eventually joining the more lenient order of San Jerónimo in 1669. In the convent Sor Juana pursued her scientific studies—of which little is known—and wrote the bulk of her literary works despite the opposition of her confessor and the archbishop of Mexico.

The first volume of her collected works was published in Madrid in 1689, with the publication of the second volume occurring in 1692. In 1694, under ecclesiastical pressure, Sor Juana renounced all literary activity, sold her library and scientific instruments, and signed in blood a profession of faith in which she described herself as "the worst of all." She died on April 17, 1695, during an epidemic. An unfinished poem and some money were found in her cell. The third volume of her collected works was published in 1700.

Her poetry, especially "Dream" (1692), which is less a description of a dream than an allegory of the acquisition of knowledge, has been read as a feminist interpretation of Cartesian thought and, alternatively, as the most complex instance of the confluence of hermetic science—as exemplified by the works of the German Jesuit Athanasius Kircher (1601–1680)—and literature in the Baroque period. However, it is in her autobiographical works, such as the "Letter of Monterrey" (1681), addressed to her confessor, and the public "Response to Sor Filotea de la Cruz" (1691), a true *apologia pro vita sua,* that her most explicit critique of the limitations placed on the intellectual and scientific endeavors of women by the colonial patriarchal religious and political hierarchies can be found. In defense of her right to engage in intellectual activity, Sor Juana identifies in the "Response" a genealogy of women intellectuals—including such diverse examples as Hypatia of Alexandria (370–415), Saint Gertrude the Great (1256–1311), and Queen Christina of Sweden—and argues that humanistic and scientific pursuits are compatible with theology and necessary for its comprehension. Sor Juana also defended the importance of what in her time were spaces and activities for scientific knowledge, claiming that "Aristotle would have written more if he had cooked" (Sor Juana 1951–1957, p. 460).



Sor Juana Inés de la Cruz, 1651–1695. Sor Juana Inés de la Cruz was a Mexican nun renowned for her phenomenal knowledge of the arts and sciences of her day, her devotion to scientific inquiry, and her lyric poetry. *(Philadelphia Museum of Art/Corbis-Bettmann. Reproduced by permission.).*

Although Sor Juana's tragic fate demonstrates that her words were ignored by the misogynist and antirational establishment of seventeenth-century colonial Mexico, her criticisms of the ethical limitations of patriarchal science and knowledge have begun to be acknowledged as prefiguring feminist approaches to the study and history of science.

JUAN E. DE CASTRO

SEE ALSO *Colonialism and Postcolonialism; Feminist Ethics.*

BIBLIOGRAPHY

Hill, Ruth Ann. (2000). *Sceptres and Sciences in the Spains: Four Humanists and the New Philosophy (Ca. 1680–1740).* Liverpool, England: Liverpool University Press. In this study, the author analyzes the influence of the scientific philosophies developed by Francis Bacon and Pierre Gassendi, among others, on Sor Juana and three other Spanish and Spanish-American humanists (Gabriel Álvarez de Toledo, Pedro de Peralta Barnuevo, and Francis Botello de Moraes).

Juana Inés de la Cruz, Sor. (1951–1957). *Obras Completas de Sor Juana Inés de la Cruz,* ed. Alfonso Méndez Plancarte. Mexico City, Mexico: Fondo de Cultura Económica. This is the standard Spanish-language edition of Sor Juana's complete works.

Juana Inés de la Cruz, Sor. (1997). *Poems, Protest, and a Dream: Selected Writings,* trans. Margaret Sayers Peden. New York: Penguin. A good translation of some of Sor Juana's key texts.

Merrim, Stephanie, ed. (1991). *Feminist Perspectives on Sor Juana Inés de la Cruz.* Detroit: Wayne State University Press. An important collection of articles that study Sor Juana from feminist perspectives.

Paz, Octavio. (1988). *Sor Juana, or, the Traps of Faith,* trans. Margaret Sayers Peden. Cambridge, MA: Harvard University Press. Written by Mexico's best-known poet and essayist and a Nobel Prize winner himself, this book is a convincing reconstruction of Sor Juana's intellectual and social environment.

Trabulse, Elías. (1995). "El universo científico de Sor Juana Inés de la Cruz." *Colonial Latin American Review* 4(2): 40–50. Trabulse is one of the foremost historians of science during the Mexican colonial period and this is probably the most readily available in the United States of his articles on Sor Juana.

INTERNET RESOURCES

"The Sor Juana Inés de la Cruz Project." Available from http://www.dartmouth.edu/~sorjuana. On this Website one can find Sor Juana's complete works, as well as some of the most important critical articles written on her.

JUNG, CARL GUSTAV

Psychologist Carl Gustav Jung (1875–1961), who was born in the village of Kessweil, Switzerland on July 26, and died on June 6 in Zurich was, along with Sigmund Freud (1856–1939), a creator of depth psychology. His controversial research in this area has ethical implications for both makers and users of modern technology. Jung received an undergraduate degree in psychiatry at the University of Basel and completed his doctoral studies at Burghölzli mental hospital in 1902. In 1907 he achieved international recognition with his seminal study of dementia praecox (schizophrenia), leading to a five-year collaboration with Freud, the originator of psychoanalysis. By 1912, however, Jung found his ideas diverging from those of Freud, and from that point until the end of his life, Jung's intellectual journey was both creative and independent.

Like his former mentor, Jung was determined to penetrate and comprehend the human psyche at the deepest possible level. Unlike Freud, who emphasized the central importance of childhood experience in the understanding of neuroses, Jung focused on adult psychology, treating patients whose neuroses did not seem rooted in infantile experiences and fantasies. Among Jung's now-familiar concepts are the personality traits of introversion and extroversion; psychological types (which lead to the standardized Myers-Briggs typology test); stage of life distinctions, including description of the mid-life crisis; primitive mental frameworks called archetypes embedded in a collective unconscious; and the notion of the *Shadow,* a part of the psyche all but inaccessible to the conscious mind but often revealed in dreams.

Carl Jung, 1875–1961. A Swiss psychologist and psychiatrist, Jung was a founder of modern depth psychology. *(© Bettmann/Corbis.)*

Jung's body of work, together with that of Freud and Alfred Adler (1870–1937), formed the basis of modern psychoanalytic techniques. These methods of treating mental disorders are today used alongside behavioral and cognitive therapy and (increasingly) psychoactive drugs. Criticism of Jung has tended to focus on the teleological (i.e., that psychic events have a purpose towards future development) and mystical elements of his thought, a significant source of the latter being his explorations of his own complex psyche. His belief in *synchronicity,* a non-causal linkage of mental and physical phenomena, has also been criticized as speculative and without scientific foundation.

Can the concepts of the collective unconscious and the Shadow help people to better understand their connection to the natural world and to their own technological creations? Prominent Jungian psychologists James Hillman (b. 1926), Stephen Aizenstat, Marie-Louise von Franz (1915–1998), and Robert Sardello have postulated that psychological health in the modern world may demand less focus on the narrow confines of the human mind and more on the connection of the human mind, both conscious and unconscious, with the rest of the natural and technological world. Historian Theodore Roszak (b. 1933) has suggested that an *ecological unconscious* links the human psyche with the natural world just as Jung's collective unconscious links human beings with each other, while biologist Edward O. Wilson (b. 1929) has argued that evolution has built into human beings an innate connection with and affinity for the natural world that should be explored by psychologists.

Jung himself was much concerned with the impacts of modern life on the psyche. Four years before his death, he published *The Undiscovered Self*, in which he argues that European civilization's obsession with the externalities of life had left largely untouched the mysteries of the human mind.

The psyche, which is primarily responsible for all the historical changes wrought by the human hand on the face of this planet, remains an insoluble puzzle and an incomprehensible wonder, an object of abiding perplexity—a feature it shares with all of Nature's secrets. In regard to the latter, says Jung, human beings still have hope of making more discoveries and finding answers to the most difficult questions. But in regard to the psyche and psychology there seems to be a curious hesitancy to explore.

Jung's fear was that humankind's collective Shadow, empowered by modern technology, could be released destructively in all its irrational fury. "The more power man had over nature, the more his knowledge and skill went to his head, and the deeper became his contempt for the merely natural and accidental, for all irrational data—including the objective psyche, which is everything that consciousness is not" (Jung 1957, p. 47).

Failure to advance self-understanding thus becomes, in Jung's view, a dangerous moral problem:

> It is not that present-day man is capable of greater evil than the man of antiquity or the primitive. He merely has incomparably more effective means with which to realize his propensity to evil. As his consciousness has broadened and differentiated, so his moral nature has lagged behind. That is the great problem before us today. *Reason alone no longer suffices*. (Jung 1957, p. 54, Jung's emphasis)

In *Memories, Dreams, Reflections* (1961), Jung's personal memoir completed just weeks before his death, he stresses that the solution to the problem of evil lies in self-knowledge, to be arrived at through psychological inquiry:

> Today we need psychology for reasons that involve our very existence . . . [W]e stand face to face with the terrible question of evil and do not know what is before us, let alone what to pit against it. And even if we did know, we still could not understand "how it could happen here." (Jung 1961, p. 331)

His argument for the necessity of such psychological knowledge remains a basic challenge for the future development of scientific technology. For Jung, solutions to the problems of evil do not lie in simply extending power over nature, but in better understanding humankind and its place in the universe.

WILLIAM M. SHIELDS

SEE ALSO *Freud, Sigmund; Psychology.*

BIBLIOGRAPHY

Bair, Dierdre. (2003). *Carl Jung: A Biography*. Boston: Little, Brown.

Jung, Carl Gustav. (1969). *Collected Works*, trans. Richard Francis Carrington Hull. Princeton, NJ: Princeton University Press. Definitive English edition of Jung's complete works and letters.

Jung, Carl Gustav. (1989 [1961]). *Memories, Dreams, Reflections*, trans. Richard Winston, and Clara Winston. New York: Random House. Jung's autobiography, oriented towards personal transformations and inner discoveries rather than narrative.

Jung, Carl Gustav. (1990 [1957]). *The Undiscovered Self*, trans. Richard Francis Carrington Hull. Princeton, NJ: Princeton University Press. Jung stresses the importance of exploring the human psyche.

Main, Roderick. (1997). *Jung on Synchronicity and the Paranormal*. Princeton, NJ: Princeton University Press.

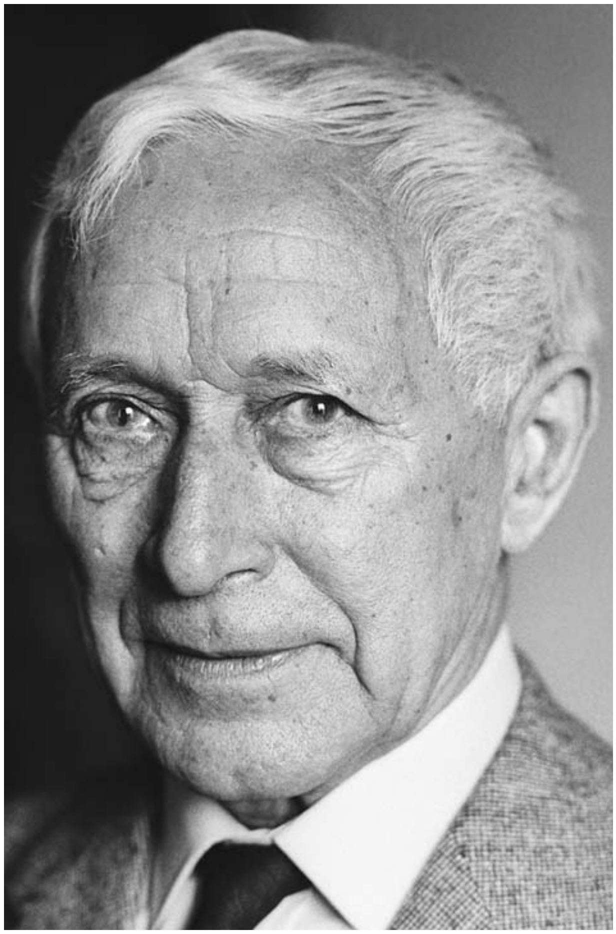
Roszak, Theodore, Mary E. Gomes, and Allen D. Kanner, eds. (1995). *Ecopsychology: Restoring the Earth and Healing the Mind*. San Francisco: Sierra Club Books. Collection of essays, with introductions by Lester Brown and James Hillman, exploring how the health of the earth affects the minds of human beings.

Roszak, Theodore. (2002). *The Voice of the Earth: An Exploration of Ecopsychology*, 2nd edition. Kimball, MI: Phanes Press. The historian's latest work on the connection between the human psyche and the planet Earth.

Wilson, Edward O. (1986). *Biophilia*. Cambridge, MA: Harvard University Press. Prominent biologist argues that love of all life can be expressed by the "conservation ethic."

JÜNGER, ERNST

Ernst Jünger (1895–1998) was a German soldier and a controversial author who was best known for his militarism and prophetic descriptions of a new world being created by the interplay of nationalism, industrialization, and advances in technology. Born in Heidelberg on March 29, Jünger served on the western front in World War I. During the interwar years he studied entomology, contributed to several right-wing journals, and criticized both the Weimar Republic and the National Socialists. Although politically opposed to many aspects of Adolf Hitler's regime, Jünger served as an officer in the German army in World War II. After the war he continued to write novels, including prescient depictions of dystopias, and pioneered the prose style now called magic realism. His work was independent and dispassionate, indifferently observing and commenting on historical and social developments. A longtime friend of and influence on the philosopher Martin Heidegger (1889–1976), Jünger died in Wilflingen, Germany, on February 17.



Ernst Jünger, 1895–1998. German author Jünger was one of the most original and influential German writers and intellectuals of the 20th century. *(© Sophie Bassouls/Corbis Sygma.)*

World War and Mobilization

World War I left a lasting impression on Jünger. Three characteristics of that conflict shaped his view of the world: the destructive power of the new armaments, their lethality, and the consequential subordination of individual courage to the power of machines. In the end whoever made the best use of the war industry would be victorious. The new weapons changed the character of killing and dying because violence was inflicted at a distance and on a massive scale. The person who falls is not seen, his last breath is not heard, and his blood does not splatter the aggressor. At a distance death is wrapped in indifference and anonymity. The slaughter becomes more sudden, massive, and above all reciprocal.

Jünger's first book, *In Stahlgewittern* (1920), is a memoir of his four years on the western front. In this work he showed his ideological embrace of technology even as he struggled with the tension between human will and the power of mechanized warfare. His interpretation of the larger meaning of the war is presented in *Die Totale Mobilmachung* (1931). The title refers to the fact that the mobilization of all forces, including industrial and productive capacity, becomes decisive in the definition of conflicts. Jünger read these phenomena as signs of a historical transition. A new reality was emerging, dominated by the "figure of the worker."

In his single most influential work, *Der Arbeiter: Herrschaft und Gestalt* (1932), Jünger developed his vision of a radically antibourgeois future based on total mobilization. This work often is interpreted as a totalitarian or authoritarian rebuttal of the bourgeois conception of freedom, the market economy, and the liberal nation-state. In it Jünger envisioned the "worker" as the destiny of the coming age, to be characterized by technocratic control in place of the anarchy of liberal individualism. The bourgeois individual will be replaced by the worker "type" in an "organically constructed" political order. Freedom will become identical to obedience. Individuals will be folded into the unity of the whole. Both this metaphysical substructure, or gestalt, of the worker and Jünger's political philosophy of detachment deeply influenced Heidegger.

Der Arbeiter also is predicated on Jünger's concept of "heroic realism," which seeks out the danger that bourgeois reason domesticates by making all risk calculable. In opposition to bourgeois concerns for comfort and convenience, modern technology has an inner destructive character as "the way in which the gestalt of the worker mobilizes the world" (Junger 1932, p. 156). The conversion of all activity into some kind of work is a manifestation of the predominance of this work character. Indeed, the term *worker* does not so much designate a class or social affiliation as it defines a *Lebenstand,* or "state of life," to which Jünger attributed the formative power emerging in history. Jünger thus disassociates his conception from the proletariat of Marxism. It is indicative of Jünger's political complexity that *Der Arbeiter* was regarded by the right as communistic and by the left as fascist.

Total mobilization and the predominance of the worker express a new reality in which the efficacy of an action has priority over its legitimacy. In this sense Jünger's philosophy is aligned with Friedrich Nietzsche's (1844–1900) "active nihilism" and Heidegger's "empire of technics." In fact, Jünger's greatest influence on Heidegger stems from this metaphysical analysis of technology as an essential way of being in the world.

Outside National Socialism

Jünger's *Auf den Marmorklippen* (1939) is a covert criticism of National Socialist tyranny. A poetic and obscure book that seems to aestheticize violence, it presents types more than concrete characters and in that way achieves a general critique of totalitarianism. Indeed, by the time of the 1938 *Krystall Nacht* (the Nazi attack on Jewish businesses in Germany) it was evident to Jünger that the National Socialist regime was essentially the same crude form of proletariat totalitarianism as the Bolshevik regime in Russia.

Gläserne Bienen (1957) raised the moral dilemma of the use of technology in society and foreshadowed modern developments in robotics and nanotechnology, presenting a world where "even the molecules were controlled." The novel questioned how people might retain a sense of place and identity in light of the accelerating pace at which the old is replaced by the new. It also expressed a growing contempt for both an impersonalized, bureaucratized society and the scientific, materialistic worldview that discredits meaning and purpose and cosiders humans to be lowly cosmic accidents.

Jünger did not produce a systematic philosophy, but his complex, inconsistent, and fierce independence often captured an emerging technoscientific world in an indifferent but therefore critical gaze. Jünger disdained any nostalgic form of antitechnology but refused to hail a world of sustained technological progress culminating in rationality and moral decency. His heroic realism is a qualified yes that comes out of an encounter with the emerging: It is as useless to attempt to avoid the power of modern technology as it is naive to ignore its enormous potential for destruction.

MARCOS GARCÍA DE LA HUERTA
TRANSLATED BY JAMES A. LYNCH

SEE ALSO *German Perspectives; Heidegger, Martin.*

BIBLIOGRAPHY

Jünger, Ernst. (1920). *In Stahlgewittern.* [Storm of steel]. Translated into English by Basil Creighton. (1929). *Storm of Steel: From the Diary of a German Storm-Troop Officer on the Western Front.* Garden City, NY: Doubleday.

Jünger, Ernst. (1931). *Die Totale Mobilmachung.* Translated into English by Joel Golb and Richard Wolin. (1993). "Total Mobilization." In *The Heidegger Controversy: A Critical Reader,* ed. Richard Wolin. Cambridge, MA: MIT Press.

Jünger, Ernst. (1932). *Der Arbeiter: Herrschaft und Gestalt.* Hamburg: Hanseatische Verlagsanstalt. Sections 44 through 57 are translated as "Technology as the Mobilization of the World through the Gestalt of the Worker" in Carl Mitcham and Robert Mackey, eds. (1983). *Philosophy and Technology: Readings in the Philosophical Problems of Technology.* New York: Free Press.

Jünger, Ernst. (1939). *Auf den Marmorklippen.* Translated into English by Stuart Hood. (1947). *On the Marble Cliffs.* London: John Lehmann.

Jünger, Ernst. (1957). *Gläserne Bienen.* Translated into English by Louise Bogan and Elizabeth Mayer. (1960). *The Glass Bees.* New York: Noonday.

Jünger, Ernst. (1977). *Eumeswil.* Translated into English by Joachim Neugroschil. (1993). *Eumeswil.* New York: Marsilio.

Nevin, Thomas. (1996). *Ernst Jünger and Germany: Into the Abyss 1914–1945.* London: Constable. A biography that covers the first half of Jünger's life.

JUSTICE

Justice has to do with the distribution of benefits and burdens, rewards and punishments. Among the most important benefits and burdens of contemporary society are science and technology, their products and their costs. Although science and technology are involved with the administration of legal justice in many ways—from their uses in forensics to identify and prosecute criminals to the testimony of scientific and engineering experts in civil cases—the primary focus in this entry will be on the nature of justice in its own right, pointing out some implications for science and technology.

Versions of Justice

As an instrument for the distribution of benefits and burdens, the general concept is clear, but the various interpretations of the concept, and its applications are more contentious. Is justice a transcendent reality, as Plato held? A formal property having to do with proportional distribution, as Aristotle contended? Simply what contracting parties invent in mutually self-interested agreements, as Thomas Hobbes argued? An artificial construct as David Hume maintained? Or does justice have to do with ownership, a rendering to each according to one's due, as Polemarchus reports in Plato's *Republic* (331e) was the definition of the poet Simonides—a view also advanced by the Roman legal philosophers Cicero and Ulpian, as well as Thomas Aquinas? Is it possible that scientific and technological progress promote justice, especially the just power of human beings over the unjust forces of nature, as Francis Bacon argued? Or is a kind of natural justice thereby diminished, as Socrates in the *Republic* (372e) and Jean-Jacques Rousseau, in quite different ways, both proposed?

The traditional symbol of justice is a woman wearing a blindfold, holding a pair of equally balanced scales in one hand, and a sword in the other. The metaphor points to the symmetry between the quality of human judgment on one side and the rewards or punishments on the other. Justice is blind to all irrelevant considerations such as birth or social status or race or gender, and is concerned only with giving one what is deserved.

The earliest definition of justice in the West is the Simonides quote from Plato's *Republic:* "Justice is to render each person his due," giving to each person what each deserves, based on the person's character traits, including ability, virtues, and vices. If one is excellent, a suitable reward is appropriate. If one is vicious, punishment is warranted. A mediocre individual earns a mediocre benefit. Indeed Plato's *Republic* describes a meritocracy, made up of people in three classes, categorized according to their abilities.

The classic conception applies both to distributive and retributive versions of justice. Distributive justice concerns the distribution of benefits and burdens. Retributive justice deals with punishments and rewards. Immanuel Kant argued that not only should people who are good be rewarded with happiness in proportion to their goodness, but people who willfully do bad things should be unhappy in proportion to their bad intentions. Following this thought, he argued that crimes such as murder justified imposition of the death penalty. Kant used this thinking as a premise for the existence of God and life after death, arguing that justice required a god and a future existence for persons to receive their just rewards and punishments.

This classic view has been held by many philosophers throughout history. It is found in the Hindu and Buddhist idea of karma, which holds that each person will be reincarnated according to individual moral character, and in the Bible, which states, "whatsoever a man soweth that shall he also reap" (*Gal.* 6:7). Somewhat unexpectedly, even Karl Marx in his labor theory of value (a worker should be rewarded for the full value of his work) seems to share the classical theory of just desert. The utilitarian philosopher John Stuart Mill also advocated a version of this doctrine, deeming it the central meaning of justice, which in turn signifies simply the most stringent requirements of utilitarian morality. Is justice simply the secular analogue to the religious doctrine of rewards and punishment according to merit? Contemporary political philosophers, such as John Rawls and Derek Parfit rejected or qualified the salience of this classic conception of justice as desert by arguing more egalitarian or need-based conceptions.

Contemporary Conceptions

In current discussions Rawls's *A Theory of Justice* (1971) and Robert Nozick's *Anarchy, State, and Utopia* (1974) remain common reference points. Rawls argues a view of *justice as fairness* defined by that impartial, hypothetical contract that people would adopt from behind a veil of ignorance regarding with what benefits or burdens they might begin their lives in a social order. Extending a perspective developed in John Hospers's *Libertarianism* (1971), Nozick defends justice as grounded in rights to liberty and ownership. Other contemporary analyses of justice include arguments by Parfit (1984), that justice requires some consideration of need; and by Michael Walzer (1983) and Nicholas Rescher (2002) that justice is not a single concept, but a plurality of concepts relative to different social contexts.

According to Hume, questions of justice typically arise when, in situations of scarcity, human beings seek to adjudicate between competing claims for limited goods. Such goods might be material benefits, social prestige, or power—any of which could be closely associated with science or technology. Suppose 100 competitors apply for a highly desirable position such as candidate at a leading graduate program in science or director of a major engineering project. What are the correct moral and legal criteria by which to decide who should be granted the position? Should selection be based on technical knowledge, need, utility, previous effort, likely contribution to be made? Should market forces be a factor? Race, ethnicity, or gender? If in the past blacks or women or the disabled were systematically discriminated against, should affirmative action come into play?

Or consider the use of kidney dialysis machines in a county hospital that can afford only five machines, but has a waiting list of twenty or thirty people. How should doctors decide which five people should be treated? By lottery? By a process of first come first served? By greatest need? By merit? By desert? By utility, for example, if one of the candidates is the mayor of a town that is part of the county and who has served the community well for many years? Or should a complex set of factors (including age, contribution, responsibilities, merit, and need) be used?

The most significant controversial issue in the debate over distributive justice is that of economic justice. How should wealth be divided up in society? Should the free enterprise system determine how much money and wealth people end up with or should an effort be made to redistribute wealth through some sort of income tax policy? Should there be a vigorous welfare program, ensuring that no one falls below a certain economic threshold?

Types of Justice: Formal and Material

Theories of justice may be divided into *formal* and *material* types. A formal theory of justice provides the formula or definition of justice without directly filling in the content or criteria of application. Material theories of justice specify the relevant content to be inserted into the formulas. They dictate what the relevant criterion is. The classical principle of formal justice, based on Book V of Aristotle's *Nicomachean Ethics* is that "equals should be treated equally and unequals unequally." The formula is one of proportionality:

$$A \text{ has } X \text{ of } P = A \text{ should have } X \text{ of } Q$$

$$B \text{ has } Y \text{ of } P = B \text{ should have } Y \text{ of } Q$$

That is, if person A has X units of a relevant property P, and B has Y units (where Y is more or less than X), then A should pay proportionally more or less of the relevant burden Q than B. For example, if A has worked eight hours at a job and B only four hours, and time worked is the relevant criterion for reward, A should be paid twice as much as B.

The formal principle is used in law in the guise of *stare decisis*, the rule of precedent—like cases should be decided in like manner. The principle applies not only to the case of distributive justice, but also of retributive justice or punishment and commutative justice, in which obligation is based on a promise or contract that requires fulfillment.

The formal principle of justice seems reducible to the principle of universalizability: Treat like cases similarly unless there is a relevant difference, which itself is simply the principle of consistency. Be consistent in decisions. If there is no relevant difference between agents, treat them similarly. Insofar as there is no relevant moral difference between the sexes, this applies to the morality of sexual relations. If it is all right for Jack to engage in premarital sex, then it is also all right for Jill to engage in premarital sex; but if it is immoral for Jill to engage in premarital sex, it is also immoral for Jack. The formal principle of justice does not indicate whether some act is right or wrong, but simply calls for consistency. If people were content to live only with the formal principle, they might treat others very badly and still be considered just. As player Henry Jordan once said of Vince Lombardi, the legendary coach of football's Green Bay Packers, "He treated us all the same—like dogs."

Some philosophers, such as Stanley Benn, believe that the formal principle of equal treatment for equals implies a kind of *presumption* of equal treatment of people. But there are problems with this viewpoint. As Joel Feinberg (1970) points out, sometimes the presumption is for unequal treatment of people. Suppose that a father suddenly decides to share his fortune and divides it in two, giving half to his oldest son and half to his neighbor's oldest son, but nothing to his other children. This kind of impartiality is arguably misguided and, in reality, unjust. Society must determine in which respect people are equal and so deserve the same kind of treatment; this seems to be a material problem, not a purely formal one. In other words, Benn confuses an *exceptive principle* (Treat all people alike except when there are relevant differences among them) that is formal with a *presumptive principle* (Treat all people alike *until it can be shown* that there are relevant differences among them).

The formal principle does not tell which qualities determine which kinds of distribution of goods or treatment. Thus material principles are needed to supplement the formal definition. Aristotle's own material principle involved merit: People are to be given what they deserve. A coach could justifiably treat his players like dogs only if they were doglike; otherwise, he should treat them more humanely.

Types of Justice: Patterned and Nonpatterned

Material theories of justice may be divided into *patterned* and *nonpatterned* types of justice. A patterned principle chooses some trait(s) that indicates how the proper distribution is to be accomplished. It has the form:

To each according to ————.

Robert Nozick (1974) rejects patterned types of principles, such as those of Aquinas, Rawls, and Rescher, because this type of attempt to regulate distribution constitutes a violation of liberty. The point can be illustrated by considering how a great inventor can justly upset the patterned balance. Suppose the existence of a patterned situation of justice based on equality. Imagine also that there is a great demand for some inventor's product and that people are willing to pay the inventor well for it. If millions of people pay for the product, the inventor takes home a great deal more than the patterned formula allows, but seems to have a right to it. Nozick's point is that, in order to maintain a pattern, one must either interfere to prevent people from allocating resources as they wish, or intervene to take from people resources that others have transferred to them.

Nozick argues for a libertarian view of nonpatterned justice, which he calls the *theory of entitlement*. A distribution is just if all people have those things to which they are entitled. In determining what people are entitled to, the original position of holdings or possessions is an important factor, as is what constitutes a just transfer of holdings. Borrowing from John Locke's theory of property rights, Nozick argues that people have a right to any possession so long as ownership does not worsen the position of anyone else.

Continuing Debates

As in the past, justice in the early twenty-first century remains a widely contested concept. The main current rival positions are the classic theory of just desert, egalitarian theory of distribution according to need, and rights theories. The challenge for political philosophy is to sort out the competing claims of such theories and make sense of people's deepest but conflicting intuitions—especially with regard to the uses and influences of science and technology.

With regard to retributive or criminal justice, the scientific study of human behavior has, for instance, raised important questions about levels of human accountability. To what extent should psychology and neuroscience inform the legal justice system? Forensics and studies of evidence that, for instance, question the reliability of eyewitness accounts, along with increased reliance on scientific experts, likewise have implications for court procedures. Some philosophers such as Brian Barry (1989) argue the importance of the sciences of game theory and decision theory to analyses of justice.

With regard to distributive justice, science and technology, by their discoveries and inventions especially in the areas of new drugs and lifesaving medical devices, create new challenges for justice. How shall society use these drugs and therapies? Should drugs for AIDS be distributed gratis to African countries that cannot afford to pay the market price? Is it just for pharmaceutical companies, which produced the drugs, to charge the same price to all buyers, or should allowances be made for depth of need and relative ability to pay?

With regard to science and technology in general, what constitutes a just distribution of the benefits of scientific discoveries and engineering inventions? Do owners of patents have an obligation to make some sacrifice in foregoing potential profits from their work to enhance distribution? Or does justice allow them to sell their work to the highest bidder, independent of the social result? Does the state promote justice through the regulation of science and technology, or is regulation properly constrained by respect for liberty and property? In advanced technological societies where, according to Langdon Winner (1986), technological design can be a hidden form of politics, and for Ulrich Beck (1986), the avoidance of risk is now a scarce commodity, do different theories of justice imply different responsibilities for scientists, engineers, citizens, politicians, or corporations? Indeed in a social system in which corporations are granted the status of legal persons, and serve as major vehicles for scientific and technological research, development, and innovation, what concept of justice best enlightens responsibilities in the public realm?

Finally because of technological transformations of the public realm, questions of justice have been extended both spatially and temporally. Increased telecommunications promotes questions of international justice. Increased ability to impact future generations raises questions of intergenerational justice.

LOUIS P. POJMAN

SEE ALSO *Death Penalty; Environmental Justice; Equality; Grant, George; Rawls, John; Science, Technology, and Law.*

BIBLIOGRAPHY

Barry, Brian. (1989). *Theories of Justice*. Berkeley: University of California Press.

Beck, Ulrich. (1986). *Riskogesellschaft: Auf dem Weg in eine andere Moderne*. Frankfurt: Suhrkamp. English translation: *Risk Society: Towards a New Modernity*, London: Sage, 1992.

Benn, Stanley. (1967). "Justice." In *Encyclopedia of Philosophy*, ed. Paul Edwards. New York: Macmillan.

Feinberg, Joel. (1970). *Doing and Deserving: Essays in the Theory of Responsibility*. Princeton, NJ: Princeton University Press.

Hospers, John. (1971). *Libertarianism: A Political Philosophy for Tomorrow*. Los Angeles: Nash Publishers.

Nozick, Robert. (1974). *Anarchy, State, and Utopia*. New York: Basic Books.

Parfit, Derek. (1984). *Reasons and Persons*. New York: Oxford University Press.

Rawls, John. (1999). *A Theory of Justice*, revised edition. Cambridge, MA: Harvard University Press. Originally published in 1971.

Rescher, Nicholas. (2002). *Fairness: Theory and Practice of Distributive Justice*. Somerset, NJ: Transaction Publishers.

Walzer, Michael. (1983). *Spheres of Justice: A Defense of Pluralism and Equality*. New York: Basic Books.

Winner, Langdon. (1986). *The Whale and the Reactor: A Search for Limits in an Age of High Technology*. Chicago: University of Chicago Press.

JUST WAR

The term *just war* refers to the major moral tradition of Western culture that deals with the justification and limitation of the use of force by public authority. Just war tradition has particular relevance for moral reflection about many scientific and technological developments related to military affairs.

Historical Background

Just war tradition can be traced back to Saint Augustine (354–430) in the fourth and fifth centuries and through him to the Old Testament and the ideas and practices of classical Greece and Rome. Augustine, however, did not write systematically or at length about the idea of just war; his treatment of these issues is found in passages about the use of force in works on various topics. A coherent, systematic body of thought and practice on just war did not emerge until the Middle Ages. The thought of Augustine and other earlier Christian writers was drawn together by the canonist Johannes Gratian, whose *Decretum* dates to the middle of the twelfth century. Two generations of canonists who built on Gratian's work, the Decretists and the Decretalists, took the development of the just war idea into the thirteenth century. In the second half of that century theologians, including most notably Thomas Aquinas (1224–1274), placed the canonical materials in an overarching theological framework that showed both a strong dependence on Augustine's thinking and a new effort to give ideas about just war a footing in natural law.

During the thirteenth century but more during the fourteenth and fifteenth centuries, secular factors began to reshape this canonical and theological concept into a broad cultural consensus. These factors were the growing study of Roman law, especially the idea of *jus gentium* (law of peoples or nations); the maturation of the chivalric code as a guide to the conduct in arms of the international brotherhood of knights; and increased reflection on the experience of governing found in works dealing with the characteristics of a good ruler.

By the end of the Hundred Years War in the mid-fifteenth century the resulting synthesis (seen particularly in writers such as the theologian and scholar Honoré Bonet [1340–1410] and the poet and historian Christine de Pisan [1363–1430]) had defined a cultural consensus in western Europe on the justified use of armed force and the restraints to be observed in using that force. This consensus included the major factors that continue to define the idea of a just war. From canon law and theology came the requirements that for a resort to armed force to be just it must be undertaken on the authority of a sovereign and for the public good; be for a just cause, defined as defending the common good, retaking that which had been taken wrongly, and punishing evil; and right intention, defined negatively as the avoidance of self-aggrandizement, bullying, implacable hatred, and so on, and positively as aiming to restore the peace that had been violated.

The chivalric code joined canon law to provide two kinds of restraint on the employment of force: noncombatant immunity, defined by lists of persons not normally involved in war and thus not to be subjected to direct harm in war, and limits on means, defined by efforts to ban certain weapons (specifically arrows and siege machines) as *mala in se*. The *jus gentium* and the growing consolidation of political authority reinforced these developments in useful ways: the former by placing them in a broader theoretical framework to define relationships among autonomous political communities and the latter by sovereigns' adoption of these rules both in the use of force to maintain public order and in warfare against external threats.

In this manner the just war tradition was passed to the modern era. Theological and secular theorists of the law of nations, including the theologian Francisco de Vitoria (1492–1596) in the sixteenth century and the jurist Hugo Grotius (1583–1645) in the seventeenth, placed the inherited just war tradition in the context of a general theory of international law based on natural law and the *jus gentium*. After Grotius and as a result of the international order created by the Peace of Westphalia (1648), emphasis on the former part of the tradition, by then called the *jus ad bellum*, began to be reduced as sovereigns' rights to use force were redefined as *compétence de guerre* at the same time that a new emphasis was placed on the restraints to be observed in the use of force, the *jus in bello*.

This has been the pattern of the development of the just war tradition during the modern period. Beginning in the 1860s with the work of Francis Lieber and the U.S. Army's General Orders No. 100 of 1863 and, at almost the same time, the international adoption of the First Geneva Convention, positive international law has played a major role in defining the just war *jus in bello*. Through much of the nineteenth century and continuing into the nuclear age, moral thought on war has focused on efforts to rule out recourse to armed force by states, in effect denying that a *jus ad bellum*, a justification of the resort to armed force, exists any longer, or severely restricting the terms of such justification. During this period, because of its concentration on eliminating war, moral thought effectively lost sight of the just war *jus in bello*. At the same time, however, the increasing codification of international law reframed the tradition's *jus in bello* as positive-law rules for the conduct of nations in war.

The law of armed conflict in international law remains one of the important arenas for the efforts to restrain war first defined in the just war tradition. In moral thought, largely as the result of work by the theologian Paul Ramsey (1913–1988) and the political philosopher Michael Walzer (b. 1935) and public debate occasioned by the U.S. Catholic bishops' 1983 pastoral *The Challenge of Peace*, just war thinking has reemerged in American and some European debates over the use of armed force, informing not only the religious and philosophical spheres but also public policy discussions and professional military education. Just war is studied in all the service academies and the war colleges and by military lawyers, and it is a common topic in academic and policy-oriented conferences and workshops on military issues.

Science and Technology

Both historically and in recent debates just war tradition has responded to developments in the science and technology of the use of force. In the Middle Ages this involved efforts to eliminate the use of weapons that were deemed too harmful or destructive. Specifically, there was an effort to ban crossbows and bows and arrows, which could penetrate armor and kill, whereas the normal weapons of knights—swords, maces, and lances—were likely to injure but not kill armored opponents. Siege weapons capable of causing heavy and indiscriminate damage when used against fortified places were also the target of a ban.

These themes were carried forward into efforts to restrict or eliminate certain weapons or uses of weapons in positive international law. The first Hague Conference (1899) sought to ban exploding bullets for being too lethal and tending to inflict especially cruel wounds. That conference sought to ban asphyxiating gases, though this did not become positive law until the 1925 Geneva Protocol on gas warfare. Various efforts, beginning from the first Hague Conference, have been made to prohibit bombardment of unfortified population centers from the land, sea, and air. Since World War II international conventions have been adopted prohibiting the use of chemical and biological weapons as "weapons of mass destruction," and the nuclear proliferation treaty has sought to restrict possession of nuclear weapons as a way to limit the likelihood of their use. A 1980 United Nations Convention prohibits or restricts the use of certain conventional weapons "deemed to be excessively injurious or to have indiscriminate effects." The 1997 Ottawa Convention, responding to technologies that have made antipersonnel mines cheap, difficult to detect, and ubiquitous, formally prohibits their production, stockpiling, transfer, and use.

These are all examples from positive international law, a major modern carrier of the just war tradition. In the moral debate some have argued that the entire technology of contemporary warfare—not only weapons of mass destruction, including nuclear weapons, but also conventional weapons because of their ability to produce widespread death and destruction—is disproportionately and often indiscriminately harmful. This position, often called "modern-war pacifism" (including nuclear pacifism as one of its forms) holds that the technology of modern warfare is so destructive that the moral requirements of the *jus in bello*, avoidance of direct harm to noncombatants and of disproportionate destruction, cannot be met, and so there can be no just resort to force.

Opponents of this position, including Ramsey, Walzer, and James Turner Johnson (b. 1938), distinguish between the availability of highly destructive weaponry and the decision about how to fight: The latter is a moral decision, and it implies moral control over whatever means are available. In the debates over nuclear weapons during the early 1980s this difference of judgment about the technology of warfare led to two sharply different policy conclusions. Nuclear pacifists argued against nuclear weapons as inherently immoral and against the development of targeting technologies intended to make them more accurate and thus more discriminating. Others argued that development of such capabilities was a moral imperative both because it could reduce direct harm to noncombatants and because it opened the door to the development of lower-yield warheads, including conventional explosives, that could perform the same strategic and tactical functions as high-yield nuclear and thermonuclear warheads.

Questions of Technological Superiority

The policy decision at that time was to continue developing more accurate targeting technologies and delivery systems. Since then this line of development has matured progressively to produce a "revolution in military affairs" characterized by laser- and satellite-guided bombs and missiles, stealth technology that allows airplanes to get close enough to their targets to enable direct guidance of weaponry onto a target, drone airplanes and satellite imaging to identify and target enemy armed forces without collateral damage to noncombatants, and increasingly sophisticated means of gathering enemy intelligence to lower the levels of force needed for combat.

These developments first became general knowledge with publicity over the "smart bombs" of the 1991 Persian Gulf War. The use of such technology also marked the bombing of Serbia in the conflict over Kosovo (1999), and it was both ubiquitous and decisive in the conflicts in Afghanistan (2001) and Iraq (2003), where in the latter the technological superiority of the U.S. and British forces made possible a campaign that used far lower numbers of troops than previously would have been necessary, destroyed the Iraqi army while coalition forces suffered only a small number of casualties, and allowed bombs and missiles to destroy major Iraqi government targets with unprecedentedly low levels of collateral damage.

All this is morally significant from the standpoint of the just war tradition, for even in an age of weapons of massive destructive power such technology allows armed force to be used in a way that honors the just war requirements of noncombatant immunity and as low a level of destruction as possible. At the same time, from the perspective of the technologically inferior, the use of superior technology may appear to represent a refusal to accept an equal playing field in which courage and loyalty to opposing causes have a fair chance to compete with each other. What is to be made of this objection?

The latter argument cannot be used to justify means of fighting that disregard moral and legal restraints. In the moral terms of the just war tradition as well as the legal terms of the law of armed conflict, technologically superior and inferior adversaries are equally bound by the same rules. Technological inferiority is no excuse, for example, for terrorist actions against civilians or the Fedayeen Saddam's use of noncombatants as human shields in the 2003 Iraq war, both of which were clear violations of the moral concept of noncombatant immunity and the legal restrictions laid down in international law. In a conflict involving technologically asymmetrical adversaries each force is restricted, both morally and legally, to means that do not violate noncombatant immunity and do not involve prohibited weapons, such as weapons of mass destruction.

Technological asymmetry is not a new problem ushered in by precision-guided munitions. In earlier ages technological superiority was conferred by the use of Greek fire, firearms, rifled handguns and artillery, repeating rifles, the use of railroads for military transport, semaphore signaling systems and later the telegraph and radio, and the development of armored fighting vehicles. A technologically inferior armed force faces an enormous practical problem: how to match or overcome an enemy that is technologically superior. However, this is a practical problem, not a moral one. The idea of a "level playing field" means that both adversaries must play by the same rules; it does not mean that within the framework of those rules neither side may use means that it alone possesses.

The possession of superior technology, it may be argued, imposes a special moral responsibility to use that technology in ways that honor the *jus in bello* restraints. The moral rule of double effect has long been used to determine when collateral harm to noncombatants is morally allowed; by this rule such harm is allowed only when it is the indirect, formally unintended result of an attack on a legitimate military target that cannot be attacked except with such collateral harm. Thus, when an enemy places artillery next to a school or deploys troops with rifles to fire from the windows of a hospital, the artillery and the troops can be attacked despite the harm to the school and hospital and the noncombatant persons who may be inside.

However, Michael Walzer (1977) has argued that the rule of double effect also should be understood to impose a proportionality criterion; therefore, a projected attack against an otherwise legitimate target should not go forward if the collateral harm to noncombatants is judged to be disproportionate to the ends to be gained from the attack. In such cases, an alternative weapon or another means of neutralizing the target should be used or the target should be bypassed. This reasoning seems to have been employed in the targeting decisions made by U.S. forces in the 2003 Iraq conflict, in which the choice of weapons systems, the angle of attack, the time of day, fuse timing, and other factors were employed to avoid or reduce collateral damage. The possession of superior technology thus imposes an added moral burden: to use that technology to avoid harm that would be allowed in its absence.

This means that from a moral standpoint based on the just war tradition the question of the technology of warfare does not stand alone. It is also necessary to consider whether overall planning and policy, strategy, rules of engagement, means of command and control, tactics, and military training allow the use of the available technology in ways consonant with the aims of discrimination and proportionality. Not only does the U.S. military in the early twenty-first century have a virtual monopoly on the technology of the "revolution in military affairs," it is the only national military that has made operational all these elements in the channel of decision that leads toward conducting military actions within the framework required by the *jus in bello*. Arguably, the ability to conduct war more closely in accordance with just war requirements implies the moral obligation to do so. For example, carpet bombing of a mixed combatant-noncombatant area to destroy a legitimate target cannot be the moral option if precision guidance technology allows that target to be destroyed without harming noncombatants.

The question is what this implies for societies that lack such technology: Do they have the obligation to develop it, or may they not fight wars anymore? On just war reasoning, they have the moral obligation to use whatever means they have in the most moral way possible; they do not, for example, have the moral right to target civilians directly or use weapons of mass destruction, which are both indiscriminate and disproportionate. Beyond this they are obliged to try to develop more discriminate and proportionate means of fighting within the capabilities available to them and taking into account their other responsibilities. If they cannot fight according to the minimum standards of noncombatant immunity and avoidance of weapons *mala in se*, by just war reasoning they should not fight. However, the question whether to engage in armed conflict with a technologically superior adversary is not one of morality but one of political prudence.

The moral obligation to develop more discriminating and proportionate means of fighting extends also to technologically advanced militaries. During the Vietnam War Paul Ramsey (1968) argued for the use of incapacitating gases as morally preferable to the use of weapons such as napalm and even bullets because those gases could incapacitate soldiers without killing them or producing lasting harm. The United States Defense Advanced Research Products Administration has been encouraging research and development in nonlethal weapons technologies. Just war reasoning tends to support the development and use of such weapons in principle, though any particular weapon, even if nonlethal, still would have to be judged by the standards of the *jus in bello*.

In summary, just war tradition places the use of armed force in a moral framework in which some technologies are good and others are bad. The criterion is whether a specific technology makes it possible to use military force, when justified and used on public authority for the common good, in ways that honor the principles of noncombatant immunity and minimal overall destructiveness.

JAMES TURNER JOHNSON

SEE ALSO *Aggression; Atomic Bomb; Augustine; Biological Weapons; Chemical Weapons; Military Ethics; Science, Technology, and Law; Thomas Aquinas; Weapons of Mass Destruction.*

BIBLIOGRAPHY

Best, Geoffrey. (1980). *Humanity in Warfare*. New York: Columbia University Press. A historical study of the development of international laws on war, peace, and neutrality from the eighteenth through the twentieth centuries.

Elshtain, Jean Bethke. (2003). *Just War against Terror*. New York: Basic Books. An argument for the justification of the war on terror from a just war standpoint.

Johnson, James Turner. (1981). *Just War Tradition and the Restraint of War*. Princeton, NJ, and Guildford, Surrey, UK: Princeton University Press. A historical and thematic study of the just war tradition and its relation to the conduct of war from the Middle Ages through the twentieth century.

Johnson, James Turner. (1999). *Morality and Contemporary Warfare*. New Haven, CT, and London: Yale University Press. A just war analysis of contemporary warfare.

National Conference of Catholic Bishops. (1983). *The Challenge of Peace: God's Promise and Our Response*. Washington, DC: United States Catholic Conference. A landmark pastoral letter examining the Catholic tradition on war and peace in the context of the Reagan-era debate over nuclear weapons.

Ramsey, Paul. (1961). *War and the Christian Conscience*. Durham, NC: Duke University Press. A landmark study drawing Christian just war theory from the idea of love of neighbor and applying this theory to nuclear war.

Ramsey, Paul. (1968). *The Just War: Force and Political Responsibility*. New York: Charles Scribner's Sons. A collection of essays on political ethics, the idea of just war, and moral conduct applied to nuclear war and insurgency.

Russell, Frederick H. (1975). *The Just War in the Middle Ages*. Cambridge, UK, and New York: Cambridge University Press. A thorough and detailed historical study of the development of the just war idea from the twelfth-century canonists through Thomas Aquinas and his circle in the late thirteenth century.

Walzer, Michael. (1977). *Just and Unjust Wars*. New York: Basic Books. A reconstruction of the just war idea on the basis of philosophical analysis with historical illustrations, aimed at recapturing this idea for political and moral theory.

K

KANT, IMMANUEL

Immanuel Kant (1724–1804) was born in Köningsberg, East Prussia (now Kaliningrad, Russia), on April 22 and died there on February 12, having lived such an uneventful life that one early commentator questioned whether he had one. Yet his critical philosophy constituted a watershed in Western intellectual history. For science, technology, and ethics the significance of the Kantian watershed lies in the analysis of human experience as constructive and the argument that reason has insight only into that which it produces according to its own plan. With this argument Kant developed a new critical interpretation of scientific knowledge and of ethical reason that presents both as exhibiting constructive, not to say technological, dimensions.

Prior to Kant, modern philosophy was characterized by a contest between rationalism and empiricism. Rationalists such as René Descartes (1596–1650) and Gottfried Wilhelm Leibniz (1646–1716) considered reason to be the origin of all true knowledge, sensation merely a degraded form of thought or source of illusion. By contrast, empiricists such as Francis Bacon (1561–1626) and John Locke (1632–1704) argued that all knowledge derived from the senses, with thought being no more than an extension of sense perception. Kant's precritical writings included works in natural philosophy, aesthetics, and ethics reflective of the rationalist tradition. But reading the British empiricist David Hume (1711–1776) awakened Kant from what he described as his "dogmatic slumbers." This awakening led, in turn, to a synthesis of these two approaches in his major work, *The Critique of Pure Reason,* which argued that the form of human experience is constructed a

Immanuel Kant, 1724–1804. The major works of this German philosopher offer an analysis of speculative and moral reason and the faculty of human judgment. He exerted an immense influence on the intellectual movements of the 19th and 20th centuries. *(© Corbis-Bettmann. Reproduced by permission.)*

priori by reason while its material content arises a posteriori from sensation. This is the core of Kant's transcendental or critical idealism, which he subsequently extended into ethics and aesthetics in order to respond to what he considered the three main questions of philosophy: What can I know? What ought I to do? What can I hope for? He later added a fourth question that synthesized the first three: What is the human being?

The Critique of Pure Reason (1781)

Kant's major work undertakes what he terms a "Copernican revolution" in philosophy. Whereas traditionally philosophy had begun with particular objects of experience, Kant's transcendental method begins with experience in general and tries to uncover the "transcendental preconditions" that make such experience possible. For Kant, objects are seen as fitting into human representational structures rather than representational structures simply arising from objects. As Hume had shown, the necessity that these representational structures possess, the fact that all objects must appear in space and time, simply cannot be derived from sensory experience. According to Kant, then, space and time are the *a priori* forms of sensibility, the ideal or transcendental forms that make it possible for human beings to experience any object.

Only as a manifold of content within space and time is sense intuition or experience possible. But objects that first appear to the senses within the necessary structures of space and time are further known using concepts such as substance and causality. For Kant, the expectation that events necessarily have causes is not so much derived from experience as brought to experience, although of course the particular causes are determined by experience. Experience would not be what it is, would not be intelligible or knowable, without these *a prior* pure concepts of the understanding. The justification of these categories rests with their constitutive role in human experience and the fact that they work to make experience possible.

What is it that is known when sensation and understanding cooperate in this way to make experience scientifically intelligible? The answer is phenomena. Perhaps the single most important distinction in Kant's thought is that between phenomena and noumena, things as they appear to people and things in themselves, respectively. The former are open to positive knowledge, whereas the latter can be thought but never known in a positive or scientific sense.

The human mind nevertheless has a tendency to try to extend itself beyond phenomena to things-in-themselves. This includes claiming to have positive knowledge of supersensible realities such as God, the soul, and freedom, the topics of traditional metaphysics. These ideals of pure reason can never be scientifically verified. Thus Kant argued that traditional metaphysics, which focuses on objects that transcend experience rather than the transcendental preconditions of experience, is not an authentic form of knowledge. Yet, although the ideals of pure reason cannot be experienced they can be thought, and in their thinking serve what Kant calls a regulative function.

Critique of Practical Reason (1788)

The second critique turns from science to ethics and deals with practical or moral reasoning. This book was preceded by an introductory *Foundations of the Metaphysics of Morals* (1785), which developed a deontological theory of ethics, that is, one based on the primacy of duty. For Kant, the only unconditional good is a good will, one that wills to do what is a duty merely because it is a duty, or to choose duty for its own sake. The philosophical challenge for ethics is to explicate what this means, and to identify the transcendental preconditions of its possibility.

Kant thus approaches ethics not in terms of the consequences of actions or whether decisions make a person happy, but in terms of moral obligation. The idea of duty leads Kant to the idea of freedom as its basis. Although with regard to many actions the will may be influenced by factors outside itself, that is, be heteronomous, at least in some instances the will is able to decide for itself, that is, act autonomously. In exercising its own decision-making capacity, the will may also reason according to hypothetical imperatives (If one wants *X* then do *Y*) or categorical imperatives (Do *Y*, no matter what). Practical reason at the highest level displays a spontaneity that makes its own law for itself, simply because this is the right way to act, independent of any particular consequences.

Hypothetical reasoning may be described as the basis of technological thinking. Indeed, Kant calls one form of a hypothetical imperative a technical imperative, which focuses on discovering the means to achieve some end. Categorical reasoning, by contrast, focuses on the identification of worthy ends. According to Kant the most worthy end, and thus categorical imperative, is to act according to a maxim that is universal, that is, applies to all, or to treat all persons as ends in themselves. Human beings have an inherent worth or dignity, unlike objects that have exchange value. To recognize this and act accordingly is to begin to construct something more than a traditional society or state, which presumes people acting out of self-interest and treats others as means to their own ends, and to begin to construct instead a new kind of social order that Kant calls a "kingdom of ends." This moral ideal has been applied widely to a range of ethical issues related to science and technology, from the treatment of human subjects in medical research, to privacy in the use of computers and debates about the permissibility of human reproductive cloning.

The second critique postulates freedom, the existence of God, and immortality of the soul as necessary presuppositions of moral experience. Freedom is necessary to make sense of the human experience of moral responsibility, God to guarantee the ultimate triumph of moral order, and immortality to allow for the final realization of the good will. In this regard, practical reason provides access to a supersensible reality closed to science, though in a manner that can only be an issue of rational faith.

The Third Critique and Kant's Influence

Kant's *Critique of Judgment* (1790) attempted to show how theoretical and practical reason—science and ethics—are unified in the sense of beauty. For Kant, the judgments of beauty and purpose provide a sensible symbol of the supersensible realm. They suggest that the natural and ethical realms make up a unified whole. The purposeful structures humans observe especially in organic bodies and their beauty provide clues to the further understanding of nature. The idea that nature is purposeful lies behind the human belief that a system of laws of nature is possible. It can also lead to the extension of humanity's empirical investigations of nature. Judgments of beauty are based on a subjective feeling of delight in an object, but this feeling has a universal validity deriving from the harmony of the faculties of imagination and understanding. The feeling of the sublime depends upon the moral feeling Kant supposed common to all of humanity.

Taken together, Kant's three critiques thus answer what he takes to be the basic questions of philosophy. The fourth question was to find its answer in a study of anthropology. What can be known are intelligent constructions of science that constitute the basic form of knowledge. What ought to be done is to treat human beings as ends in themselves in order to establish a kingdom of ends. For the individual human being there is hope for personal immortality in order to be able to make infinite moral progress. For the human race there is the hope that human progress will be instantiated in the moralization of the human race, so that the advance of human capacities, including humankind's scientific understanding of the world, may contribute to the construction of a harmonious moral social order.

Kant's influence is inestimable. Although in the next generation Georg Wilhelm Friedrich Hegel (1770–1831) challenged Kant's distinction between phenomena and noumena, Hegel's alternative system never became as influential as Kant's. Future efforts to explicate the unique power and limitations of science and the independent validity of ethics have repeatedly returned to formulations of what have become known as various forms of neo-Kantianism. Ernst Cassirer (1874–1945), for instance, widened Kant's appreciation of human construction in science to include the entire range of cultural symbolic production, including the realms of language, myth, and religion. Bernard Gert's *Morality: Its Nature and Justification* (2004) develops a Kantian-like set of moral rules, often explicitly considering issues related especially to biomedical technologies.

More generally, Friedrich Dessauer (1881–1963) developed a broadly Kantian interpretation of technology, going so far as to propose a fourth Kantian critique of the transcendental preconditions of technological invention (Mitcham 1994). More recently, Ernesto Mayz Vallenilla (1989) has provided an analysis of the transformations of technical rationality brought about by new instrumentations that reflects a Kantian and phenomenological heritage. Finally, detached from its transcendental moorings, Kant's approach may also be seen as supporting contemporary social constructivist interpretations of science and technology (Bijker, Hughes, and Pinch 1987).

In his first critique, Kant sought to limit positive scientific knowledge to phenomenal reality so that noumena may be posited without interference by rational faith and that ethics may be able to rest on its own foundations. In this way, ethics could be freed from the dogmatic assumptions and skepticism associated with traditional metaphysics.

> [E]ven the *assumption*—as made on behalf of the necessary practical employment of my reason—of *God*, *freedom*, and *immortality* is not permissible unless at the same time speculative reason be deprived of its pretensions to transcendent insight . . . thus rendering all *practical extension* of pure reason impossible. I have therefore found it necessary to deny *knowledge*, in order to make room for *faith*. The dogmatism of metaphysics, that is, the preconception that it is possible to make headway in metaphysics without a previous criticism of pure reason, is the source of all that unbelief, always very dogmatic, which wars against morality. (Kant 1965 [1781], pp. Bxxix–Bxxx)

Kant's philosophy sought the harmonious development of human faculties but ended in separating scientific intellection and ethical reflection. Both exhibit the free and spontaneous constructive activity of the human mind. Yet Kant did not foresee how scientific (and technical) development could outpace the application of ethical reflection. As a result, ethical thought often appears to lag behind technoscientific achievements. To what extent should ethical concerns establish limits on scientific inquiry? This question manifests itself repeatedly in contemporary discussions of advancing science, new technologies, and ethics.

DARYL J. WENNEMANN

SEE ALSO *Axiology; Deontology; Discourse Ethics; Freedom; Leibniz, G. W.; Risk and Emotion; Scientific Ethics.*

BIBLIOGRAPHY

Bijker, Wiebe E.; Thomas P. Hughes; and Trevor J. Pinch, eds. (1987). *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Cambridge, MA: MIT Press. A collection of essays exploring the social construction of technology.

Cassirer, Ernst. (1953, 1955, 1957, and 1996). *Philosophy of Symbolic Forms,* trans. Ralph Manheim and John Michael Krois. 4 vols. New Haven, CT: Yale University Press.

Gert, Bernard. (2004). *Morality: Its Nature and Justification,* rev. edition. Oxford and New York: Oxford University Press. The second extensive revision of Gert's *The Moral Rules: A New Rational Foundation for Morality* (1970).

Kant, Immanuel. (1902–1997). *Gesammelte Schriften* [Collected works], ed. the Royal Prussian Academy of Sciences (and its successors). 29 vols. Berlin: Georg Reimer (subsequently Walter de Gruyter). The standard German edition of Kant's works.

Kant, Immanuel. (1965 [1781/1787]). *Critique of Pure Reason,* trans. Norman Kemp Smith, unabridged edition. New York: St. Martin's Press.

Kant, Immanuel. (1990 [1785]). *Foundations of the Metaphysics of Morals,* trans. Lewis White Beck, 2nd edition. New York: Macmillan.

Kant, Immanuel. (1993 [1788]). *Critique of Practical Reason,* trans. Lewis White Beck, 3rd edition. New York: Macmillan.

Kant, Immanuel. (2000 [1790]). *Critique of the Power of Judgment,* edited by Paul Guyer, translated by Paul Guyer and Eric Matthews. Cambridge, UK: Cambridge University Press.

Körner, Stephan. (1955). *Kant*. Harmondsworth, UK: Penguin. A basic introduction to Kant's philosophy.

Mayz Vallenilla, Ernesto. (1989). *Fundamentos de la meta-técnica* Caracas, Venezuela: Monte Avila Editores. English translation: *The Foundations of Meta-Technics,* tr. Carl Mitcham. Laham, MD: University Press of America, 2004. A phenomenological analysis of the transition from the technical to the meta-technical forms of space and time.

Mitcham, Carl. (1994). *Thinking through Technology: The Path between Engineering and Philosophy*. Chicago: University of Chicago Press. A critical introduction to the philosophy of technology.

KENNEDY INSTITUTE

SEE *Bioethics Centers.*

KIERKEGAARD, SØREN

Søren Aabye Kierkegaard (1813–1855) was born in Copenhagen, Denmark, on May 5. A prolific author, he produced an impressive series of books devoted to philosophical and religious themes, including a parallel series published under various pseudonyms. He is perhaps best known for his critical engagement with the guiding values of Protestant Christendom in the mid-nineteenth century. Fearing that Christianity had become dangerously enmeshed in the bourgeois malaise sweeping Europe at the time, he urged his readers to aspire to lives of greater passion, intensity, inwardness, and faith. In a sustained provocation that won him few contemporary admirers, he vowed to reintroduce the practice of Christianity into Christendom.

Kierkegaard's most influential pseudonymous work, *Fear and Trembling* (1843), challenges the primacy assigned to the universality of ethical life. With specific reference to the biblical story of Abraham on Mount Moriah, Kierkegaard raises the possibility that some religious obligations may actually trump the recognized ethical obligations of contemporary Christian practice. As indicated, supposedly, by the trial of Abraham, the pursuit of faith may eventually oblige individuals to seek the truth of their existence *beyond* the ethical universal, in the religious sphere. Through his pseudonym, Johannes *de silentio,* Kierkegaard alleges that the "greatness" of Abraham remains an anomaly within contemporary Christian belief and practice. Abraham can be considered "great" only by virtue of his faith, and the most compelling expression of his faith was his decision to obey his God's command to sacrifice his only son Isaac. If Johannes is correct in his analysis, then the "greatness" of Abraham is inextricably linked to his willingness to perform what Johannes calls a "teleological suspension of the ethical," that is, an abrogation of

Søren Kierkegaard, 1813–1855. The Danish philosopher and religious thinker was the progenitor of 20th-century existential philosophy.

his moral obligations in the service of a higher, religious obligation.

Some readers insist at this point that Kierkegaard simply misidentifies or exaggerates the "greatness" of Abraham. Still others allow that Christians continue to honor Abraham only as a symbol of their Judaic prehistory. Yet, the point Kierkegaard raises bears further consideration: Do people not, at least occasionally, admire individuals who exempt themselves from acknowledged moral conventions? If so, how can people persist in their avowed allegiance to ethical universality as the highest expression of human flourishing? Do people not in fact reserve an even higher status for those "knights of faith" who, like Kierkegaard's Abraham, sacrifice morality for a supposedly higher purpose?

As these questions indicate, Kierkegaard's critical engagement with conventional morality was motivated in large part by the overriding value he attaches to the life of authentic individuality. Although conventional morality serves most people, most of the time, as a perfectly adequate expression of their humanity, it proves to be inadequate, and even inhospitable, to those who seek an authentic, singular existence. The individuals whom Kierkegaard most admired find the truth of their existence not outside themselves (for example, in public expressions of the ethical universal), but *within* themselves, in the passion and spirit that constitute their essential inwardness. The greatest expression of inwardness, he further believed, is faith, wherein the individual is raised above the ethical universal and placed in an absolute relationship to God. Kierkegaard thus concluded that conventional morality may actually pose a formidable obstacle to the pursuit of a life of faith.

Kierkegaard rarely commented directly on the rise of modern technology, but his writings are peppered with insights into the subtle ways in which emerging technologies contribute to the overall leveling of social life. The busyness that defines life in the modern epoch is both supported and exacerbated by the introduction of technological wonders, which enable modern people to distract themselves ever more effectively from their spiritual emptiness. While not the cause of the spiritual poverty that Kierkegaard detects around him, technology encourages people to postpone indefinitely the difficult regimen of self-examination and introspection that he prescribed.

Toward the end of his life, Kierkegaard engaged in an increasingly vituperative attack on the Danish state church, which, he believed, had fallen captive to the dispassionate values of bourgeois modernity. Owing in part to the fallout from this attack, he died in disrepute on November 11. Since the time of his death, however, his philosophical reputation has grown steadily. In the early twenty-first century he is widely read for his pioneering contributions to depth psychology; his prescient criticisms of the spread of bourgeois values; his fresh interpretations of Christian faith and practice; his astute observations on contemporary political life; his challenge to ethical universality; and, perhaps most prominently, his spirited defense of authentic individuality.

DANIEL CONWAY

SEE ALSO *Alienation; Existentialism.*

BIBLIOGRAPHY

Arbaugh, George E., and George B. Arbaugh. (1967). *Kierkegaard's Authorship: A Guide to the Writings of Kierkegaard.* Rock Island, IL: Augustana College Library.

Hannay, Alastair. (2001). *Kierkegaard: A Biography.* New York: Cambridge University Press.

Kierkegaard, Søren. (1985). *Fear and Trembling,* trans. and introduction by Alastair Hannay. New York: Viking Penguin.

Kierkegaard, Søren. (1989). *Sickness unto Death,* trans. and introduction by Alastair Hannay. New York: Viking Penguin.

Kierkegaard, Søren. (1997). *Christian Discourses: The Crisis and a Crisis in the Life of an Actress*, ed. and trans. with introduction and notes by Howard V. Hong and Edna H. Hong. Princeton, NJ: Princeton University Press.

KUHN, THOMAS

Historian and philosopher of science, Thomas Kuhn (1922–1996), who was born in Cincinnati, Ohio, on July 18, was perhaps the most influential theorist of science in the second half of the twentieth century. Kuhn received all his degrees (in physics) and his first job at Harvard University, though he failed to be awarded tenure there in 1956, shortly after the departure of his mentor, Harvard President James Bryant Conant. Kuhn was finally tenured at Princeton University in 1964, on the basis of what remains his best known book, *The Structure of Scientific Revolutions* (1962). In 1979 Kuhn moved to the Massachusetts Institute of Technology (MIT), where he eventually retired as Laurence Rockefeller Professor of Philosophy and Linguistics. Essays from Kuhn's Harvard and Princeton years appear in *The Essential Tension* (1977). Essays from his MIT years are collected in *The Road Since Structure* (2000). At the time of his death, in Cambridge, Massachusetts, on June 17, Kuhn had been long working on an update of the perspective first developed in *Structure*.

Kuhn's influence rests mainly on *Structure,* his second book, which departs from the then prominent logical empiricist efforts to understand science through its rational reconstruction in favor of a more historically based appreciation of its internal dynamics. Kuhn presents a theory of scientific change as a cycle of relatively clearly defined phases, centered on the creation, development, and destruction of a *paradigm,* a word that has entered the general vocabulary in the early twenty-first century. For Kuhn, the distinctiveness of science lies in the ability of its practitioners to take hold of the means of knowledge production by agreeing on a theoretical framework, methods, and suitable problems to pursue. Kuhn's protean use of paradigm to cover every aspect of this process has led to much confusion. Nevertheless the overall thrust of his account is clear. *Normal science,* the rather routine pursuit of paradigmatic puzzles, is the heart of the scientific enterprise, and the source of whatever progress science displays. Kuhn's picture was very much at odds with the more heroic Galilean image of scientists as bold destroyers of tradition. On the contrary, for Kuhn, scientists themselves worked within strict traditions of practice that were typically passed down through apprenticeship with master practitioners.

Kuhn's image of science is profoundly conservative, a point overlooked by most of his supporters. To be sure, *revolution* figures in the title of Kuhn's first two books—the first being *The Copernican Revolution* (1957)—and is the basis on which many readers have imagined him to be a *radical* thinker. Nevertheless Kuhn draws on a conception of revolution received from the conservative political tradition, whereby a revolution eventuates in a restoration of natural order. Thus, for Kuhn, revolutions in science happen only as a last resort, when the paradigm can no longer solve the problems it has set for itself. In that case a *crisis* ensues, the result of which is a new paradigm that then provides the basis for a new kind of normal science. Philosophically inspired criticism of fundamental assumptions in science is licensed only once a paradigm is in crisis. Under normal circumstances, scientists take a more *heads-down* approach to their work.

The widespread misunderstanding of Kuhn's theory has been an ironic source of its influence. Although Kuhn himself was careful to restrict the evidence base of his theory to roughly three centuries of the history of the physical sciences (1620–1920), he was quickly read as referring to a pattern of change that could be found in all sciences—even the humanities—across all periods. This misreading is partly due to the fact that Kuhn does not distinguish science by reference to its technological applications or material impact on the world. On the contrary, for Kuhn, a field becomes scientific by becoming autonomous from such external concerns. Thus physics is a science not because it produces real-world effects but because physicists are in full control of the physics research agenda. Many of Kuhn's hopeful readers outside of physics drew the conclusion that their own fields could similarly acquire the status of science by generating their own paradigms. Thus in the early 2000s virtually every discipline outside physics has at least one theorist or methodologist whose reputation is based on the claim of having founded a paradigm of some sort.

In first two decades after it was written, *The Structure of Scientific Revolutions* was subject to much philosophical criticism, especially from Karl Popper and his followers. They questioned the normative backdrop to Kuhn's history of science: Was Kuhn effectively valorizing the most conformist elements of scientific practice? The answer appeared to be yes, but that did not prevent the book from entering the philosophical canon after 1980. Eventually most philosophers took for granted Kuhn's overall account of scientific change, especially his methodological assumption that science needs to be understood from the *inside*, so to speak. A mark of Kuhn's influence on contemporary discussions in the history, philosophy, and sociology of science is the preoccupation with demonstrating one's mastery of the inner workings of a science. In his later years, Kuhn grew closer to the standard philosophical understanding of these matters, while openly dissociating himself from *relativist* and *constructivist* sociologists who claimed to have been inspired by his work.

In taking the measure of Kuhn's legacy, it is puzzling how a physicist with an amateur understanding of the history, philosophy, and sociology of science could have had such a profound impact on these fields, which already enjoyed a relatively high degree of sophistication. In effect, Kuhn's *Structure* offered a historian's sense of philosophy, a philosopher's sense of sociology, and a sociologist's sense of history. That this particular book should have such an enduring impact cannot be explained simply by its content, because many of its supposedly distinctive theses could also be found in the work of contemporaries such as Norwood Russell Hanson, Paul Feyerabend, and Stephen Toulmin. However, unlike them, Kuhn singularly benefited from the patronage of Conant, to whom *Structure* is dedicated. *Structure* was written while Kuhn taught in a general education program that Conant had created to instill faith in science as an autonomous enterprise in a time—the Cold War—when it would be increasingly subject to public scrutiny. This helps explain Kuhn's peculiar inclusions and omissions. As conceptual horizons become detached from Kuhn's Cold War moorings, his work will probably lose its hold on the meta-scientific imagination.

STEVE FULLER

SEE ALSO *Progress; Scientific Revolution.*

BIBLIOGRAPHY

Fuller, Steve. (2000). *Thomas Kuhn: A Philosophical History for Our Times*. Chicago: University of Chicago Press.

Hoyningen-Huene, Paul. (1993). *Reconstructing Scientific Revolutions*. Chicago: University of Chicago Press.

Kuhn, Thomas. (1957). *The Copernican Revolution*. Chicago: University of Chicago Press.

Kuhn, Thomas. (1970). *The Structure of Scientific Revolutions*, 2nd edition. Chicago: University of Chicago Press. First edition published in 1962.

Kuhn, Thomas. (1977). *The Essential Tension*. Chicago: University of Chicago Press.

Kuhn, Thomas. (2000). *The Road Since Structure*. Chicago: University of Chicago Press.

Lakatos, Imre, and Alan Musgrave, eds. (1970). *Criticism and the Growth of Knowledge*. Cambridge, UK: Cambridge University Press.

ENCYCLOPEDIA OF science technology AND ethics

EDITORS AND CONSULTANTS

EDITOR IN CHIEF

Carl Mitcham
Professor, Liberal Arts and International Studies, Colorado School of Mines; Faculty Affiliate, Center for Science and Technology Policy Research, University of Colorado, Boulder

ASSOCIATE EDITORS

Larry Arnhart
Professor, Political Science, Northern Illinois University

Deborah G. Johnson
Anne Shirley Carter Olsson Professor of Applied Ethics and Chair, Science, Technology, and Society, University of Virginia

Raymond E. Spier
Emeritus Professor, Science and Engineering Ethics, University of Surrey

SPECIAL EDITORIAL CONSULTANT

Stephanie J. Bird
Editor, Science and Engineering Ethics

CONSULTANTS

Robert H. Blank
Professor, Public Policy, Brunel University

George Bugliarello
Professor, Civil Engineering; Chancellor, Polytechnic University, Brooklyn

Ruth Chadwick
Professor, Institute of Environment, Philosophy, and Public Policy, Lancaster University, UK

Eric Cohen
Ethics and Public Policy Center

Stephen H. Cutcliffe
Professor, History; Professor and Chair, Science, Technology, and Society Program, Lehigh University

Paul T. Durbin
Professor Emeritus, Philosophy, University of Delaware

Deni Elliott
Poynter Jamison Chair in Media Ethics and Press Policy, University of South Florida

Franz Allen Foltz
Associate Professor, Science, Technology, and Society, Rochester Institute of Technology

Robert Frodeman
Associate Professor and Chair, Philosophy and Religion Studies, University of North Texas

Francis Fukuyama
Bernard L. Schwartz Professor in International Political Economy, Johns Hopkins University

Rachelle Hollander
Baltimore, Maryland

Sheldon Krimsky
Professor, Urban and Environmental Policy and Planning, Tufts University

José Antonio López Cerezo
Professor, Philosophy of Science, University of Oviedo, Spain

Valerie Miké
Clinical Professor, Public Health, Weill Medical College of Cornell University

Helen Nissenbaum
Associate Professor, Culture and Communication, Computer Science, New York University

Roger A. Pielke, Jr.
Professor, Environmental Studies; Director, Center for Science and Technology Policy Research, University of Colorado, Boulder

Michael Ruse
Lucyle T. Werkmeister Professor of Philosophy, Florida State University

Daniel Sarewitz
Professor, Science and Society; Director, Consortium for Science, Policy, and Outcomes, Arizona State University

A. George Schillinger
Professor Emeritus, Management, Polytechnic University, Brooklyn

Paul B. Thompson
W. K. Kellogg Professor of Agricultural, Food and Community Ethics, Michigan State University

Nancy Tuana
Professor, Philosophy; Director, Rock Ethics Institute, Pennsylvania State University

Vivian Weil
Professor, Ethics; Director, Center for the Study of Ethics in the Professions, Illinois Institute of Technology

Caroline Whitbeck
Elmer G. Beamer–Hubert H. Schneider Professor in Ethics, Case Western Reserve University

John Ziman
Emeritus Professor, Physics, Bristol University (dec.)

ENCYCLOPEDIA OF science technology AND ethics

EDITED BY

CARL MITCHAM

volume

3

l–r

MACMILLAN REFERENCE USA

An imprint of Thomson Gale, a part of The Thomson Corporation

THOMSON GALE™

Detroit • New York • San Francisco • San Diego • New Haven, Conn. • Waterville, Maine • London • Munich

THOMSON
GALE

Encyclopedia of Science, Technology, and Ethics

Carl Mitcham, Editor in Chief

For more information, contact
Macmillan Reference USA
An imprint of Thomson Gale
27500 Drake Rd.
Farmington,
Hills, MI 48331-3535
Or you can visit our Internet site at
http://www.gale.com

LIBRARY OF CONGRESS CATALOGING-IN-PUBLICATION DATA

Encyclopedia of science, technology, and ethics / edited by Carl Mitcham.
p. cm.
Includes bibliographical references and index.
ISBN 0-02-865831-0 (set, hardcover : alk. paper)—ISBN 0-02-865832-9 (v. 1) —
ISBN 0-02-865833-7 (v. 2)—ISBN 0-02-865834-5 (v. 3)—ISBN 0-02-865901-5 (v. 4)
1. Science—Moral and ethical aspects—Encyclopedias.
2. Technology—Moral and ethical aspects–Encyclopedias.
I. Mitcham, Carl. Q175.35.E53 2005
503—dc22 005006968

This title is also available as an e-book.
ISBN 0-02-865991-0
Contact your Thomson Gale representative for ordering information.

Printed in the United States of America
10 9 8 7 6 5 4 3 2 1

L

LASSWELL, HAROLD D.

Born in Donnellson, Illinois, Harold D. Lasswell (1902–1978) was an innovator in a number of scientific disciplines and the major figure in developing the policy sciences. The son of a teacher and a Presbyterian minister, he was educated at the University of Chicago, earning a doctorate in political science and then joining the faculty in 1926. In 1938 Lasswell moved to Washington, DC, to serve as a researcher and policy adviser. After the war, as a professor at Yale, Lasswell collaborated with the lawyer legal scholar Myres S. McDougal (1906–1998) and others on law, science, and policy. His broad interests and travels brought him into direct contact with many of the major intellectual and political figures of his time.

Lasswell wrote that "it is growth of insight, not simply of the capacity of the observer to predict the future operation of an automatic compulsion, or of a non-personal factor, that represents the major contribution of the scientific study of interpersonal relations to policy" (1951, p. 524). Insight brings those factors into conscious awareness, leaving the individual free to take them into account in making choices. Freedom through insight often modifies interpersonal relationships; hence, all propositions about those relationships are subject to new insight. Lasswell took the lead in developing the intellectual tools of the policy sciences to integrate and apply natural and social science insight to the fuller realization of human dignity for all, including freedom.

In his presidential address to the American Political Science Association, Lasswell chose "to inquire into the possible reconciliation of man's mastery over Nature [through science-based technologies] with freedom, the overriding goal of policy in our body politic" (1956, p. 961). At the outset he considered atomic weapons in order to entertain the proposition that "our intellectual tools have been sufficiently sharp to enable political scientists to make a largely correct appraisal of the consequences of unconventional weapons for world politics." After using those tools to sketch the kind of analysis that could have been done before the use of atomic weapons in 1945, he concluded that the profession had not institutionalized procedures to anticipate technical developments that had been reported publicly before the war and clarify in advance the main policy alternatives open to decision makers: "As political scientists we should have anticipated fully both the bomb and the significant problems of policy that came with it" (Lasswell 1956, p. 965).

Lasswell qualified this statement of professional responsibility, however: "I do not want to create the impression that all would have been well if we had been better political scientists, and that we must bear upon our puny shoulders the burden of culpability for the state of the world today. We are not so grandiose as to magnify our role or our responsibility beyond all proportion. Yet I cannot refrain from acknowledging . . . that we left the minds of our decision makers flagrantly unprepared to meet the crisis precipitated by the bomb" (1956, p. 965). Moreover, the profession was not responsible for information on the bomb withheld by officials. "We must however assume responsibility for any limitation of theory or procedure that prevented us from making full use of every opportunity open to us" (Lasswell 1956, p. 964).

Turning to the future, Lasswell asserted, "It is our responsibility to flagellate our minds toward creativity, toward bringing into the stream of emerging events conceptions of future strategy that, if adopted, will increase the probability that ideal aspirations will be more approximately realized" (1956, p. 966). Lasswell accepted that responsibility when he applied the intellectual tools of the policy sciences to potential applications of science in production of material goods and evolution of intelligent organisms (including humans) and machines as well as weapons. Particularly creative and prescient were certain remarks on the implications of genetics, embryology, and intelligent machines for evolution (Lasswell 1956, pp. 975–977):

- Because new species already had been created or re-created experimentally, "A garrison police regime fully cognizant of science and technology can, in all probability, eventually aspire to biologize the class and caste system by selective breeding and training."
- Because machines already had solved complex problems, "at what point do we accept the incorporation of relatively self-perpetuating and mutually influencing 'super-machines' or 'ex-robots' as being entitled to the policies expressed in the Universal Declaration [of Human Rights]?"
- Perhaps most disturbing was "the possibility that super-gifted men, or even new species possessing superior talent, will emerge as a result of research and development . . . introducing a biological elite capable of treating us [as] imperial powers have so often treated the weak."

Lasswell concluded by outlining a program of contextual and problem-oriented research using the tools of the policy sciences to address the aggregate effects of any specific innovation: "Our first professional contribution . . . is to project a comprehensive image of the future for the purpose of indicating how our overriding goal values are likely to be affected if current policies continue" (1956, pp. 977–978). The concluding task is "inventive and evaluative. It consists in originating policy alternatives by means of which goal values can be maximized. In estimating the likely occurrence of an event (or event category), it is essential to take into account the historical trends and the scientifically ascertained predispositions in the world arena or any pertinent part thereof."

Lasswell later noted discrepancies between the earlier promises of science-based technology and current reality: "If the promise was that knowledge would make men free, the contemporary reality seems to be that more men are manipulated without their consent for more purposes by more techniques by fewer men than at any time in history" (1970, p. 119). After a diagnosis of such discrepancies, he observed that their potential effects on science are not trivial, "for science has grown strong enough to acquire visibility, and therefore to become eligible as a scapegoat for whatever disenchantment there may be with the earlier promises of a science-based technology." The proposal again called for the perfecting of institutions to apply the intellectual tools of the policy sciences (Lasswell 1971, Lasswell and McDougal 1992) on a continuous basis toward policies to advance human dignity for all.

Relatively few scientists have answered the call despite the continuing relevance of Lasswell's proposal. This may be partly the result of a specialized vocabulary that critics claim is a barrier to the policy sciences. Nevertheless, if more scientists do not come forward, humankind's growing mastery of nature will jeopardize human dignity and the privileged position of science in society.

RONALD D. BRUNNER

SEE ALSO *Freedom; Governance of Science; Political Economy; Political Risk Assessment; Science Policy; Soft Systems Metholology.*

BIBLIOGRAPHY

Lasswell, Harold D. (1951). "Democratic Character." In his *The Political Writings of Harold D. Lasswell*. Glencoe, IL: Free Press.

Lasswell, Harold D. (1956). "The Political Science of Science: An Inquiry into the Possible Reconciliation of Mastery and Freedom." *American Political Science Review* 50, no. 4 (December): 961–979.

Lasswell, Harold D. (1970). "Must Science Serve Political Power?" *American Psychologist* 25(2) (February): 117–123.

Lasswell, Harold D. (1971). *A Pre-View of Policy Sciences*. New York: Elsevier.

Lasswell, Harold D., and Myres S. McDougal. (1992). *Jurisprudence for Free Society: Studies in Law, Science and Policy*. New Haven, CT: New Haven Press; Dordrecht, The Netherlands: Martinus Nijhoff Publishers.

LEIBNIZ, G. W.

Diplomat and court councilor to the house of Brunswick in Hanover, Gottfried Wilhelm Leibniz (1646–1716) was born in Leipzig on July 1. By the age of twenty-one he had earned a doctorate of law and written a *Dissertation on the Art of Combination,* which allowed him to lecture in philosophy. Though he never formally held an academic position (he had jobs as a jurist, librarian, mining engineer, and historian), his duties in Hanover enabled him to travel and meet many well-known thinkers of his time, such as mathematician Christian Huygens (1629–1695), who tutored Leibniz in mathematics during the latter's visit to Paris from 1672 through 1676. While he published several scholarly articles and only one book during his lifetime, the *Theodicy,* his large body of posthumously published work reveals Leibniz's contributions to mathematics, logic, science, law, philosophy, and ethics.

A rationalist, Leibniz exhibited a characteristically modern ambition with an ambitious scientific attempt to create a universal science of all human knowledge, which consisted of a universal, simple (i.e., numerical) language and a formalized calculus for reasoning. Though he eventually acknowledged the impossibility of completing the task because of the perspectivity of human knowing, he pursued this project until the end of his life. Leibniz's crowning achievement was his discovery of the infinitesimal calculus. Although Isaac Newton (1643–1727) discovered the infinitesimal calculus several years earlier, their achievements were independent and Leibniz's system of notation (published before Newton's) continues to be used in the early twenty-first century.

G. W. Leibniz, 1646–1716. Leibniz was a German mathematician and philosopher. Known as a statesman to the general public of his own times and as a mathematician to his scholarly contemporaries, he was subsequently thought of primarily as a philosopher. *(The Library of Congress.)*

To understand Leibniz, one must acknowledge the fundamental premise behind his thought: God created the best of all possible universes by achieving the maximum amount of diversity consonant with unity. This cannot be proven but must be accepted as true for rational inquiry to be possible. From this premise Leibniz identified five basic *a priori* metaphysical principles to guide inquiry: the principle of sufficient reason (for every event or thing there is a reason for its being what it is rather than otherwise) the principle of non-contradiction (that an essence cannot contain opposite properties in the same way at the same time) the principle of perfection (that God always creates by choosing the maximum amount of perfection) the principle of the identity of indiscernibles (that no two things can be identical in all respects save spatial location) finally, the principle of continuity (that there are no "gaps" in the perfection of the created order). In revised version, these premises may still be argued to underlie even empirical scientific research.

Leibniz's scientific method, "the conjectural method a priori," assumes certain hypotheses to demonstrate that natural occurrences follow from them. It is a priori because it relies on his five basic metaphysical principles. Leibniz used it to improve the mechanics of philosopher René Descartes (1596–1650) by distinguishing between speed and velocity, and to criticize Newton's description of force. Moreover, this method was not meant merely for demonstration, but also for technological invention (which motivated Leibniz: for example, he invented a calculator). Most of his technologies nevertheless failed, but many of his proposals foreshadowed later technological developments. For example, he attempted to use windmills to remove water from mines and proposed a system of ball bearings to improve the efficiency of carriage rides.

Leibniz rejected Descartes's metaphysical dualism of mind and matter, and its major scientific presupposition, namely that the physical universe is a *res extensa,* whose causality is exclusively mechanistic. One reason for rejecting matter as the basic element of the universe is its infinite divisibility. This leads to an infinite regress when trying to explain matter, thereby constituting a violation of the principle of sufficient reason. Instead, Leibniz argued for the monad as the most basic element of reality.

Monads are immaterial, "windowless" (that is, there is no causal interaction between monads), microcosms of the universe, the basic activity of which is perception. God harmonizes each monad (which contain all of their predicates analytically) according to his supremely perfect divine plan. Moreover, each person, as a unified collection of monads, has a unique perspective on the universe and, consequently, gets at some degree of truth. Hence, Leibniz insisted that rational inquiry must take place within an intersubjective community.

Leibniz's emphasis on intersubjectivity is reflected in his ethics, which focuses on three concepts: wisdom, virtue, and justice. Wisdom leads to happiness because all moral action must be guided by thought. Happiness is a durable state of pleasure (i.e., understood as perfection). Virtue is the habit of acting according to wisdom, and justice is the charity of the wise person, who pursues the good of others. These are assumed to be the motivations of all technology.

Leibniz's impact cannot be adequately measured. In addition to influencing such thinkers as Immanuel Kant, Edmund Husserl, and the quantum physicist David Bohm, Leibniz's aspirations continue to be a resource for those seeking to reconcile modern science, technology, and ethical responsibilities.

CHRISTOPHER ARROYO

SEE ALSO *Husserl, Edmund; Kant, Immanuel; Theodicy.*

BIBLIOGRAPHY

Collins, James. (1954). "Leibniz." In his *A History of Modern European Philosophy*. Milwaukee, WI: Bruce.

Hostler, John. (1975). *Leibniz's Moral Philosophy*. London: Gerald Duckworth.

Leibniz, Gottfried Wilhelm. (1989). *Philosophical Essays*, trans. Roger Ariew and Daniel Garber. Indianapolis, IN: Hackett.

Leibniz, Gottfried Wilhelm. (1991). *Discourse on Metaphysics and Other Essays*, trans. Daniel Garber and Roger Ariew. Indianapolis, IN: Hackett.

Rescher, Nicholas. (1979). *Leibniz: An Introduction to His Philosophy*. Oxford: Basil Blackwell.

Ross, G. MacDonald. (1984). *Leibniz*. Oxford and New York: Oxford University Press.

LEOPOLD, ALDO

Aldo Leopold (1887–1948), who was born in Burlington, Iowa, on January 11, was a pioneer of the American environmental movement. His essay "The Land Ethic," published in *A Sand County Almanac* (1966 [1949]), has become a foundational text of American environmental ethics. Leopold challenges his readers to reevaluate their relationship to the land they inhabit and act in accordance with a "land ethic" that "enlarges the boundaries of the community to include soils, waters, plants, and animals, or collectively: the land" (Leopold 1966, p. 239). In his work the land and the biotic community become more than symbolic or abstract entities; they become beings with an intrinsic right to exist. Extending ethics and rights to the land, according to Leopold, necessarily "changes the role of *Homo sapiens* from conqueror of the land-community to plain member and citizen of it" (Leopold 1966, p. 240). Leopold died in Baraboo, Wisconsin, on April 21.

Leopold's love of the land began when as a young naturalist he hunted and fished in his native Iowa. He took his interest in the natural world to Yale's School of Forestry in 1904. During his four years at the school founded by Gifford Pinchot (1865–1946), the first director of the U.S. Forest Service, Leopold absorbed the utilitarian philosophy of the early conservationists (Nash 1989). He served in the Forest Service from 1909 to 1928, working in Apache National Forest in Arizona and then managing the Carson National Forest in New Mexico. By 1928 his earlier studies in ecology and practice of game and forest management had taught him to see the world as a web of interrelated systems. He also came to understand the lasting consequences of individual action on the landscape. In "The Land Ethic" Leopold uses the term *biotic pyramid* to describe the dynamic relationships that exist among organisms and their environments. "Land," he argues, "is not merely soil; it is a fountain of energy flowing through a circuit of soils, plants, and animals" (Leopold 1966, p. 253). In 1933 Leopold accepted an appointment in wildlife management at the University of Wisconsin.

The year 1935 was an important one for Leopold: His concern for vanishing American primitive areas led him to cofound the preservationist group the Wilderness Society. Leopold also purchased an abandoned, 120-acre farm in Sauk County, Wisconsin. It was in that setting that Leopold tried to articulate what it means to have an ethical relationship to the land. *A Sand County Almanac*, the record Leopold created of his years on the farm and his maturing environmental philosophy, was published in 1949, a year after he died fighting a fire on a neighbor's farm.

In his short piece "Axe in Hand" from *Almanac* Leopold provides an illuminating vignette on bias, showing how he imagines his relationship to the plants and animals that coinhabit his space and how he executes, sometimes literally, his decisions involving land management. The context for Leopold's dilemma is the felling of a tree; the decision he must make is between the white pine and the red birch, two species that crowd each other in those woods. Leopold examines the biases that influence a conservationist, which he defines as the axe wielder "who is humbly aware that with each stroke he is writing his signature on the face of the land." He is specifically intent on examining the "logic, if any" behind his own biases (Leopold 1966, p. 73). Leopold understands that his biases are a filter through which he passes the details of the landscape, making his world and the objects in it comprehensible.

The examination of individual biases—in this case Leopold's inquiry into his preference for the pine over the birch—forms the first stage in the development of an ethical relationship to the land. What Leopold describes is land as a system with an integrity of its own. The boll weevil, for instance, will or will not attack the pine if certain relations with the birch exist or do not exist. Some plants will thrive and others will not, depending on whether the birch or the pine is there to give them shelter. When the axe wielder enters the scene, he has the potential to disrupt that system. His examination of bias enables Leopold to see all the possible consequences of his actions and act in a thoughtful manner.

In this essay Leopold paints a portrait of a community in which he is as much a part of the environment as are the trees, insects, and birds; he, like them, has a role to play. In "Axe in Hand" Leopold demonstrates what he calls in "The Land Ethic" the "ecological conscience"; that conscience, he writes, "reflects a conviction of individual responsibility for the health of the land" (Leopold 1966, p. 258). Leopold summarized the principle behind the land ethic as follows: "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise" (Leopold 1966, p. 262). Leopold's land ethic forces a reevaluation of the "value" of land broadly conceived and requires that limits be placed on the individual in favor of the health of the biotic community.

TINA GIANQUITTO

SEE ALSO *Environmental Ethics; Multiple Use; Wildlife Management.*

Aldo Leopold, 1886–1948. Leopold was an early environmentalist who laid the groundwork for many of the conservation laws and policies in place today. *(AP/Wide World Photos.)*

BIBLIOGRAPHY

Callicott, J. Baird. (1989). *In Defense of the Land Ethic: Essays in Environmental Philosophy*. Albany: State University of New York Press. See the essay, "Leopold's Land Aesthetic."

Leopold, Aldo. (1966 [1949]). *A Sand County Almanac*. New York: Oxford University Press. Classic text of American environmental ethics; collection of essays detailing Leopold's experiences on his farm and his environmental philosophy.

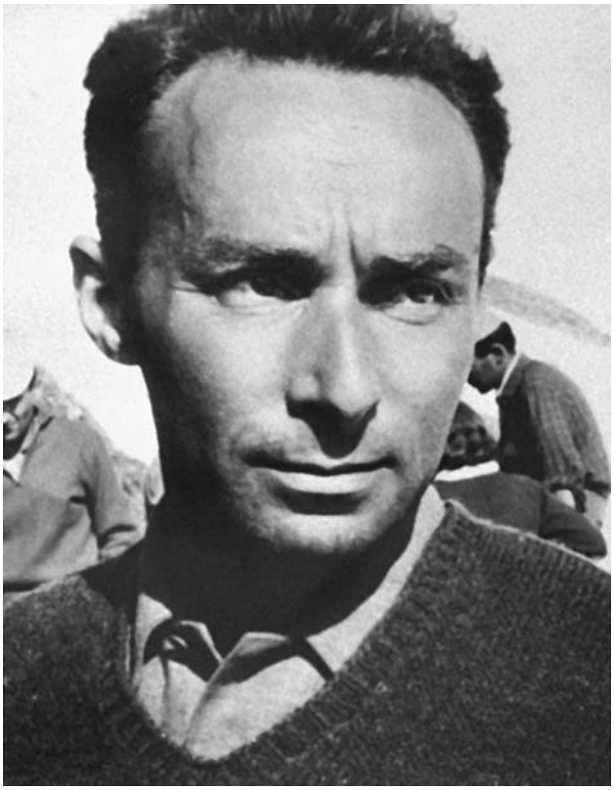
Meine, Curt. (1991). *Aldo Leopold: His Life and Work*. Madison: University of Wisconsin Press. Authoritative biography of Leopold.

Nash, Roderick Frazier. (1989). *The Rights of Nature: A History of Environmental Ethics*. Madison: University of Wisconsin Press. Traces the history of environmental ethics.

Scheese, Don. (1996). *Nature Writing: The Pastoral Impulse in America*. New York: Twayne.

LEVI, PRIMO

Primo Levi (1919–1987) was born to an assimilated Jewish family in Turin, Italy. In 1944, after training as a chemist, Levi joined a group of antifascist partisans, was captured, and was deported to the concentration camp at Auschwitz. He survived and returned to Turin in



Primo Levi, 1919–1987. An Italian author and chemist, Levi was considered one of the foremost writers of concentration camp literature. *(The Library of Congress.)*

1945, at which point he embarked on joint careers as an industrial chemist and an author, publishing the account of his experiences titled *Se questo e un uomo* (If this is a man) in 1947. The book, published in the United States as *Survival in Auschwitz,* is considered to be among the finest accounts of the death camps.

Levi retired from his work as a chemist in 1978 and fell to his death in his Turin apartment building on April 11, 1987. Debate continues about whether Levi, who experienced repeated bouts of depression, killed himself or fell by accident.

Throughout his work Levi stressed the connections between science, literature, and ethics. His use of chemistry as an inspiration for storytelling in *The Periodic Table* (1984) made scientists more attuned to literature and readers of literature more appreciative of science.

One theme unifying Levi's diverse essays and short stories is his belief in the importance and value of work. Levi believed that human beings are naturally constituted to need to work, to strive toward a goal and solve problems encountered in doing so. He emphasized the importance of practice and effort and saw science as a particularly important forum for the struggle to survive and grow.

Levi argued that technology does not necessarily alienate humanity from nature but can enhance the rapport between them. At the same time he emphasized the capacity of humanity for self-transformation, which necessarily means defying and altering nature. He believed that through its inventions humankind has turned its back on nature, damaging both people and the natural world but also improving the lot, and raising the stature, of individuals. Levi argued that one must learn from nature but that one also learns from struggling against it.

Levi eschewed both triumphalism and despair regarding humanity's prospects and the contributions to them made by science. He emphasized that progress will always be noisy, dangerous, and limited. However, because people are adaptable and capable of courage, reason, and strength, progress is possible. Levi celebrated the "cheerful strength" and "sober joy" connected with thought and invention, which allow human beings to endure and learn. He spoke of himself as a man sustained by curiosity about the world and emphasized the value of the inquiry that human curiosity fuels. However, he also acknowledged that the struggle to unlock the secrets of nature through measurement and categorization can be monstrous as well as heroic.

Levi, who was particularly worried by the proliferation of nuclear weapons, called on his fellow scientists and technicians to "return to conscience," to become aware of their immense and potentially sinister power. He insisted that science is not neutral; it either helps or harms human beings. Scientists should not stop doing research for fear of the possible negative consequences of their work, but they should concern themselves with the results of their work and avoid research that leads to immoral results. Scientists should resist the temptation of material rewards and intellectual stimulation, engage in work that will benefit and not harm their fellow human beings, and speak out against the misuse of science by others.

Levi's short stories often satirize the arrogance, ambition, and desire for control or enrichment that can lead scientists to ignore or abandon moral scruples in pursuing and applying knowledge. He warned against submissiveness to power and urged that "a precise moral consciousness" be instilled in scientists as part of their training; he also recommended that scientists take a sort of Hippocratic oath to do no harm (Levi 2001, pp. 71, 89–90).

Levi's reflections on the ethical dimension of science emphasize potential benefits as well as limitations, hope as well as danger, and the joys of discovery as well as moral responsibility. He believed that human beings are alone in a universe not made for their well-being and warned that although science gradually reveals the secrets of the cosmos, those secrets do not provide answers to "big questions" regarding the aims of human life; those answers can come only from within human beings. People's reason for being, he concluded, rests on their nature as, in the words Levi quoted from Pascal, "thinking reeds" who seek knowledge and excellence, and this quest is the source of human dignity.

JOSHUA L. CHERNISS

SEE ALSO *Holocaust; Science, Technology, and Literature; Work; Scientific Ethics.*

BIBLIOGRAPHY

Levi, Primo. (Italian edition 1947; English edition 1961). *Se questo e un uomo* [Survival in Auschwitz: The Nazi assault on humanity], trans. Stuart Woolf. New York: Collier. Reprint, New York: Simon & Schuster, 1996. Levi's first book, an account of, and meditation on, his experiences at Auschwitz.

Levi, Primo. (1966). *Storie naturali.* Selections published in English in *The Sixth Day,* trans. Raymond Rosenthal. Turin: Einaudi; London: Michael Joseph, 1990

Levi, Primo. (1971). *Vizio di forma.* Selections Published in English in *The Sixth Day,* trans. Raymond Rosenthal. Turin: Einaudi; London: Michael Joseph, 1990. A collection of short stories, many of them fantastic parables addressing the moral dimensions of science and technology.

Levi, Primo. (Italian edition 1975; English edition 1984). *Il sistema periodico* [The periodic table], trans. Raymond Rosenthal. Turin: Eidaudi; New York: Schocken. A collection of autobiographical tales and reflections, each one associated with and inspired by an element from the periodic table.

Levi, Primo. (Italian edition 1986; English edition 1989). *Racconti e saggi* [The mirror maker], trans. Raymond Rosenthal. New York: Schocken. A collection of short stories and essays, many of them addressing the ethics of scientific work.

Levi, Primo. (2001). *The Voice of Memory: Interviews, 1961–87,* ed. Marco Belpoliti and Robert Gordon. New York: New Press.

Thomson, Ian. (2002). *Primo Levi.* London: Hitchison.

LEVINAS, EMMANUEL

Emmanuel Levinas (1906–1996), who was born in Lithuania of Jewish parents, studied the Hebrew Bible along with the works of the Russian authors Aleksandr Pushkin (1799–1837), Fyodor Dostoyevsky (1821–1881), and Lev Tolstoy (1828–1910). In 1928 and 1929 he attended the philosopher Edmund Husserl's (1859–1938) lectures in Freiburg, Germany, and started writing a dissertation on Husserl's theory of intuition. He also attended lectures given by the philosopher Martin Heidegger (1889–1976). Levinas was largely responsible for introducing Husserl and Heidegger to French philosophers, most notably Jean-Paul Sartre (1905–1980).

Emmanuel Levinas, 1906–1995. Levinas was a major philosopher of the 20th century who attempted to proceed philosophically beyond phenomenology and ontology and to engage in a more immediate and irreducible consideration of the nature and meaning of other persons. (© *Bassouls Sophie/Corbis Sygma.*)

Levinas's first major work, *Totality and Infinity,* was published in 1961. It was only in the 1980s that a wider audience acknowledged Levinas's work, and his thought eventually became central to postmodern ethics. A number of authors, including philosophers and theorists such as Jacques Derrida (b. 1930), Zygmunt Bauman (b. 1925), John D. Caputo (b. 1940), Robert Bernasconi (b. 1950), and Simon Critchley (b. 1960) adopted his ideas, so that any discussion of ethics outside the analytical tradition would be incomplete without reference to Levinas. This is also true with regard to ethics in science and technology.

Ethics: Not Theory but Happening

For Levinas ethics is not a theory, a rule, an idea, or knowledge of how people ought to act or live. In this sense it can be said that his work falls outside the traditional field of ethical theory. For Levinas ethics is a profound and disruptive event in which the Other disrupts and shatters the self-certain I. Levinas uses the term *Other* (with a capital letter) to refer to the absolute singularity of each human being. Ethics is a disruptive event in which a person's claims to rights and deserts is questioned radically in the face of the infinitely singular person before that individual here and now—the "widow and the orphan." If such persons call on an individual for help or support, that act recalls the individual's guilt, pointing out that that individual has from his or her very beginning taken the place in the sun of the person who has asked for assistance. Levinas would argue that an individual's particular existence has its origin in and through a terrible and violent act seizing the place of the Other who is calling on that individual. This primitive primacy of the individual's guilt, the birth of the ethical question, is Levinas's most profound insight, elaborated in all his works.

Why is the individual already guilty? In taking up his or her personal existential project (to be that particular person), the individual has taken the "place in the sun" of the Other. Further, in making sense of the world and those who cross his or her path, the individual continues to *reduce* the Other to the themes and categories (mother, criminal, politician, manager, man, black, etc) of his or her comprehension. Others become "domesticated" as themes or categories "for-me" through and by the individual's ongoing comprehension of them. This domestication prolongs and extends the violence that began at the birth of a person's individual existential project. Thus, that person has been guilty from the start. For Levinas ethics becomes possible when a person acknowledges that the Other—the particular singular person facing the individual—is infinitely more than any idea (theme, category, attribute) that the individual can use in his or her ongoing comprehension. How, then, can a relationship with the Other be anything but comprehension, how can one encounter the other as Other? Working this out is Levinas's task.

Levinas claims that ethics happens in the "saying" or speaking of language. When the particular Other faces a person and speaks or makes a nonlinguistic gesture, there is more in the words than the message: There is a residue, a trace, of the Other that disturbs the hearer. Levinas uses the familiar event of a doorbell ringing and disturbing one's work and thoughts, but when one opens the door, there is nobody there. Was there nobody there? Did the hearer imagine it? The hearer cannot recall anything but the disturbance. Just when the hearer settles back into his or her thoughts, the doorbell rings again, but there is never somebody there. In the recalling of ethics people are affected without the source of the affection becoming something they can think about as such. It is this relationship of incessantly there but never present that Levinas calls proximity: the disturbing face before the individual that is (re)calling that individual's responsibility. The only recourse in this moment of ethics is to respond, to take up the responsibility for one's original and ongoing violence. For Levinas one is a particular person because one has these particular responsibilities. This is the only possibility for ethics. As he expresses it: "In her face the Other appears to me not as an obstacle, nor as a menace I evaluate, but as what measures me. For me to feel myself unjust I must measure myself against infinity" (Levinas 1996b, p. 58).

Is the individual not also a face? Who will look out for that person? These questions lead to the issue of justice. The radical asymmetrical ethics of Levinas must be reinserted into the symmetrical relationship of justice in which all people are equal before the law. Thus, Levinas claims that it is necessary to add "the third" (all other people) to the relationship of the self and the Other. This is the moment of justice. It involves the need to compare what is never comparable, the dilemma a judge faces in the courtroom every day: to treat all people as equal even though they are absolutely different ("singulars" in Levinas's terminology). Nevertheless, for Levinas the urgency of justice stems from the radical asymmetry of the original ethical relationship. Without such a radical asymmetry—the ethical relationship—the claim of the Other always can be subject to codes, rules, and regulations. Then justice becomes mere calculation and (re)distribution. Thus, justice has its standard, its force, in the proximity of the face of the Other: "The equality of all is born by my inequality, the surplus of my duties over my rights. The forgetting of self moves justice" (Levinas 1991 (1974), p. 159).

Implications for Science, Technology, and Ethics

Levinas's ethics is important in thinking about ethics more generally. One could say that it is a call to rescue ethics from theory. Nevertheless, Levinas's work is particularly important to science and technology. In the epistemological categories of science and the mechanisms and algorithms of technology the absolute singular (the individual particular person) does not fit well. One could see how the singular person becomes a subject, subjected to the logic of the method. In the mechanisms and algorithms of technology the individual person can become an exception (perhaps an error) to be discarded in favor of the categories those technologies rely on for their smooth operation.

Given this seemingly obvious conclusion one could draw from Levinas' ethics above, it is surprising to find that Levinas (1990) takes a very positive view of science and technology. In discussing the space program he argues that science and technology strips nature of its divine pretentions, thereby allowing humans to harness it in the service of humanity. Nevertheless, such a view that posits science and technology as neutral 'tools' that can and ought to be applied in the service of humanity denies the value ladenness of science and technology as well as the political structures within which these human endeavours function. Thus, as Peperzak (1997) argues: "the inherent violence of technology cannot be overcome by technological practice. The micro-ethical practice of persons who are well disposed to others, nature, and art, notwithstanding the distorting networks in which these people function, can point the way towards a better disposed constellations of justice, technological utility, and natural beauty" (p. 143).

Thus, ethically minded designers of technology must ask which categories they assume when they are designing. What about those who do not fit? Moreover, as people apply science and technology in the ordering of society, many singular faces may suffer as they fall through the cracks of method and machine. Does that mean that science and technology are inherently violent? Levinas (1990) would argue that this is necessary violence in the service of freedom and justice. Nevertheless, in its service of justice the ultimate measure should be the proximity of the face of the Other; without this standard it would pursue its path as pure violence.

One could say that Levinas's ethics leaves humankind with plenty and with nothing. The call of the Other is powerful, but how can it be worked out in every instance? Ethical theories such as utilitarianism and consequentialism provide resources to decide what one ought to do in a particular case. However, according to Levinas, all people are guilty and must respond, yet when they respond, they may perpetuate violence. Derrida (1992) claims that Levinasian ethics is impossible because it provides no clear answer or procedure for deciding what to do. This, paradoxically, is an answer. It is the impossibility of ethics that provides the urgency of ethics and interrogates every decision. If making ethical decisions were possible through the use of a rule or procedure, people might forget the plight of the particular individual, the Other. Impossibility is what keeps people open to the possibility of encountering the other as Other in every situation. For Derrida and Levinas it is impossibility that makes ethics possible.

Is Levinas's ethical system anthropocentric? Can other animals and other things have a face? Are they also absolute singulars? Does Levinas deny a responsibility toward nonhuman others? A number of authors have argued against Levinas's ethics on these grounds. Feminist authors have stated that his work is based on the predominant view of the male ego of autonomy and competition as opposed to the female ego of affiliation, empathy, and nurturing (Chanter 1988). Deep ecologists have argued against his exclusion of nature from the realm of morality (Gottlieb 1994). Levinas scholars such as John Llewelyn (1991) and Adriaan Peperzak (1997) have responded to these criticisms. In contrast to these critical comments, Benso (2000), with the help of Heidegger, uses Levinas to make a powerful argument for an "ethics of things." Such an approach points toward the application of Levinas's thought to science, technology, and ethics.

LUCAS D. INTRONA

SEE ALSO *French Perspectives; Heidegger, Martin; Phenomenology.*

BIBLIOGRAPHY

Benso, Silvia. (2000). *The Face of Things*. Albany: Sate University of New York. Presents an argument for the "enlargement" of Levinas's ethics to include objects.

Chanter, Tina. (1988). "Feminism and the Other." In *The Provocation of Levinas: Rethinking the Other*, ed. Robert Bernasconi and David Wood. London: Routledge. A feminist response to the ethics of Levinas.

Derrida, Jacques. (1992). "Force of the Law: The 'Mystical Foundation of Authority.'" In *Deconstruction and the Possibility of Justice*, ed. Drusilla Cornell, Michel Rosenfeld, and David Gray Carlson. London: Routledge. An important essay that draws on Levinas's ethics to give an account of the way ethics interacts with the question of justice.

Gottlieb, Roger S. (1994). "Ethics and Trauma: Levinas, Feminism, and Deep Ecology." *Cross Currents* 44(2): 222–240.

Levinas, Emmanuel. (1969 [1961]). *Totality and Infinity*, trans. Alphonso Lingis. Pittsburgh: Duquesne University Press. This book is Levinas's first major account of his ethics.

Levinas, Emmanuel. (1990) "Heidegger, Gagarin and Us." In *Difficult Freedom: Essays on Judaism*, trans. S. Hand. London: The Athlone Press, 231–234. This is the only essay where Levinas explicitly addresses the question of science and technology.

Levinas, Emmanuel. (1991 [1974]). *Otherwise Than Being or Beyond Essence*, trans. Alphonso Lingis. Dordrecht, Netherlands: Kluwer Academic. This book is the later, and more subtle account of Levinas's ethics.

Levinas, Emmanuel. (1996a). "Ethics as First Philosophy." In *The Levinas Reader*, ed. Sean Hand. London: Blackwell. A very good, succinct account of why Levinas's ethics is so radically different from traditional ethical theory.

Levinas, Emmanuel. (1996b). "Philosophy and the Idea of Infinity." In *Collected Philosophical Papers: Emmanual Levinas*, ed. Alphonso Linis. Bloomington: Indiana University Press.

Llewelyn, John. (1991). "Am I Obsessed by Bobby? (Humanism of the Other Animal)." In *Re-Reading Levinas*, ed. Robert Bernasconi and Simon Critchley. Bloomington: Indiana University Press. Addresses the question of the applicability of Levinas's ethics for other animals.

Peperzak, Adriaan Theodor. (1997). *Beyond: The Philosophy of Emmanuel Levinas*. Evanston, IL: Northwestern University Press. Comprises of a number of essays on Levinas's philosophy. It serves as a very useful introduction written in an accessible style.

LEWIS, C. S.

Novelist, critic, poet, essayist, and Christian apologist Clive Staples Lewis (1898–1963) was born in Belfast on November 29, served in France, and was wounded during World War I. He completed his undergraduate studies at University College, Oxford, in 1922, and from 1925 until 1954 was a Fellow of Magdalen College, Oxford, and tutor in English. From 1954 until just before his death he was Professor of Medieval and Renaissance Literature at Cambridge.

Lewis once wrote that although he was a rationalist who had *scientific impulses*, he could have never been a scientist. He considered the role and direction of science for nearly three decades and mentioned and alluded to it in many of his works. He was aware of its limitations and methodology, and was respectful of its status as a type of knowledge that could be used for the benefit of humanity. Lewis praised genuine scientific accomplishment and said that scientific reason, if accurate, was valid, although it was not the only kind of reasoning. Truth, value, meaning, and other ideals were necessary presuppositions to the scientific method but were not themselves scientific phenomena.

Lewis was sometimes accused of being unscientific and discrediting, or even attacking, scientific thinking. In reality he criticized what he called *scientism*, a reductionist outlook on the world that popularized the sciences. Scientism (*science deified*) occurred when a naturalistic worldview was linked to the empirical method of experimentation. Scientism as radical empiricism rejected the truth of a nonquantifiable reality such as God.

C. S. Lewis, 1898–1963. An author and scholar, Lewis is known for his work on medieval literature and for his Christian apologetics and fiction, especially *The Chronicles of Narnia*. *(AP/Wide World Photos.)*

Lewis saw the Genesis creation accounts as non-literal folk tales or myths. In *The Problem of Pain* (1940), he presented a modified view of creation and the Fall because scientific evidence that "carnivorousness was older than humanity" had led him to believe that evil had manifested itself long before Adam (Lewis 1940, p. 121). He had a theistic view of evolution but resisted attempts to draw broad philosophical implications from various scientific theories of it. He was never directly opposed to science, but believed many scientific theories were tentative and dependent on changing presuppositions and *climates of opinion*. Early evidence from his letters indicate that he denied that biological evolution was incompatible with Christianity; in later letters he became increasingly pessimistic about evolutionism as a progressive philosophy. Earlier he felt that the theory of evolution was often held because of dogmatic, not scientific reasons, but he never gave up his long-held view that biological evolution was compatible with Christian accounts of creation. He opposed evolutionism as a philosophical theory, not evolution as a biological theory.

In many of his writings Lewis tried to redefine the role of science and its proper role in society. He believed that scientism was in error in that it reduced life to abstractions and denied the possibility that physical events and human experiences had God behind them. He observed that since scientism was only concerned with how things behave, it was not qualified or capable of *looking behind things*, particularly the power behind the universe.

In his much-praised defense of natural law, *The Abolition of Man* (1943), Lewis discussed the possibility of a world that no longer believed in objective truth and value. He saw this as possibly leading to a power struggle in which societal elites tried to control and recondition society. "Man's conquest of Nature, if the dreams of some scientific planners are realized, means the rule of a few hundreds of men over billions and billions of men . . . Each new power won *by* man is a power *over* man as well" (Lewis 1955, p. 70).

Many of Lewis's ideas in *The Abolition of Man* were expressed dramatically in his space novel *That Hideous Strength* (1945). In the story, the degeneration of humanity nearly occurs as a result of a gross scientific materialism controlled by bureaucrats that is devoid of all idealistic, ethical, and religious values. Lewis satirized materialistic scientists in *That Hideous Strength* by showing them as ignoring metaphysical reason and refusing to submit their claims to any kind of moral or religious authority.

He wrote his trilogy of space novels (the others being *Out of the Silent Planet* [1938], and *Perelandra* [1943]) as a result of reading Olaf Stapledon's (1886–1950) *Last and First Men* (1930) and the Cambridge biochemist J. B. S. Haldane's (1892–1964) essay "Man's Destiny" (1927), both of which took interplanetary travel seriously but contained an immoral outlook that denied God. He was openly critical of Stapledon's fictional universes, in which science represented the greatest good and Christian ideals played no essential role. After reading Stapledon's *Star Maker* (1937), Lewis said that the race Stapledon described was concerned primarily for the increase of its own power by technology, a technology that was indifferent to ethics, and a *cancer in the universe*.

PERRY C. BRAMLETT

SEE ALSO *Anglo-Catholic Cultural Criticism; Christian Perspectives.*

BIBLIOGRAPHY

Aeschliman, Michael D. (1998). *The Restitution of Man: C. S. Lewis and the Case against Scientism.* Grand Rapids, MI: Eerdmans. A succinct examination of Lewis's role as spokesman for the classical Christian philosophical tradition that has opposed scientific materialism since the seventeenth century.

Lewis, C. S. (1940). *The Problem of Pain.* London: Geoffrey Bles.

Lewis, C. S. (1955). *The Abolition of Man.* New York: Collier Books.

Lewis, C. S. (1996). *That Hideous Strength.* New York: Scribner.

Philmus, Robert M. (1972). "C. S. Lewis and the Fictions of Scientism." *Extrapolation* 13(2)(May): 92–101.

Sammons, Martha D. (1976). "C. S. Lewis's View of Science." *CSL: The Bulletin of the New York C. S. Lewis Society* 7(10)(August): 1–6.

Schultz, Jeffrey D., and John G. West Jr., eds. (1998). *The C. S. Lewis Readers' Encyclopedia.* Grand Rapids, MI: Eerdmans. See particularly entries on M. D. Aeschliman, "science," Perry C. Bramlett, "the fall," Thomas Howard, "that hideous strength," Thomas T. Talbott, "the problem of pain," John G. West, Jr., and "the abolition of man."

LIBERALISM

Liberalism as a theory about politics and society upholds freedoms of belief, inquiry, expression, action, association and elections. In liberalism, freedom coalesces with value-commitments to equality, individualism, toleration, pluralism, and rationality. All of these commitments have interacted with science and technology in multiple ways.

Classical Liberalism

Liberals differ over determining the nature of freedom. Isaiah Berlin's distinction between negative and positive freedoms (freedom *from* as against freedom *to*) is useful in explaining the difference between classical and modern forms of liberalism.

In classical liberalism, freedom is interpreted in terms of a *private* sphere of non-interference that is supported by the rule of law. Free agents are protected from arbitrary interference, being left to enjoy their possessions, to retain personal beliefs, and to act in preferred ways on the condition that they respect the freedom of others to do the same. Support for private property and free markets goes hand in hand, in classical liberalism, with a prescription that power (economic as well as political) be divided so as to alleviate the risk of its being abused.

John Locke (1632–1704), whose *Second Treatise of Civil Government* (1690) started the tradition of liberal thought, encapsulated classical liberalism in stating that "Liberty is to be free from restraint and violence from others which cannot be, where there is no Law" (1960, p. 324). Locke's form of liberalism supported parliamentary government and the rule of law in England against absolute monarchy.

Among French thinkers, Charles de Secondat, Baron de Montesquieu, in *The Spirit of the Laws* (1748), praised the English constitution for its separation of the powers of government and reflected adversely on the absolutism of the French monarchy. Tolerance, aversion to fanaticism, and advocacy of freedom of discussion and of the press characterize the writings of the eighteenth-century *philosophes,* including Marquis de Concordet and Francois-Marie Voltaire. After the turmoil of the French Revolution and of Napoleon Bonaparte's rule, Benjamin Constant (1767–1830) and Francois Guizot (1787–1874) conceived of a liberalism that was conservative and admiring of English political institutions, while Alexis de Tocqueville (1805–1859) warned that democracy gives no guarantee of freedom and might end in tyranny.

Pre-eminent among German liberals, Immanuel Kant (1724–1804) conceived of liberty as the will determining itself according to its rational law, converting pure reason into practical reason. Kant's state is a legal organization, *limited* in its role of ordering legal rights, reconciling the free will of each individual with that of all others. The sphere of morality, for Kant, consists in individual conscience as the judge of the righteousness of acts. In 1927 Guido de Ruggiero contended that Kant's liberalism served to constrain the exercise of power in Germany through the nineteenth century because, "even in periods of the strictest absolutism," governments were checked "by a profound consciousness of" being restricted to the sphere of rights (de Ruggiero 1927, p. 220). In his *Essay on the Limits of the Action of the State* (1851), Wilhelm von Humboldt argued that the worthy faculties and qualities of individuals only develop in an environment that a minimalist state protects as free and pluralist. In Germany, as in France, liberals were nowhere near as committed to the market economy as were their English counterparts.

Among the sources of nascent U.S. liberalism was Locke with his ideas of natural rights, government by consent, and the entitlement of subjects to revolt against a government that betrays their trust. French *philosophes* could envision human perfectibility, but the liberals who contributed to the formation of the U.S. republic were skeptical. Their understanding of human nature derived from the Scottish Enlightenment: Adam Ferguson, David Hume and, particularly, Adam Smith who, in *The Wealth of Nations* (1776), argued for capitalist economics (the price mechanism as a beneficent *invisible hand*), the rule of law in a constitutional order, and equal freedom. Smith believed that a strong presumption exists against governmental activity, but his advocacy of laissez faire was not doctrinaire. A rule of thumb with Smith was that government should arrange social conditions in ways that would assist the market to provide public services; Jeremy Bentham and his circle embraced this theory. Adopting the principle of utility as his axiom, policies being calculated to advance the greatest happiness of the greatest number in society, Bentham inferred that joint stock companies should bid for government contracts to operate public institutions (prisons and poor houses).

Modern Liberalism

The emphasis in *modern* liberalism is placed on freedom as empowerment (freedom *to*). There has been no closer approximation to the ideal type of classical liberal society than nineteenth-century England in the era of William Gladstone and Richard Cobden. Nevertheless, after the reform of Parliament in 1832, governments in England—partly from the impetus received from Benthamite utilitarianism—became more active: reforming the administration of the poor law and of public health; regulating working hours, the police, and inspection of factories; and overhauling the civil service and local government.

Liberal thought in England also underwent a major revision with Lionel Hobhouse in 1911 describing the *liberal socialism* of John Stuart Mill (1806–1873) as the link *between the old and the new liberalism.* The *new liberalism* of the Hegelians Thomas Hill Green (1836–1882) and Bernard Bosanquet (1848–1923), appreciated the value of freedom as a positive power and recommended a more constructive mode of government. Agreeing with Mill that the core of liberalism consists in the "liberation of ... [the] spiritual energy" of agents (Hobhouse 1911, p. 137), Hobhouse proposed that the state should act so as to secure the economic conditions that would enable individuals to develop their faculties and to fully participate in the life of the community.

Two world wars and the intervening Great Depression led governments to assume a greater role in European and North American societies. John Maynard Keynes's *General Theory of Employment* (1936) explained how governments should use their fiscal powers of taxing and spending to regulate economic activity and control money supply as a means of mitigating the business cycle and unemployment.

In 1935, in the United States, John Dewey (1859–1952) expressed hostility to the free market order and its disparities in wealth. The Humboldt-Mill ideal of individual development as grounded in freedom that had impressed Green and Hobhouse was assimilated by Dewey and by many other liberal philosophers through the twentieth century. Dewey saw the ends of liberalism—"liberty and the opportunity of individuals" to fully realize "their potentialities"—as requiring governmental planning of "industry and finance" (1963, p. 51, 55).

The ideal of individual development is discernible in the most important work of liberalism to appear in the second half of the twentieth century, John Rawls's *A Theory of Justice* (1971). Arguing for redistribution and the welfare state, Rawls relied on principles of liberal justice. One of Rawls's tenets attributes freedoms of conscience, conduct, and religion to citizens; his other basic belief dictates that a redistribution of resources may only take place on the condition that the least well-off members of society will benefit from it. As a corollary, inequalities determined by an agent's social circumstances, and by that person's talents and abilities, are deemed to be illegitimate.

Prominent among the responses to Rawls's Kantian liberalism is *communitarianism*. Michael Sandel in *Liberalism and the Limits of Justice* (1982) demurred to Rawls's use of an abstracted individual to reason about justice, envisaging the self as being socially formed, and the individual as exercising reason only within the community.

The term *modern* liberalism does not mean that classical liberalism is an anachronism. The writings of neoliberals—Ludwig von Mises, Friedrich Hayek, Ayn Rand, and Milton Friedman—that influenced the governments of Margaret Thatcher and Ronald Reagan, confirm the durability of the classical liberal position. Neoliberals argued that the meliorist activity of democratic governments must be kept to a minimum if liberal societies are to avoid what Hayek sign-posted as *the road to serfdom*.

The distinction between classical and modern liberalisms is not a sharp one, the positions shading off into each other. Walter Lippmann (1889–1974), for example, was convinced that many services in modern society can only be provided by large governmental enterprises and he defended a redistribution of wealth as socially stabilizing. Lippmann held with the ideals of Smith, however, which turned him against Franklin Roosevelt's New Deal and other forms of *collectivism*. The political thought of Karl Popper (1902–1994) can be located with Lippmann's near the middle of the continuum between classical and modern liberalisms.

Science and Technology as Supporting the Achievement of Liberal Ideals

Liberalism and science have commonly been seen as buttressing each other. While recognizing that scientific research needed governmental funding, liberals argued that because scientists are experts in research they should be free to select their topics of, and methods for, research. In the 1940s, Michael Polanyi defended the autonomy of science against Soviet-style planned research, and Popper supported free inquiry by showing that knowledge advances in an unpredictable manner. Like Polanyi and Popper, Robert Merton depicted science as an exemplary liberal community, highlighting norms of universalism, communalism, disinterestedness, and organized skepticism.

Since the detonation of the atomic bomb, with the proliferation of weapons of mass slaughter and with the deterioration of the environment, even liberals have become ambivalent toward science and technology, although most remain sure that science and technology are conducive to liberal values. Without science and technology, liberals argue, freedoms of modern society—of the press and of the airwaves, for example—would be attenuated. Freedoms of election and association benefit from electronic communications and rapid transport. The technology of publishing serves the marketplace of ideas, and media technology helps in checking the power of government. Travel and the mass media expose more people to foreign cultures, encouraging tolerance of ethnic and cultural diversity. Dissemination of information by way of the Internet assists people in making free choices on matters of health, religion, education, and politics. In contributing to the material conditions of life that underlie the enjoyment of all liberties, science and technology have helped people, particularly in Europe and North America, to live longer, suffer less pain, and enjoy better health and greater comfort.

Science and Technology as Impeding the Attainment of Liberal Ideals

Much of the liberal image of science is out of date. In the early twenty-first century most scientists are a part of *big science*. Typically research is conducted by large teams, is capital-intensive, and is shrouded in secrecy because most scientists aim at producing innovations for industrial and governmental sponsors. While liberals are correct in claiming that science ails when governments and corporations instruct scientists on how to conduct their research, the fact remains that governmental controls on scientific research have become more stringent.

Science and technology may support the liberal values of freedom and tolerance, but in a number of ways they also *standardize* culture and social practices, as James Scott has argued. Paul Feyerabend (1924–1994) examined the idolization of science and technology—scientism and the cult of the expert—that so often takes responsibility away from laypeople and leads to the denigration of non-scientific beliefs and practices. In the first half of the nineteenth century, liberals (Tocqueville, Humboldt, and Mill) worried that newspapers and railways were creating a social *mass* that was hostile to individuality, diversity, and freedom. Concern about technology and the masses was also voiced by Max Weber (1864–1920) and José Ortega y Gasset (1883–1955). In the twentieth century, assembly line mass production and deskilling of the workforce in accordance with the precepts of Frederick Winslow Taylor's *scientific management* gave further impetus to standardization.

Social elites of scientists and technologists have privileged access to government policy makers and to funding agencies. They promote and benefit from scientism and standardization, having a major say over the curriculum and attracting the lion's share of resources for research in their fields.

In the hands of governments and corporations, modern science and technology have intruded deeply into the *private realm*. Although totalitarianism provided the most graphic evidence of mental regimentation by the electronic mass media, the mass media in democracies have been accused of *manufacturing consent*, indoctrinating consumers, and promoting irrationality. Computers and other information handling systems, security cameras, wire taps, and interception of on-line communications represent technologies that subject a citizenry to electronic *surveillance*.

STRUAN JACOBS

SEE ALSO *Civil Society; Communitarianism; Conservatism; Democracy; Lock, John; Merton, Robert; Mill, John Stuart; Neoliberalism; Polanyi, Michael; Popper, Karl; Rawls, John.*

BIBLIOGRAPHY

Arblaster, Anthony. (1984). *The Rise and Decline of Western Liberalism*. Oxford: Basil Blackwell. A major critique of the tradition.

Bellamy, Richard. (1992). *Liberalism and Modern Society*. Cambridge, UK: Polity Press.

de Ruggiero, Guido. (1927). *The History of European Liberalism*, trans. R. G. Collingwood. London: Oxford University Press. A classic study of liberal theory and practice up to the early twentieth century.

Cranston, Maurice. (1967). *Freedom*, 3rd edition. London: Longmans.

Dewey, John. (1963). *Liberalism and Social Action*. New York: G. P. Putnam's Sons. Diagnosis of, and prescription for, the ills of liberalism during the Great Depression.

Feyerabend, Paul (1975). *Against Method*. London: New Left Books. How to liberalize science.

Gray, John. (1986). *Liberalism*. Minneapolis: University of Minnesota Press.

Greenleaf, W. H. (2003). *A Much Governed Nation*. London: Routledge. Part of his magisterial history of liberalism in England.

Hart, David. (1998). *Forged Consensus: Science, Technology, and Economic Policy in the United States, 1921–1953*. Princeton, NJ: Princeton University Press.

Hobhouse, Lionel. (1911). *Liberalism*. London: Thornton Butterworth. The evolution of liberal thought in the second half of the nineteenth century.

Locke, John. (1960). *Two Treatises of Government*. Cambridge, England: Cambridge University Press. The great source of liberal ideas.

Manent, Pierre. (1994). *An Intellectual History of Liberalism*, trans. Rebecca Balinski. Princeton, NJ: Princeton University Press. Instructive on the development of French liberalism.

Manning, D. J. (1976). *Liberalism*. London: J. M. Dent & Sons.

Massimo, Salvadori. (1977). *The Liberal Heresy*. London: The Macmillan Press. Wide-ranging; somewhat uncritical.

Mulhall, Stephen, and Adam Swift. (1996). *Liberals and Communitarians*. Oxford: Blackwell. Careful examination of recent theories.

Ryan, Alan. (1995). *John Dewey and the High Tide of American Liberalism*. New York: W. W. Norton. A scholarly account of the career of Dewey.

Scott, James. (1998). *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed*. New Haven, CT: Yale University Press. The case against sweeping radicalism.

LIBERTARIANISM

Libertarianism is the belief that one has the right to dominion over one's own person, including the fruits of one's labor. Adults are entitled to make their own decisions and agreements. Coercion, particularly by the government, is wrong.

In contemporary American politics libertarians side with the far left in favoring personal freedom and side with the far right in favoring economic freedom. Thus, libertarians argue for the decriminalization of recreational drug use on the grounds that adults should have the right to make choices about their bodies. Libertarians oppose a national health care system as coercive and inevitably interfering with the rights of individuals to make their own choices about health care.

Libertarians view other ideologies as overly paternalistic. Politicians routinely begin a sentence with "We must," as in " We must reduce our dependence on foreign oil" or "We must spend more on education." A libertarian asks, "Who is this 'we'?" Libertarians argue that individuals can decide for themselves how much to spend on their own education. Moreover, people who want to see others obtain more education are free to donate funds for that cause. To libertarians "We must spend more on education" translates into "The government is going to coerce individuals into paying for their own or others' education."

For many people economic freedom is justified on utilitarian grounds. Those individuals endorse free markets because markets deliver economic growth and a high average standard of living. For libertarians economic freedom is justified on first principles. Even when government regulation is intended to make people better off, libertarians oppose such regulation as coercive. Thus, libertarians would not endorse most regulation carried out in the name of protecting consumers, preferring instead that consumers be expected to protect themselves.

Libertarianism faces a number of challenges. First, libertarians must establish the boundaries between freedom and coercion. In theory, one person's freedom can negate another's. The libertarian solution to this problem is to focus on property rights. If a person's property is clearly defined, no one may take that property without that person's consent. The libertarian's ideal role for government is to enforce property rights and nothing else.

Second, libertarianism is criticized for taking social institutions and cultural norms for granted. That is, libertarians speak as if society could function with only markets as institutions. However, markets operate in a context of cultural values and government protections, and chaos would result if those protections were taken away.

On the left critics of libertarianism argue that without social welfare programs the poor might turn to crime or armed insurrection. Without public education people might not acquire the basic tools needed to function in and maintain their society. On the right critics of libertarianism argue that individual morality is too fragile to prevail in the noncoercive environment favored by libertarians. Without the restraints imposed by religion, social opprobrium, and legal sanction people's behavior would degenerate, ultimately reaching the point where they no longer were capable of respecting themselves or one another.

Third, libertarianism is criticized as an ideology that ignores inequality and scorns the disadvantaged. This line of criticism is embedded in lines such as "The rich man and the poor man have equal freedom to sleep in the gutter" and "Freedom of the press exists only if you own one" (the second quote is attributed to the journalist A. J. Liebling).

These critics argue that property rights are not sufficient to make everyone free. They suggest that those born without sufficient endowments of land, capital, and aptitude are at the mercy of the powerful even in the absence of coercion. In response libertarians argue that government programs enacted for the benefit of the disadvantaged often are counterproductive, circumscribing freedom without aiding the intended beneficiaries.

History of Libertarianism

Libertarianism has its roots in Enlightenment philosophy, particularly the writings of the philosopher John Locke (1632–1704). Locke argued that dominion over one's own body and one's own property is a natural right. Locke viewed government as legitimate only if it has the consent of the governed. In Chapter 8 of the *Second Treatise on Government* Locke wrote, "The only way whereby any one divests himself of his natural liberty, and puts on the bonds of civil society, is by agreeing with other men to join and unite into a community for their comfortable, safe, and peaceable living one amongst another, in a secure enjoyment of their properties, and a greater security against any, that are not of it." Locke was a major influence on the founders of the United States, who embodied the contractual theory of government in the U.S. Constitution. The U.S. Bill of Rights also reinforced libertarian ideas of natural rights.

Another major libertarian work is *On Liberty* by the philosopher John Stuart Mill (1806–1873). Mill argued that social condemnation could be as oppressive as government coercion.

In the twentieth century one of the most important libertarian thinkers was Friedrich Hayek (1899–1992), who argued against the dominant view that a modern economy requires central planning and a welfare state. Hayek believed that the price system, fed by local information in markets, is more efficient than any central planner. For him the coercion required to implement the welfare state would undermine freedom and thus was *The Road to Serfdom* (1944).

The Internet and Libertarianism

In 1996, John Perry Barlow, a writer and activist in the Electronic Freedom Foundation (EFF), composed "A Declaration of the Independence of Cyberspace," which argued that government should adopt a hands-off approach with respect to the Internet. Barlow's declaration exemplifies the symbiotic relationship between the Internet and libertarian thinking. Barlow's words contain echoes from Locke ("We are forming our own Social Contract."), Mill ("We are creating a world where anyone, anywhere may express his or her beliefs, no matter how singular, without fear of being coerced into silence or conformity."), and Hayek ("our culture, our ethics, or the unwritten codes that already provide our society more order than could be obtained by any of your impositions") (quoted in Barlow 1996, Internet site).

The Internet is, like the U.S. Constitution, designed as an agreement among consenting individuals. It is a set of communication protocols that allow data to be transmitted from one computer to another. Any communication that uses Internet Protocols (IP) can be sent over the Internet. The protocols impose only minimal constraints on the information that can be transmitted. Video, telephony, text, and data all can be sent via IP.

The Internet is also decentralized. No single computer acts as a hub or main distribution point. Instead, like Hayek's spontaneous order, the Internet relies on local information, contained in routing tables, to pass data from any computer on the network to another. Also, the Internet is configured to facilitate anonymity. This tends to shift the balance of power away from government officials and toward individuals. As a result it has proved all but impossible to regulate pornography and junk mail on the Internet.

The Internet was designed to have multiple routes between endpoints, which makes it more difficult both to attack militarily and to regulate. John Gilmore, a libertarian Internet activist, famously said, "The Internet interprets censorship and damage, and routes around it."

Personal computers and the Internet have changed the relationship between individuals and large organizations. One does not need to own a printing press to publish ideas that can reach the masses. One does not need to lease stores to sell goods to people all over the world. One does not need a mainframe computer costing millions of dollars to write a piece of software.

Because individuals are now better able to bypass large organizations, the rationale for government intervention as a check against corporate power has lost its appeal to many people who make a living using computers and the Internet. In *Cyberselfish*, a critical survey of libertarianism in the technology community, the journalist Paulina Borsook wrote that "with geeks, the attitude, mind-set, and philosophy is libertarianism" and "libertarians are the most vocal political thinkers and talkers in high tech" (Borsook 2000, pp. 3 and 7).

Intellectual Property

The low cost of distributing and copying content on the Internet has opened a schism within the libertarian community concerning the issue of intellectual property. Some libertarians argue that intellectual property rights are legitimate, based on Locke's principle that one has a natural right to property created by one's labor. According to this view, if one composes a song or another creative work, one has a property right that should be protected.

Other libertarians, including Barlow, believe that ideas should not to be regarded as property. One person can use an idea without infringing on another person's ability to use that idea. Barlow argues in the tradition of Thomas Jefferson, who wrote, "He who receives an idea from me, receives instruction himself without lessening mine; as he who lights his taper at mine, receives light without darkening me" (Quoted in Barlow 1996, Internet site).

A potential libertarian approach to the issue of copyright is Digital Rights Management (DRM). The idea behind DRM is that the composer of a creative work would embed in its digital representation a digital "lock" that could be opened only by a consumer who agreed to purchase and use the work within the limitations intended by the author.

However, there are those who doubt that DRM can be effective. Those critics say that the ability of individuals to circumvent DRM will make it impossible to rely on the private sector alone to protect intellectual property. Instead, DRM will require government involvement in the design and enforcement of restrictions on the specifications of equipment. For example, the Digital Millenium Copyright Act (DMCA) criminalized the production of technology that could be used to circumvent copyright restrictions. Many libertarians were troubled by the DMCA.

Biotechnology

The libertarian position on biotechnology, nanotechnology, and other potentially revolutionary scientific developments is one of laissez-faire. The libertarian view is that individuals are capable of addressing the ethical issues raised by new technologies without government interference.

Libertarians tend to dismiss concerns such as those raised by the President's Commission on Bioethics. In *Beyond Therapy* (President's Council of Bioethics 2004) the commission argues that biotechnology poses ethical problems by potentially enhancing human capabilities, eliminating death, and giving parents control over the characteristics of their children. Libertarians believe that individuals are capable of dealing with these issues as they arise. Moreover, libertarians argue that the sort of regulatory regime that would be needed to enforce controls over such technologies would be draconian.

Privacy

Libertarians are mindful of the effect of technology on privacy. Some technologies, such as miniature cameras, radio identification tags, and powerful storage and processing for large databases, seem to threaten privacy. Other technologies, such as the decentralized Internet and cryptography, seem to enhance privacy.

David D. Friedman has painted one scenario for the way these technologies could play out. In Chapter 1 of his draft *Future Imperfect* he writes, "Put all of these technologies together and we may end up with a world where your realspace identity is entirely public, with everything about you known and readily accessible, while your cyberspace activities, and information about them, are entirely private—with you in control of the link between your cyberspace persona and your realspace identity."

The last point—that the individual will control the link between electronic identity and physical identity—is crucial. If the opposite scenario were to emerge, in which the government always would have the ability to trace electronic communications to an individual person, the potential for totalitarian control would appear to be high.

In *The Transparent Society* (1998) David Brin has suggested that the inevitable improvement in surveillance technology is going to cause privacy to be replaced by transparency. Cameras are certain to become smaller, digital radio tracking devices will become more powerful, and all forms of surveillance will become cheaper. In light of this outlook Brin argues that freedom and autonomy can best be preserved by ensuring that individuals have as much access to information about government and large corporations as those organizations have access to information about individuals.

The Future of Libertarianism

In the late industrial age libertarianism went into eclipse. For most of the twentieth century it appeared that the future belonged to powerful manufacturing enterprises and the large government that was thought necessary to regulate and plan the industrial economy. In the Internet age many people are seeing the potential for unplanned order emerging from the decisions of individuals. This has revived libertarianism as an important philosophy.

Libertarianism may have reawakened, but it is far from triumphant. Libertarian approaches to government policy on recreational drugs, education, and health care remain far from the mainstream, where paternalism remains entrenched. Moreover, technology poses problems for which libertarianism, typically absolutist and unabashed, lacks clear answers. Intellectual property poses a conflict between the natural right to own the product of one's labor and the right to engage in free expression and activities that do not infringe directly on another person. New technologies also provide surveillance potential in ways that require libertarians to reconsider the fundamental basis for privacy.

ARNOLD KLING

SEE ALSO *Communitarianism; Democracy; Human Rights; Locke, John; Market Theory; Natural Law; Skepticism; Smith, Adam.*

BIBLIOGRAPHY

Boaz, David. (1994). *Libertarianism: A Primer*. New York. Free Press.

Borsook, Paula. (2000). *Cyberselfish: A Critical Romp through the Terribly Libertarian Culture of High Tech*. New York: PublicAffairs.

Brin, David. (1998). *The Transparent Society: Will Technology Force Us to Choose between Privacy and Freedom?* Reading, MA: Perseus. A remarkably prescient book on the challenges that surveillance technology will pose for privacy and liberty.

Caldwell, Bruce. (2004). *Hayek's Challenge: An Intellectual Biography of F.A. Hayek*. Chicago: University of Chicago Press.

Hayek, F. A. (1944). *The Road to Serfdom*. London: Routledge.

Lessig, Lawrence. (1999). *Code and Other Laws of Cyberspace*. New York: Basic Books.

Postrel, Virginia. (1998). *The Future and Its Enemies: The Growing Conflict over Creativity, Enterprise, and Progress*. New York: Free Press.

President's Council on Bioethics. (2004). *Beyond Therapy: Biotechnology and the Pursuit of Happiness*. Washington, DC: President's Council on Bioethics.

Stock, Gregory. (2003). *Redesigning Humans: Choosing Our Genes, Changing Our Future*. Boston: Houghton Mifflin.

Thierer, Adam, and Clyde Wayne Crews, Jr., eds. (2002). *Copy Fights: The Future of Intellectual Property in the Information Age*. Washington, DC: Cato Institute. Exemplifies the differences among libertarians on intellectual property issues.

INTERNET RESOURCES

Barlow, John Perry. (1996). *A Declaration of the Independence of Cyberspace*. Available at http//:www.eff.org/~barlow/Declaration-Final.html.

Friedman, David D. (2003). *Future Imperfect*. Available at http//:www.patrifriedman.com/prose-others/fi/commented/Future_Imperfect.html.

Locke, John. *Second Treatise of Civil Government*, Chapter 8. Available at http://www.constitution.org/jl/2ndtr08.htm.

Mill, John Stuart. *On Liberty*. Available at http://www.bartleby.com/130/.

LIBERTY

SEE *Freedom*.

LIFE

In consideration of the ethical uses of science and technology the phenomenon of life, especially human life, has repeatedly played significant roles in both progressive and conservative arguments. In modern philosophy notions of life have also made repeated appearances, from Thomas Hobbes's claim that the fundamental aim of politics is to replace the insecurity of life in the state of nature with a more secure life by means, in part, of technology, to Friedrich Nietzsche's appeal to a life ideal that transcends concerns of personal security. Contemporary debates about the limits of biomedical interventions in terms of whether or not human life begins at conception and feminist criticisms of cultural tendencies to disembody life thus reflect and advance long-standing concerns. Indeed, at the beginning of philosophy in Europe, one of Socrates's fundamental theses was that "The unexamined life [*bios*] is not worth living for humans" (*Apology* 38a); and as a manifestation of his divinity, the Christian scriptures record Jesus's claim to being "the way, the truth, and the life [*zoe*]" (John 14:6).

Life Sciences

Science has from its earliest forms distinguished two fundamental realms in nature: the nonliving and the living. Aristotle (384–322 B.C.E.) was among the first systematic investigators of nature and for centuries provided an authoritative orientation that took its bearings from the living. For Aristotle, living entities reveal the workings of nature better than the nonliving; life provides the key to explain the nonliving—in contrast to modern natural science, which seeks an explanation of life in terms of nonlife. Certainly life more clearly displays the dynamism and purposefulness that Aristotle sees as central to reality as a whole. Purposefulness, final causation, and teleology conceptualize that by which entities seek natural states or places proper to their kind. The acorn matures in order to become an oak tree because that is its inner nature; the oak tree maintains its state through metabolism because this inner nature has been achieved. Living things have an internal principle of motion and rest, which can be grasped by reason, whereas the nonliving are moved by external forces, the rationality of which is more difficult to comprehend.

For modern natural science, however, it is the external forces moving nonliving entities that are most readily calculable, thus giving rise to physics in a new sense. René Descartes (1596–1650), for instance, proposed that animals are simply complex machines, and that all life functions (except human thinking) could be explained in terms of mechanical interactions. From the beginning, however, the adequacy of this view has been contested, and the reduction of life to physics and chemistry challenged. The vitalism of Hans Driesch (1867–1941) and Henri Bergson (1859–1941), who argued that life involved some nonphysical element or is governed by special principles, was but one of the more pronounced examples.

Traditional explanations for the variety of life—namely, that either species are eternal or divinely created—and how organisms change over time had long been scrutinized before Charles Darwin (1809–1882) published *On the Origin of Species*. It was Darwin's theory of evolution by natural selection, however, that produced the first comprehensive account of the changing diversity of life that appeared to go beyond simple mechanism without rejecting it. Fused with the model of biological inheritance developed by Gregor Mendel (1822–1884), the synthesis of evolution by natural selection operating on the gene became the cornerstone of modern biology.

In the early 1940s the Austrian physicist Erwin Schrödinger (1887–1961) proposed that genes functioned by means of a "molecular code-script" present in chromosomes. This pointed toward the idea of molecular biology. A decade later, in 1953, James D. Watson (b. 1928) and Francis Crick (1916–2004) discovered the double-helix molecular structure of DNA. Analyses of DNA eventually elucidated the connection between genetic information and the traits of living organisms, which describes the transcription and translation of genetic information into proteins.

Redefining Life

Difficulties nevertheless remain for developing a post-Aristotelian definition of life as a biological phenomenon. One common approach has been to consider an entity living if it exhibits the following characteristics at least once during its existence: growth, metabolism, reproduction, and response to stimuli. Yet in some sense fire meets all these criteria. Moreover, some entities are not clearly either living or nonliving. Chief among these are viruses, which contain protein and nucleic acid molecules that make up living cells but require the assistance of those cells to replicate. In response, life can be further described as cellular and homeostatic—even though this would continue to classify viruses as anomalous.

Systems theorists such as Ilya Prigogine, Fritjof Capra, and Francisco Varela, however, have preferred to define life as a complex, autopoeitic (self-creating), dissipative feedback system. This conception gave rise to the Gaia hypothesis of James Lovelock and Lynn Margulis, which conceives of the entire biosphere as living insofar as it maintains conditions favorable to its continued existence.

What about the possibility of human-made, artificial life? This term can refer to a number of different research programs. Genetic engineering (and even animal breeding) creates forms of life that might not otherwise occur in nature. For Christopher G. Langton computer programs that model life processes by means of complex algorithms constitute artificial life or "a-life." Some theorists go even further to argue that beyond modeling, life is a process that can be abstracted away from any particular medium and need not necessarily depend on carbon-based chemical solutions.

Precisely when human life begins, whether at conception or some point further along in embryonic development, is also a highly contested issue. The premodern view that human life begins at the "quickening"—that is, when a woman experiences the first movements of a new child in her womb—has been altered by the very biological science that often proposes to treat embryos as no different than many other rudimentary organisms.

Life Philosophies

All such modern definitions have difficulty accounting for life as having any intrinsic ethical significance. The purposelessness of natural selection and the lowered status of humans in a hierarchy of being challenge traditional moral and theological beliefs. When life is conceived as an assemblage of adaptations to random and constantly changing circumstances, there remain no forms or essential types to imitate, and no harmonious order or basic good to maintain. Yet despite the most sophisticated explanations, purposefulness does appear to be an aspect of the living.

One response has been the development of a life philosophy (German *Lebensphilosophie*) that arose as a reaction against Enlightenment rationalism. Life is prioritized over mere understanding, and life philosophy has had many variants, including artistic movements in which life is used as a concept to assess and critique modern society. Certainly over the course of the nineteenth and twentieth centuries life as "vitality" or vividness, a sense of both spiritual striving and joyous experiencing, played an important role in literature, art, and music as a touchstone of criticism of the scientific and technological. Among the most important representations of this view are attempts made by Arthur Schopenhauer (1788–1860) and Friedrich Nietzsche (1844–1900) to grasp life as an all-encompassing metaphysical category or first philosophy.

Nietzsche's life philosophy differed from the thought of Schopenhauer in its naturalism. In his genealogical work, he traced the development of the life-denying ascetic ideal that he saw as dominant in Western (and most Eastern) philosophy and religion. Value comes to being always in support of life, but ascetic philosophies give vital ideals a life-devaluing interpretation. Anything that is part of the natural, changing, life-world is interpreted as wrong and sinful, and ideals of truth and virtue are rooted in otherworldly, changeless realms. The ascetic ideal removes all source of value from nature, whereas modern natural science removed any faith in a realm outside of nature. One interpretation of the "death of God" is the extinction of this transcendent, nonhuman, and ahistorical realm to ground human values. There is nothing but life on which to base values, including truth. Whether Nietzsche successfully distinguished this revaluation of values from nihilism remains a subject of dispute.

During the mid-twentieth century life philosophy made a new appearance in the forms of phenomenology and existentialism. Phenomenology especially criticized science as separating itself from the human lifeworld or as disembodying experience. Related arguments have been carried forward in feminist criticisms such as those of Barbara Duden and Donna Haraway. In her studies of women's medicine and experiences such as pregnancy, Duden (1993) defends the primacy of lived experience over its conceptual analysis. In her notion of "companion species," Haraway (2003) criticizes the primacy of conceptual oppositions in favor of mutuality of living relationships, which harks back to the work of Pytor Kropotkin (1842–1921) and his notion of "mutual aid" among organisms.

Whether molecular biology can account for what is apparently goal-directed behavior in organisms likewise continues to spark controversy (see, e.g., Allen, Bekoff, and Lauder 1998). Finally, given the difficulties of understanding the ethical significance of biological life in the modern sense, philosophers such as Hans Jonas (1966) and Leon R. Kass (1985) have even attempted to revive an Aristotelian approach that would understand the most elementary forms of life in terms of higher forms of life rather than vice versa.

The Human Condition, Bioethics, and Biotechnology

According to Hannah Arendt (1958) the life of human activity, or *vita activa,* may be distinguished into labor, work, and action. Labor pertains to the biological processes of the human body, work to the world of artifice, and action to politics. Political action is so central to the human condition that the Romans used the same term (*inter homines esse*) to signify both "to live" and "to be among men." But as Arendt also notes, "life" takes distinct forms in each level of the *vita activa.* In the first instance life is related to the futile, biological labors of the body in which there is a kind of "deathless everlastingness of the human as of all other animal species" (p. 97). In the second instance life takes on the worldliness of work with distinct beginnings and ends and can be told as a story.

The first notion of life corresponds to the Greek *zoe,* from which English derives *zoology;* the second corresponds to the Greek *bios,* from which comes *biography* and a sense of the historical. For Arendt the modern world may be characterized by an effulgence of *zoe* as labor moved from the most-despised to the most-esteemed position with a productivity that outstripped all traditional work and overwhelmed action. But action and speech, beyond the necessary but lower forms of the *animal laborans* (labor) and *homo faber* (work), is the highest form of human life. The measure of all things, she claims, "can be neither the driving necessity of biological life and labor nor the utilitarian instrumentalism of fabrication and usage" (p. 174).

The term *bioethics* was initially coined by the biologist Van Rensselaer Potter (1911–2001) to refer to an ethics grounded on the science of life, rather than on religion or philosophy. It has since come to signify the field that studies the intersection of biology and biography, or the science of life studied scientifically and life lived experientially (Kass 2002). The focus on biography and the good life, rather than mere biological life, has taken on more importance as new biomedical technologies expand the capacities of human biology, or what Arendt would call the labor of human bodies. This is best illustrated by advances in life-extending techniques used in palliative care. In many instances, one's biological life is extended well beyond the duration of one's biographical life among the world of things and within the plural realm of action and speech. This raises ethical questions about what it means to die a dignified death and who should make such decisions in various circumstances.

Advances in biotechnology offer new powers to alter and to some degree control the phenomena of life. This has brought both reward and risk. In agricultural uses, biotechnology has raised concerns about risks, especially involving uncertain ecological interactions and health effects. In biomedical uses, similar health risk issues occur along with questions of informed consent and privacy. Additionally, the controversial techniques of abortion, cloning, and stem cell research sustain heated debates about when human life begins. New reproductive techniques have stimulated questions about how much control the present generation ought to have over future generations.

This last issue highlights the fact that both in agricultural and medical biotechnology, traditional ethical issues are complemented by deeper concerns about the proper limits to the human activity of "remaking Eden" and "relieving man's estate." How ought humankind responsibly exercise its power over life and where should limits be drawn? For example, even though biomedical technologies offer obvious rewards in terms of satisfying deep human desires, they can also serve (intentionally or not) to diminish human life. As the President's Council on Bioethics remarked in *Beyond Therapy* (2003), "To a society armed with biotechnology, the activities of human life may come to be seen in purely technical terms, and more amenable to improvement than they really are" (p. xvii). Promoting the genuine flourishing of human life is foremost a matter of understanding the good life rather than commanding the tools to manipulate life processes.

CARL MITCHAM
ADAM BRIGGLE

SEE ALSO *Bioethics; Environmental Ethics; Medical Ethics.*

BIBLIOGRAPHY

Allen, Colin; Marc Bekoff; and George Lauder, eds. (1998). *Nature's Purposes: Analyses of Function and Design in Biology*. Cambridge, MA: MIT Press.

Arendt, Hannah. (1958). *The Human Condition*. Chicago: University of Chicago Press.

Duden, Barbara. (1993). *Disembodying Women: Perspectives on Pregnancy and the Unborn,* trans. Lee Hoinacki. Cambridge, MA: Harvard University Press.

Haraway, Donna. (2003). *The Companion Species Manifesto: Dogs, People, and Significant Otherness*. Chicago: Prickly Paradigm Press.

Jonas, Hans. (1966). *The Phenomenon of Life: Toward a Philosophical Biology*. New York: Harper and Row.

Kass, Leon R. (1985). *Toward a More Natural Science: Biology and Human Affairs*. New York: Free Press.

Kass, Leon R. (2002). *Life, Liberty and the Defense of Dignity: The Challenge for Bioethics*San Francisco: Encounter Books.

Schrödinger, Erwin. (1944). *What Is Life? The Physical Aspect of the Living Cell.* Cambridge, UK: Cambridge University Press. Based on lectures delivered at Trinity College, Dublin, 1943.

U.S. President's Council on Bioethics. (2003). *Beyond Therapy: Biotechnology and the Pursuit of Happiness*. Washington, DC: President's Council on Bioethics.

LIMITED NUCLEAR TEST BAN TREATY

The Limited Nuclear Test Ban Treaty (LTBT) was signed by the United States, Great Britain, and the Soviet Union in Moscow on August 5, 1963. Ending more than eight years of negotiations, the LTBT prohibits nuclear weapons tests or other explosions in the atmosphere, outer space, or underwater. While the treaty does not ban underground nuclear explosions, it does prohibit tests if they would cause "radioactive debris to be present outside the territorial limits of the State under whose jurisdiction or control" the explosions were conducted. In addition, by signing on to the treaty the countries agreed to the goal of "the discontinuance of all test explosions of nuclear weapons for all time."

Emergent History

After the end of World War II, Great Britain and the Soviet Union joined the United States in the nuclear club and the United States and the Soviet Union tested their first hydrogen bombs in 1952 and 1953 respectively. Public concern about nuclear testing began to grow, especially after the March 1954 test of a thermonuclear device by the United States at Bikini atoll. This test was expected to have a yield equivalent to approximately eight million tons of trinitrotoluene (TNT), but in actuality was about fifteen megatons, or almost double the predictions. The fallout from the explosion greatly exceeded geographical expectations, contaminating a Japanese fishing vessel, the Lucky Dragon, as well as Bikini atoll.

This incident, as well as others, increased the awareness of the effects of fallout and the issue of continued nuclear tests garnered greater public scrutiny. Organizations such as Women Strike for Peace and Physicians for Social Responsibility were formed to increase public pressure on western governments for signing a treaty, as well as informing the public of the dangers of nuclear testing. For instance, Women Strike for Peace originated from an international protest of women against atmospheric testing. Physicians for Social Responsibility documented the presence of strontium-90—a highly radioactive waste product of atmospheric nuclear testing—in children's teeth across the country. As it became apparent that no region of the world was untouched by radioactive fallout, there was increasing apprehension about the possibility of global environmental contamination and the resulting genetic effects. It was in this atmosphere that efforts to negotiate an end to nuclear tests began in May 1955 in the Subcommittee of Five of the United Nations Disarmament Commission.

International interest in the course of the negotiations was intense and sustained. The issue was brought up in statements and proposals at international meetings and the United Nations General Assembly addressed the issue in a dozen resolutions, repeatedly pressing for an agreement to be reached. While the United States, Great Britain, and the Soviet Union engaged in a tripartite effort—The Conference on the Discontinuance of Nuclear Weapons Tests—almost continuously from October 31, 1958 to January 29, 1962, no treaty could be drafted due to differences on a number of issues.

Basic Treaty Issues

The issue of a control and enforcement mechanism to verify compliance to a comprehensive test ban was the primary point of disagreement between the parties. Western European and U.S. powers, especially, were concerned that it would be more dangerous to accept pledges without the means to verify that they were being complied with than to not have a treaty at all. The Soviets, for their part, felt that because, "in the present state of scientific knowledge" (Premier Bulganin writing to President Eisenhower on October 17, 1956, from U.S. Department of State Bureau of Arms Control) no explosion could be produced without being detected, then there could be an immediate agreement to prohibit tests without an international control mechanism at all.

To resolve the issue of how compliance could best be verified, the Geneva Conference of Experts met in July and August 1958 and was attended by representatives from the United States, Great Britain, Canada, France, the Soviet Union, Poland, Czechoslovakia, and Romania. The group of experts developed and agreed on the technical aspects of a verification system to monitor a ban on atmospheric, underwater, and underground tests. This control system included an elaborate network of more than 150 land control posts, ten ship-borne posts, and special aircraft flights. In addition it allowed for on-site inspections to determine whether seismic events were caused by earthquakes or by explosions. While the United States and Great Britain said they would be willing to negotiate an agreement based on the establishment of an international control system, the Soviet Union responded by linking the test ban to other arms control issues and resumed testing. The other nuclear powers refrained from testing until 1961, after France tested its first nuclear weapon in 1960, and in 1962, the four nuclear powers conducted a record 178 nuclear tests.

Disagreement on a control system was focused on four main areas:

(a) The Veto. The Soviet Union wanted all operations to be subject to a veto while the United States maintained that the inspection process should be automatic in order to be effective.

(b) On-Site Inspections. The Soviet Union capped on-site inspections at three per year while the United States and Great Britain insisted that the number should be determined by detection capability and necessity. Eventually the United States said it would accept a minimum of seven inspections, which was rejected by the Soviet Union.

(c) Control Posts. Neither side could agree on the number and location of posts or of the automatic seismic observation stations that would supplement nationally owned control posts. The argument of the Soviet Union that these national posts and observation stations would make inspections unnecessary was rejected by the United States and Great Britain.

(d) The Organization and Control Commission. The Soviet Union proposed a *troika* of administrators for the Control Commission, including one neutral, one Western European or North American, and one Communist member. The Western European and North American countries argued that this would make the Control Commission powerless and unable to take action. The Soviet Union eventually acquiesced to opposition concerns and abandoned this position.

Treaty Creation and Ratification

After the Cuban Missile Crisis in October 1962, both sides were anxious to alleviate public fears about nuclear weapons and therefore restarted the three-power conference on a test ban treaty in July 1963. While the Soviet Union would not agree to a treaty that prohibited underground testing, the three powers were able to agree on a partial ban on atmospheric, outer space, and underwater testing, which were all easily verifiable without intrusive inspections. In just ten days, the three parties had developed and signed the LTBT. The U.S. Senate ratified the agreement on September 24, and President John F. Kennedy signed the LTBT into law on October 7, 1963. The LTBT formally entered into force on October 10, and it is of unlimited duration.

Although the LTBT was touted by all parties as a success, and indeed it was so as it greatly reduced dangerous atmospheric fallout and deadly radiation, including strontium-90, secondary results were mixed. Because neither France nor China signed the LTBT, they continued to test intermittently until the early 1980s. India, Pakistan, and Israel, all signatories of the treaty, were able to join the nuclear club despite the limited ban. And in the United States and the Soviet Union, nuclear weapons development and testing continued unabated, although all tests were moved underground. Additionally there was less international public pressure to develop a comprehensive test ban treaty as the most visible sign of the arms race, atmospheric testing, was eliminated. However despite these failings, the LTBT was an important and symbolic first step and served as a precedent for future arms control treaties.

JESSICA L. COX
MARGARET COSENTINO

SEE ALSO *Baruch Plan; International Relations; Nuclear Ethics; Nuclear Non-Proliferation Treaty; Weapons of Mass Destruction.*

BIBLIOGRAPHY

"Treaty Banning Nuclear Weapons Tests in the Atmosphere, in Outer Space and Under Water (Partial Test Ban Treaty—PTBT)." (August 2000). *Inventory of International Nonproliferation Organizations and Regimes*. Monterrey, CA: Monterrey Institute For International Studies.

INTERNET RESOURCES

Burr, William, and Hector L. Montford, eds. (2003). "The Making of the Limited Test Ban Treaty, 1958–1963." George Washington University. Available from http://www.gwu.edu/~nsarchiv/NSAEBB/NSAEBB94/.

Kimball, Daryl, and Wade Boese. (2003). "Limited Test Ban Treaty Turns 40." *Arms Control Today* 33, no. 8 (October). Available from http://www.armscontrol.org/act/2003_10/LTBT.asp

"Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water." U.S. Department of State. Bureau of Arms Control. Available from http://www.state.gov/error_404.html

LIMITS

The question of human limits, both cognitive and moral, is a persistent theme in the history of religion and philosophy. Both Siddhartha Gautama (Buddha, c. 563–c. 483 B.C.E.) and Socrates (469–399 B.C.E.) argued, in quite different ways, for the human acceptance of limits. Indeed, in general premodern traditions in human culture widely acknowledged both theoretical and practical limits on human knowledge and action.

Thus ever since the founding of modernity, with its appeals to transcend many traditional limits in the development of science and technology—and even certain aspects of the human condition—the question of whether and to what extent there might be new limits to the modern project has been a recurring theme. Late eighteenth and early nineteenth century poets such as Johann Wolfgang von Goethe (1749–1832) and William Blake (1757–1827) called for recognition of cognitive limits in modern science; nineteenth and early twentieth century novelists such as Charles Dickens (1812–1870) and John Steinbeck (1902–1968) argued for placing social and political limits on industrial technological practices; and philosophers of limits such as Karl Marx (1818–1883), Friedrich Nietzsche (1844–1900), and Oswald Spengler (1880–1936) proposed the existence of historical and cultural limits to modern development as a whole.

Limits to Growth

Such general discussions were given a new, specialized form with the 1972 publication of *The Limits to Growth* by the team of Donella Meadows, Dennis Meadows, and Jørgen Randers, which brought the environmental predicament of industrial progress to the attention of a world audience. On the basis of a computerized world model, the celebrated but controversial study claimed that continuing high rates of growth would lead to (a) a depletion of vital global resources, (b) increasing pollution, and (c) population outrunning the world's potential food supplies. The study suggested that, unless swift action was taken, absolute limits to growth would appear in the course of the twenty-first century, causing population size and industrial capacity to drop rapidly. This message was instantly seen as a blow against the creed of economic growth dominating at the time, both in the Western and the Communist world. Subsequently, the rift between growth advocates and growth skeptics has continued to divide the contemporary world of science and of politics; in fact, this division reaches deeper than conventional distinctions such as conservative/progressive or right/left.

Do Limits Exist?

The debate on limits carries on where classical economics had left off. Thomas Malthus (1766–1834), for example, still had the implicit vision of the Earth as a closed space, with limits to the size of population and level of human achievement it could sustain. He argued that lack of food supply would ultimately constrain population growth, throwing into doubt the idea of the inevitability of progress. However, he underestimated both the variability of growth and the capacity of technology to overcome natural limits. In contrast, neo-classical economics, operating on the background assumption of the infinite power of science and technology, had subsequently ignored the dependence of economic systems on natural systems completely. This shortcoming had left economic science blind to the impending environmental crisis in the twentieth century.

The attempt of Meadows, Meadows, and Randers to expose this failure set off a replay of the controversy between the "closed space" and "infinite ingenuity" schools of thought. While the former insists on the finiteness of both resource inputs and waste sinks, the latter emphasizes the practically infinite substitutability of natural resources by technology and organizational innovation (Simon 1981). What matters to the biosphere is the scale of resource flows, not just their efficient allocation (Daly 1996). Markets may reduce the volume of resource use through substitution of natural inputs, but continuing growth will eventually cancel out these efficiency gains, increasing volumes again. It is the overall scale of resource flows with respect to both input sources and waste sinks that determines the relationship between the economy and the biosphere.

Scientific findings suggest that for the first time in history, human-induced material flows are presently outgrowing nature-induced flows. In other words, the technosphere eclipses the biosphere. Some well-known facts are symptoms for this imbalance: Humankind has already exhausted 40 percent of known oil reserves, transformed nearly 50 percent of the land surface, appropriates more than half of all accessible freshwater, increases greenhouse gases in the atmosphere over and above natural variability, and causes extinction rates to increase sharply in marine and terrestrial ecosystems (Steffen et al. 2004, p. 6). In general terms, human impacts on the Earth are approaching or exceeding in magnitude the impact of some of the great forces of nature. In addition, they operate on much faster time scales than rates of natural variability. Estimates following the ecological footprint methodology imply that human activities presently exceed the Earth's capacity by 15 to 20 percent—without taking the needs of other living beings into account (Wackernagel et al. 2002). Ecological overshoot has become the distinguishing mark of human history.

What To Do about Limits?

The way "limits" are understood has consequences for politics and ethics. One metaphor for conceptualizing limits is that of a cliff face: The concept implies a fixed line beyond which collapse looms. It insinuates that crucial changes happen in an abrupt as well as catastrophic fashion, making everyone suffer equally. However, changes may also occur in a gradual as well as insidious fashion, and may burden some more than others. A metaphor based on a tapestry—each act of destruction is like pulling a thread from the tapestry—would emphasize linear and not just non-linear processes, multiple smaller losses and not just overall collapse. In particular, it would highlight the presence of political choices along the gradient of degradation (Davidson 2000). The tapestry metaphor, more than the cliff metaphor, encourages one to judge wreckage not only as prelude to the collapse, allows one to trace the differential impact of losses on social groups, and stimulates the politically and ethically essential question: What thresholds are considered tolerable/intolerable for whom and on what grounds?

Thresholds of ecosystem changes represent "limits" only for humans; any definition of limits is therefore a political act. Moreover, limits are rarely scientifically knowable; their definition is therefore an ethical act as well. As a consequence, any definition implies choices in terms of human welfare, equity, and the common good. A first approach centers on risks, putting the spotlight on possible physical, technical, and economic losses resulting from the technology or economic policy in question. Emphasis is placed on the precautionary principle of preventing the worst from happening. Guardrails, for instance, are suggested in order to avoid abrupt and irreversible changes from which human societies would find it difficult or impossible to recover (German Advisory Council on Global Change 1997).

A second approach focuses on institutions, because the rise of external limits is brought about by structures of growth and accumulation that are internally insatiable and limitless. This approach highlights the constellation of social and economic factors driving perilous developments (Harvey 1996). Proposals range from the reform of price structures to the containment of the profit motive, from the reallocation of research funds to the phase-out of certain technologies.

Finally, a third approach calls for a reconsideration of values, bringing into sharp relief the civilizational losses incurred by the predominance of the logic of growth. Natural limits are often preceded by the appearance of social and cultural limits; before growth causes physical perturbations, collective and individual well being has suffered (Illich 1973, Hirsch 1976). Recognizing limits, therefore, implies the emergence of fresh opportunities by restoring a balance. In this approach, limits acquire a positive connotation, making a more accomplished life possible. They turn out to be productive for a civilization that regards economic power and growth only marginally important.

WOLFGANG SACHS

SEE ALSO *Ecological Footprint; Precautionary Principle.*

BIBLIOGRAPHY

Daly, Herman E. (1996). *Beyond Growth: The Economics of Sustainable Development.* Boston: Beacon Press.

Davidson, Carlos. (2000). "Economic Growth and the Environment: Alternatives to the Limits Paradigm." *BioScience* 50: 433–440.

German Advisory Council on Global Change. (1997). *World In Transition: The Research Challenge*. Berlin: Springer

Harvey, David. (1996). *Justice, Nature, and the Geography of Difference*. Cambridge, MA: Blackwell.

Hirsch, Fred. (1976). *Social Limits to Growth*. Cambridge, MA: Harvard University Press.

Illich, Ivan. (1973). *Tools for Conviviality*. New York: Harper & Row.

Meadows, Donella, Dennis Meadows, and Jørgen Randers. (1972). *The Limits to Growth*. New York: Universe Books.

Meadows, Donella, Dennis Meadows, and Jørgen Randers. *Beyond the Limits: Confronting Global Collapse, Envisioning a Sustainable Future*. White River Junction, VT: Chelsea Green.

Meadows, Donella, Dennis Meadows, and Jørgen Randers. (2004). *Limits to Growth: The 30-year Update*. White River Junction, VT: Chelsea Green.

Simon, Julian L. (1981). *The Ultimate Resource*. Princeton, NJ: Princeton University Press.

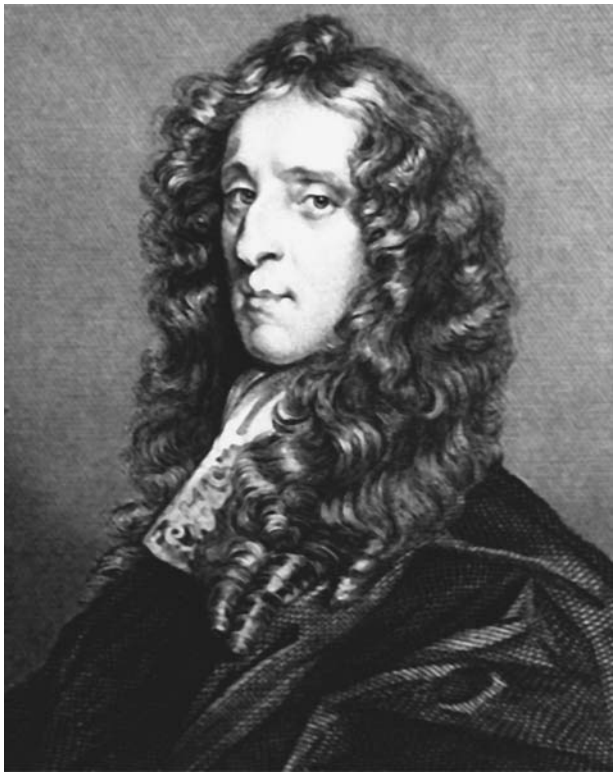
Steffen, Will, et al. (2004). *Global Change and the Earth System: A Planet Under Pressure*. Berlin: Springer.

Wackernagel, Mathis; Niels B. Schulz; Diana Deumling; et al. (2002). "Tracking the Ecological Overshoot of the Human Economy." *Proceedings of the National Academy of Sciences* 99: 9266–9271

LOCKE, JOHN

John Locke (1632–1704), was an English philosopher, Oxford academic, and occasional bureaucrat. He was born at Wrington, Somerset, on August 29 and died at Oates, Essex on October 28. Locke's fame as a philosopher rests chiefly on two works: *An Essay Concerning Human Understanding* (1689) and *Two Treatises of Government* (1689). The former became a chief textbook of the European enlightenment and subsequent philosophy. The latter deeply influenced both the Declaration of Independence (1776) and the Constitution of the United States (1787), a document that made promoting the "progress of science and useful arts" one of its distinguishing features (Article I, section 8). These facts establish his reputation as one of the most influential modern philosophers and signal his importance in issues related to science, technology, and ethics.

Locke's strategy in his two most influential works is characteristic of early modern thought. First he sets out to clear away errors and conceits left over from classical and medieval science. Next he reduces the subject to its most basic natural constituents, as yet unmodified by culture. Only then does he set about reconstructing new systems of epistemology and political philosophy.



John Locke, 1632–1704. An English philosopher and political theorist, Locke began the empiricist tradition and thus initiated the greatest age of British philosophy. He attempted to center philosophy on an analysis of the extent and capabilities of the human mind. *(Rutgers University Library.)*

The *Essay*

Part One of the *Essay* is devoted to a refutation of the doctrine of innate ideas, according to which all human beings are born with certain principles already stamped upon their minds. It might seem doubtful that the importance of this doctrine justifies the attention that Locke devotes to it; however, its demolition whets the appetite for a more satisfactory account of the mind.

Locke holds to the view that all human ideas are reducible to experiences, a doctrine known as *empiricism*. An *idea* here means anything in the contents of the mind that is definite enough to have a name. Impressions, such as *hot* and *red*, received from the external world are the primary source of ideas. But unlike more uncompromising empiricists, such as David Hume, Locke admits of a second source of ideas: reflection upon the operations of human minds. One may observe what the mind does with the material provided by sensation and so acquire ideas of *thinking*, *willing*, and the like. So, though there are no innate ideas, there are innate sources of information.

Some ideas, such as *hard* or *perception* are indivisible. These are received passively by the mind. But the mind can also act on elementary ideas in three ways: by combining several into one complex idea; by comparing one with another; and by abstracting some idea from the setting in which it actually occurs. By such operations the mind can furnish itself with a potentially unlimited stock of complex ideas. These in turn fall into three categories: *relations* between ideas, *substances* that may exist on their own; and *modes* that exist only in something else. Thus the sun is a substance; it is bright in relation to terrestrial fire; and its brilliance is one of its modes.

Though all complex ideas are products of the mind, they can be anchored in the real world. A substance is known only by its qualities, which are the impressions it makes on the senses. Its primary qualities belong to it independently of observation, so a stone has weight and shape whether anyone perceives it or not. Secondary qualities depend on an observer. The stone is brown only in the right light, and in the eyes of some beholder. One cannot conceive but that these qualities subsist in some underlying thing, but has no idea of what that thing is. Locke subscribes, however, to the corpuscular or atomic theory of matter and supposes that the substratum consists of invisibly small particles.

Locke's philosophy of mind narrows the distance between speculation and technology. Chemistry, once it has purged itself of any alchemical conceits and has arrived at knowledge of the elements, not only understands the world better but provides human beings with means to manipulate it. Similarly Locke offers both a better account of human knowing and a set of useful instruments both for scientific and philosophical investigation.

This raises the question of the rank of philosophy with respect to science and technology. In one respect Locke's view of this matter seems closer to the medieval than to the classical conception. For the Greeks, philosophy was more elevated and more complete than any science, if indeed it did not incorporate all the sciences. In medieval scholarship, philosophy is famously regarded as the *handmaiden of theology*, usually in so far as it supports and clarifies faith. For Locke, philosophy seems to become the handmaiden of the sciences.

In the Epistle to the *Essay* Locke distinguishes between the *Master-Builders* and the *Under-Labourers* of the sciences. Among the former are Robert Boyle, Thomas Sydenham, Christiaan Huygens, and Isaac Newton, whose works stand as monuments to posterity. Locke counts himself among the latter, whose job it is merely to clear the ground and remove the rubbish that obstructs the advance of science. If this is Locke's view, he has reduced philosophy to a preparatory exercise, much of which is necessary only because of the abuses of language committed by psuedophilosophers. Locke's *Essay* is certainly similar to contemporary academic philosophy, which understands itself as clarifying questions up to the point that science can get a grip on them.

The scientists named by Locke are conspicuous for both theoretical and technological achievements. Boyle constructed an air pump; Newton and Huygens built advanced telescopes; Sydenham pioneered new medical treatments. But it is clear that for Locke their greatness lay more in their theoretical work than in any useful devices they may have contrived. He shows no inclination to subordinate the sciences to technology. A few lines after mentioning Newton, he identifies philosophy as "nothing but a true knowledge of the nature of things" (Locke 1975, p. 10). Whatever Locke's view of his business in the "Essay," he had a view of philosophy broad enough to encompass the sciences. It is closer to the classical view than is often supposed.

The *Two Treatises*

In his *First Treatise*, Locke demolishes Robert Filmer's argument in favor of the divine right of kings. This sets the stage for the *Second Treatise*: If political authority does not originate in God's appointment of Adam, then its origin must be sought in human nature.

Typically Locke identifies and isolates the elementary building block of political societies: This is the human being in the *state of nature*. The latter indicates a condition of perfect freedom and equality, with no one having any authority over another. But it is not, as Thomas Hobbes (1588–1679) supposed, a state of license. For there is a natural law available to all human beings, directing them to respect one another's life, liberty, and property.

Oddly enough, it is not viciousness that requires the formation of governments, but the human capacity for righteous indignation. In the state of nature, each person is entitled to punish any transgression of rights. But as each person judges primarily in his or her own favor, one person's enforcement of natural law is another's transgression of the same. Thus the universal distribution of the executive power can lead to endless cycles of revenge. The way to avoid this is for all to surrender their portions of the executive power to some common judge, to whom appeal may be made in case of conflict.

Human beings thus leave the state of nature in order to more securely enjoy those rights that they possessed while still in it. Universal consent is the foundation of political authority, which may be invested in such forms (for example, kings and parliaments) as the subjects think fit. However that grant of authority is always conditional rather than absolute. When the government forfeits the consent of its subjects, or by aggression or neglect fails to protect their liberties, it effectively abdicates. The people are then entitled to abolish it and form a new one.

Property Rights

Locke's theory of property, set forth in Chapter 5 of the *Second Treatise,* is among the greatest achievements of seventeenth-century political and economic thought. Here Locke cuts to the original position immediately: In the beginning all things belonged equally to all human beings, and each had leave to take from the earth whatever he or she needed. What then is the origin of any private rights to property?

Each person has ownership of his or her own body and labor. In order for some external good such as food to be enjoyed it must sooner or later be appropriated. After an apple is consumed it joins with the perfect privacy of the flesh. Locke argues that the moment of appropriation comes when someone's labor is mixed with the bounty of nature. When acorns are first gathered from the wild, they become private property. The right of appropriation is universal, the only limit is that one may gather only what one can use.

Locke weds this account with a theory of economic progress, which includes in turn a labor theory of value and a theory of money. The greater part of the value of any product originates in the labor required to produce it. Invested in a loaf of bread, for example, is a plowed and cultivated field, harvested and milled wheat, a bricked and furnished bakery. All this labor represents a vast increase in the wealth available to humankind over what unimproved nature provides.

But how is it possible to encourage people to labor beyond what their needs require or the durability of their produce allows? The answer lies in money, the exchange of the products of one's labor for some durable medium of nominal rather than real value. When someone settles and improves a piece of land, it is taken out of the common stock; however, in return for money, the settler gives back more value than he or she took away. Locke understood that this process, repeated across a wide range of industries, was an engine of unprecedented economic growth. For that reason, one of the most important ends of government was the protection of private property.

Locke's theory of property may be set comfortably in the context of a fundamental modern project: the conquest of nature. The natural world is not charitable to human beings. It provides little of what they need in advance of their labor. But the potential wealth that exists in nature is vast beyond calculation. Thus the aboriginal inhabitants of America who, Locke says, "are rich in land but poor in the comforts of life" exemplify the situation of human beings in the state of nature (Locke 1988, p. 296). By encouraging labor, a system of money and property rights will result in the most thorough cultivation of nature, for the comfort of all humankind.

It is clear that Locke's approach to all three topics elevates the products of human invention far above the natural materials from which they are fashioned. Complex ideas are more interesting and useful than simple ones. There is both more security and more freedom under government than out from under it. If a government acts to protect property rights, human beings will then make whatever they need to relieve the poverty into which the species was born. Nature will be reduced to a storehouse of useful materials.

KENNETH C. BLANCHARD JR.

SEE ALSO *Hume, David; Liberalism; Libertarianism; Mill, John Stuart; Skepticism.*

BIBLIOGRAPHY

Goldwin, Robert. (1987). "John Locke." In *History of Political Philosophy,* 3rd edition, ed. Leo Strauss and Joseph Cropsey. Chicago: University of Chicago Press. 1st edition, 1963; 2nd edition, 1972. One of the most thorough essays on Locke's place within the larger context of modern thought.

Locke, John. (1975). *An Essay Concerning Human Understanding,* ed. Peter H. Nidditch. Oxford: Oxford University Press.

Locke, John. (1988). *Two Treatises of Government,* ed. Peter Laslett. Cambridge, UK: Cambridge University Press. A very useful edition of Locke's most important political work, including a very extensive introductory essay on the historical context of the works.

Locke, John. (1997). *Political Essays,* ed. Mark Goldie. Cambridge, UK: Cambridge University Press. A thorough collection of Locke's major and minor essays, including his essays on the Law of Nature.

Mackie, John L. (1976). *Problems from Locke.* Oxford: Oxford University Press. A consideration of Locke's essay in light of contemporary science and analytical philosophy.

Walmsley, Jonathan. (2004). "Locke's Natural Philosophy in Draft A of the Essay." *Journal of the History of Ideas* 65(1): 15–37. A treatment of Locke's early views and of his collaboration with Sydenham.

LOGICAL EMPIRICISM

Logical empiricism (LE) is a term that was coined by the Austrian sociologist and economist Otto Neurath (1880–1945) to name the philosophical work of the Vienna Circle and related work being pursued by the physicist and philosopher Hans Reichenbach (1891–1953) and his associates. Related terms include *logical positivism*, *neopositivism*, and *scientific empiricism*. The basic intention of LE was to formulate a scientific philosophy for understanding the relationship between science and society. In historico-philosophical terms the aim was to combine the empiricist legacy of philosopher-scientists such as Hermann von Helmholtz (1821–1894), Ernst Mach (1838–1916), Henri Poincaré (1854–1912), and Pierre Duhem (1861–1916), with the new logic developed by Gottlob Frege (1848–1925), David Hilbert (1862–1943), and Bertrand Russell (1872–1970). The intended synthesis was not simply a theoretical project. Logical empiricists considered themselves part of a progressist movement for a more rational and enlightened society. As stated in the so-called Manifesto of the Vienna Circle, LE aimed to foster a "scientific world-conception" ("wissenschaftliche Weltauffassung") that would help create a better world for all people.

The Scientific World-Conception

The characteristic method of LE was logical analysis, which used mathematical logic to clarify the logical structure and meaning of assertions. In this way LE aimed for a logical analysis of scientific and philosophical language that would distinguish clearly between meaningful and meaningless sentences; fight against metaphysics, which was considered as a hotbed of meaningless "pseudo-sentences"; and provide a "unified science" (*Einheitswissenschaft*) that would be formulated in a logically analysed language cleansed of metaphysical elements.

LE claimed that logical analysis demonstrated that there are only two kinds of meaningful propositions, the analytic a priori propositions of logic and mathematics and the synthetica posteriori propositions of empirical sciences. All other assertions were to be considered cognitively meaningless. This holds in particular for all metaphysical propositions. The most famous argument to this effect is found in "Overcoming Metaphysics by Logical Analysis of Language" 1932 by Rudolf Carnap (1891–1970). Moreover, "overcoming metaphysics" was not simply an internal philosophical issue because logical empiricists considered metaphysics to be a medium for propagating politically and morally pernicious ideologies that had to be fought not only in the academic sphere but also in the political arena.

Politically, most logical empiricists were democratic socialists or unorthodox Marxists and thus were partisans of an "engaged scientific philosophy." A few, such as Moritz Schlick (1882–1936) and Friedrich Waismann (1896–1959), were less political but shared a progressive, liberal outlook.

For all logical empiricists scientific philosophy was a collective enterprise that had to contribute to the construction of a modern, enlightened society. That task was to be carried out in close collaboration with the sciences and other progressive cultural forces, such as the artists and architects belonging to the *Neue Sachlichkeit* movement or the Bauhaus. When LE was at its peak in the late 1920s and early 1930s, the more radical logical empiricists of the Vienna Circle, such as Neurath and Carnap, regarded themselves as "social engineers" engaged in the task of forging the philosophical and scientific tools for building a new socialist society. This is expressed emphatically in the concluding lines of the *Manifesto of the Vienna Circle*: "We witness the spirit of the scientific world-conception penetrating in growing measure the forms of personal and public life, in education, upbringing, architecture, and the shaping of economic and social life according to rational principles. The scientific world-conception serves life, and life receives it" (Sarkar 1996, Vol. I, pp. 329– 330).

LE included a multifaceted and variegated group of philosophers and scientists. Its internal diversity often is underestimated. LE was less a school with a common doctrine than a movement whose members shared vaguely progressist convictions. Even closely related thinkers such as Carnap and Neurath disagreed on many basic philosophical issues. Here the focus is on few leading figures of the Vienna Circle: Schlick, its founder; Carnap and Neurath; and Carl Gustav Hempel (1905–1997), the most influential representative of LE in the United States.

In the early 1930s the LE movement in Europe gradually dissipated as a result of disastrous, political developments and indivdual events. The mathematician Hans Hahn (1879–1934), considered by some to be the "real" founder of the Vienna Circle, died in 1934, and Schlick was murdered by a demented student in 1936. In 1934 Carnap left Vienna and moved to the German university in Prague. After the rise of National Socialism in Germany (1933) and clerical fascism in Austria (1934) most logical empiricists emigrated. The majority went to the United States, including Carnap, Reichenbach, and Hempel. The history of LE thus divided into two periods: a European period ending in the mid-1930s and an Anglo-American period from the 1930s until its dissipation in the 1960s.

Major Figures and Their Ideas

The founder and official leader of the Vienna Circle was Schlick, who studied physics under Max Planck (1858–1947). Later Schlick turned to philosophy, and in 1922 he was appointed to the chair of natural philosophy at the University of Vienna as the sucessor to Ludwig Boltzmann (1844–1906) and Ernst Mach (1838–1916). Beginning in 1923, he and his assistants Herbert Feigl (1902–1988) and Friedrich Waismann organized a discussion group (first called the "Schlick circle") that soon became known as the "Vienna Circle."

Schlick had begun as a "critical realist", and later was influenced by Ludwig Wittgenstein (1889–1951). In *The Turning-Point in Philosophy* (1930) Schlick emphatically endorsed Wittgenstein's thesis that the philosophy of science is not to be considered a system of knowledge but instead a system of acts: "[P]hilosophy . . . is that activity whereby the meaning of statements is established or discovered. Philosophy elucidates propositions, science verifies them" (Sakar 1996, vol. II, p. 5). This entailed the idea that only propositions that are meaningful can be verified. Philosophy, as philosophy of science, thus is left with the task of explaining what is meant by verification. Following Wittgenstein, Schlick proposed that the meaning of a proposition is established by its method of verification, that is, method for determining whether it is true or false. Formulated negatively, a proposition for which no verification procedure can be imagined is a meaningless pseudo-sentence.

The principle of verifiability initially appears to be quite plausible. However, it turns, out to be impossible to construct a definition that would classify all the statements of empirical science as meaningful while disqualifying all metaphysical assertions as meaningless. Even if it was easy to formulate criteria that rendered meaningful observational statements such as "it is cold outside now," it turned out to be extremely difficult to distinguish in a principled manner meaningful scientific statements such as "all electrons have the same charge" or "f = ma" from meaningless metaphysical pseudo-statements such as "the absolute is perfect".

Probably the best-known representative of LE is Carnap; there is even a misleading tendency to identify LE with Carnap's philosophy. Carnap began his philosophical career as a neo-Kantian with *The Logical Structure of the World (Der Logische Aufbau der Welt)* (1928), which proposed constitutional theory as a scientific successor to traditional epistemology and philosophy of science. Constitutional theory was to be a general theory of rational reconstruction of scientific knowledge in the logico-mathematical framework of Alfred North Whitehead (1861–1947) and Bertrand Russell's (1872–1970) *Principia Mathematica*. In informal terms the constitution of a concept provides coordinates that determine its logical place in a conceptual system.

Subsequently, Carnap replaced constitutional systems with more empiricist constitutional languages and pursued the philosophy of science as the study of the structure of the languages of science. According to Carnap, the task of philosophy is to construct linguistic and ontological frameworks that can be used in the ongoing progress of scientific knowledge. In *Testability and Meaning* (1937) he argued that philosophy should not formulate its principles as assertions such as "All knowledge is empirical" or "All synthetic sentences that we can know are based on experiences" or the like—but rather in the form of a proposal or requirement. By such a formulation, he maintained, "greater clarity will be gained both for carrying on discussion between empiricists and anti-empiricists as well as for the reflections of empiricists" (Sakar 1996, Vol. II, p. 258). Throughout his philosophical career Carnap saw the task of logical empiricist philosophy of science as formulating a general theory of linguistic frameworks to provide conceptual tools for the enhancement of science and philosophy, as already had been done implicitly in the 1929 manifesto.

The sociologist, economist, and philosopher Neurath was the most radically "engaged philosopher" in the Vienna Circle. He was the driving force behind the rapid change from an academic discussion group to an international philosophical movement that eventually was to dominate the philosophy of science in the mid-twentieth century. A pitiless fighter against traditional metaphysics, Neurath made his most important positive contribution to the scientific world-conception in the form of the project of "unified science."

In contrast to the essentially negative program of eliminating metaphysics, the project for a unified science is the great constructive paradigm of LE. According to Neurath, scientific knowledge does not have the form of an all-embracing deductive system but constitutes an encyclopedia. According to encyclopedism, as he termed his account, scientific knowledge has the following five characteristics: It is fallible, pluralistic, holistic, and locally but not globally systematizable, and it is not an image of the real world. Neurath conceived the encyclopedistic project as a large-scale politico-scientific and philosophical program aimed at the highest possible level of the integration of the sciences without succumbing to the temptation of an exaggerated rationalism that would force the sciences into the straihtjacket of a metaphysical system.

The foundation for Neurath's encyclopedism was a robust physicalism according to which all concepts can be defined ultimately and entirely in terms of physicalist concepts and/or the concepts of logic and mathematics. Physicalist concepts are not simply the concepts of physics but instead are the concepts of everyday language dealing with middle-sized spatio-temporally located things and processes. Physicalist language, cleansed of metaphysical phrases and enriched by scientific concepts, was conceived as a mixed language containing precise and vague terms side by side. Depending essentially on the concrete practices of everyday life, Neurath's encyclopedism turned scientific knowledge into historically and socially situated knowledge. This had strong implications for its form. Instead of the "pseudorationalist" conception of a timeless objective "system" of knowledge that would create a picture of the world "as it really is," Neurath put forth a more flexible, nonhierarchical encyclopedia as the appropriate model for human knowledge.

Although Neurath's account of LE is the version most congenial to science, technology, and social studies, this has not been recognized widely. One reason for this misunderstanding is Neurath's death in 1945, which made it impossible to promote his version of LE in the Anglo-American world. Since the 1980s, however, Neurath's vision has received a considerable reconsideration in both the United States and Europe.

Carl Gustav Hempel was Reichenbach's student in Berlin but also spent time in Vienna. After emigrating to the United States via Belgium he became Carnap's assistant in 1937. He began his philosophical career with a dissertation on the logical analysis of the concept of probability. In the 1950s and 1960s he became the most influential logical empiricist in the English-speaking philosophical community. His papers set a standard for the logical analysis of concepts. For instance, his contributions to the theory of scientific confirmation and explanation, especially the covering-law model, determined the agenda of analytic philosophy of science for decades. His "Fundamentals of Concepts Formation in Empirical Science" (1952) served as an introduction to philosophy of science for generations of students.

Hempel was particularly engaged in pointing out difficulties and paradoxical features in many core concepts of the philosophy of science, arguing for the necessity of a thoroughgoing logical analysis. The "raven paradox" is a famous example: If it is a law of nature that all ravens are black, the observation of a black raven may count as a (partial) confirmation of this law. Moreover, it is reasonable to assume that laws of nature should be independent of their logical formulation. Thus, the law that all ravens are black has the logical form "All R are B," which is logically equivalent to "All non-B are non-R." With this conceded, a green frog, as something that is not black and not a raven, counts as a (partial) confirmation of the original law. However, this is absurd. Hence, something in the conception of natural law and confirmation seems to be wrong. The raven paradox shows that philosophers do not understand even the most basic concepts in the philosophy of science fully.

Hempel's philosophical work was characterized by a careful and circumspect application of modern logic that made the achievements of logical analysis attractive even for those who were not professional logicians and philosophers. For instance, *The Function of General Laws in History* (1942) exerted influence far beyond the confines of philosophy. It is one of the few LE analyses that has had an impact in the humanities. In *Problems and Changes in the Empiricist Criterion of Meaning* (1950) Hempel further criticized the various logical empiricist attempts to formulate a waterproof criterion for distinguishing meaningful and meaningless assertions. In later years Hempel was influenced by Thomas Kuhn (1922–1996), belying the claim that LE and historical accounts of science are necessarily opposed.

Assessment

A special problem in LE is the transformation of the movement when the intellectual exodus from Europe to the United States took place in the 1930s. The transplantation of LE did not leave its philosophical content unaffected. Although a comprehensive history of LE has not been written, important differences between the two versions can be noted easily. European LE was politically much more radical than its U.S. successor. Although the Vienna Circle showed a vigorous interest in political and social issues such as education, technology, architecture, and art, in the United States the political dimension of LE became less visible. For instance, Carnap was a dedidated supporter of the civil rights movement until the end of his life.

One factor in this change from a radically "engaged scientific philosophy" to an academically confined "philosophy of science" is surely the fact that logica empiricists had to adapt to a different political and societal context in which the application of their traditional political categories was difficult. Another reason may have been that to survive in exile it was expedient to use a language that was more cautious than that which was acceptable in the "Red Vienna" of the late 1920s. After all, LE started in the United States among a rather obscure philosophical group of emigrants without much of a reputation. Only gradually did it become the mainstream in Anglo-American philosophy of science and epistemology in the 1940s and 1950s.

The dominance of LE did not last long, however. First, many of the internal problems of the movement, such as the issue of distinguishing neatly between meaningful and meaningless statements, stubbornly resisted a satisfying solution. Second, analytic philosophers such as Willard van Orman Quine (1908–2000) and Hilary Putnam (b. 1926) attacked the very basis of the logical empiricist philosophy of science, that is, the distinction between the synthetic/analytic and the observational/theoretical levels of empirical knowledge. Third, authors such as Norwood Russell Hanson (1924–1967) and Thomas Kuhn (1922–1996) shifted the emphasis from the strictly logical toward the historical and sociological aspects of scientific theorizing, thus challenging the autonomy of a logical philosophy of science in the style of Carnap.

In a sense these and related developments were welcomed as liberations from the straitjacket of the so-called "received view." For instance, one immediate consequence of the logical empiricist thesis that meaningful statements are either analytic or empirical was that all value judgments are cognitively meaningless. Value statements are not analytic because they say nothing about the world and are not empirical because they cannot be verified. Hence, they are meaningless. The dichotomy between analytic and empirical statements led logical empiricists to a strictly noncognitivist (emotivist) ethics according to which there can be no knowledge of values in a proper sense. This stance is not to be considered as necessarily leading to a loss of interest in moral and political problems. All members of the Vienna Circle took a strong interest in the political and social events they were living through. These problems, however, were considered as practical problems, to be strictly separated from the theoretical problems science and philosophy were dealing with.

This emotivist account of ethics, which leaves only a small niche for "theoretical meta-ethics," that is, the logical analysis of moral statements, is insufficient. In a world in which science and technology present increasing numbers of ethical questions and difficulties, it does not provide reasoned arguments formorally relevant actions.

At the same time the complete dismissal of LE by the self-proclaimed "revolutionary" postpositivist philosophy of science might have been a bit hasty, especially if one takes into account its lesser-known European variants. Indeed, the differences between LE and postpositivist philosophy of science might have been unfairly exaggerated. With regard to Neurath's and Hempel's versions of LE, it does not seem far-fetched to suggest that to some extent the allegedly unbridgeable gap between LE and its successors has been an interest-guided social construction. As usual, the critics of LE were unaware of how much they had absorbed of the belief system they so eagerly berated.

In summary, one may propose that LE was a rich philosophical movement that set the stage for a large part of the philosophy of science and epistemology during the twentieth century. However, despite this general claim, a balanced assessment of the movement has not been formulated. In particular, the relationships between LE and its successor disciplines, such as the various currents of "postpositivist" philosophy of science, cultural studies of science, and science, technology, and society studies (STS), are not yet fully appreciated.

ANDONI IBARRA
THOMAS MORMANN

SEE ALSO *German Perspectives; Science, Technology, and Society Studies; Wittgenstein, Ludwig.*

BIBLIOGRAPHY

Carnap, Rudolf. (1967 [1928]). *The Logical Structure of the World.* Berkeley and Los Angeles: University of California Press. Basic work of logical empiricism of the Vienna Circle.

Carnap, Rudolf. (1937). *The Logical Syntax of Language.* London: Routledge and Kegan Paul. Basic work of logical empiricism.

Friedman, Michael. (1999). *Reconsidering Logical Positivism.* Cambridge, UK: Cambridge University Press. Collection of trail-blazing essays for the recent re-evaluation of logical empiricism, particularly Carnap's philosophy.

Giere, Ronald N., and Alan W. Richardson, eds. (1996). *Origins of Logical Empiricism*. Minnesota Studies in the Philosophy of Science XVI. Minneapolis and London: University of Minnesota Press.

Hempel, Carl Gustav. (2000). *Selected Philosophical Essays*, ed. Richard Jeffrey. Cambridge, UK: Cambridge University Press.

Kuhn, Thomas S. (1970). *The Structure of Scientific Revolutions*. Chicago: Chicago University Press. Basic work of post-empiricist philosophy of science.

Neurath, Otto. (1981). *Gesammelte philosophische und methodologische Schriften*, 2 vols., ed. Rudolf Haller and Heiner Rutte. Vienna: Hölder-Pichler-Tempsky. Collected philosophical and methodological works of Neurath.

Sakar, Sahotra. (1996). *Science and Philosophy in the Twentieth Century: Basic Works of Logical Empiricism*, 6 vols. New York and London: Garland. Six volumes of reprints of the classic papers of logical empiricism and related currents of philosophy.

Stadler, Friedrich. (2001). *The Vienna Circle: Studies in the Origins, Developments, and Influence of Logical Empiricism*. Vienna and New York: Springer. Provides the most complete account of logical empiricism in Europe.

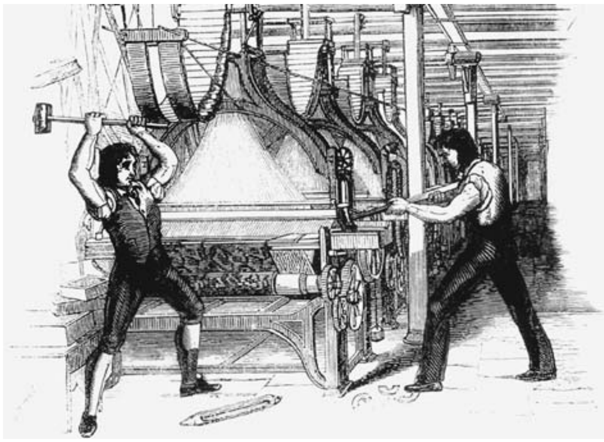
LUDDITES AND LUDDISM

Luddite and *Luddism* are terms of both derision and praise. Depending on context, they have been used to indicate either mindless opposition to or critical assessment of technology and science.

Origins

The first Luddites were English textile workers who in 1811 and 1812, during the Industrial Revolution, resisted and rebelled against the use of wide-frame knitting machines, shearing machines, and other machines of mass production. The term is based on a mythical Ned Ludd who supposedly led the workers in their resistance. The Luddites, however, were not one unified political group. They reflected their regions and local trade organizations, hence the more appropriate use of the terms Manchester, Yorkshire, and Midland Luddites.

Much of the knitting of stockings and other apparel was done in cottages and small shops by knitters (stockingers) who sometimes owned their own frames but usually rented them from the hosiers (the knitting-frame was invented by William Lee in 1589 and introduced in the Midlands in the mid-1600s). The knitting-frame, operated by an individual at home, could make 600 stitches per minute as opposed to about 100 stitches by hand-knitters. Frame-knitting in cottages sustained a way of life for more than a century.



Depiction of the Luddite Rebellion. The rebellion began in 1811 when organized bands of men in England s Midlands began breaking into hosiery factories and smashing looms used to weave stockings. Claiming allegiance to "General Ludd," the Luddites were skilled craftsmen driven to despair by changes in weaving technology that cost them wages and worsened the effects of the already ongoing economic crisis. *(© Mary Evans/Thomas Philip Morgan.)*

The rebellion began in March 1811 in the Midland shire of Nottingham (home of the legendary Robin Hood) and then spread north to Manchester and Yorkshire. At the height of the rebellion, knitters, croppers, and other textile workers smashed textile machinery almost on a daily basis. The Midland Luddites were particularly well organized and led a sustained campaign of focused machine breaking without resorting to the more general violence evident in their northern counterparts. The open rebellion ended in 1812 with arrests and subsequent hangings.

The original Luddite rebellion grew out of intolerable economic and political conditions that threatened the livelihoods of the textile workers and eventually destroyed their cottage industry and their way of life. Economic factors included a depressed market resulting in part from Napoleon's economic blockade of British trade and Britain's counter-blockade of European ports. Wages decreased substantially at a time when a number of poor harvests in 1809 nearly doubled the price of bread.

Political conditions also fueled the rebellion. Fearful the French Revolution would spread to the working class, the Parliament passed the Combination Acts of 1799 and 1800 to outlaw trade unions and muzzle workers, making it a criminal offense for workers to join together to petition employers for fair wages and better working conditions. Furthermore the government's policy of non-intervention in industrial relations abandoned the working class to the captains of capitalist industry. In addition the Midland Luddites believed the acts of Parliament contravened the charter from King Charles II that founded the Framework Knitters' Company. In rebelling, the Midland frame-knitters upheld the principles of their charter to regulate their trade.

Historically Luddism may thus be described as an assertion of the right of organized trade to protect its way of life from the unfair introduction of technology, from technology that reduces the quality of the product, and from political measures that would change the trade without the consent of the trade workers.

Developments

Although the Romantic poet George Gordon Lord Byron (1788–1824) defended Luddites against their critics, by the mid-1800s the term had largely disappeared from use. Then in 1959 the novelist C. P. Snow in his famous lecture defending "The Two Cultures and the Scientific Revolution" revived it to stigmatize *literary intellectuals* such as T. S. Eliot and William Butler Yeats as *natural Luddites*. Following Snow, the term became a common way to disparage critics of the cultural influence of modern science as simply uninformed antitechnologists.

In the late-twentieth century, however, critics attempted to turn the tables on those who would dismiss them as technophobes by adopting the term *neo-Luddite* and *neo-Luddism* as a badge of honor for those who refuse to uncritically accept virtually everything that techno-economic momentum throws up. As Langdon Winner (1986) argued, technology critics are no more antitechnology than art and literature critics are anti-art and anti-literature. The most influential defense of this critical stance was perhaps Chellis Glendinning's "Notes Toward a Neo-Luddite Manifesto" (1990), which argued that technology and technological systems may be beneficial to global capitalism but are not necessarily beneficial to human beings, the environment, and the common good. Although neo-Luddism is not a well-defined creed, it commonly includes critiques of consumer culture, television, and high-energy use automobiles while promoting enhanced participation in technological design, social and economic equity, and respect for nature. Some representatives draw inspiration from religious traditions, especially Quakers, Mennonites, Amish, and Shakers. Others argue an inherent will to power in modern technology that threatens human dignity rather than enhancing it.

FRANK H. W. EDLER

SEE ALSO *Industrial Revolution; Modernization.*

BIBLIOGRAPHY

Bailey, Brian. (1998). *The Luddite Rebellion*. New York: New York University Press.

Binfield, Kevin, ed. (2004). *Writings of the Luddites*. Baltimore, MD: Johns Hopkins University Press.

Fox, Nichols. (2002). *Against the Machine: The Hidden Luddite Tradition in Literature, Art, and Individual Lives*. Washington, DC: Island Press/Shearwater Books.

Glendinning, Chellis. (1990). "Notes Toward a New-Luddite Manifesto." *Utne Reader* 38(March/April): 50–53.

Sale, Kirkpatrick. (1995). *Rebels Against the Future: The Luddites and Their War on the Industrial Revolution: Lessons for the Computer Age*. Reading, MA: Addison-Wesley.

Winner, Langdon. (1986). *The Whale and the Reactor: A Search for Limits in an Age of High Technology*. Chicago: University of Chicago Press.

LUHMANN, NIKLAS

German sociologist Niklas Luhmann (1927–1998) was born in Lüneburg on December 6. In more than seventy books and 450 papers, he developed what is perhaps the most comprehensive theory of modern society, in which ethics plays an important, but secondary, role. Educated in legal science, Luhmann was inspired by the phenomenology of Edmund Husserl, the systems theory of Talcott Parsons, the theory of autopoiesis of Humberto Maturana, the second order cybernetics of Heinz von Foerster, and the form calculus of G. Spencer-Brown. He synthesized these elements into a systems theory of impressive scope and radicalism, representing what he saw as a paradigm shift in the social sciences. He died on November 6 in Bielefeld, Germany.

A Universal Systems Theory

Luhmann distinguished between physical, biological, mental, and social systems, but his main focus was on social systems, which he subdivided into interactions, organizations, and society as a whole. His main theoretical tool was the *distinction*. In order to observe social systems, the observer must use a *guiding distinction*. Luhmann chose the distinction between system and environment, but admitted that others were possible.

A radical tenet of Luhmann's systems theory is the thesis that social systems consist only of communication—not of persons, of artifacts, or even of actions. Communication is defined as the unity of three selections: information, utterance, and understanding, to which is added the acceptance or rejection of the receiver to continue the communication. Because communications are transient events, the system must generate linguistic structures and themes to create and combine new communications. Social systems are autopoietic systems, creating their own elements within their network of elements. Even though human beings, as information-processing units, are necessary for communication, they are not part of the communication, but of its environment. The physical world is likewise not part of the communication, but is only its object, and it is not the function of communication to mirror the physical world. By using the theory of autopoiesis, Luhmann made systems theory dynamic, with time and change at its center. Everything in a social system is contingent, meaning that alternatives are always possible.

According to Luhmann, social systems cannot be understood in terms of *rationality*, *norms*, or *human beings*. Change must be seen as evolution, a choice among existing alternatives. There is no one point of view from which society can be correctly observed and described. With the cultural death of God, and the attendant loss of the only ostensibly *right* worldview, a poly-centered world remains. In his late-twentieth-century analysis, Luhmann claims that the most fruitful way of imagining society is as a world community with no center, no purpose, and no overarching rationality.

Luhmann analyzes society as a unity of functional subsystems, each having is own symbolic generalized medium and its own guiding distinction. Society can be observed from many points of view, economic (where the medium is money), political (power), scientific (truth), intimate (love), and more. The number of functional subsystems is an empirical question. In addition to his two principal works, *Soziale Systeme* (1984) and *Die Gesellschaft der Gesellschaft* (1997), Luhmann wrote a series of monographs dealing with the various social subsystems.

Functional subsystems make communication more effective. By using symbolic generalized media, it is possible to communicate on a world scale because the simple binary form allows for simplification, motivation, and measurement of success or failure. An observer can quickly decide whether or not he will take over the point of view inherent in the medium. Symbolic generalized media can differ—in operation mode and time relations, among others—but all share a common structure. Though the most effective communications in modern society are oriented towards functional subsystems, Luhmann acknowledged that what is good for a functional subsystem is not necessarily good for society as a whole because proponents of each subsystem have biased and narrow views.

Technology can also be seen as a functional subsystem, operating in the medium of effectiveness. Its code is functioning or broken, its programs are blueprints, its institutions are organizations and universities, and its contribution to society is maintenance of regular processes. Technology has its own internal dynamics and thus it might clash with or be helpful to other functional subsystems.

Functional subsystems are not action systems. They *do* nothing, but can be conceived as semantic discourses. The action systems of twenty-first-century society are organizations; specialized organizations define themselves as agents of a particular functional subsystem, such as technology, religion, or law.

Morals and Ethics in Functional Subsystems

In real life, subsystems must cooperate. Because their respective criteria for success and failure are not the same, conflicts arise with no objective solution, thus creating a need for normative or ethical solutions. As a consequence, many functional subsystems develop special professional ethics criteria to deal with the integration of highly specialized products and methods in society.

It should be noted that no functional subsystem uses the moral distinction between right and wrong. One reason for this is empirical: A moral distinction is not precise enough to facilitate communication. It has too many dimensions. A moral evaluation might focus on motives or on consequences, and be dependent on religious or subcultural assumptions. Moralizing creates conflict, not consensus. Instead Luhmann views morality as a tool for distributing *esteem*, which depends not on professional skills but on the qualities of a person as a whole.

Morals have important social functions and Luhmann wrote extensively on moral issues though he flatly rejected any attempt to understand society in moral or purposive terms. Luhmann conceded that moral distinctions are used with the same spontaneity as empirical distinctions in daily life. Using the distinction between moral and ethics, he argued that ethics is a theoretical reflection of the social phenomenon of morals, and concluded that the most important task of ethics is to warn against morals. He had no illusions as to the effectiveness of ethics to control technological development. Because there is no ethical consensus in modern society, no ethical control is possible or desirable.

Each functional subsystem has its own criteria for success or failure, but it also has a tendency to exaggerate its own importance and blind itself to other criteria. Economy focuses on money, politics on power, and science on truth. When criteria clash, no super rationality can create a rational solution. Luhmann had a lifelong debate with the German philosopher Jürgen Habermas regarding this issue. Habermas stresses the possibility of rational consensus, while Luhmann argues that conflict is not only inevitable, but also fruitful. Consensus is only a transient phase in the ongoing communication of social systems.

Luhmann accepted that functional subsystems have evolved as centers for solving specific tasks, however, he argued the need for *criteria for criteria* or second order criteria. But such criteria, which might be called ethical criteria, are not socially binding. There is no universally accepted viewpoint from which the social and moral implications of technology or pollution, for example, can be observed and judged right or wrong.

Luhmann described each functional subsystem as having its own complexity and society as a whole as a hypercomplex entity composed of many functional subsystems. However Luhmann posited no solutions to the problems he presented. With no rationality, there is only evolution to rely on: Something will happen, perhaps better, perhaps worse, perhaps catastrophic. When nations, organizations and persons try to control technology, they are controlled by the technology they want to control and are unable to control all the other actors trying to control. Technology, like life, will find its way.

OLE THYSSEN

SEE ALSO *German Perspectives; Habermas, Jürgen.*

BIBLIOGRAPHY

Luhmann, Niklas. (1984). *Soziale Systeme*. Frankfurt am Main, Germany, Suhrkamp Verlag. English translation, *Social Systems*. Sanford, CA: Stanford University Press (1995).

Luhmann, Niklas. (1997). *Die Gesellschaft der Gesellschaft*. Frankfurt am Main, Germany: Suhrkamp Verlag

LYOTARD, JEAN-FRANÇOIS

French philosopher Jean-François Lyotard (1924–1998), who was born in Vincennes, France, on August 10, was an originator of what became known as postmodernism. After teaching philosophy in secondary schools in France and Algeria, Lyotard was awarded a position at the University of Paris VII, where he also served as a council member of the Collège international de philosophie. Toward the end of his life he also held visiting professorships in the United States. Lyotard died of leukemia in Paris on April 21.

Lyotard's work is marked by a persistent interest in the relations between science, technology, ethics, and politics, as can be seen in the work for which he is most well known, *The Postmodern Condition: A Report on Knowledge* (1984), which focuses on the state of knowledge in highly developed countries. According to Lyotard, the sciences and late twentieth-century societies were in the midst of a legitimation crisis because of the inability to provide a justification in the form of an overarching explanation of the relations between science, technology, and society.

Lyotard explains the crisis using Ludwig Wittgenstein's (1889–1951) notion of language games. A language game is a field of discourse defined by a set of internal rules that establish the types of allowable statements. Different discourse practices, such as science and ethics, have become distinct language games, adhering to different sets of rules. Because disparate language games prohibit statements that fail to conform to their rules, it is impossible to give a single, overarching account that would guarantee the legitimacy of all possible discourse practices. For this reason, Lyotard states that the postmodern situation is marked by an "incredulity toward meta-narratives" (Lyotard 1984, p. xxiv).

If Lyotard is correct and it is no longer permissible to give an overarching account for the diversity of discourse practices, then the postmodern condition demands a new response to the problem of legitimation. Lyotard claims that the appropriate response to the problem in a society marked by the postmodern condition is "paralogy." In the practice of paralogy, the goal of producing an overarching legitimation narrative is replaced by an attempt to increase the possible language moves in a particular language game. Hence, paralogy champions the diversity of discourse practices by prohibiting the hegemony of a single discourse over all others. Paralogy thus resists the tendency to treat ethics and politics as forms of scientific knowledge or technology.

The Postmodern Condition has implications for ethics that are further developed in *The Differend: Phrases in Dispute* (1988). A *différend* is Lyotard's label for an irresolvable conflict between two phrases or parties. The *différend* as a conflict between phrases was implied in Lyotard's earlier work as the inability to unify diverse language games. In this work, however, rather than being concerned with the legitimation of knowledge, Lyotard develops the notion of the *différend* to include a certain type of injustice that occurs to differing language games (or genres), specifically the cognitive and ethical.

The ethical genre, according to Lyotard, is concerned with prescriptive statements of the form "you ought," whereas the cognitive genre consists of descriptive statements. Ethics, with its prescriptive statements, is a discourse of obligation. As such, ethics takes the form of phrases marked by an asymmetry between the addressor and the person addressed. The person who says "You shall not lie" commands interlocutors and places obligations upon them, but the statement "Lying is wrong" leaves out the relation between persons that is characteristic of ethical discourse. Consequently for Lyotard, the nature of ethics is covered over in attempts to transform the prescriptive into the descriptive.

In response to this threat, the task of philosophy, according to Lyotard, is to champion and protect the diversity of discourse and practice. While not providing a unifying account of the relations between genres, philosophy is marked by an obligation to bear witness to the *différend*. Although primarily focused on discourse, this responsibility extends to the sociopolitical world, in which there is the continuous threat of one social entity (individual persons or cultures) being overpowered by another.

Lyotard's thinking continues to be a powerful, cautionary note for the relations between science, technology, and ethics. Rather than subsume distinct discourses under a unifying account, his work argues for maintaining that which marks each as different.

KEM D. CRIMMINS

SEE ALSO *French Perspectives; Postmodernism.*

BIBLIOGRAPHY

Bennington, Geoffrey. (1988). *Writing the Event*. New York: Columbia University Press. Critical exposition of Lyotard's philosophy.

Lyotard, Jean-François. (1984). *The Postmodern Condition: A Report on Knowledge*, trans. Geoffrey Bennington and Brian Massumi. Minneapolis: University of Minnesota Press. Originally published as *La condition postmoderne: Rapport sur le savoir* (Paris: Minuit, 1979).

Lyotard, Jean-François. (1988). *The Differend: Phrases in Dispute*, trans. Georges Van Den Abbeele. Minneapolis: University of Minnesota Press. Originally published as *Le différend* (Paris: Minuit, 1983).

Lyotard, Jean-François. (1988). *Peregrinations: Law, Form, Event*. New York: Columbia University Press.

Lyotard, Jean-François. (1997). *Postmodern Fables*, trans. Georges Van Den Abbeele. Minneapolis: University of Minnesota Press. Originally published as *Moralités postmodernes* (Paris: Galilée, 1993).

Rojek, Chris, and Bryan S. Turner, eds. (1998). *The Politics of Jean-François Lyotard: Justice and Political Theory*. New York: Routledge. Collection of eight articles.

Silverman, Hugh J., ed. (2002). *Lyotard: Philosophy, Politics, and the Sublime*. New York: Routledge. Collects sixteen articles.

LYSENKO CASE

The debate on the relative influence of heredity and environment took a distinctive form in the Soviet Union in the turbulent years between the 1920s and the 1960s. There was among many committed communists a sense that the socialist revolution should transform everything, including the foundations of knowledge. There was intense debate about what constituted a Marxist approach to every discipline, including biology.

Lysenko's Practice and Theory

Into this context came Trofim Denisovich Lysenko (1898–1976), a young agronomist from the Ukraine, who emerged into the limelight in 1927 in connection with an experiment in the winter planting of peas to precede the cotton crop in the Transcaucasus. The results he achieved in a remote station in Azerbaijan were sensationalized in the national Communist Party newspaper *Pravda*. The article projected an image of him as a sullen, barefoot scientist close to his peasant roots. Lysenko subsequently became famous for *vernalization*, an agricultural technique that allowed winter crops to be obtained from summer planting by soaking and chilling the germinated seed for a determinate period of time. Lysenko then began to advance a theory to explain his technique. The underlying theme was the plasticity of the life cycle. Lysenko came to believe that the crucial factor in determining the length of the vegetation period in a plant was not its genetic constitution, but its interaction with its environment. By the mid-1930s he rejected the existence of genes and held that heredity was based on the interaction between the organism and its environment, through the internalization of external conditions. He recognized no distinction between genotype and phenotype.

Lysenko's theory was an intuitive rationalization of agronomic practice and a reflection of the ideological environment surrounding it rather than a response to a problem formulated in the scientific community and pursued according to rigorous scientific methods. Lysenko seemed to achieve results at a time when there was a great demand for immediate solutions and a growing impatience with the protracted and complicated methods employed by established scientists. This brought a sympathetic predisposition to whatever theoretical views Lysenko chose to express, no matter how vague or unsubstantiated.

Even Lysenko's practical achievements were extremely difficult to assess. His methods were lacking in rigor. His habit was to report only successes. His results were based on extremely small samples, inaccurate records, and the almost total absence of control groups. An early mistake in calculation, which caused comment among other specialists, made him extremely negative regarding the use of mathematics in science.

But Lysenko was the man of the hour, one who had come from humble origins under the revolution and who directed all his energies into the great tasks of socialist construction. He was pictured as the model scientist for the new era, and was credited with conscientiously bringing a massive increase in grain yield to the Soviet state, while geneticists idly speculated on eye color in fruit flies.

Genetics on the Defensive

Catching the ideological demagoguery that was beginning to flourish among a certain section of the young intelligentsia, some denounced the science of genetics as reactionary, bourgeois, idealist, and formalist, and contrary to the Marxist philosophy of dialectical materialism. Its stress on the relative stability of the gene was supposedly a denial of dialectical development as well as an assault on materialism. Its emphasis on internality was thought to be a rejection of the interconnectedness of every aspect of nature. Its notion of the randomness and indirectness of mutation was held to undercut both the determinism of natural processes and human abilities to shape nature in a purposeful way.

The new biology, with its emphasis on the inheritance of acquired characteristics and the consequent alterability of organisms through directed environmental change, was well suited to the extreme voluntarism that accompanied the accelerated efforts to industrialize and collectivize. The idea that the same sort of willfulness could be applied to nature itself was appealing to the mentality of those who believed that Soviet man could transform the world. Lysenko's voluntarist approach to experimental results and to the transformation of agriculture was the counterpart of Joseph Stalin's voluntarist approach to social processes, undoubtedly a factor in Stalin's enthusiastic support of Lysenko during this period.

Trofim Lysenko, kneeling in a field, measuring the growth of wheat. During the Soviet famines of the 1930s, Lysenko proposed techniques for the enhancement of crop yields, rejecting orthodox Mendelian genetics on the basis of unconfirmed experiments, and gained a large popular following. But in 1964 his doctrines were officially discredited, and intensive efforts were made toward reestablishing orthodox genetics in the Soviet Union. *(© Hulton-Deutsch Collection/Corbis.)*

Other political leaders and scientific administrators were not so easily swayed. Geneticists defended their work and had very influential support. There was strong resistance within the Academy of Sciences. The debate reached a climactic point at a special session of the Lenin Academy of the Agricultural Sciences in 1936, devoted to a discussion of the two trends in Soviet biology. The official goal was to achieve a reconciliation of the two schools, some kind of accommodation for genetics within the framework of Lysenko's agrobiology. The outcome was the opposite. The open confrontation of the two trends resulted in drawing the lines more sharply than ever and in highlighting the irreconcilability of the two contrasting approaches.

The sharpest speech in the defense of genetics came from the American geneticist Hermann J. Muller, a foreign member of the Academy of Sciences, who had come to work in the Soviet Union out of a belief in the possibilities of science under socialism. Muller was also inclined to philosophical reflection on science and had definite views as to the place of genetics within the framework of a dialectical materialist philosophy of science. He turned the charge of idealism against the Lysenkoites and accused them of hiding behind the screen of a falsely interpreted dialectical materialism.

The growing ascendancy of Lysenko coincided with the purges that reached into virtually every Soviet institution from 1936 to 1939. The campaign against geneticists became more and more vicious and slanderous. Scientific and philosophical arguments gave way to political ones. The pursuit of genetics was branded as racism and fascism. Geneticists were named and accused of sabotage, espionage, and terrorism. Many were arrested. Of these some were shot, while others died in prison. Still others were witch-hunted, lost their jobs, and were forced into other areas of work. Institutes were closed down. Journals ceased to publish. Books were removed from library shelves. Texts were revised. Names became unmentionable. The 7th International Congress of Genetics, which was scheduled to be held in Moscow in August 1937, was cancelled. When the congress did take place in Edinburgh in 1939, no Soviet scientists were present, not even the internationally respected geneticist N. I. Vavilov, who had been elected its president.

By 1938 Lysenko had been elected to the Academy of Science and replaced Vavilov as president of the Lenin Academy of Agricultural Sciences. In 1940 Vavilov was arrested and Lysenko replaced him as director of the Institute of Genetics of the Academy of Sciences. In 1941 Vavilov stood trial and was found guilty of sabotage in agriculture. After several months of incarceration, Vavilov's death sentence was commuted, but he died in prison in 1943 of malnutrition. Although some of the more outspoken and defiant survived, many gave way under the pressure, engaged in abasing self-criticism, and acknowledged the superior wisdom of Lysenko. The degree of demoralization was overwhelming.

Assessment

Lysenkoism reached its peak in 1948 with official Communist Party endorsement. But almost immediately after Stalin's death in 1953 it went into decline. Vavilov, for instance, was posthumously rehabilitated in 1955. However Lysenkoism continued to be a force in Maoist China, where a promotional congress was held in 1956. The case was thus a protracted episode in the history of science under Communism, and has been the subject of many commentaries.

These analyze the scientific, political and philosophical issues in quite divergent ways. Soyfer and others represent it as a story of personal opportunism and political terror, as a cautionary tale against the dangers of ideological distortion of science. This position tends to see philosophy and politics as alien impositions upon science. Joravsky, Graham and Lecourt put more emphasis on the complexity of the philosophical issues, although with varying degrees of hostility or sympathy with Marxism. Medvedev's account is of historical significance as a critique coming from someone within the world of Soviet science. Some searching and sophisticated explorations of the issues have come from within Marxism, most notably by Lewontin, Levins, and Young. This position is marked by an insistence that science is inextricatably tied to philosophy and politics, even to ideology, opening up a more nuanced investigation of the varying modes of interaction and a more complex critique of Lysenkoism.

HELENA SHEEHAN

SEE ALSO *Communism; Russian Perspectives.*

BIBLIOGRAPHY

Graham, Loren. (1973). *Science and Philosophy in the Soviet Union*. London: Allen Lane.

Huxley, Julian. (1949). *Heredity, East and West: Lysenko and World Science*. New York: H. Schuman.

Joravsky, David. (1970). *The Lysenko Affair*. Cambridge, MA: Harvard University Press. Reprint, Chicago: University of Chicago Press, 1986.

Lecourt, Dominique. (1977). *Proletarian Science: The Case of Lysenko,* trans. Ben Brewster. Atlantic Highlands, NJ: Humanities Press. Introduction by Louis Althusser.

Levins, Richard, and Richard Lewontin. (1985). *The Dialectical Biologist*. Boston: Harvard.

Lysenko, Trofim Denisovich. (1946). *Heredity and Its Variability*, trans. Theodosium Dobzhansky. New York: King's Crown Press.

Lysenko, Trofim Denisovich. (1948). *The Science of Biology Today*. New York: International Publishers. The Presidential address at the V.I. Lenin Academy of Agricultural Sciences, July 31, 1948.

Manevich, Eleanor D. (1990). *Such Were the Times: A Personal View of the Lysenko Era in the USSR*. Northampton, MA: Pittenbruach Press. Foreword by Eric Ashby.

Medvedev, Zhores A. (1969). *The Rise and Fall of T. D. Lysenko,* trans. Il Michael Lerner, with Lucy G. Lawrence. New York: Columbia University Press.

Roll-Hansen, Nils. (2004). *The Lysenko Effect: The Politics of Science*. Amherst, NY: Prometheus Books.

Sheehan, Helena. (1993). *Marxism and the Philosophy of Science: A Critical History*. Atlantic Highlands, NJ: Humanities Press.

Soyfer, Valerii. (1994). *Lysenko and the Tragedy of Soviet Science,* trans. Leo Gruliow, and Rebecca Gruliow. New Brunswick, NJ: Rutgers University Press.

Young, Robert. (1978). "Getting Started on Lysenkoism." *Radical Science Journal* 6/7: 81–105.

M

MACHIAVELLI, NICCOLÒ

Niccolò Machiavelli (1469–1527), born in Florence on May 3, was a Florentine statesman and Renaissance Italy's greatest political philosopher; he died in Florence on June 21. He is often regarded as the first to take a scientific approach to politics.

Major Contributions to Political Thought

Machiavelli is known chiefly as the author of two books, *The Prince* and *The Discourses on Livy* (both c. 1517). The former concerns the acquisition of principalities, a form of government in which the state belongs to an individual or a family. The latter is a meditation on republics, in which the state is public rather than private property. The notoriety of these books is largely due to the absolute ruthlessness advocated by Machiavelli. In *The Prince,* he recommends acting against faith, charity, humanity, and religion. In *The Discourses,* he criticizes Giovampagolo Baglioni because that tyrant had the opportunity, but not the courage, to murder the Pope.

Niccolò Machiavelli, 1469–1527. Machiavelli was an Italian political philosopher during the Renaissance. His most famous book, *Il Principe,* was a work intended to be an instruction book for rulers. Published after his death, the book advocated the theory that whatever was expedient was necessary—an early example of utilitarianism and realpolitik. *(Corbis. Archivo Iconografico, S.A./Corbis.)*

Despite their practical orientation, *The Prince* and *The Discourses* are works of political science. Machiavelli asks theoretical questions: how states are born and what sustains them. But his work marks a fundamental break with premodern political thought. Classical and medieval thinkers were concerned above all with the difference between good and bad forms of government; Machiavelli ignores that distinction in favor of hard realism. In the first chapter of *The Prince,* he classifies states solely according to how they are acquired. In chapter fifteen, he dismisses those who dream of imagined principalities; perhaps referring to heaven, or Plato's *Republic.* Machiavelli thus narrows the horizon of political science; the question is not what kind of government is best, but how do people get the kind they want.

To answer this question, Machiavelli first explains the origin of states. He observes that hereditary principalities are established based on habit: People accept the regime because they are accustomed to it. But every established government was once new. How does a new state survive long enough to *become* hereditary? Machiavelli ignores the traditional answers: God's blessing or natural development. Perhaps just dumb luck? But fortune is fickle by definition, and does not sustain any one thing for long. Because all states originated from some source, Machiavelli proposes that certain people have, within themselves, the power to conquer fortune, to create armies, and to establish and maintain states.

He calls this power *virtue,* a word suggesting the premodern idea of moral excellence. But in fact, Machiavelli's definition of virtue supports the ruthlessness he advocates. Morality and justice as commonly understood exist only as the products of established states. Machiavellian virtue must exist before the state is founded, and is therefore beyond ordinary right and wrong. It does, however, require that certain temptations be resisted: The prince must never rely on fortune or the grace of others, or put off until tomorrow a murder he needs to commit today.

Whereas ancient philosophers were conservative, more concerned with preserving decent governments than with creating new ones, Machiavelli encourages innovators. He especially admires those who create principalities and republics from scratch, or rejuvenate existing ones. In all cases, he insists that the innovator must rely on his own virtue, and have *arms of his own.* By this, Machiavelli means soldiers, loyal to the prince alone. He severely criticized Italian states for their reliance on mercenary and *auxiliary* arms. Paid soldiers, or those borrowed from another prince, have no connection to the innovator's virtue, and so cannot be a secure foundation for the state.

Pertinence to Modern Political Thinking

Machiavelli is regarded by some as the founder of value-free political science. He describes politics as it is, not as it might be, and shows how this knowledge can be exploited to bring greater order into human affairs. But Machiavelli's science is anything but value-free: He prefers glory to security, and admires innovators more than conservatives. Though he writes both for republics and tyrants, many have argued that he favors one over the other. In fact, he clearly has a preference for republics, but believes that the founding father of every republic needs to possess unrestrained power.

Machiavelli's writing has never gone out of fashion. Perhaps this is because he had the courage to face certain hard truths about modern thought. In order to conquer chance and nature, the early moderns were willing to reject the authority both of divine and natural right, thus imposing no moral restraints on the technological power unleashed by their new sciences. Machiavelli's political science vividly illustrates the consequences of their boldness.

Machiavelli paid relatively little attention to the rise of modern science and technology, concentrating much more on the topic of political reform. It was left to Francis Bacon and others to apply Machiavellian principles to the conquest of nature as a whole. But Machiavelli's thought did at least hint at the Baconian project. He speculates that it was natural famine that drove large populations of barbarians out of their homelands in the east to inundate the Roman empire. He likens the movement of such peoples to floods, and speaks of strong political institutions as dams and dikes that can restrain such floods. Machiavelli is thus developing a science of politics that is technological in the modern sense.

KENNETH C. BLANCHARD, JR.

SEE ALSO *Modernization; Scientific Revolution.*

BIBLIOGRAPHY

Machiavelli, Niccolò. (1996). *The Discourses on Livy,* trans. Harvey C. Mansfield and Nathan Tarcov. Chicago: University of Chicago Press.

Machiavelli, Niccolò. (1998). *The Prince,* trans. Harvey C. Mansfield. Chicago: University of Chicago Press. Mansfield's translations are by far the best available. They are readable and precise, and include useful introductions and a glossary of Machiavelli's terms.

Skinner, Quentin. (2001). *Machiavelli: A Very Short Introduction.* Oxford: Oxford University Press. A very brief introduction to Machiavelli aimed at the general reader.

Strauss, Leo. (1995). *Thoughts on Machiavelli.* Chicago: University of Chicago Press. A difficult but penetrating study of Machiavelli. Strauss argues that Machiavelli was the founder of modern political thought.

MANAGEMENT

• • •

OVERVIEW

The term *management* can name both an activity and persons in charge of the activity. As activity, the term derives from the Italian *maneggiare*, meaning to handle or control a horse, which is itself rooted in the Latin *manus*, or hand. In the late 1500s the word was applied to the governing body of a theater and from there to other business activities, including those involved with industrial manufacture. Shifts in the ownership of large-scale manufacturing companies led to what has been termed a managerial revolution, in which direct control and decision-making became invested in neither owning capitalists nor wage-earning workers but in salaried managers (Burnham 1941, Chandler 1977). This shift has influenced both science and technology, with "big science" and "technoscience" increasingly managed by neither science nor engineering workers—a development that poses questions of ethical responsibility for both technical professionals and managers. Attempts to systematize informal management techniques into either a science or a technology of management further highlight ethical issues.

Historical Background

Humans have always collaborated to reach shared goals. Distributed tasks for common ends require coordination, planning, control, and organization—all of which are as subject to ethical assessment along with the ends to which they are subordinate. For example, in Plato (c. 428–347 B.C.E.) one can find both praise for the division of labor that engenders expertise in specialized workers (*Republic*) and criticisms of the pretensions of technical specialization (*Apology* and *Gorgias*). Thus, although the term did not exist as such, "management" has often been read back into such preindustrial orders of household, tribe, city-state, military, or church. What distinguishes modern management from traditional political or religious organization and leadership is its greater emphasis on the systematic coordination of means.

Management did not take on its contemporary connotations until the technological, economic, political, and social changes of the Industrial Revolution (c. 1750–1850). Specifically, certain organizational problems arose in the embryonic factory system that led to the genesis of modern management practices and eventually the formalization of management study (Wren 2005). It was also during this era that attitudes to work began to change, although slowly, from ceaseless, futile labor to opportunities for personal wealth and social progress. Central to this transformation were the Renaissance revival of science and reason and the Protestant work ethic with its notion of a worldly "calling" that Max Weber (1930) argued paved the way for market-based capitalist economies.

The modern understanding of management in terms of leading an organization toward a goal through the deployment and manipulation of resources (material, human, financial, and intellectual) was further shaped by classical and nineteenth-century economic theory and the development of technical production elements such as standardization, specialization, and work planning. The emergence of modern technologies and the market economy challenged managers to develop a body of knowledge on how best to administer and utilize human and technological resources. By the middle of the nineteenth century, Robert Owen (1771–1858) and others were developing theories pertaining to the human element of management including worker training, organizational structure, span of control, and the effects of fatigue on performance. By the 1880s, university courses in management were being offered, based in part on the work of Andrew Ure (1778–1857), who developed training programs for managers in the early factory system.

The first comprehensive theories of management appeared around 1920 in the work of scholars such as Henri Fayol (1841–1925), who outlined five functions for managers and synthesized fourteen principles for organizational design and effective administration. Some theorists such as Ordway Tead (1891–1973) applied principles of psychology to management, whereas Elton Mayo (1880–1949) and others approached it from a sociological perspective. In *The Practice of Management* (1954), Peter F. Drucker (b. 1909) presents a contrast to the Fayolian process texts by introducing the notion of "management by objectives," which replaces control from above with self-control and greater worker empowerment in the goal of reaching well-defined objectives.

In *The Managerial Revolution* (1941), James Burnham (1905–1987) sets management theory within a broad historical narrative of political economy and technological change. Burnham saw industrial production coming to be controlled neither by the owners (capitalism) nor the working class (socialism). Rather, a new managerial class was replacing the bourgeois capitalist as a dominant social force, as ever more complex systems of production separated control from ownership. For Burnham, technological progress necessitates a hierarchy of managers among whom direction and coordination of production becomes a highly specialized skill.

In *The Visible Hand* (1977), Alfred D. Chandler Jr. (b. 1918) presents a similar argument but one less oriented toward prophecy. Chandler claims that neither the traditional family firm nor market mechanisms are able to coordinate the increasingly swift and complex flows of goods made possible by technological innovation. Managers of large, multiunit businesses fill this need for coordination, and in so doing assume strong economic and social power, giving rise to managerial capitalism: "In many sectors of the economy the visible hand of management replaced what Adam Smith referred to as the invisible hand of market forces" (p. 1). But while acknowledging the centrality of technology in bringing about increased managerial control, Chandler fails to explore fully the role of scientists and engineers.

The managerial revolution may have held true in heavy industry, but it seems less valid for service and information economies, where bigger and more complex is not always better. Indeed the continual evolution of technological, political, and economic contexts ensures that management theories are constantly being revised. Some of the more recent developments in management thought include operations research, the theory of constraints, reengineering, complexity theory, and information technology–driven theories. A general trend in management thought is toward systems-based, adaptive processes capable of integrating several categories (e.g. human resources, marketing, and production) into a complex, flexible web of organizational administration.

Management as Science

The conceptualizing and ordering of management as a science did not begin in earnest until the nineteenth century. And although Charles Babbage (1792–1871) made significant contributions to management science, Frederick Winslow Taylor (1856–1915) is viewed as the founder of the field. In 1895 Taylor wrote a seminal paper titled "A Piece-Rate System" that developed a set of management techniques designed to stimulate maximum worker productivity and efficiency. This helped fuel the rising emphasis on efficiency and rationality in decision-making that sought the "one best way." Theodore Roosevelt, Gifford Pinchot, and other conservationists spearheaded this movement by preaching a "gospel of efficiency" in natural resource management, which was "an attempt to supplant conflict with a 'scientific' approach to social and economic questions" (Hays 1959, pp. 266–267).

In *The Principles of Scientific Management* (1985 [1911]), Taylor acknowledged the inefficiencies in natural resource use, but argued that wasteful practices in human resource management were just as damaging to the goals of efficiency, productivity, and prosperity. The Industrial Revolution had vastly increased resources and capital and improved technologies, but crude ways of organizing and administering these resources hampered productivity. Taylor set out to prove that the best management is a true science, resting upon a clearly defined foundation of laws, rules, and principles. Furthermore, he sought to show that the fundamental principles of scientific management are applicable to all kinds of human activities, from the simplest individual acts to the work of huge corporations.

Among other organizational techniques, this "true science" involved standardizing measures of productivity and quality; developing time, motion, and method studies; and improving the relationship between mangers and workers. In one instance, Taylor was able to reduce the number of people shoveling coal at Bethlehem Steel Works from 500 to 140 by designing more ergonomic shovels. Taylor believed the credo of rational efficiency would lead to prosperity for all, thus abolishing class hatred, but many labor leaders felt that scientific management meant autocracy in the workplace. In fact, Taylor was questioned at length by Congress in 1911 and 1912 on the grounds that some of his methods treated workers like machines.

Frank Gilbreth (1868–1924) and Lillian Gilbreth (1878–1972) were associates of Taylor, and their studies culminated in laws of human motion from which evolved principles of motion economy. The Gilbreths coined the term *motion study* and used cameras to record motions and improve efficiencies even in domestic chores. Other important pioneers in scientific management included Henry Gantt (1861–1919) and Charles Bedaux (1886–1944). After World War II, scientific management played a key role in boosting economic productivity. Statistical and mathematical techniques were applied to planning and decision analyses. Physics Nobel laureate Patrick Blackett (1897–1974) combined these techniques with microeconomic theory to produce the science of operations research, which has been greatly enhanced by the use of computers.

The work of social scientists such as Elton Mayo uncovered many aspects of human interaction in the workplace that had been ignored by other theorists. Specifically, he noted that worker motivations (e.g., feelings, multiple needs, personal goals) are often outside the bounds of the logical, rational human being posited by scientific management, and that workers think and act not as individuals but as members of formal or informal groups (see also McGregor 1960). This type of work led to the rise of human relations management. The period between 1950 and 1970 witnessed a sevenfold increase in managerial employment. It was during this time that behavioral science became widely applied to management practices by theorists such as Rensis Likert (1903–1981). There is a wide range of contemporary scientific theories of management, and it is clear that the best fit for improving performance depends in part on contextual contingencies.

Indeed in many areas alternatives and complements to scientific management stress the importance of building flexibility into systems in order to accommodate the surprises generated by nature, cognitive limitations, and the pace of global commerce. One example is adaptive management (e.g., Brunner et al. 2005), which is a diverse field developed in the 1970s and based on the incorporation of multiple stakeholders in decision-making processes in order to shift to bottom-up, open-ended management structures. In natural resource management, the underlying realization is that the politics of most problems (even many highly technical ones) cannot be elided by focusing solely on scientific expertise and efficiency. In the business world, the driving factors in the shift away from overly rigid forms of scientific management are the need for flexibility to maintain competitiveness and the realization that many valued outcomes are not readily captured by quantification.

Thus scientific management has from its beginnings been a diverse field that has given rise to equally diverse criticisms. It has been both praised and stigmatized as technocratic, insofar as technocracy can be conceived as an ideological-free pursuit of efficient production and a form of production that excludes the consideration of human values. In natural resource policies, technical management has been argued to impede common-interest solutions (Brunner et al. 2005). In business, although it can lead to greater competitiveness via increased efficiency, scientific management can also rigidify an organization, robbing it of flexibility and creativity.

More generally, Alasdair MacIntyre (1984) criticizes the notion of managerial expertise that derives from the dominant conception of the social sciences as somehow mimicking the natural sciences. For MacIntyre, "What managerial expertise requires for its vindication is a justified conception of social science as providing a stock of law-like generalizations with strong predictive power" (p. 88). He then identifies four sources of systematic unpredictability in human affairs, which he claims undermine the very notion of managerial expertise. He concludes that the concept of managerial expertise, or the idea that anyone can consciously manipulate the social order, is a moral fiction: "Our social order is in a very literal sense out of our, and indeed anyone's, control" (p. 107). What appears to be pragmatic, scientifically managed social control is but the skillful imitation of such control. This does not deny the enormous power exercised by bureaucratic managers, it is just that "the most effective bureaucrat is the best actor" (p. 107).

Nevertheless, regardless of outcomes and the fact that the term has fallen out of use, "'scientific management,' as well as its near synonym, 'Taylorism,' have been absorbed into the living tissue of American life" (Kanigel 1997, p. 6). Indeed, the history of scientific management mirrors the development of science more broadly, having evolved from the ideal of disclosing a single right answer to the reality of uncovering an imbroglio of human values intertwined with artifacts and systems, in which uncertainty and ambiguity are multiplied along with the importance of context and values.

Management as Technology

Parallel with attempts to develop management as a science—and as a science with applications—have been attempts to conceptualize management as a technology. Here the leading theorist has been Peter Drucker, who argues for an identification between management and modern technology. Just as in premodern technology work was more important than the tools with which work was performed—that is, work is the context from which tools receive their meaning—so in modern technology management or the organization of activity is the whole that unifies material resources, human labor, financial capital, and machines. Central to any wealth production is the process of ordering, interrelating, or managing the parts in order to assemble a productive business enterprise, which Drucker identifies as a "*system* of the highest order" (1970, p. 55).

For Drucker, management as technology may also be understood as an extension of biological evolution. Management is an adaptive process that orders (and reorders) different aspects of the world (through productive work); as such management is the most general contemporary expression of the human capacity for purposeful, nonorganic evolution. Tools and technologies are not just givens for management but, like the materials and human beings who make up a productive enterprise, are able to be transformed by management—and then transformed again in response to the changed context that the original transformation produces. Management involves a recursive process in which it takes its own successes and failures into account. "The organization of work, in other words, is . . . the major means of that purposeful and nonorganic evolution which is specifically human" (pp. 48–49).

Related to Drucker's view of management as technology is an argument by intellectual historian Bruce Mazlish (1993) regarding the relation between humans and machines. For Mazlish modern history is characterized by the rejection of four discontinuities: between Earth and the rest of the cosmos (Newtonian mechanics, which used the same laws to explain terrestrial and planetary phenomena), between animals and humans (Darwinian evolution, which argued for a natural development from animals to humans), between the unconscious and rationality (Freudian psychology, which presented reason as tied to the unconscious), and between machines and humans (through the integration of computers and humans). By arguing that human beings are defined by their coevolution with machines, a coevolution they must learn to manage, Mazlish likewise presents management (without using the term) as the fulfillment of technology.

Insofar as this is the case, of course, the science and technology of management must also be brought to bear on science and technology, especially big science or technoscience, which has become a complex enterprise. As first identified by the historian of science Derek J. de Solla Price (1963) and scientist-science administrator Alvin M. Weinberg (1967), science that depends on large-scale funding and coordinates many disciplines to achieve a common goal (such as the Manhattan Project to create the atomic bomb) requires increasingly sophisticated techniques of management. The same goes for macroengineering projects such as the U.S. interstate highway system or the European Channel Tunnel (or Chunnel). When this is the case it can reasonably be argued that the science and technology involved have become manifestations of management.

Management Ethics and Policy

In an influential analysis of how theories of human nature influence managerial practice, Douglas McGregor observed that "the more professional the manager becomes in his use of scientific knowledge, the more professional he must become in his sensitivity to ethical values" (1960, p. 12). Indeed, professionals can expect to be granted professional autonomy by the societies in which they operate only "to the extent that human values are preserved and protected" (p. 14). As the prominence of scientific and technological management has increased, so has the question of the relation between management and ethics—both ethics in management and the management of ethics.

In many instances management ethics is not strongly distinguished from business ethics. As in business ethics, key issues in management ethics include standards of communication, conflict of interest, responsibilities to stockholders, treatment of employees, social and environmental responsibilities, leadership obligations, and more. But because of their managerial roles, managers more than businesspersons or entrepreneurs also have to deal with the ethics of introducing ethics into business operations. One of the central issues in management ethics is thus how to introduce and manage ethics in a corporation or other enterprise that is also being managed for shareholder profit and/or stakeholder interests. One of the key questions for management ethics is thus: What is the proper role for ethics in management? Given the practical orientation of management, this includes: How is ethics best managed?

With regard to managing science and technology, the distinctive forms of scientific research and technological development organizations and processes must also be taken into account. Claude Gelès and colleagues (2000), for instance, argue that because most management texts assume a context of traditional business organizations using repetitive tasks and mass production to make a profit, they are not relevant to the management of scientific laboratories that use exploratory research and creativity to produce new knowledge and technical innovation. To achieve their aim of managing innovation to produce more innovation, science and technology managers need to be aware of the special characters of scientists and engineers, and of institutional resistances to new knowledge and technical innovation. They also need to be aware of the special ethical challenges involved in the scientific production of knowledge associated with temptations to scientific misconduct and the need to promote best practices in the responsible conduct of research.

Finally, because management takes place largely by means of establishing policies, the management of science is intimately related to science policy, especially that type of science policy known as policy for science. Here the work of Weinberg, as a reflective scientist manager of a big science and technology organization (Oak Ridge National Laboratory), provides basic orientation. For Weinberg, it is useful to distinguish internal and external criteria for decision-making in the management of science. Internal criteria focus on whether a particular research program is ripe for pursuit and on the competencies of the scientists involved. External criteria are of three types: scientific merit, technological merit, and social merit. Finally, Weinberg argues that especially in big science, which depends for its existence on financial support from the larger nonscientific community, and because science cannot be presumed to be the summum bonum (supreme good) of a society, "the most valid criteria for assessing scientific fields come from without rather than from within the scientific discipline" (1967, p. 82).

CARL MITCHAM
ADAM BRIGGLE

SEE ALSO *Business Ethics; Science Policy; Science, Technology, and Society Studies; Work.*

BIBLIOGRAPHY

Bowie, Norman E., and Patricia H. Werhane. (2005). *Management Ethics.* Malden, MA: Blackwell. A business ethics text with a "management ethics" title.

Brunner, Ronald D.; Toddi A. Steelman; Lindy Coe-Juell; et al. (2005). *Adaptive Governance: Integrating Science, Policy, and Decision Making.* New York: Columbia University Press. A comprehensive critique of scientific management with the preferred alternative of adaptive governance demonstrated through several case studies.

Burnham, James. (1941). *The Managerial Revolution: What Is Happening in the World.* New York: John Day.

Chandler, Alfred D., Jr. (1977). *The Visible Hand: The Managerial Revolution in American Business.* Cambridge, MA: Harvard University Press, Belknap Press.

Drucker, Peter F. (1954). *The Practice of Management.* New York: Harper.

Drucker, Peter F. (1970). *Technology, Management, and Society.* New York: Harper and Row. See especially the chapter "Work and Tools."

Fayol, Henri. (1949). *General and Industrial Management,* trans. Constance Storrs. London: Pitman. Originally published, 1916.

Gelès, Claude; Gilles Lindecker; Mel Month; and Christian Roche. (2000). *Managing Science: Management for R&D Laboratories.* New York: Wiley. An examination of the most appropriate principles and techniques for the management of research organizations.

Hays, Samuel P. (1959). *Conservation and the Gospel of Efficiency: The Progressive Conservation Movement, 1890–1920.* Cambridge, MA: Harvard University Press.

Hosmer, LaRue Tone. (2003). *The Ethics of Management,* 4th edition. Chicago: McGraw-Hill/Irwin. 1st edition, 1987.

Kanigel, Robert. (1997). *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency.* New York: Viking. A 675-page treatise on the implications of Taylor's life and work for modern society.

MacIntyre, Alasdair. (1984). *After Virtue,* 2nd edition. Notre Dame, IN: University of Notre Dame Press. An account of the decline of virtue ethics into modern emotivism and a defense of virtue ethics as a viable moral framework for the modern world.

Mayo, Elton. (1933). *The Human Problems of an Industrial Civilization.* New York: Macmillan.

Mazlish, Bruce. (1993). *The Fourth Discontinuity: The Co-evolution of Humans and Machines.* New Haven, CT: Yale University Press.

McGregor, Douglas. (1960). *The Human Side of Enterprise.* New York: McGraw-Hill. Distinguishes two theories of human nature (Theory X, in which human beings dislike and avoid work, and Theory Y, in which work is as natural as play or rest), and argues that the second is more consistent with social scientific research and has better implications for management practice.

Price, Derek J. de Solla. (1963). *Little Science, Big Science.* New York: Columbia University Press. 2nd edition published as *Little Science, Big Science—and Beyond* (New York: Columbia University Press, 1986).

Spender, J.-C., and Hugo J. Kigne, eds. (1996). *Scientific Management: Frederick Winslow Taylor's Gift to the World?* Boston: Kluwer Academic. A collection of seven essays on Taylor's contributions and their impacts around the world.

Taylor, Frederick Winslow. (1985 [1911]). *The Principles of Scientific Management.* Easton, PA: Hive Publishing.

Van de Ven, Andrew H.; Harold L. Angle; and Marshall Scott Poole, eds. (2000). *Research on the Management of Innovation: The Minnesota Studies.* New York: Oxford University Press. Originally published, New York: Harper and Row, 1989. A series of longitudinal case studies undertaken by faculty at the University of Minnesota.

Weber, Max. (1930). *The Protestant Ethic and the Spirit of Capitalism,* trans. Talcott Parsons. New York: Scribner. Also translated by Stephen Kalberg (Los Angeles: Roxbury, 2002), with various printings of each version. Originally published as journal articles in 1904 and 1905, then later in book form as *Die Protestantische Ethik und der Geist des Kapitalismus.*

Weinberg, Alvin M. (1967). *Reflections on Big Science.* Cambridge, MA: MIT Press. Influential, critical studies by a leading scientist and manager of science.

Wren, Daniel A. (2005). *The History of Management Thought,* 5th edition. Hoboken, NJ: Wiley. Previous editions were titled *The Evolution of Management Thought.*

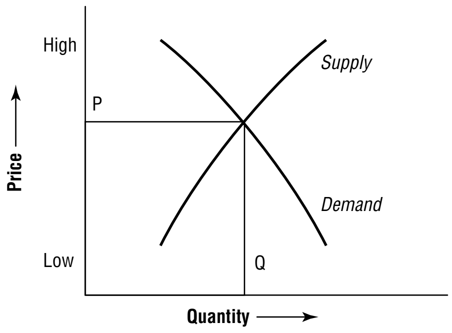
MODELS OF

Management is the process of reaching individual and collective goals by working with and through human and nonhuman resources to improve the world. Managerial values include performance effectiveness (achieving goals), operational efficiency (not wasting resources in the process), sustainable innovation (continually improving outputs and processes), and adding value (as measured by stakeholder responsiveness). Good managers demonstrate sound judgment by balancing these four competing but complementary values.

The four values inherent to some degree at all levels of management are embodied in four management mod-

FIGURE 1

Market Clearing Price



SOURCE: Courtesy of Joseph A. Petrick.

els. Those models focus on rational goals, internal process, human relations, and open systems (Quinn et al. 1995), each of which involves ethical issues that have relevance for the management of science and technology.

Rational Goal Model

The rational goal model, which Frederick Taylor (1856–1915) introduced at the beginning of the twentieth century, stresses the importance of managerial external control that results from the exercise of director and producer role responsibilities in order to employ humans and other tools to engineer optimal productivity (Taylor 1911). Performance effectiveness is achieved through setting goals, speeding productivity, and increasing profits faster than external competitors can and by using time-and-motion studies, financial incentives, and technological power to maximize output.

Three of Taylor's followers—Henry Gantt (1861–1919) and Frank (1868–1924) and Lillian (1878–1972) Gilbreth—expanded the rational goal approach by using new engineering techniques (time and motion studies) that enhanced the ability of technological experts to expand productivity. Time and motion studies provided detailed information about job activities such as grasping, searching, transporting, or assembling and the time it took to complete them in order to measure normal and superior productivity standards.

The strength of this model is that it accounts for managers' providing structure and initiating action. The exclusive and extreme emphasis on the rational goal model, however, imposes fast-paced, robotlike movements on people that were impossible to sustain, and this neglect of individual psychosocial needs in the pursuit of economic returns tends to result in offended individuals and destroy cohesion at the organizational level.

At the microeconomic and geopolitical levels the rational goal model of management was advanced indirectly by Alfred Marshall (1842—1924) and James Burnham (1905—1987), respectively. Marshall was a neoclassical economist who explained how the price and output of a good are determined by both supply and demand curves, such as the price and output of new automobiles that are determined by the demand of the buyers and the supply from the manufacturers, that are like scissor blades that intersect at an optimal point of equilibrium. It is at this point of equilibrium that buyers, sellers, and/or managers could and should rationally optimize their utility values by clearing the external market (see Figure 1).

Burnham's later neoconservative geopolitical works argue that because of the unceasing desire for power among an oligarchy of managerial elites from the three major global "super-states," the struggle for external political control of the world requires a decisive victory by strong-willed U.S. political leadership that exercises an aggressive geopolitical strategy by using all the offensive resources at its disposal. The perceived overreliance on the rational goal model at the microeconomic and geopolitical levels to secure external global control has led to the expected results of offended stakeholders and has destroyed cohesion at those extraorganizational levels as well.

Internal Process Model

The internal process model introduced by Henri Fayol (1841–1925) in the first quarter of the twentieth century stresses the importance of managerial internal control that results from the exercise of the monitor and coordinator role responsibilities in order to exert authority over humans to maintain the stability of hierarchic administration. Operational efficiency is achieved through information management, documentation control, and consolidated continuity and by emphasizing process measurement, smooth functioning of organizational operations, and the maintenance of structural order (Fayol 1916). Fayol described the five functions of management as planning, organizing, commanding, coordinating, and controlling and laid down fourteen principles of good administration, with the most important elements being specialization of labor, unity and chain of command, and the routine exercise of authority to ensure internal control.

Another key exponent of operational efficiency in managing large groups was the sociologist Max Weber (1864–1920), who described and advocated the indispensability of bureaucracy. Weber's ideal bureaucracy included authority, hierarchy, formal rules and regulations, and impersonality in rule application. His ideal bureaucrat neutrally and efficiently manages by the book and follows orders from above even if they go against his or her personal convictions.

When the internal process model is applied to politico-economic control, socialist and communist regulatory infrastructures constrain the negative externalities of the free market but create the risk of stifling technological and politico-economic innovations through overregulation. The strength of this model is that it accounts for managers' maintaining structure and collecting information. The exclusive and extreme emphasis on the internal process model, however, results in stifled progress and neglected possibilities at the organizational and extraorganizational levels.

Human Relations Model

The human relations model, which Elton Mayo (1880–1949) popularized in the second quarter of the twentieth century, stresses the importance of the managerial internal flexibility that results from the exercise of facilitator and mentor role responsibilities in order to improve human relations at work and enhance extraorganizational stakeholder responsiveness. Stakeholder responsiveness is achieved by showing managerial consideration for employees' psychosocial needs to belong, fostering informal group collaboration, and providing recognition at work as well as promoting managerial social responsibility and humane community building in society (Mayo 1933). Mayo's research at the Hawthorne Works demonstrated that management consideration, employee group affiliation, and special recognition motivated can increase productivity.

Peter Drucker (1909–2005), although critical of Mayo's perceived psychological manipulation of employee loyalty, promotes the value of the socially responsible use of managerial power and humane community building. He argues that in a global knowledge society managerial power can and should be applied to the nonprofit sector because that appears to be the primary sector that is focusing on creating socially responsible citizens and giving knowledge workers a sphere in which they can make a positive difference and re-create meaningful communities.

The strength of this model is that it accounts for managers' showing consideration and facilitating supportive interaction with intraorganizational and extraorganizational stakeholders. The exclusive and extreme emphasis on the human relations model, however, creates the risk of slowing production at work and abdicating decision-making authority in society.

Open Systems Model

The open systems model introduced by Paul Lawrence (b. 1933) and Jay Lorsch (b. 1934) in the third quarter of the twentieth century stresses the importance of the managerial external flexibility that results from exercising the innovator and broker role responsibilities in order to adapt continually to changing environmental forces (Lawrence and Lorsch 1967). Sustainable innovation is achieved by cultivating organizational learning cultures, developing cross-functional organizational competencies for continuous creativity, and respecting quality and ecological system limits while negotiating for external resource acquisition, building sustainable entrepreneurial networks, and enabling creative system improvement.

W. Edwards Deming (1900–1993) used statistical quality control to separate special and common causes of variation, fixing the former and accepting the latter to improve production systems continually by narrowing the range of acceptable performance variation over time. Deming's message to managers was that because most performance variations are the result of common causes, that is, fall within a normal range of statistical variation, managers should focus on improving the production system instead of overcontrolling employees.

Paul Shrivastava (b. 1939) focuses on entrepreneurial ecocentric management of sustainable development systems that technologically prevent and/or control pollution of nature and corruption of sociopolitical systems over time. The strength of this model is that it accounts for managers' envisioning improvements and acquiring resources for sustainable system development. The exclusive and extreme emphasis on the open systems model, however, results in disrupted operational continuity and energy wasted on unrealistic change projects.

Ethics of Management

The four management models for handling behavioral complexity have management ethics parallels in handling moral complexity, that is, inclusively balancing the competing moral values of achieving good results, following the right rules, cultivating a virtuous character, and creating supportive contexts (Petrick and Quinn 1997). In effect, the way people manage—make managerial judgments—implicitly and/or explicitly discloses their moral value priorities: the relative emphases they place on results, rules, character, or context in their moral choices. Rational goal "bottom line" managers are naturally disposed to emphasize results-oriented teleological ethics theories; internal process "by the book" managers are naturally disposed to emphasize rule-oriented deontological ethics theories; human relations "bleeding heart" managers are naturally disposed to emphasize character-oriented virtue ethics theories; and open systems "change agent" managers are naturally disposed to emphasize context-oriented situation ethics theories. Nevertheless, just as the balance and inclusiveness of the four management models determine the quality of managerial behavioral complexity judgment, the balance and inclusiveness of the four ethics theories determine the quality of managerial moral complexity judgment as well.

Especially in bringing these ethical issues to bear in the management of science and technology, the economist Adam Smith's (1723–1790) social calculus of adding individual selfish motives to the greater good must be supplemented by the insight that managers often are faced with ethical responsibilities that run counter to their actual or perceived self-interest. Otherwise, management ethics would be synonymous with corporate profit or self-promotion. A case in point would be the uncritical scientific endorsement of genetically modified human foods for global profit without morally considering the harmful effects of genetically modified foods on the health of current and future human generations.

Management ethics involves a complex and inclusive balancing of multiple stakeholder interests, internal and external to organizations, domestically and globally. For example, business managers that focus only on advancing the financial interests of investors while neglecting other stakeholders' interests, such as those of employees, society, and nature, are increasingly criticized for an unduly narrow and short-term managerial ethics perspective. The ability to simultaneously and/or sequentially optimize moral results, rules, character, and context in a sustained way for multiple stakeholders at intraorganizational and extraorganizational levels is becoming the touchstone of sound management ethics and the basis of hope for moral progress in the future.

JOSEPH A. PETRICK

SEE ALSO *Bureaucracy; Engineering Ethics: Overview; Entrepreneurism; Stakeholders; Work.*

BIBLIOGRAPHY

Deming, W. Edwards (1993). *The New Economics for Industry, Government, Education*. Cambridge, MA: MIT Center for Advanced Engineering Study.

Drucker, Peter F. (1973). *Management: Tasks, Responsibilities and Practices*. New York: Harper and Row.

Evans, William A. (1981). *Management Ethics: An Intercultural Perspective*. Boston: Martinus Nijhoff. Covers several topics and focuses on the theme of individual responsibility. Develops a guide to management ethics.

Fayol, Henri. (1916). *General and Industrial Management*. London: Pittman.

Lawrence, Paul, and Jay Lorsch. (1967). *Organization and Environment*. Cambridge, MA: Harvard University Press.

Mayo, Elton. (1933). *The Human Problems of an Industrial Civilization*. New York: Macmillan.

Petrick, Joseph, and John Quinn. (1997). *Management Ethics: Integrity at Work*. Thousand Oaks, CA: Sage.

Quinn, Robert E.; Sue R. Faerman; Michael P. Thompson; and Michael R. McGrath. (1995). *Becoming a Master Manager: A Competency Framework*, 2nd edition. New York: Wiley.

Shrivastava, Paul. (1996). *Greening Business: Profiting the Corporation and the Environment*. Cincinnati, OH: Thomson Executive Press.

Taylor, Frederick. (1911). *The Principles of Scientific Management*. New York: Harper and Brothers.

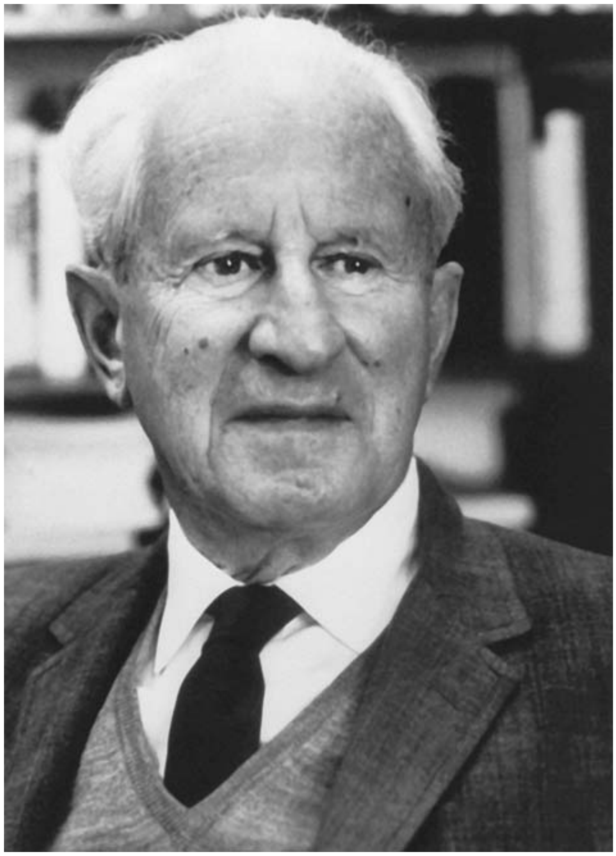
MARCUSE, HERBERT

Herbert Marcuse (1898–1979) was born in Berlin on July 19. After earning a doctorate in literature in 1922, he studied philosophy with Martin Heidegger (1889–1976) in Freiburg from 1928 to 1933. Troubled by Heidegger's affiliation with the National Socialist party, Marcuse joined the philosophers Max Horkheimer (1895–1973) and Theodore Adorno (1903–1969) at the Institute for Social Research in Frankfurt before fleeing to New York in 1934. Marcuse remained for the rest of his life in the United States, where he continued the institute's interdisciplinary work in critical social theory. He died on July 29 in Starnberg, after having suffered a stroke on a trip to Germany. Marcuse synthesized the works of Heidegger, Karl Marx (1818–1883), and Sigmund Freud (1856–1939) into a unique philosophical perspective from which he analyzed the nature of social control and the prospects for liberation in advanced industrial capitalist and communist societies.

Among Marcuse's contributions to critical social theory was his analysis of science and technology as instruments of social and political domination. Echoing Heidegger, Marcuse spoke of the "technological a priori" of scientific-technical rationality that projects nature as potential instrumentality. Technological rationality homogenizes people and nature into neutral objects of manipulation. That rationality is easily co-opted by economic and political power. However, science and technology merely function in the service of social control; they could be transformed to serve different ends, such as freedom, individuality, and creativity.

Marcuse's 1941 article "Some Social Implications of Modern Technology" argued that technological rationality undermines traditional "individual rationality" (autonomy) by employing efficiency as the single standard of judgment. Industrialized societies take advantage of the notion of efficiency to induce people to accept mass production, mechanization, standardization, and bureaucracy. Consequently, Marcuse argued, appeals to enlightened self-interest and autonomy appear progressively quaint and irrational in the face of a technological rationality that makes conformity seem reasonable and protest seem unreasonable.

In the mid-twentieth century political power—including state capitalism, fascism, and state socialism—developed seemingly rational, even pleasurable, means of social control that integrated individuals into a homogeneous society. The result was a "one-dimensional" society that eroded the capacity for individuality, critical thinking, and practical resistance. However, Marcuse maintained that the same impersonal rationality that made individualism unnecessary could be harnessed to realize rather than repress human capacities. Technological rationality could be used as an instrument to foster democracy, autonomy, and individuality. Marcuse was pessimistic about the prospects for that transformation because the technological apparatus tends to incorporate and subsume all opposition. However, despite Marcuse's pessimism regarding the achievement of such a transformation, he maintained that it was in principle possible.



Herbert Marcuse, 1898–1979. Marcuse was a leading 20th-century New Left philosopher in the United States and a follower of Karl Marx. His writing reflected a discontent with modern society and technology and their "destructive" influences, as well as the necessity of revolution. He was considered by some to be a philosopher of the sexual revolution. *(© UPI/Corbis-Bettmann.)*

In his most influential book, *One-Dimensional Man* (1964), Marcuse continued to argue that advanced industrialized societies employ science and technology to serve existing systems of production and consumption but claimed that technological rationality itself required transformation; it could not remain value-neutral if it were to lead to real human liberation. Marcuse also extended his analysis of the role of science and technology in manipulating human needs through advertising, marketing, and mass media. The scientific and technical aspects of a society are used to increase productivity and dominate humans and nature. The result is a carefully managed society that creates a one-dimensional person who willingly conforms to a society that limits freedom, imposes false needs, stifles creativity, and co-opts all resistance.

At the end of *One-Dimensional Man* Marcuse expresses the hope that humans one day will develop technologies for the "pacification of the struggle for existence" that will reduce misery and suffering and promote peace and happiness. Developing those technologies would require a political reversal, not simply more technological advances. A radical break from existing capitalist modes of production is needed to generate a new science and new technology. Science and technology then would become the instruments of liberation, not domination. New technologies would lead to new modes of cooperative production, energy sources, management, and communities; a new science of liberation would serve the interests of freedom and help satisfy genuine human needs. In his later work Marcuse considered the contributions that utopianism, student revolts, feminism, and aesthetic interests might make to the emergence of a new science and technology.

Marcuse was enormously popular in the 1960s and 1970s, and although his fame has been eclipsed since that time by that of Jürgen Habermas (b. 1929) and

French postmodern thinkers, he left an enduring legacy in critical social theory. He created a widely influential framework for analyzing the connections among political economy, science, technology, mass media, and culture in a way that not only identifies social domination and oppression but also attempts to identify the potential for social transformation leading to human liberation.

DAVID M. KAPLAN

SEE ALSO *Critical Social Theory; Habermas, Jürgen.*

BIBLIOGRAPHY

Alford, C. Fred. (1985). *Science and the Revenge of Nature: Marcuse and Habermas*. Gainesville: University of Florida Press.

Held, David. (1980). *Introduction to Critical Theory: Horkheimer to Habermas*. Berkeley: University of California Press.

Kellner, Douglas. (1984). *Herbert Marcuse and the Crisis of Marxism*. Berkeley: University of California Press.

Marcuse, Herbert. (1941). "Some Social Implications of Modern Technology." *Studies in Philosophy and Social Science* 9, no. 3 (1941): 414–439.

Marcuse, Herbert. (1964). *One Dimensional Man*. Boston: Beacon Press.

Marcuse, Herbert. (1969). *An Essay on Liberation*. Boston: Beacon Press.

Marcuse, Herbert. (1972). *Counterrevolution and Revolt*. Boston: Beacon Press.

Marcuse, Herbert. (1978). *The Aesthetic Dimension*. Boston: Beacon Press.

Pippen, Robert, and Andrew Feenberg, eds. (1988). *Marcuse: Critical Theory and the Promise of Utopia*. South Hadley, MA: Bergin and Garvey.

MARKETING

SEE Advertising, Marketing, and Public Relations.

MARKET THEORY

The market system allows individuals to exchange goods and services voluntarily, based on prices, without knowing one another. For instance, the cup of coffee a person drinks in the morning was brought to that person by thousands of strangers, who cultivated, harvested, processed, manufactured, packaged, shipped, stocked, and sold goods at various stages of production along the way.

One way to appreciate the distinctiveness of market-mediated trade among strangers is to contrast it with other ways in which people transact with one another. The anthropologist Alan Fiske (2004) suggests that all interpersonal transactions can be sorted into four relational models:

- In a communal sharing transaction, such as a family dinner, every member in the relationship is entitled to share in what is available.
- In an authority ranking transaction, such as a decision made in a traditional military unit or a corporation, there is a clear hierarchy, with people lower in the hierarchy deferring to those who are higher up.
- In an equality matching transaction, such as taking turns going through a four-way stop, people operate according to an intuitive sense of balance and fairness.
- In a market pricing transaction, such as buying a used car, people make decisions on the basis of their calculations of the costs and benefits.

The cognitive psychologist Steven Pinker, author of *The Blank Slate* (2002), argues that among these four modes of transactions market pricing is a relatively new phenomenon in the development of the human species:

> Market Pricing is absent in hunter-gatherer societies, and we know it played no role in our evolutionary history because it relies on technologies like writing, money, and formal mathematics, which appeared only recently (Pinker 2002, p. 234).

An important aspect of hunter-gatherer societies is that people belonged to tribes or bands of fewer than 150 people. Everyone knew everyone else, and people expected to interact with one another repeatedly. Small groups with repeated interactions are conducive to establishing trust and confidence in reciprocity, which are requirements for communal sharing and equality matching. When societies become larger and people must interact with strangers, something must replace trust and confidence. Only authority ranking or market pricing can "scale up" to large groups.

Economic historians see the modern market system as having arisen only within the last 300 years. Two features of the modern market system were largely absent until that time. One was flexibility of prices in response to supply and demand. In contrast, ancient and feudal trade took place at prices fixed by custom, authority, and tradition. A second feature of modern markets is that they enable people to work for money and trade for food. Before modern times markets did not have sufficient depth and breadth to allow for specialization and cash crops.

Before 1500 almost all people existed at a subsistence level, living on what they could cultivate. Feudal lords took any excess production and in return provided some public goods, notably protection. As late as 1700 the practice of raising a crop for cash and buying goods and services for money was relatively unknown. Even under late feudalism trade was relatively unimportant, and the terms of exchange were fixed by tradition rather than adjusting to supply and demand. The feedback loop between prices and production did not operate.

Between 1700 and 1850 the market system arose in Western Europe and North America. Better farming techniques allowed people to produce surplus food, giving them something to trade and releasing labor to work in manufacturing. Improvements in transportation, particularly railroads, facilitated specialization and trade. Increasingly, people moved from subsistence farming to a money economy in which they obtained cash for either a crop or physical labor. They then exchanged money for goods and services. Land, labor, and capital became responsive to market conditions.

Adam Smith was the first philosopher to articulate the virtues of the market system fully. In *The Wealth of Nations* (1776) Smith argued that trade was more efficient than self-sufficiency. With trade people can enjoy a wide variety of goods and services while specializing in their labor. In addition, Smith pointed out that the self-interest of producers worked to the benefit of consumers. When consumer demand increases for a good, the price goes up, attracting more producers.

The fact that higher prices induce more production is known as the law of supply. Similarly, a higher price for one good induces consumers to buy less of that good. This is known as the law of demand. Together, the laws of supply and demand determine an equilibrium price and level of output for each good. This impersonal, self-adjusting process is what distinguishes a market economy. In contrast, in a planned economy a bureaucrat determines prices and output levels. In a feudal economy prices are set by custom.

The concept of a market remains counterintuitive in the early twenty-first century. This can be seen in discussions of energy policy, in which it is suggested that the United States could become independent of foreign oil by reducing its domestic consumption and increasing the production of alternative energy. In fact, the world energy market is highly integrated. If the United States reduced its demand for oil, the world oil price would be reduced. However, Americans still would be affected by a disruption in the world supply of oil because such a disruption still would cause the price to rise.

The Ethics of the Market

The market system has ethical virtues in the view of libertarians and utilitarians. The libertarian view is that voluntary exchange among consenting adults is preferable to coercive allocation of resources by government. The utilitarian case for markets, which goes back to Smith, is that market exchanges make people better off.

Markets improve living standards in two ways. First, for any state of knowledge and technology markets achieve an efficient allocation of resources. Flexible prices and competition send signals that accomplish this. Consumers choose the goods and services that satisfy their wants most effectively. Firms choose the inputs and outputs that maximize the value of what is produced. Workers choose the occupations that best apply their talents and interests to social needs.

The second way in which markets improve living standards is through a Darwinian selection of innovative products and processes. Entrepreneurs attempt new techniques, with successful methods surviving and achieving widespread adoption. As unprofitable firms go out of business, failed innovations and obsolete methods fall by the wayside.

The support that markets give to innovation accounts for the high standard of living in the contemporary developed world relative to the past or to the underdeveloped world. The difference is large. Whereas the poorest people in the early 2000s and people who lived 500 ago lived on the equivalent of less than a dollar per day, the average American consumes more than $30,000 in goods and services each year. Market-driven South Korea has a standard of living more than ten times that of communist North Korea.

Feedback between Technological Innovation and Markets

Technological innovation and markets reinforce each other. Markets promote innovation by rewarding success and punishing failure. Technological change broadens markets and makes them more efficient.

Every innovation faces resistance. Scientists may doubt the validity of the theory behind an innovation. Firms are reluctant to discard tried-and-true production methods. Workers in existing industries find their livelihoods threatened by new competition. Consumers may be afraid of new products.

Interest groups that are threatened by new technology attempt to mobilize social institutions to retard innovation. Governments are asked to intervene. For example, some countries in Europe have banned genetically modified food. In the United States opposition to Wal-Mart stores often is driven by store owners and labor unions seeking to stifle competition.

Markets overcome resistance to innovation. The impersonal price system gives its approval to innovations that increase productivity and consumer well-being as firms that adopt the innovations earn profits. Simultaneously, the demise of unprofitable businesses frees resources to be used in more productive ways.

In addition to the ability of markets to foster innovation there is positive feedback from technological innovation to markets. Each improvement in transportation, communication, and trading technology serves to strengthen the market system, increasing the scope of transactions occurring in markets.

The revolution in oceangoing shipping that took place in the fifteenth century helped spur trade, which in turn fostered the transition from feudalism to a market economy. The invention of the steam engine and the railroad lowered shipping costs, enabling cash crops to replace subsistence farming. The internal combustion engine increased the mobility of labor and goods, leading to an increased share of economic activity taking place in the market. Electric motors and labor-saving devices helped release women from household labor and move into market-paid work. In modern times the Internet has increased the breadth of markets, including new possibilities for international trade in white-collar services.

Ethical Concerns with the Market System

There is a long-standing set of ethical concerns with markets. Major problems include inequality, failure to provide public goods, and erosion of cultural traditions.

Markets provide different rewards to different individuals. Those with talent, capital, entrepreneurial instincts, and luck do well. Those who lack valuable talents and/or encounter bad luck do poorly.

Critics of the market system believe that goods and services should be distributed more equally. The socialist thinker Karl Marx (1818–1883) described capitalism not as a neutral system of market pricing but a hierarchical system, with the ruthless capital-owning class exploiting the helpless working class. "From each according to his abilities, to each according to his needs" was Marx's slogan, promising the alternative of communal sharing. However, as anti-Marxists such as Max Weber (1864–1920) and Friedrich Hayek (1899–1992) predicted, large economies could not be made to operate efficiently without markets. Hayek in particular emphasized that the information developed by the price system and individual incentives is much more effective than is central planning.

Critics of inequality tend to view the economy as a zero-sum game, with the success of some individuals necessarily coming at the expense of others. Supporters of the market system view it as a positive-sum game, making it possible for nearly all people to raise their standard of living.

Another area where critics see a zero-sum game is in terms of resource constraints. The argument is that the earth's resources are finite and will be "used up." Economists counter by pointing out that human ingenuity seems boundless. As a result, Jerry Muller comments, "the history of capitalism, as Schumpeter observed, is of finding new ways to make use of formerly insignificant resources. Coal ... petroleum ... uranium ... sand for silicon chips. We may well be at the beginning of the fourth wave of capitalist industrial innovation, the biotechnology revolution" (Muller 2002, p. 391).

Federal Reserve Chairman Alan Greenspan is fond of pointing out that the physical weight of the American gross national product (GDP) is declining, an indication of reduced pressure from economic growth on physical resources. This trend may continue as nanotechnology allows products to be built from raw atoms. Rodney Brooks of the Massachusetts Institute of Technology talks about the possibility of not having to cut down trees and carve wood to make a table but instead simply growing a table with genetic engineering. The technology futurist Ray Kurzweil has suggested in *The Age of Spiritual Machines* (1999) that the information component of GDP is asymptotically approaching 100 percent, which would imply that physical scarcity will never constrain growth.

Another criticism of markets is that they give choices to individuals at the expense of collective purpose. It is argued that there is no overall direction or goal for a market economy. Those who want society to have a common objective see the market as too anarchic. A related criticism of markets is that they fail to pursue cultural ideals: The market may not reward fine art, classical music, or religion.

One strength of the market is that it promotes innovation. However, the market may fail to preserve cultural values and institutions. Occupations made obsolete by market forces represent ways of life that are no longer sustainable. Unique cultural identity may be replaced by homogeneous, anonymous market forces.

Market Imperfections

Economists have found a number of flaws in the market system. The most important are externalities and imperfect information. An externality is a cost or benefit that is not internalized by the market. Pollution is the classic example. The pollution caused by an automobile does not cost its owner anything but the total pollution caused by all automobiles is costly to society. Even though laissez-faire leads to too much pollution, economists still favor market-oriented approaches, including taxes on pollution and tradable pollution "permits." These solutions preserve the flexibility and efficiency of the market while forcing the market to internalize the cost of pollution. Consumers' lack of information provides a rationale for a number of government interventions in the market. For example, government meat inspection helps ensure the safety of meat and regulation of medicines helps protect consumers from harmful or ineffective drugs.

Modern Challenges for the Market System

The market system faces a number of challenges from modern technology. The increased importance of health care and education, the increased role of research and development, the issue of network externalities, and the increased importance of information goods all raise issues for the market.

As human capital increases in importance relative to material resources, health care and education are accounting for an increasing share of the economy. These sectors traditionally have been ones in which government involvement has been extensive.

Health care expenses can soar for the people least able to afford them. Someone who is sick often cannot work. The elderly, who are most likely to have illnesses, are on fixed incomes. Private health insurance may be prohibitively expensive for those with the highest likelihood of needing costly health care. All these issues provide a rationale for government provision of health-care coverage, at least for some segment of the population.

The question is where to draw the line between the market and government involvement. At one extreme are national health-care systems that attempt to put the entire sector under government control. However, this leads to bureaucratic rationing of care and, as is the case any time market forces are suppressed, to slow adoption of new technology and lack of innovation. The United States, which has the most market-oriented health-care system in the industrialized world, also does the most to advance the state of the art through pharmaceutical development, diagnostic equipment, and innovative medical procedures.

Education is another area where the individuals with the greatest needs may be least able to afford the best service. As with health care there is a long tradition of government involvement. Critics argue that this has meant slow innovation and the persistence of ineffective schools. Some economists believe that a more market-oriented approach of giving parents vouchers and letting entrepreneurs supply schooling would be more effective.

The inequality that characterizes market outcomes may be a more significant issue as education and health care increase in importance. One may be able to shrug at the differences between what the rich and the poor can afford in terms of cars or wine, but it is more difficult to feel comfortable when the rich are able to obtain better medical care and education.

Economic growth depends on research and development. In the future the fields of computer science, biotechnology, and nanotechnology will be particularly important to the economy. As a theoretical matter, "basic research," which is generally applicable but yields no immediate profits, will be undersupplied by markets and will have to be supported by the government. By the same token "applied research," which is specific and provides immediate rewards, is best done by private firms so that unprofitable ideas are discarded quickly.

In practice the distinction between basic research and applied research is not as easy to draw. In any event the questions of how much the government should invest in research and where it should invest are very important. People's future standard of living will depend to a large extent on how well those decisions are made.

Modern technology gives rise to networks, in which the size of the network is a source of value. For example, the value of a fax machine is low if no one else has one. When everyone else has a fax machine, the value is much higher. The same is true for e-mail accounts, instant messaging services, CD burners, and popular word-processing file formats.

People may choose a word-processing program for compatibility with their colleagues even though they would prefer the features in a different program. In theory everybody could choose to use an inferior program because it is the program others are using. In that way the market gravitates toward an inferior standard. This possibility is called a network externality.

Another aspect of the economy that has changed in recent years is the increased importance of information goods relative to physical goods. Information goods pose a challenge to the market system.

With physical goods the price system is effective at allocating resources. The price of a bicycle or an apple reflects the marginal cost of producing and distributing those goods. Moreover, there is rivalry in consumption: The bicycle that one person rides is one that another person cannot ride; the apple that a person eats is an apple that nobody else can eat.

With information goods the marginal cost of production and distribution approaches zero. Once an essay or a song is stored as information (bits) on a computer, it costs very little to copy those bits or send them to another computer halfway around the world. Furthermore, an author's ability to read an essay on his or her computer does not interfere with another person's ability to read that essay.

The dilemma caused by information goods is that the marginal cost of production and distribution is zero but the up-front development costs may be substantial. For example, consider the case of a new pharmaceutical to treat diabetes or AIDS. That drug may cost hundreds of millions of dollars to develop. However, the pills can be manufactured for pennies apiece. What should be the price? On the one hand, the price should be low enough not to discourage use, which at the margin costs very little. On the other hand, the price should be high so that companies recover their up-front costs and have an incentive to continue to innovate.

There are a variety of possible pricing mechanisms for information goods, none of which is perfect. In the case of pharmaceuticals the government grants a temporary monopoly in the form of a patent. This allows drug companies to set prices above marginal cost so that they can recover the cost of research. However, at the margin this discourages the use of medications because the price is higher than the marginal cost of production.

The challenge with research-intensive goods is to come up with a way to cover fixed costs while leaving the marginal price as low as possible to encourage broad use. Price discrimination—charging higher prices to the consumers most willing to pay—can be not only profitable but also socially optimal. Alternatively, it may be desirable for many consumers to combine to cover up-front costs through a subscription model or a membership model. It may be desirable for taxpayers to cover some up-front costs through a subsidy or prize offered by the government.

Doomsday Scenarios

There is a long-standing tension between economic growth and cultural stability. Markets, which facilitate the former, undermine the latter. Many futurists project an acceleration of technological change in the twenty-first century. This has the potential to raise the standard of living dramatically, but it also has the potential to cause great culture discontinuity. There are many examples:

- In computer science, Kurzweil (1999) argues that Moore's law, which roughly states that the power of computers doubles about every eighteen months, implies that there will be a computer with the intelligence of a human brain by about 2030. Moreover, once computers catch up with humans, they will surpass humans rapidly. Thus, the long-term future is one in which humans and machines will be integrated and coevolve, with the human species becoming inferior or extinct.
- In nanotechnology Eric Drexler (1986) and Bill Joy (2000) warn of the possibility of chemical production processes expanding uncontrollably. In the worst case, dubbed the "gray goo scenario," a substance could reproduce indefinitely until it swallowed the planet.
- In biotechnology the President's Commission on Bioethics (2003) emphasized a number of possible dystopian scenarios, including one in which human beings are designed and created to serve the purposes of their masters. The commission also pointed to issues raised by medicines that enhance performance or might prolong life indefinitely.

If these doomsday scenarios are possible technologically, markets are unlikely to prevent them. Accordingly, fear of doomsday scenarios could lead people to favor strong, worldwide government action to intervene in markets. Opposition in Europe to genetically modified food and opposition in the United States to embryonic stem-cell research could be symptoms of antimarket regulation to come.

The Future

Markets are conducive to technological innovation, and vice versa. People who place a high value on the benefits of technological innovation tend to want to expand the scope of the market. People who are more concerned with the risks of technological innovation are more inclined to favor government intervention.

The chief benefit of technological innovation is that it raises people's standard of living. People's labor, capital, and natural resources become more productive as they use science and engineering to develop more efficient techniques for satisfying human wants.

The combination of markets and technological innovation creates economic inequality. Successful entrepreneurs, business leaders, and others earn outstanding rewards. Unskilled workers have a higher standard of living than was the case a century ago, but they are significantly less wealthy than those at the top of the income distribution.

Markets and innovation also cause cultural dislocation. Old ways of life disappear, and people must adapt to new circumstances. The possibility appears to exist for dramatic, discontinuous change.

People are close to having capabilities that may undermine their identity as human beings. Will people merge with machines? Will pharmacology or genetic engineering give people control over their emotions, memories, aging process, and physical and cognitive skills? Will scientific discoveries serve primarily to enhance the lives of the rich, or will they also give new opportunities to the poor?

The market offers only one way to answer these types of questions: with trial and error. Individual responses to opportunities and incentives will cumulate to an overall social result. Those who want the outcome to be arrived at by a different process, such as the deliberations of moral philosophers and experts, will seek to find a way to disrupt the decentralized, experimental market mechanism and replace it with something more planned and controlled.

ARNOLD KLING

SEE ALSO *Capitalism; Environmental Economics; Libertarianism; Smith, Adam.*

BIBLIOGRAPHY

Blinder, Alan S. (1987). *Hard Heads, Soft Hearts: Tough-Minded Economics for a Just Society*. Reading, MA: Addison-Wesley.

Drexler, K. Eric. (1986). *Engines of Creation*. Garden City, NY : Anchor Press/Doubleday.

Kurzweil, Ray. (1999). *The Age of Spiritual Machines: When Computers Exceed Human Intelligence*. New York: Viking.

Mokyr, Joel. (2002). *The Gifts of Athena: Historical Origins of the Knowledge Economy*. Princeton, NJ: Princeton University Press.

Muller, Jerry Z. (2002). *The Mind and the Market*. New York: Knopf. Muller provides an intellectual history of pro-market and anti-market philosophers from Adam Smith through the contemporary age.

North, Douglass C. (1981). *Structure and Change in Economic History*. New York: Norton. Emphasizes the role of political and social institutions in the development of modern markets.

Pinker, Steven. (2002). *The Blank Slate*. New York: Viking.

President's Council on Bioethics. (2003). *Beyond Therapy: Biotechnology and the Pursuit of Happiness*. Washington, DC: Author.

Rosenberg, Nathan, and L. E. Birdzell, Jr. (1986). *How the West Grew Rich: The Economic Transformation of the Industrial World*. New York: Basic Books. The authors explain how market institutions evolved from feudalism in Western Europe.

Shapiro, Carl, and Hal. D. Varian. (1999). *Information Rules: A Strategic Guide to the Network Economy*. Boston: Harvard Business School Press.

Stock, Gregory. (2003). *Redesigning Humans: Choosing Our Genes, Choosing Our Future*. Boston: Houghton Mifflin.

Smith, Adam. 1998 (1776). *An Inquiry into the Nature and Causes of the Wealth of Nations*. Washington, DC: Regency.

INTERNET RESOURCES

Brooks, Rodney. (2002). "Beyond Computation: A Talk With Rodney Brooks." Available from http://www.edge.org/3rd_culture/brooks_beyond/beyond_index.html.

Fiske, Alan Page. (2004). "Human Sociality." Available from http://www.sscnet.ucla.edu/anthro/faculty/fiske/relmodov.htm.

Joy, Bill. (2000). "Why the Future Doesn't Need Us." *Wired* 8.04. Available from http://www.wired.com/wired/archive/8.04/joy.html.

MARX, KARL

Karl Marx (1818–1883) was born in Trier, Prussia on May 5 and died in London on March 14. He was educated in Trier and at the universities of Bonn and Berlin, thus coming under the influence of Georg Wilhelm Friedrich Hegel (who he later radically criticized) before receiving his doctorate in philosophy from the University of Jena in 1841. Throughout most of his adult life, he was assisted both financially and intellectually by Friedrich Engels (1820–1895), with whom he coauthored such works as *The German Ideology* (1845–1846) and "The Communist Manifesto" (1848).

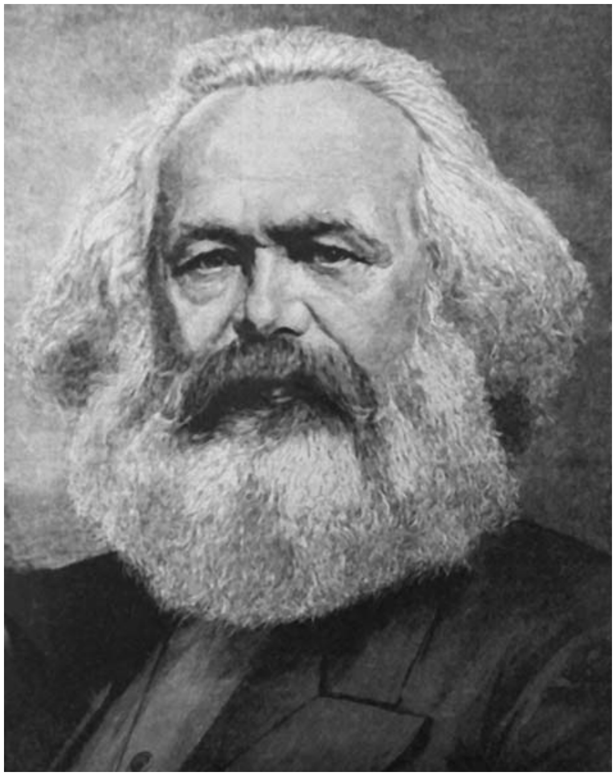
Marx wrote mainly on capitalism as an economic system, and is most closely identified with the multivolume *Capital* (Vol 1 [1867]; Vol. 2 [1885]; Vol.3 [1894], Vols. 2 and 3 published by Engels after Marx's death). This massive 2,500 page work explores the capitalist system in terms of the logic of its functioning, its historical progression, and its fate. Marx's writings on science are scattered and fragmentary, and his discussions of technology, though more detailed, are largely unsystematic. Therefore this entry will concentrate more on his views on ethics and morality, the implications of which are enormous.

Technology and Science

Technology and science played an important role in Marx's thought. His general theory of human history, *historical materialism*, gave technology a major role in forming the foundation of society and in the process of historical change. Every society rests on an economic base or mode of production, which includes both forces and relations of production. The forces of production consist mainly of the level of technological development a society has achieved and of the features of the natural environment in which it is located. Relations of production are the social and economic relations people enter in the process of production and involve the ownership of the productive forces. The productive forces might be owned and controlled by the entire society, or, more commonly, by a relatively small segment of society. Those who own the productive forces dictate their operation and often subject the mass of the population to conditions of severe exploitation and oppression. The other major part of every society is the superstructure, which consists of politics, law, family life, religion, and the mode of consciousness, or collective forms of thought and feeling. The superstructure rests on the economic base and is largely determined by it.

Marx regarded the earliest societies as constituting forms of primitive communism. Here people lived by using simple technologies of hunting, fishing, agriculture, and animal husbandry. Because of the communal nature of such societies and the absence of class divisions and exploitation, they would have been idyllic except for their low level of technological development, which prevented people from adequately satisfying basic needs. Gradually, however, progress in technology enhanced human power to manipulate the environment, but in ways that led to the formation of private property and class divisions. European society passed through a slave mode of production in ancient times and then a feudal stage. Capitalism succeeded feudalism.

Despite his savage criticisms, Marx appreciated the great achievements of capitalism, the foremost being its enormous capacity for the development of technology in the form of modern industry. In his general theory of history, Marx saw capitalism as a prerequisite for the development of socialism because the latter, in order to meet basic human needs and allow for everyone's self-realization and self-fulfillment, requires material abundance. Capitalism developed technology to a level sufficient for the creation of this abundance. But socialism would develop technology even further, thus allowing for the elimination, or at least the reduction, of the most unpleasant and burdensome forms of work.



Karl Marx, 1818–1883. This German philosopher, radical economist, and revolutionary leader founded modern "scientific" socialism. His basic ideas—known as Marxism—form the foundation of socialist and communist movements throughout the world. *(The Library of Congress.)*

Marx had much less to say about science than he did about technology, but he was a major proponent of science, both because of its ability to produce intellectual knowledge and its capacity for the development of industry. In the section of the "Economic and Philosophical Manuscripts" (1844) devoted to private property and capitalism, Marx writes that "natural science has invaded and transformed human life all the more *practically* through the medium of industry; and has prepared human emancipation" (Marx 1978b, p. 90). Also "Natural science will in time subsume under itself the science of man, just as the science of man will subsume under itself natural science: there will be *one* science" (Marx 1978b, p. 91).

Indeed Marx regarded historical materialism as a scientific theory that could be empirically verified (Husami 1980). He was also a great admirer of Charles Darwin and highly commended *Origin of Species* (1859) to Engels, saying that it served as a basis in nature for their theory of history. Later, in his speech at Marx's grave, Engels was to say, "Just as Darwin discovered the law of development of organic nature, Marx discovered the law of development of human history" (Engels 1978, p. 681).

Ethical Perspective

Marx did not have an ethical theory, or a theory of justice, in the sense of such great moral philosophers as Immanuel Kant or John Rawls. In fact Marx explicitly disavowed all talk of justice and rights, in part because they belong to the juridical superstructure rather than the technoeconomic base. In capitalist society, juridical notions are part of the way in which the capitalist mode of production and its ruling class are maintained. In "Critique of the Gotha Programme" (1875) he argues that, in discussions of socialism, notions of justice and rights are *obsolete verbal rubbish* and *ideological nonsense*. Under socialism there will be no need for rights and liberties, their *raison d'etre* having disappeared. The rights and liberties found in capitalist society only exist because capitalism is a highly inadequate mode of production from a human point of view (Buchanan 1982).

In his famous essay "On the Jewish Question" (1843), Marx drew an important distinction between political freedom and human freedom. Political freedom consists of the constitutional liberties that people have in capitalist society: the right to property, speech, and assembly, equal treatment before the law, and so on. Political rights are a cover for an absence of human rights. Human freedom involves the opportunity of all individuals not only to have the full satisfaction of their basic needs, but also the opportunity to realize their essential nature as human beings through creative and self-fulfilling work. In capitalist society, everyone has political freedom but only a few can achieve true human freedom. Only in socialist society can human freedom become commonly achieved. This vision of freedom is intimately tied to Marx's views on technology, because true human freedom requires a very advanced level of technology, which a fully realized socialist society will have.

Nevertheless although Marx did not develop an ethical theory and rejected its need or desirability, he did have moral or evaluative notions that guided his critique of capitalism and his advocacy of socialism. Marx was a moralist who had no moral theory, that is, he "advocates principles that are supposed to guide present-day social and political choice in the same way as a political morality" (Miller 1984, p. 51). In various writings, Marx refers to the misery and sufferings of the working class under capitalism, of the deadening and degrading nature of work created by the capitalist division of labor (and thus of the alienation and dehumanization of the worker), and of how capitalism "enforces on the laborer abstinence from all life's enjoyments" (Husami 1980, p. 43). The capitalist class receives all the material and intellectual benefits of society while the proletariat assumes all its burdens. Capitalism exploits the worker, and exploitation is variously described as robbery, embezzlement, plunder, and theft. Husami argues that these evaluative notions are tantamount to a conception of justice despite the fact that Marx formally rejected all talk of justice.

Marx also seemed to have a theory of distributive justice (Husami 1980). As set forth in *Critique of the Gotha Programme* (1875), the first phase of the new socialist society will be guided by the principle *to each according to his abilities*. Workers receive from society payment in accordance with the labor contribution they make. Individuals differ in their mental and physical endowments and some contribute more labor than others; those who contribute more receive more in return. But inequalities never become significant because society provides for every person's social needs (healthcare, education, and so on). Whatever inequalities do exist are not the result of power and class differences because private ownership of the means of production has been abolished.

But this first phase of socialist society, having just emerged from capitalist society, is still stamped with defects. There will emerge a higher phase of socialist or communist society, and "only then can the narrow horizon of bourgeois right be crossed in its entirety and society inscribe on its banner: From each according to his ability, to each according to his needs" (Marx 1978b, p. 531). In this phase, society takes into consideration the fact that individuals differ not only in their talents and abilities, but also in their needs. Because some individuals have greater needs than others, they should be rewarded accordingly. This highest form of socialist society is guided by the principle of full individual self-development, and as such must provide each person with the resources necessary for that development. Inequalities therefore remain. Again, however, these inequalities do not arise from class position (because there are no classes) and do not involve any exploitation. Moreover the inequalities are not great and do not affect the satisfaction of basic needs related to physical well-being and education, because these are automatically provided to everyone. (See Wood [1980] for a very different interpretation of Marx on justice. For an interpretation partway between Husami's and Wood's, see Brenkert [1980].)

Historical Failures and Legacy

The implications of Marx's thinking on science and technology are relatively minor, but his thought has enormous implications for an ethical assessment of society. Marx's predictions concerning future socialist revolutions and the content and nature of socialist society have been overwhelmingly repudiated by the past 100 years of history. Socialist revolutions occurred where Marx did not expect them, and utterly failed to occur in those places where he thought they would. And the so-called socialist societies that did develop were for the most part a grotesque deformation of what he expected. These failures lie both in a flawed theory of history—Marx badly misunderstood the historical trajectory of capitalism—and in a failure to appreciate the importance of a theory of justice and morality. Marx's view that political rights and liberties are merely expressions of a defective bourgeois mode of production, and as such will be irrelevant and unnecessary in a socialist mode of production, opened the way for, and gave license to, some of the most brutal dictatorial regimes in human history. Marx did not foresee this outcome, and certainly would have vehemently rejected it. The ideals may have been noble, but their actual implementation proved to be an entirely different matter.

Many different kinds of Marxism have developed since Marx's time, including the critical theory of the Frankfurt School (Adorno, Horkheimer, Marcuse, Habermas), the Italian Marxism of Antonio Gramsci, French existentialist Marxism (Sartre), Wallerstein's world-system theory, and anticolonialist theory. Some of these are as different from one another, and from classical Marxism, as they are similar. Critical theory, for example, is highly critical of modern science and technology in a way that would have been inconceivable to Marx. In terms of ethics, a wide range of complex positions can be found.

STEPHEN K. SANDERSON

SEE ALSO *Alienation; Capitalism; Communism; Critical Social Theory; Freedom; Hegel, Georg Wilhelm Friedrich; Marxism; Political Economy; Socialism; Sociological Ethics; Work.*

BIBLIOGRAPHY

Brenkert, George G. (1980). "Freedom and Private Property in Marx." In *Marx, Justice, and History*, eds. Marshall Cohen; Thomas Nagel; and Thomas Scanlon. Princeton, NJ: Princeton University Press. An attempt to map out a position on Marx and justice part way between the positions of Husami and wood.

Buchanan, Allen E. (1982). *Marx and Justice: The Radical Critique of Liberalism*. Totowa, NJ: Rowman & Allanheld. Takes the position that Marx had no formal theory of justice or rights and disdained any discussion of such with respect to the virtues of socialism.

Cohen, Marshall; Thomas Nagel; and Thomas Scanlon, eds. (1980). *Marx, Justice, and History*. Princeton, NJ: Princeton University Press. An important collection of essays on the role of justice in Marx's thinking.

Engels, Friedrich. (1978). "Speech at the Graveside of Karl Marx." In *The Marx-Engels Reader*, ed. Robert C. Tucker. Text originally published in 1883.

Husami, Ziyad I. (1980). "Marx on Distributive Justice." In *Marx, Justice, and History*, eds. Marshall Cohen; Thomas Nagel; and Thomas Scanlon. Princeton, NJ: Princeton University Press. Sets forth the position that Marx had a theory of justice (including two principles of distributive justice) and judged capitalism to be unjust.

Marx, Karl. (1967 [1867]). *Capital*, Vol. 1, trans. Samuel Moore and Edward Aveling. New York: International Publishers. The most important volume of Marx's great work in which he sets forth the laws of functioning of capitalist society and its evolution.

Marx, Karl. (1967 [1885]). *Capital*, Vol. 2, ed. Friedrich Engels. New York: International Publishers.

Marx, Karl. (1967 [1894]). *Capital*, Vol. 3, ed. Friedrich Engels. New York: International Publishers.

Marx, Karl. (1978a). "Critique of the Gotha Programme." In *The Marx-Engels Reader*, ed. Robert C. Tucker. Text originally published in 1875. An important discussion by Marx of the place of human abilities and needs in the future socialist society.

Marx, Karl. (1978b). "Economic and Philosophical Manuscripts of 1844" In *The Marx-Engels Reader*, ed. Robert C. Tucker. Text originally published in 1844. Youthful essays written by Marx on such topics as alienation, private property and communism, and Hegelian philosophy.

Marx, Karl. (1978c). "On the Jewish Question." In *The Marx-Engels Reader*, ed. Robert C. Tucker. Text originally published in 1843. A famous essay in which Marx draws an important distinction between political freedom and human freedom. The famous early essay on the coming of communist society, including a brief sketch of its principles of organization.

Marx, Karl, and Friedrich Engels. (1970 [1845–1846]). *The German Ideology*, ed. C. J. Arthur. New York: International Publishers. The work in which Marx and Engels lay out their general theory of society and history, historical materialism.

Marx, Karl, and Friedrich Engels. (1978). "Manifesto of the Communist Party." In *The Marx-Engels Reader*, ed. Robert C. Tucker. Text originally published in 1848.

Miller, Richard W. (1984). *Analyzing Marx: Morality, Power, and History*. Princeton, NJ: Princeton University Press. An extremely important book that critically examines the nature of historical materialism and the extent to which the concept of justice played an important role in Marx's critique of capitalism.

Tucker, Robert C., ed. (1978). *The Marx-Engels Reader*, rev. edition. New York: Norton. An excellent collection of selections from all of the important works of Marx and Engels.

Wood, Allen W. (1980). "The Marxian Critique of Justice." In *Marx, Justice, and History*, ed. Marshall Cohen; Thomas

Nagel; and Thomas Scanlon. Princeton, NJ: Princeton University Press. Argues that Marx had no formal theory of justice and did not condemn capitalism as unjust.

MARXISM

An intellectual tradition and political movement initiated by Karl Marx (1818–1883) and Friedrich Engels (1820–1895), Marxism has devoted much attention and debate on matters of science, technology, and ethics. Marx and Engels themselves were particularly influenced by Darwinism and saw themselves as extending an understanding of organic evolution into human history. They believed that developments in the natural sciences of their times required elaboration of the philosophical and sociological consequences in the direction of a dialectical and historicist form of materialism. But they were critical of existing materialist currents as undialectical and existing dialectical positions as idealist. In the intellectual division of labor between Marx and Engels, Marx devoted his efforts to economics, while Engels wrote on philosophy, science, culture, morality, and gender, and entered into polemics with critics. His *Dialectics of Nature,* published posthumously in 1927, explores the philosophical implications of the natural sciences.

Marxism held that capitalism has played a crucial part in developing science and technology, but that only socialism could fulfill their potential and organize an equitable distribution of their benefits. For Marxism, capitalism was an inherently contradictory mode of production. It was a system based on the primacy of market forces and private ownership of the means of social production, generating a basic class division between those who own the means of production and those who own only their labor power. Although capitalism led to an unprecedented development of productive forces, rising standards of living, and advances in science and technology, it also created massive inequality, parasitism, and alienation. Capitalism was a historically necessary stage in human development, but socialism was a necessary next step. A socialist system based on the social ownership of the means of social production would create a social order based on the principle "from each according to his or her abilities, to each according to his or her needs."

Marxism pioneered the field of sociology of knowledge, including the sociology of science and technology. It has insisted that science and technology are not isolated, self-contained activities, but develop in complex interaction with a whole range of other processes: philosophical, cultural, political, and economic forces. Within this interaction, the mode of production is decisive. All existing scientific theories, technological developments, economic structures, political institutions, philosophical positions, legal codes, moral norms, sexual roles, cultural trends, aesthetic tastes, and even common sense are inextricably interrelated and determinately shaped by the dominant mode of production. Marxism thus made extraordinarily strong claims regarding the philosophical assumptions and sociohistorical basis of scientific knowledge. At the same time it put considerable emphasis on ideology, arguing against the view that science itself is neutral and that only the use or abuse of science is ideological. Yet Marxism perceived recognition of these aspects as enhancing science and not being in conflict with the rationality and credibility of science.

Developments in the USSR

There have been many twists and turns in the history of Marxism due to the impact of new scientific discoveries, technological developments, philosophical trends, and political formations. Marxists of subsequent generations got caught up in many controversies. Along with political conflicts over evolutionary versus revolutionary paths to socialism, those of the second generation took various positions on the epistemological implications of the natural sciences. Vladimir Ilyich Lenin's (1870–1924) *Materialism and Empirio-Criticism* (1909) is a product of the philosophical debates of that period.

After the October revolution of 1917 that gave rise to the Union of the Soviet Socialist Republics (USSR), Marxism came to power as the official ideology of the new Soviet state, meaning that its visionary ideas could be tested in social practice. There were fiery debates about how to do so in virtually every sphere: from strategies for industrialization and agriculture to nationalities policy about the fate of different nationalities/national cultures within the USSR, socialist morality, science policy, free love, and the future of the family.

In the early years of the revolution, the movement for proletarian culture, *proletkult*, led by Alexander Alexandrovich Bogdanov (1873–1928), a doctor who advocated a collectivist subjectivism in the philosophy of science, argued that the culture of the bourgeoisie—from art and literature and morality to science and technology—was saturated with class ideology and could not serve the needs of the proletariat. *Proletkult* required a specifically proletarian culture, including proletarian science, because science had been shaped by the capitalist mode of production and needed to be collectivized and revolutionalized, putting an end to the fragmentation of scientific knowledge and the competitive drive of capitalist production. For *Proletkult* socialism was impossible without science, but it was also impossible with bourgeois science. Lenin and others took issue with this argument, contending that it was premature and sectarian to sweep aside the existing intelligentsia and existing knowledge. Lenin insisted that it was necessary to embrace bourgeois science and knowledge while critically reconstructing it. Bogdanov's movement dissipated within a few years, especially after he, as director of the Institute for Research in Blood Transfusion, died in an experiment on himself.

Nevertheless the USSR put much emphasis on working out a distinctive approach to science and technology under the banner of Marxism. Many political and philosophical debates flourished through the 1920s. The relationship of philosophy to the empirical sciences was very much in play through the prolonged debate between those who were grounded in the empirical sciences and emphasized the materialist aspect of dialectical materialism and those who were more grounded in the history of philosophy, particularly Hegel, and emphasized the dialectical dimension of dialectical materialism. It has been an ongoing tension in the history of Marxism, playing itself out in the intellectual ferment and institutional transformation of a socialist revolution. Philosophy was considered to be integral to the social order. Political leaders, particularly Lenin and Nikolai Ivanovich Bukharin (1888–1938), participated in philosophical debates as if these issues were matters of life and death, of light and darkness. Even while preoccupied with urgent affairs of state, they polemicized passionately on questions of epistemology, ontology, ethics, and aesthetics.

Bukharin was an advocate of the new economic policy aimed at achieving agricultural productivity and steady industrialization, but was outmaneuvered and defeated by Joseph Vissarionovich Stalin (1879–1953). Although he had fallen from the heights of political power, he continued to work as constructively as possible and devoted himself particularly to the application of science to economic planning during the first five-year plan. Bukharin believed that Marxists should study the most advanced work in the natural and social sciences and cleanse their thinking of the lingering idealism inherent in quasimystical Hegelian formulations. In *Historical Materialism* (1921), used as a basic text in educational institutions, he interpreted dialectics in terms of conflict and equilibrium. Other Marxists, such as the Italian Antonio Gramsci (1891–1937) and the Hungarian Georg Lukacs (1885–1971), saw Bukharin as the personification of a positivist tendency in Marxism. Lukacs's book *History and Class Consciousness*, rejecting Engels's concept of the dialectics of nature, drew a storm of controversy.

In 1931 Bukharin led a Soviet delegation to the Second International Congress of History of Science in London, projecting enormous enthusiasm for the role of science in a socialist society. Boris Mikhailovich Hessen (1883–c. 1937) delivered one of the most influential papers ever in the historiography of science, giving an ideological analysis of Newton's *Principia*, setting it firmly within the social, political, and economic struggles of the seventeenth century.

Both Hessen and Bukharin perished in the purges. Bukharin was the most prominent defendant in the spectacular Moscow trials and was executed. Even during his imprisonment he continued to write of how Marxism forged the most progressive path for science and technology, as affirmed in his posthumous work *Philosophical Arabesques* (2005), which was discovered decades after his death.

Another Marxist intellectual who espoused ideas relevant to science and technology was Leon Trotsky (1879–1940). He was inclined to the mechanist position in the debates of the 1920s and saw the role of philosophy as systematizing the conclusions of all the positive sciences. After Lenin's death in 1924 Stalin also outmaneuvered Trotsky, rejecting his pursuit of a worldwide socialist revolution in favor of developing socialism in the Soviet Union. Dismissing him from the government and expelling him from the party, in 1929 Stalin forced Trotsky into exile where he was assassinated.

Beyond and Within the USSR

The intellectual energy and social purpose of the Soviet philosophers and scientists had great impact on their international audience, especially in Britain, where influential scientists, such as J. D. Bernal (1901–1971), J. B. S. Haldane (1892–1964), and Joseph Needham (1900–1995) took up the challenge of a sociohistorical analysis of science and put their energies into a movement for social responsibility in science.

Marxism captured the imagination of many intellectuals in the west in the 1930s. Some of the most brilliant, such as David Guest (1911–1938) and Christopher Caudwell (1907–1937), died in the Spanish Civil War. In *The Crisis in Physics* (1939), Caudwell extended his ideological analysis of all spheres of thought into physics, seemingly the area most remote from ideological involvement. Caudwell saw a causal connection between the crisis in physics and those in biology, psychology, economics, morality, politics, art, and, indeed, life as a whole. The cause of the crisis in physics was not only the discrepancy between macroscopic or relativity physics and quantum or subatomic physics, but the deeper problem was the metaphysics of physics. What it came down to was the lack of an integrated worldview that could encompass all the sciences with their dramatically expanding experimental results. Science was decomposing into a chaos of highly specialized, mutually repellent sciences, whose growing separation increasingly impoverished each of them and contributed to the overall fragmentation of human thought. Ironically the very development of each of the sciences in this situation accentuated the general disorientation and resulted in scientists falling back on eclecticism, reductionism, positivism, and even mysticism.

Back in the USSR, a number of those who were fervent advocates of the new social order being created there were accused of undermining it and perished. All the debates of the 1920s took a sharp turn from 1929 on with the frenzy of the first five-year plan and the intensified pressure to bolshevize every institution and discipline. The intelligentsia was told that the time for ideological neutrality was over. They had to declare themselves for Marxism and for the dialectical materialist reconstruction of their disciplines or evacuate the territory. All controversies, whether between Marxism and other intellectual trends or between different trends within Marxism, were sharply closed down through the 1930s. There was to be one correct line on every question. Any deviation was considered to be not only mistaken but treacherous.

There was resistance in many areas. Geneticists fought back against attempts by brash bolshevizers to override the process of scientific discovery. The protracted struggle over the theories of Trofim Denisovich Lysenko (1898–1976) took the debate over proletarian science into difficult and dangerous territory, making legitimate issues such as hereditarianism versus environmentalism into a struggle for power where all intellectual and ethical criteria were at times abandoned. Nikolai Ivanovich Vavilov (1887–1943), an internationally prominent geneticist and ardent advocate of the unity of science and socialism, defended genetics and resisted the onslaught of Lysenkoism. He was accused of sabotage of agriculture and died in a prison camp.

These developments in Soviet intellectual life were inextricably tied to the rhythms of Soviet political and economic life. The way forward with the first five-year plan was far from smooth and uncomplicated. There was violent resistance to the collectivization of agriculture and peasants were burning crops and slaughtering livestock rather than surrender. There was one disaster after another in the push to industrialization. There was a fundamental contradiction between the advanced goals that were to be achieved and the level of expertise in science, engineering, agronomy, and economics, indeed a general cultural level, needed to achieve them. There was panic and confusion and desperation. There was reckless scapegoating. Breakdowns, fires, famine, and unfulfilled targets were attributed to sabotage and espionage. There was a blurring of the lines between bungling and wrecking, between association with defeated positions and treason, between contact with foreign colleagues and conspiracy with foreign powers.

After the death of Stalin, subsequent Soviet leaders, particularly Nikita Sergeyevich Khrushchev (1894–1971), in the critique of Stalinism after the Twentieth Party Congress (1956), and Mikhail Sergeyevich Gorbachev (b. 1931), in the period of glasnost and perestroika (1985–1991), attempted to put Soviet life, including its science, on a new basis, but, some contend, the traumas of the period prevented such changes.

Outside the USSR: New Left Marxism

From the 1940s on, Marxism came into the ascendancy in the academies of much of Eastern Europe and parts of Asia, Africa, and Latin America following the succession of communist or socialist parties to power in such countries as Czechoslovakia, Yugoslavia, China, Mozambique, and Cuba. The academicians of the German Democratic Republic were particularly devoted to developing a philosophy of science in the sense of elucidating the philosophical implications of the natural sciences.

Marxism also played a special role in French intellectual life. Some Marxist scientists, such as the physicist Paul Langevin (1872–1946) and biologist Marcel Prenant (1893–1983) saw dialectical materialism as illuminating their sciences and looked to the Soviet Union as developing science in a way that would liberate human society. Georges Freidmann (1902–1977), however, who made original contributions to industrial sociology, came to think that Soviet science was drowning in facile formulas and sterile polemics. Later many French Marxists, such as Jean Paul Sartre (1905–1980) and Maurice Merleau-Ponty (1908–1961) adapted their Marxism to existentialism or phenomenology. Others such as Louis Althusser (1918–1990) took Marxism in the direction of structuralism. It emphasized scientificity, but did not engage meaningfully with actual science.

In the 1960s and 1970s the influence of Marxism again became a formidable force, not only in countries defining themselves as socialist, but in the most prototypically capitalist ones as well. Although it never took state power in these milieus, Marxism did seize the intellectual and moral initiative for a time.

During this period a new left arose, posing new questions to the old left, as well as to the old right and the ever shifting center. Eurocommunism represented a merging of old and new left currents, which promised much at the time. The most vibrant debates of the day were conducted within the arena of Marxism. There were many journals such as *Science and Society* (1936–), *Marxism Today* (1953–1991), Socialist Register (1964–), and *New Left Review* (1960–) in which the discussion flourished.

On all matters touching on science, technology, and ethics, there was a new left challenge. The new left view of science represented a sharp break from the old left, for example the older radical science movement in Britain, exemplified by such figures as Bernal and Haldane. Science, as the older left saw it, was a progressive force. It was essential to socialism and socialism was essential to science. The *Radical Science Journal* (1974–1983) took the Marxist emphasis on the ideological nature of science in the direction of a radical social constructivism that sometimes tended to reject the cognitive and liberating potential of science. A long-standing leftist position, characterized by a blending of neo-Kantian, neo-Hegelian, and, more recently, postmodernist ideas with Marxist ideas, is represented by the Frankfurt School's (1923–) critical social theory, which identifies science with bourgeois ideology, counterposes scientific with humanistic values, and tends to hostility toward the whole sphere of the natural sciences. The divisions of the left on the question of science flared up in the science wars of the 1990s and were dramatized by the controversy that arose between the journal *Social Text* and Alan Sokal in 1996.

From the mid-nineteenth century and continuing into the early twenty-first century, Marxism made major contributions to intellectual history. It may at times seem to be a discarded theory, but one would be mistaken in believing that Marxism might not surge again.

HELENA SHEEHAN

SEE ALSO *Class; Communism; Conservatism; Critical Social Theory; Marx, Karl; Socialism; Weil, Simone.*

BIBLIOGRAPHY

Bernal, J. D. (1954, 1957, 1965, 1969). *Science in History*, 4 vols. London: Watts, Penguin.

Bukharin, Nikolai I. (2005). *Philosophical Arabesques*. New York: New York University Press.

Caudwell, Christopher. (1939). *The Crisis in Physics*. London: John Lane.

Engels, Friedrich. (1940). *Dialectics of Nature*. London: Lawrence and Wishart.

Graham, Loren R. (1987). *Science, Philosophy, and Human Behavior in the Soviet Union*. New York: Columbia University Press.

Haldane, J. B. S. (1938). *The Marxist Philosophy and the Sciences*. London: University of Birmingham.

Jay, Martin. (1984). *Marxism and Totality: The Adventures of a Concept from Lukács to Habermas*. Oxford: Polity Press.

Joravsky, David. (1961). *Soviet Marxism and the Natural Sciences, 1917–1932*. New York: Columbia University Press.

Kolakowski, Leszek. (1978). *Main Currents of Marxism Its Rise, Growth, and Dissolution*, trans. P. S. Falla, 3 vols. Oxford: Clarendon.

Lenin, Vladimir I. (1948). *Materialism and Empirio-Criticism*. London: Lawrence and Wishart.

Lewis, William. (2005). *Louis Althusser and the Traditions of French Marxism*. Lanham, MD: University Press of America.

Rose, Hilary, and Steven Rose, eds. (1976). *The Radicalisation of Science: Ideology of/in the Natural Sciences*. London: Macmillan.

Sheehan, Helena. (1993 [1985]). *Marxism and the Philosophy of Science: A Critical History*. Atlantic Highlands, NJ: Humanities Press.

Timpanaro, Sebastiano. (1975). *On Materialism*, trans. Lawrence Garner. London: New Left Books.

MATERIAL CULTURE

Material culture may be defined as the human significance of the totality of tangible artifacts that humans have produced. These artifacts range from the mundane and perishable to the monumental and enduring, and have been linked together in distinctive ways across place and time. Scholarly attention to material culture beyond technical analyses is divided among mainstream disciplines such as history and anthropology and specializations such as art history, archaeology, history of technology, cultural geography, and philosophy of technology. In all instances, questions of the ethical implications of material culture call for reflective consideration.

Basic Transformations

Despite the manifold plurality of material cultures across places and times, the Industrial Revolution of late-eighteenth-century England introduced a watershed into human history that began a radical transformation in the general character of material culture across all of its permutations. The steam engine for the first time in human history provided a tireless, ubiquitous, and powerful prime mover. Coal became a seemingly limitless energy source, and iron and steel constituted a material for structures that were both large and finely articulated.

Already in the nineteenth century, this transformation exhibited creative and destructive aspects, both noted by Karl Marx (1818–1883) and Friedrich Engels (1820–1895) in *The Communist Manifesto* (1848). About the creative side they said: "The need of a constantly expanding market chases the bourgeoisie over the whole surface of the globe. It must nestle everywhere, settle everywhere, establish connections everywhere" (Marx and Engels 1955 [1848], p. 13). This creative process has continued over the past century and a half and is much discussed in the early 2000s under the term *globalization*.

The destructive side Marx and Engels described as follows: "All that is solid melts into the air, all that is holy is profaned, and man is at last compelled to face with sober senses his real conditions of life and his relations with his kind" (Marx and Engels 1955 [1848], p. 13). They described the dissolution more specifically in their description of how the labor power of workers was being torn out of its traditional context of personal relations, social bonds, and ownership of stores and tools and converted into a commodity whose price was being more and more depressed. Marx's *Capital* (1867) extended this analysis to all those things that used to be rooted in the production and consumption of the household and were pulled into the market by industry and commerce. This process too is still being discussed vigorously, and Anglo-American scholars have coined the term *commodification* as a covering concept.

Both creation and destruction are pervaded by a third process, a dematerialization and refinement of production and consumption. John Kenneth Galbraith (1967) noted how the basis of economic power had shifted since the eighteenth century from land via capital to expertise. Daniel Bell (1973) described a similar shift from extraction via fabrication to processing. Remarkably, Thomas J. Schlereth (1982) observed a broadly analogous process of sophistication in the scholarly concern with material culture. He distinguished the "The Age of Collecting (1876–1948)" from the "The Age of Description (1948–1965)" and the "The Age of Analysis (1965–)." The current end phase of this development is also much considered and contested in the early twenty-first century under such headings as *the computer era* or *the information age*.

Modern technology began as a widespread activity of inspired tinkering and ingenious inventing in the last third of the eighteenth century. It was well underway before the natural sciences in the nineteenth century caught up with technology and, through the explanation of heat, pressure, electricity, and materials, became an engine of innovation. Technological devices, in turn, began to open up deeper dimensions of familiar phenomena and entirely new areas of investigation. Research and development have to this day been the major sources of productivity growth and thus of an exploding material culture. By now technology and science have so fulsomely embraced one another that it has become fashionable to see them as one creature—technoscience (Ihde and Selinger 2003). It is an undeniable fact, to be sure, that much of science is undertaken for technological gain and that technology has stimulated science and made it more effective; yet technology and science remain distinguishable and, from the moral point of view, need to be distinguished.

Ethical Assessment

When it comes to its ethical examination, Marx may again be considered a founding figure in his ambivalence about the moral quality of the newly emerging material culture. Under the surface, Marx regretted the loss of traditional things and relations. Overtly, however, he considered the world of the past as one of oppression, exploitation, and even idiocy, and he embraced the Industrial Revolution and its fruits. What he emphatically found objectionable and doomed was not the quality of the new material culture, but maldistribution in the power over production and in the blessings of consumption.

Because it does not examine or question the internal moral structure and properties of the artifacts modern technology has produced, Marx's moral judgment of the material culture is an extrinsic one. It has in fact become the received wisdom of social theory that there are no morally significant internal structures or properties and that tangible technology is thus morally neutral. Accordingly, when considering how standard ethical theories and more popular moral positions bear on contemporary material culture, all those bearings turn out to be extrinsic.

This does not mean they are unimportant. Consider the two leading contemporary ethical theories. The first is the ethics of equality and liberty, masterfully represented by John Rawls (1999) and technically known as deontology. It contends that inequalities in power and prosperity are warranted only if everyone has an opportunity to become powerful and prosperous, and if inequalities are to the benefit of the poor and powerless. This implies a significant and well-warranted critique of how prosperity and the material objects of which it consists are distributed nationally and globally. At the same time Rawls makes the debatable claim that prosperity and opportunity in themselves can be defined in a morally thin or neutral sense.

The other leading contemporary moral theory is utilitarianism, which is concerned with maximizing the happiness of a given population (Sidgwick 1981 [1907]). The animating principle of utilitarianism is as intuitively simple and attractive as it is technically difficult and forbidding. Finding a measure for happiness, establishing the maximizing procedure, and defining the relevant population have turned out to be endlessly complicated and controversial problems that at every turn threaten implementation with paralysis. Utilitarianism becomes a feasible program if one substitutes prosperity for happiness and agrees to measure prosperity with money. The resulting moral theory—what may be termed monetary utilitarianism—dominates public policy decision-making in the advanced industrial countries and retains some of the affirmative and forward-looking spirit of the original conception. Maximizing becomes equated with increasing the gross domestic product by all available means, a person's happiness is measured by income and prosperity, and the relevant population is the citizenry of a nation. All this is animated by a spirit of optimism and tolerance. But utilitarianism, monetary or not, remains neutral when it comes to the moral quality of the goods that, along with the services, compose prosperity or lead to happiness. This is how utilitarians understand tolerance.

Environmentalism and Religion

The two more popular moral positions that bear on the material culture are environmentalism and religion. Environmentalists, broadly speaking, regard contemporary material culture as hypertrophic (growing excessively) and ruinous. Hence they counsel a reduction of material possession and consumption. This too is a moral injunction on the material culture—and one that is important and would be beneficial if heeded. But as practiced, environmentalism would not require a deeper understanding and a transformation of the moral quality of material culture. One might continue to enjoy the same tangible and consumable objects, albeit in environmentally sustainable versions—sitting on natural-fiber couches, drinking beer brewed from organically grown barley and hops, eating chips made from genetically unmodified corn, staring at a television set that, at the end of its useful life, the producer has to take back and recycle in its entirety. All of this would make the material culture simpler in quality and reduced in quantity, but not essentially different in character.

The most pointed and the best-known critique of the material culture comes from religious ethics. It condemns materialism—the excessive concern with material goods. Pope John Paul II has been a vocal proponent of this criticism, and his voice may seem a lonely one because, at least in the United States, Christianity and materialism seem to be anything but antagonistic. When questioned, however, Americans profess to be worried about materialism (Wuthnow 1996, Schor 1998). These worries surface in movements that range from Luddism to voluntary simplicity (Elgin 1981).

Materialism is an ill-defined phenomenon. The concern with material objects covers such disparate things—television sets and sport-utility vehicles (SUVs) are material objects, but so are musical instruments and bicycles. Can't one at least say that, no matter the kinds of material objects, there are simply too many? Aren't humans consuming too much and thus running out of raw materials, food, timber, and energy? And in the process, aren't the industrialized countries of the northern hemisphere exploiting those of the globe's southern half? According to Mark Sagoff (1997), however, these apprehensions turn out to rest on misconceptions.

Two conclusions appear to follow. First, the religious objection to materialism stands no matter how materialism is defined. Excessive concern with any kind of material object is a distraction from spiritual matters or the afterlife. Second, secular worries about materialism are unfounded, and a secular outlook on life cannot have objections in principle to the current way of taking up with material culture. Both conclusions leave one uneasy, however. As to the first, excessive concern with tangible stuff is morally objectionable by definition. But what about appreciation and enjoyment of the visible world? Some religious traditions at least think of the tangible world as created by God and therefore as fundamentally good. Secular folks who worry about materialism have something specific in mind, namely, consumerism (Wuthnow 1996, Schor 1998). Materialism in this sense is a preoccupation with a particular kind of material object, consumable objects, presumably. There is a need, then, for an intrinsic analysis of material goods and for a determination of whether their internal structure is ethically potent.

Material Goods Themselves

One school of thought has it that material goods are used to mark and enforce class distinctions (Veblen 1992, Douglas and Isherwood 1979, Schor 1998). Though this is certainly true and morally troubling, it reveals little about the specific quality of goods produced by modern technology. Horses, servants, and mansions were used to signal high status prior to the Industrial Revolution, and sumptuary laws were used to enforce class distinctions more rigorously than even Ferraris do in the early 2000s. Here again a cue may be taken from Marx or at least from his progeny. Like Marx, more recent left-liberal theorists have examined the transformation things undergo when they are drawn into market. Commodification is the term used to name this phenomenon, and the term carries connotations of disapproval, unlike the coreferential term that conservatives prefer, namely, privatization, or the term of mixed connotations, namely, commercialization.

Commodification has a clean and crisp economic definition: the process of moving something into the market—from either the intimate sphere or the public sphere—so that it becomes available for sale and purchase. In the case of a good from the public sphere, a public good is converted into a commodity, and, speaking more precisely, privatization is commodification in this latter sense only. Some of the public goods, such as justice and elementary education, are not material, of course, but others, such as transportation or a healthy environment, clearly are. The same distinction applies to intimate goods. Friendship and freedom are not material goods, but food and clothing are.

Commodification of intangible goods is morally objectionable because in this case a good commodified becomes a good corrupted. Justice bought is no longer justice, and friendship paid for is not real friendship. But no such opprobrium seems to taint tangible goods. Railroads are managed as public goods by governments in some countries, whereas in others they are private enterprises run for profit. Food and clothing have left the intimate sphere of the household so long ago that people no longer notice their peculiarities as commodities. Accordingly, Michael Walzer (1983), who has thought deeply about commodification (though he does not use the word), has drawn up a list of never-to-be-commodified goods, all of which are intangible.

Is there a way of capturing the apprehensions about consumerism, the suspicion that commodification of material goods is a process whereby "all that is holy is profaned" or that at least some holy things are profaned? The sacredness of food is certainly lost when it is shelved in a supermarket. The sacredness of nature is gone when it becomes an engineered setting for the wilderness lodge in Disney World. The holiness of things, or, more prosaically, their power to engage people deeply, is lost when things are stripped of their spatial, temporal, and social contexts, when those contexts are reconstituted and concealed technological means, and when the resulting commodities are made available for sale.

Commodification, then, is a cultural as well as an economic process. These two processes largely overlap, but not entirely. The food in a supermarket is commodified both economically and culturally. A typical farmers' market is a scene of economic commodification. The food, after all, is for sale. But significant contexts are there to be experienced directly. The local market reflects its special context in the fruits and vegetables that the local soil and climate can produce. It reflects the season with the hardy stuff appearing early in the year and the more tender things not until summer. Sellers are known for their expertise in growing this or that, and they establish ties of expectations and pleasure with their customers.

Conversely, tourists whose only concern is to capture the sights and scenes with their cameras deracinate treasures, trees, and towers and make them available as videos that can be shown anywhere and any time. They commodify their travels culturally though rarely economically. The things on those videos are severed from their here and now, but few would pay to see those desiccated things.

What is driving commodification? In its economic aspect it is certainly propelled by the pursuit of prosperity. This is a creditable desire, and many are grateful beneficiaries of at least some important parts of this affluence. The less noticed kinetic force of commodification is the desire for liberty—less noticed because one tends to think of liberty exclusively as political, the freedom from the oppression by persons. But, prior to the Industrial Revolution, there were also burdens and claims of material reality: the need to shear, card, and spin wool, and knit it into sweaters; the need to plant, water, weed, harvest, clean, prepare, and cook beans; and so on. Commodification, taken culturally, disburdens people of these requirements, and consumption can be taken in a culturally corresponding sense as the unencumbered enjoyment of commodities. Dematerialization turns out to be a consistent tendency of commodification. The less materially heavy and imposing commodities are, the more variously and easily they will be available and consumable. Technologically perfect virtual realities are the endpoint of this process.

Disburdenment too has its undeniable moral benefits, certainly when it comes to such basic parts of the material culture as water, warmth, and light. But disburdenment can hypertrophy from liberation to disengagement and lead to the physical and mental shapelessness that plagues the most advanced industrial societies. There is then a need to save or selectively reintroduce those material things that rightfully claim people's engagement and exertion, things such as musical instruments, gourmet kitchens, running trails, urbane cities, and more.

Morally debilitating commodification is not a problem for most people on the globe, namely, those who suffer from hunger, disease, illiteracy, and confinement. Appropriate globalizing of commodification is morally desirable. But finding a measure for appropriate globalization and for the readjustment of the material culture requires understanding the cultural and moral aspects of commodification. It is hard, however, to meet this task when science and technology are conceptually fused or rather confused into technoscience. Consider genetics. There are things to be found out about how genes and proteins relate to one another and how genes cooperate with one another and with environmental conditions to help produce brains, dispositions, and behavior. To come to understand these things is progress, and once clearly understood, the resulting knowledge compels assent. But there is nothing obviously progressive or compelling in the application of such knowledge. The eradication of aging and a massive deferral of dying may not be progress at all, and nothing compels one to think of those goals as desirable. These are moral issues that call for wisdom and persuasion.

ALBERT BORGMANN

SEE ALSO *Consumerism; Distance; Place.*

BIBLIOGRAPHY

Bell, Daniel. (1973). *The Coming of Post-industrial Society*. New York: Basic.

Borgmann, Albert. (1984). *Technology and the Character of Contemporary Life: A Philosophical Inquiry*. Chicago: University of Chicago Press.

Borgmann, Albert. (1995). "The Moral Significance of Material Culture." In *Technology and the Politics of Knowledge*, ed. Andrew Feenberg and Alastair Hannay. Bloomington: Indiana University Press.

Douglas, Mary, and Baron Isherwood. (1979). *The World of Goods*. New York: Basic.

Elgin, Duane. (1981). *Voluntary Simplicity*. New York: Morrow.

Galbraith, John Kenneth. (1967). *The New Industrial State*. Boston: Houghton Mifflin.

Ihde, Don, and Evan Selinger, eds. (2003). *Chasing Technoscience: Matrix for Materiality*. Bloomington: Indiana University Press. Includes work by Donna Haraway, Bruno Latour, Andrew Pickering, and the editors.

Marx, Karl. (2003 [1867]). *Das Kapital*. Cologne, Germany: Parkland.

Marx, Karl, and Friedrich Engels. (1955 [1848]). *The Communist Manifesto*, ed. Samuel H. Beer. New York: Appleton-Century-Crofts.

Rawls, John. (1999). *A Theory of Justice*, rev. edition. Cambridge, MA: Harvard University Press, Belknap Press.

Sagoff, Mark. (1997). "Do We Consume Too Much?" *Atlantic Monthly* 279(6): 80–96.

Schlereth, Thomas J. (1982). "Material Culture Studies in America, 1876–1976." In *Material Culture Studies in America*, ed. Thomas J. Schlereth. Nashville, TN: American Association for State and Local History.

Schor, Juliet B. (1998). *The Overspent American*. New York: Basic.

Sidgwick, Henry. (1981 [1907]). *The Methods of Ethics*. Indianapolis, IN: Hackett.

Veblen, Thorstein. (1992 [1899]). *The Theory of the Leisure Class*. New Brunswick, NJ: Transaction Publishers.

Walzer, Michael. (1983). *Spheres of Justice*. New York: Basic.

Wuthnow, Robert. (1996). *Poor Richard's Principle: Recovering the American Dream through the Moral Dimension of Work, Business, and Money*. Princeton, NJ: Princeton University Press.

MATERIALISM

Materialism is a term with both metaphysical and social meanings. As a metaphysical position materialism regards matter (Latin *materia*) as the primary or most real substance. In modern times materialism also has taken practical forms. Because science studies empirical objects and because material entities are more perceptible than are immaterial ones, the scientific worldview tends to assume materialism at least for heuristic purposes or on provisional grounds. Moreover, modern technological progress, especially in its early phases, provided mostly material improvements. Thus, one effect that technology seems to have had on culture is the creation of social forms of materialism such as consumerism.

Metaphysical Materialism

As a form of metaphysical monism, materialism attempts to reduce all phenomena to a single basic substance: matter. Thus, the opposites of metaphysical materialism are doctrines such as spiritualism, which holds that spirit is the ultimate reality; idealism, which sees the phenomenal world and matter as creations of the mind; and immaterialism, which rejects the reality of matter itself.

The idea of materialism was present when ancient Greek philosophy originated with Ionian natural philosophers who began to explain phenomena by referring to natural causes instead of religious myths in the sixth century B.C.E. The first systematically materialistic philosophers were the atomists Democritus and Leucippus of Abdera in the fifth century B.C.E. Among the major schools of philosophy in antiquity, Epicureanism professed materialism. In the modern period important materialists have included Pierre Gassendi (1592–1655), Thomas Hobbes (1588–1672), Heinrich Dietrich d'Holbach (1723–1789), Karl Marx (1818–1883), and Friedrich Engels (1820–1895).

One important difference between premodern and modern materialism is that the former tended to promote acceptance of the state of affairs in the world, whereas the latter is used to promote human action to change the world. Marxist materialism strongly illustrates the modern version of materialism. Indeed, Marx and Engels's philosophy developed in the former socialist countries into what was called dialectical materialism. It was materialism in the sense that it strictly denied the existence of immaterial entities, arguing that, for example, religious beliefs were part of a false ideology. The word *dialectical* referred to the quality of the laws that govern transformations in nature, history, and the human mind. Dialectical materialism saw these laws as based on the interplay of opposites.

Science, Materialism, and Ethics

Because science in principle does not make metaphysical commitments, science is not materialistic in the strict sense of the word. In fact, a more proper term for describing the way science perceives reality is *naturalistic*. The progress of modern natural science, however, has made materialism a more creditable stance than it was previously. Science studies phenomena that can be experimented on or otherwise brought to the impartial attention of the community of scientists. Clearly immaterial things such as the soul, supernatural events, values, ideals, and meanings are difficult or impossible to research scientifically. Thus, it seems from a scientific perspective that things one cannot examine scientifically are not real.

In practical life and in the adaptation of science the tendency toward materialism is manifested, for instance, in measuring. Measuring is essential in all science-related activities because exact scientific research is based on calculating measured quantities. An object of science must be measurable in some sense. Hence, it is difficult to do scientific research on phenomena in their qualitative aspects. For example, a scientist easily can determine the weight, size, and age of an ancient Chinese vase, but it is impossible to specify scientifically its degree of beauty. In consequence, quantity appears to be "more real" category than quality.

In ethics the success of natural science has had both implicit and explicit consequences. The most explicit consequence was the logical positivist argument in the 1920s that ethics is a merely emotional use of language that lacks empirical content. Although this extreme view soon softened, ethics nevertheless struggled throughout much of the twentieth century against the tendency in a culture dominated by science to perceive reality as being defined by the possible objects of science. For instance, medicine can study whether smoking harms health, but it is a value question whether harming health is wrong. The only scientific approaches to value in this sense appear to consist of empirical research on expressed preferences or arguments for the evolutionary development of certain behaviors. Because values, norms, and ideals in the normative sense—moral sociology is another question—are not objects of scientific inquiry, ethics as a rational pursuit has had a credibility problem.

Technology and Materialistic Culture

Until recently technological advancement has contributed mainly to the improvement of the material conditions of life. This has meant highly increased material well-being for the majority of the people in industrialized societies.

According to some cultural critics, however, this development has not been free of malaise. It appears to those critics that human life has lost some of its dignity in the course of material success. This lack of dignity has been pointed out in consumerism, the loss of traditional skills, the sacrifice of ideals in the search for economic profit and quick satisfaction, and so on. Culture itself has been turned into a commodity to be mass produced and marketed industrially. The rule of quantity over quality in social and political life often is expressed in attitudes that make money and financial success the final arbiters of the good.

Some analyses of contemporary culture have suggested that classical Western ethics is incapable of addressing current issues because it does not pay sufficient attention to the material culture, that is, the production and use of material goods. At the heart of such criticisms is the notion of alienation. Cultural critics are afraid that the materialistic mass culture estranges human beings from themselves, other people, and nature. When it comes to nature, ecological problems are the most pressing issues related to materialistic consumerism.

Immateriality in Science and Technology

However, science and technology also have crucial immaterial aspects. Mathematics is indispensable for science, and mathematical abstractions are clearly immaterial. Moreover, science attempts to find regular patterns in reality and to form lawlike theories to describe those patterns. The structures, laws, and theories that science develops while investigating material reality are all immaterial. In this sense the object of science is material phenomena but the results of research are immaterial concepts that give new meanings to material reality. This is especially true in the most recently developed fields in science, such as computer science, genome studies, and neurological research.

Science can ask the question "What is matter?" but its answers are extremely complex and theoretical. Matter appears to consist mostly of empty space between elementary particles. Modern physics thus challenges any idea of matter "in itself" because what can be known about matter in the early twenty-first century is eminently theoretical and experiment-dependent.

In the realm technology information technologies and nanotechnology, which are highly theory-based forms of technology, deal mostly with immaterial phenomena. Generally speaking, technology can be interpreted as making matter less significant for human beings. For instance, communication and transportation technologies have made the globe "smaller" and reduced the role of time and place, which form the ultimate framework for matter, in human life. In this sense technology has made matter "serve" humankind.

Some essential immaterial aspects can be found in production as well. The emphasis of the economic structure in advanced societies has moved increasingly toward the production of immaterial services and information processing. Furthermore, in designing and marketing material commodities, aesthetic values, symbols, concepts, and myths form something that is now called a "brand." More and more companies do not sell only a material product but market an idea and a lifestyle. One does not buy a cell phone, one buys a successful person's phone.

These transformations in the economic structure and the style of production have been referred to as dematerialization. This term denotes the reduction of material used to produce specific goods and services. Dematerialization has raised hopes that economic growth and ecological sustainability may be reconciled so that consumers characteristically will purchase functions rather than material objects.

These reflections indicate how materialism is an ambivalent issue for science, technology, and ethics. Techno-scientific development has passed through a phase of studying and molding material reality, but currently the most important fronts in science and technology involve work on largely immaterial phenomena.

TOPI HEIKKERÖ

SEE ALSO *Consumerism; Dematerialization; Material Culture; Two Cultures.*

BIBLIOGRAPHY

Cornforth, Maurice. (1971). *Dialectical Materialism.* New York: International Publishers. A basic exposition of the Soviet Marxist version of materialism.

Moser, Paul K., and J. D. Trout. (1995). *Contemporary Materialism: A Reader.* New York: Routledge. Sixteen essays defending science-based materialism or "physicalism," with the final three essays addressing issues of materialism and ethics.

Rosenberg, Bernard, and David Manning White, eds. (1971). *Mass Culture Revisited.* New York: Van Nostrand Reinhold. A good collection of articles criticizing the materialistic culture industry; first published in 1957.

Trungpa, Chögyam. (1973). *Cutting through Spiritual Materialism,* ed. John Baker and Marvin Casper. Boston: Shambhala. Finds materialism a temptation even in religious practice.

Twitchell, James B. (2000). *Lead Us into Temptation: The Triumph of American Materialism.* New York: Columbia University Press. A witty defense of cultural materialism that reviews and rejects many of the criticisms.

McCLINTOCK, BARBARA

Nobel Prize-winning geneticist Barbara McClintock (1902–1992) was born in Hartford, Connecticut on June 16, and earned a doctorate in botany at Cornell University in 1927. Her early work on maize cytogenetics in R. A. Emerson's group at Cornell University in the 1920s and 1930s (where she worked with Marcus Rhoades, George Beadle, Harriet Creighton, Charles Burnham, and others) provided crucial evidence for the chromosomal basis of genetic crossover. Later, McClintock moved to the Cold Spring Harbor Laboratory in New York where she continued her groundbreaking research in genetics. But of her many achievements, her work on genetic transposition stands out as the most revolutionary. This work, establishing the mobility of genetic elements, defied conventional assumptions of the fixity of genes on the chromosomes and went unheeded for many years by most geneticists. But in 1983, thirty-two years after her first definitive paper on the subject, she was awarded the Nobel Prize for Physiology and Medicine, and her vindication was complete. After a lifetime pattern of relative obscurity and isolation, this prize ushered in a period of widespread public recognition—recognition not only for the quality of her work, but also for the model of scientific research she both advocated and exemplified. In her own words, good scientific research needed to be premised on "a feeling for the organism." She died near Cold Spring Harbor on September 2.

Barbara McClintock, 1902–1992. American geneticist McClintock received the Nobel Prize in Physiology for her discovery that genes could move from place to place on a chromosome. *(AP/Wide World Photos.)*

McClintock is of particular interest to historians of biology for her success in breaking with tradition on a number of fronts: as a geneticist whose understanding of genes was shaped by her interests in development; as a woman who refused to be constrained by conventional notions of gender; as a scientist who dared to affirm the importance of cultivating an intimate relation to the object of one's study in the rational construction of knowledge. For her, understanding a plant requires following it from its beginning: "I don't feel I really know the story if I don't watch the plant all the way along. So I know every plant in the field. I know them intimately, and I find it a great pleasure to know them" (Keller 1983, p. 198). But McClintock has also become a controversial figure, largely owing to differences in perspective between the two biographies that have been published (Keller 1983, Comfort 2001). Controversy centers largely on two issues: first, the extent to which her early work on transposition was in fact neglected; and second, on whether or not her particular methodological style can be taken as representative of either a "feminine" or a "feminist" approach to science.

Perceptions of neglect and recognition are inevitably at least partly subjective. Certainly, McClintock felt her work to be neglected, or at best, misunderstood. Equally certainly, many colleagues held her in enormously high regard. Nevertheless, prior to her Nobel Prize, and even after the rediscovery of transposition in the mid-1970s (under the name "jumping genes"), the phenomenon was widely regarded as of marginal significance to the general processes of genetics and development. Furthermore, interviews conducted prior to 1983 provide strong support for a fairly widespread tendency, perhaps especially among molecular biologists, to regard her and her work as eccentric curiosities. After 1983, however, a sea change could be seen to take place.

As a Nobel Laureate, McClintock suddenly became a heroine with whom virtually everyone wished to be identified, including feminists and mainstream scientists. Indeed, it was only at this point that McClintock began to be perceived as a feminist heroine, and that Keller's book (published some months before the prize) began to be read as a feminist manifest. Both readings fly in the face of the evidence—evidence provided both by McClintock's life and by Keller's biography. Comfort's biography goes some way toward correcting the record, and in deflating the "McClintock myth." Unfortunately, in the process he may have unwittingly contributed to the creation of a new myth, making of McClintock too much a practitioner of "normal science," and one who now appears to have been more fully embraced by the community around her than the historical record suggests. However, the scientific community's celebration of McClintock after 1983 is evident, and attested to by numerous publications (such as, for example, the excellent overview of her work by Federoff and Botstein 1992).

EVELYN FOX KELLER

SEE ALSO *Genetic Research and Technology; Sex and Gender.*

BIBLIOGRAPHY

Comfort, Nathaniel. (2001). *The Tangled Field: Barbara McClintock's Search for the Patterns of Genetic Control.* Cambridge, MA: Harvard University Press.

Federoff, Nina V., and David Botstein, eds. (1992). *The Dynamic Genome: Barbara McClintock's Ideas in the Century of Genetics.* Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

Keller, Evelyn Fox. (1983). *A Feeling for the Organism: The Life and Work of Barbara McClintock.* New York: W. H. Freeman.

McLUHAN, MARSHALL

Herbert Marshall McLuhan (1911–1980) spent nearly all of his life in Canada. Born in Edmonton on July 21, he was raised in Winnipeg and developed an early interest in engineering. There, he earned an M.A. in English, then went to Cambridge University and received additional B.A. and M.A. degrees, and also a Ph.D. (English). A widely published author of more than thirty books, one of which has been translated into more than twenty-five languages, McLuhan taught for three decades at the University of Toronto and died in Toronto on December 31.

McLuhan virtually invented the field of media studies and its relation to culture and society. McLuhan argued that the initial content of any new medium is always a preexisting medium (so radio, for example, takes over from the music hall and the newspaper; TV subsumes radio drama and film; and so on), so that the study of how a medium is used reveals little or nothing about its formal character or effects. Content study invariably leads to moral declaration and away from knowledge of the new form. Each major new medium means a new culture, and often a new war (McLuhan and Fiore 1968). For McLuhan the usual "moralistic" approach to media matters was incapable of producing real insight into the working of media as potent cultural forms.

Works and Insights

His groundbreaking *Understanding Media: The Extensions of Man* (1964) was the first to examine the effects of technologies of communication on shaping the culture and sensibility of the users. Ralph Waldo Emerson (1803–1882) had observed, "The human body is the magazine of inventions, the patent-office, where are the models from which every hint was taken. All the tools and engines on earth are only extensions of its limbs and senses" (1870). This was a key to McLuhan's insight into human artifacts. McLuhan thus pioneered the study of the human senses as they are extended and modified by old and new media alike. *The Gutenberg Galaxy* (1962) details the impact of the printing press on late-medieval European sensibility and how it brought about the Renaissance. Later works traced the effects of electric technologies, beginning with the telegraph, in dissolving print culture and literacy and instituting a new kind of tribal mentality that extends worldwide. Although he approached the study of media by observation and analysis, the major criticism leveled at his work was that it was "not scientific."

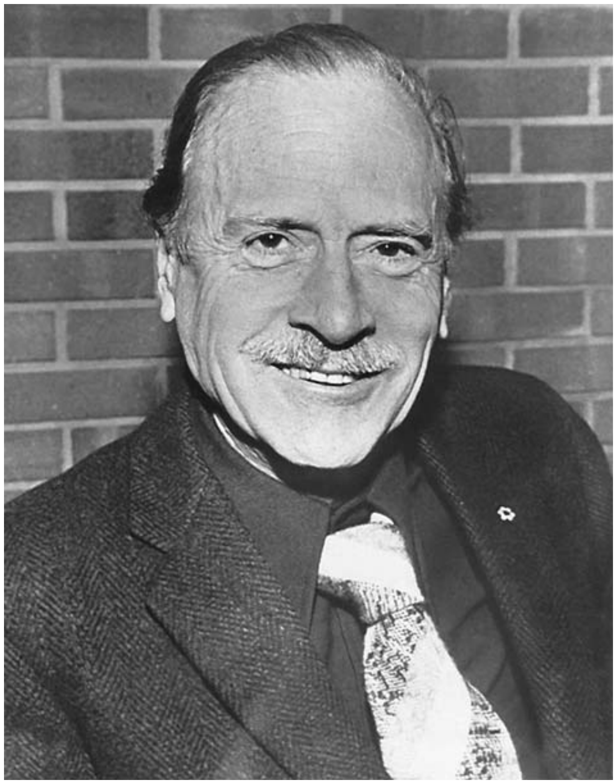
In posthumous works such as *Laws of Media: The New Science* (with Eric McLuhan; 1988) and *The Global Village* (with Bruce R. Powers; 1989), McLuhan synthesized his major discoveries and identified four scientific laws that govern the action of all human artifacts: amplification, obsolescence, reversal, and retrieval. He explored how his work integrated and updated the work of Francis Bacon (*Novem Organum*) and Giambattista Vico (*The New Science*).

McLuhan had a facility for aphorism, encapsulating a complex process in a memorable phrase such as "The medium is the message." He went to great lengths to point out that each medium, independent of the content it mediates, has its own intrinsic effects that are its unique message.

> The message of any medium or technology is the change of scale or pace or pattern that it introduces into human affairs. The railway did not introduce movement or transportation or wheel or road into human society, but it accelerated and enlarged the scale of previous human functions, creating totally new kinds of cities and new kinds of work and leisure. This happened whether the railway functioned in a tropical or northern environment, and is quite independent of the freight or content of the railway medium (McLuhan 1964, p. 8).

What he writes about the railroad applies with equal validity to the media of print, television, computers, and now the Internet. "The medium is the message" because it is the "medium that shapes and controls the scale and form of human association and action" (p. 9).

Another McLuhan term that has entered common usage is "the global village." In *Understanding Media* he wrote, "since the inception of the telegraph and radio, the globe has contracted, spatially, into a single large village. Tribalism is our only resource since the electromagnetic discovery. Moving from print to electronic media we have given up an eye for an ear" (pp. xii–xiii). The "global village," which many now see forming as a result of the Internet, was a side effect of the telegraph and of radio.



Marshall McLuhan, 1911–1980. A Canadian professor of literature and culture, McLuhan developed a theory of media and human development claiming that "the medium is the message." (© *Bettmann/Corbis.*)

Influences On and From

McLuhan's work absorbed influences from prior work on the social and cultural impact of communications technology by Harold Innis (1894–1952) and others in the arts. In integrating and extending such perspectives, McLuhan created a distinctive approach to media studies often erroneously described as emphasizing a kind of technological determinism with rhetorical excess. In reality, however, McLuhan was simply pointing out how certain technologies influence the world so that their users could learn to control them.

After a decline in reputation during his later years and soon after his death, McLuhan was rediscovered in the 1990s, and his insights into media found new application in interpreting twenty-first-century global communications developments. Among those who have taken up the study of technologies and culture, McLuhan offers one of the more comprehensive and consistent explanations for the welter of changes that accompany science and technology—changes that include new challenges for ethics and politics. Although some scholars continue to dismiss him as a maverick, he has been welcomed by pioneers in digital communications such as those associated with *Wired* magazine (founded 1993). Moreover, philosopher and media theorist Paul Levinson (1997) has drawn connections between McLuhan and the evolutionary epistemologies of Karl Popper (1902–1994) and Donald T. Campbell (1916–1996), both of which have ethical dimensions.

ERIC McLUHAN

SEE ALSO *Internet; Science, Technology, and Society Studies; Television.*

BIBLIOGRAPHY

Carpenter, Edmund, and Marshall McLuhan, eds. (1960). *Explorations in Communication: An Anthology*. Boston: Beacon Press.

Gordon, W. Terrence. (1997). *McLuhan for Beginners*. New York: Writers and Readers Publishing.

Levinson, Paul. (1997). *The Soft Edge: A Natural History and Future of the Information Revolution*. New York: Routledge.

McLuhan, Marshall. (1962). *The Gutenberg Galaxy: The Making of Typographic Man*. Toronto: University of Toronto Press.

McLuhan, Marshall. (1964). *Understanding Media: The Extensions of Man*. New York: McGraw-Hill.

McLuhan, Marshall. (1967). *Verbi-Voco-Visual Explorations*. New York: Something Else Press.

McLuhan, Marshall. (1995). *Essential McLuhan*, ed. Frank Zingrone and Eric McLuhan. Concord, Ontario: House of Anansi Press.

McLuhan, Marshall, and Barrington Nevitt. (1972). *Take Today: The Executive as Drop-Out*. Don Mills, Ontario: Longman Canada.

McLuhan, Marshall, and Bruce R. Powers. (1989). *The Global Village: Transformations in World Life and Media in the Twenty-First Century*. New York: Oxford University Press.

McLuhan, Marshall, and David Carson. (2003). *The Book of Probes*, ed. Eric McLuhan and William Kuhns. Corte Madera, CA: Gingko Press.

McLuhan, Marshall, and Eric McLuhan. (1988). *Laws of Media: The New Science*. Toronto: University of Toronto Press.

McLuhan, Marshall, and Quentin Fiore. (1967). *The Medium Is the Massage*. New York: Random House.

McLuhan, Marshall, and Quentin Fiore. (1968). *War and Peace in the Global Village: An Inventory of Some of the Current Spastic Situations that Could Be Eliminated by More Feedforward*. New York: McGraw-Hill.

Sanderson, George, and Frank Macdonald, eds. (1989). *Marshall McLuhan: The Man and His Message*. Golden, CO: Fulcrum.

MEAD, MARGARET

The most celebrated anthropologist of the twentieth century, Margaret Mead (1901–1978) was born in Philadelphia, Pennsylvania on December 16, and died in New York City on November 15. Her career began with a shift from psychology when Ruth Benedict (1887–1948) and Franz Boas (1858–1942), two of her teachers at Columbia, attracted her with Benedict's challenge that they had "nothing to offer but an opportunity to do work that matters." Bridging these two fields, Mead became a founder of the culture and personality school of anthropology; she was deeply committed to making anthropological knowledge matter—especially in a world of rapid scientific and technological change.

Mead's career took off when she went to Samoa at age twenty-three to study adolescent girls and to explore whether the emotional strains of adolescence were uniform across cultures or varied depending on socialization and experience. This led to her first book, *Coming of Age in Samoa* (1928), a bestseller that gave many readers their first awareness that their assumptions about human behavior might not always apply. Although this book was caricatured and attacked by the anthropologist Derek Freeman in 1983, twenty years of debate has affirmed her descriptions, showing that Freeman's insistence on the biological determination of variations observed fifty years after Mead's work in other areas of Samoa supplemented but could not refute Mead's basic emphasis on learned—and therefore potentially variable—behavior.

Mead's subsequent fieldwork up until World War II took her to four different New Guinea societies and to the Omaha tribe of Nebraska with her second husband, Reo Fortune, and then to Bali and another New Guinea society, the Iatmul, with her third husband, the anthropologist and ecological thinker Gregory Bateson. During this period, she focused primarily on child rearing and personality development and secondarily on gender differences, where she pioneered the comparative study of gender roles. Her work appeared both in further trade books such as *Sex and Temperament in Three Primitive Societies* (1935) and in detailed technical monographs such as *The Mountain Arapesh* (published in three parts, 1938–1949), establishing the pattern of applying her findings in the field to the dilemmas of industrialized society, and writing in several genres for different audiences. She also innovated in methodology, beginning the use of projective tests in fieldwork and, with Bateson, invented a new technique of visual anthropology exemplified in *Balinese Character* (1942). Her fieldwork archives are available at the Library of Congress.

World War II led Mead and other social scientists to focus on industrialized nations as part of the war effort. Mead collaborated with Benedict in developing the application of anthropology to contemporary cultures made inaccessible by war and political conflict, primarily through the Columbia University Research in Contemporary Cultures project. This methodology, described in *The Study of Culture at a Distance* (1953), which led to multiple publications by many authors, involved the creation of interdisciplinary and intercultural teams not unlike contemporary focus groups, and the analysis of literary and artistic materials in ways that anticipated contemporary cultural studies. Mead founded the Institute for Intercultural Studies in New York in 1944 to house these projects and a variety of later activities.

The war had precipitated rapid and often devastating culture change, and Mead's postwar focus was on change, particularly the possibilities of purposive culture change. In 1953 she returned to Pere, a Manus village in the Admiralty Islands (now part of Papua New

Guinea) she had studied with Fortune, to analyze the effects of the war on a community with little previous outside contact. In Manus, she found that a charismatic leader had promoted the choice of integration into the outside world and the villagers were positive about change rather than demoralized by it; that rapid change is sometimes preferable to gradual change; and that children could play a key transformative role (Mead 1956). Mead was one of those who introduced the concept of "culture" into the thinking of readers, with profound intellectual and ethical results, but her emphasis on purposive culture change reaffirmed ethical issues avoided by some cultural relativists, and she insisted that many human institutions, such as those of warfare and racism, be seen as human inventions that could be modified or replaced, rather than as "natural" and unavoidable. Her understanding of the role of individuals and groups in the remaking of Manus society was key to her book *Continuities in Cultural Evolution* (1964), best summarized in her often quoted phrase, "Never doubt that a small group of thoughtful committed citizens can change the world."

Mead believed that the understanding of cultural diversity offered a new kind of freedom to human societies, and she worked tirelessly and skillfully to disseminate anthropological ideas, lectured widely, published profusely, and was quick to understand the possibilities of new media. Unlike many academics, she saw communicating to the public as a professional obligation of comparable intellectual integrity to her more narrow professional writing. She also taught for many years at Columbia University and the New School for Social Research. At the same time, Mead worked with colleagues in other fields who kept her close to new developments in biology and neurology. She was an active member of the Macy Conferences on Cybernetics and on Group Process in the postwar period and of the World Federation for Mental Health. She was associated for more than fifty years with the American Museum of Natural History, serving in her later years as its Curator of Ethnology. She served as president of the American Association for the Advancement of Science and the American Anthropological Association, and was a founder of the Scientists' Institute for Public Information. She received twenty-eight honorary degrees, more than forty academic and scientific awards, and was awarded the Presidential Medal of Freedom following her death in 1978.

MARY CATHERINE BATESON

SEE ALSO *Cultural Lag; Modernization.*

Margaret Mead, 1901–1978. An American anthropologist, Mead developed the field of culture and personality research and was a dominant influence in introducing the concept of culture into education, medicine, and public policy. *(AP/Wide World Photos.)*

BIBLIOGRAPHY

Banner, Lois W. (2003). *Intertwined Lives: Margaret Mead, Ruth Benedict, and Their Circle*. New York: Knopf. A scholarly examination of Mead's early personal and professional relationships.

Bateson, Mary Catherine. (1984). *With a Daughter's Eye: A Memoir of Margaret Mead and Gregory Bateson*. New York: Harper Collins.

Côté, James E. (1994). *Adolescent Storm and Stress: An Evaluation of the Mead/Freeman Controversy*. Hillsdale, NJ: L. Erlbaum. One of many scholarly refutations of the Freeman attacks.

Freeman, Derek (1983). *Margaret Mead and Samoa: The Making and Unmaking of an Anthropological Myth*. Cambridge, MA: Harvard University Press.

Mead, Margaret. (1928 [2001]). *Coming of Age in Samoa: A Psychological Study of Primitive Youth for Western Civilization*. New York: Perennial Classics.

Mead, Margaret. (1934 [2001]). *Kinship in the Admiralty Islands*. New Brunswick, NJ: Transaction Publishers.

Mead, Margaret. (1935 [2001]). *Sex and Temperament in Three Primitive Societies*. New York: HarperCollins.

Mead, Margaret. (1938 [2002]). *The Mountain Arapesh*, 2 Vol. New Brunswick, NJ: Transaction Publishers.

Mead, Margaret. (1942 [2000]). *And Keep Your Powder Dry: An Anthropologist Looks at America*. New York: Berghahn Books. Written as a contribution to the war effort.

Mead, Margaret. (1956 [2001]). *New Lives for Old: Cultural Transformation—Manus, 1928–1953*. New York: Perennial.

Mead, Margaret. (1964 [1999]). *Continuities in Cultural Evolution*. New Brunswick, NJ: Transaction Publishers. Includes Mead's theoretical discussion of the role of small groups in cultural change.

Mead, Margaret. (1972 [1995]). *Blackberry Winter: My Earlier Years*. New York: Kodansha. Mead's partial autobiography.

Mead, Margaret. (2004). *The World Ahead: An Anthropologist Anticipates the Future,* ed. Robert B. Textor. New York: Berghahn Books. A selection of Mead's writings about the future.

Mead, Margaret, and Gregory Bateson. (1942). *Balinese Character: A Photographic Analysis*. New York: New York Academy of Sciences.

Mead, Margaret, and Rhoda Metraux, eds. (1953 [2000]). *The Study of Culture at a Distance*. New York: Berghahn Books. A manual developed from research in contemporary cultures.

MEDICAL ETHICS

Medical ethics is the most prominent branch of the broader field of bioethics. In general, medical ethics concerns itself with issues arising in the relationship between a health care professional, primarily a physician, and a specific patient. To a lesser extent medical ethics is concerned with issues of justice and equity in the delivery of and access to medical care.

Three sets of issues have dominated the discussion of medical ethics as a discipline since the 1960s. Each of these sets of questions has been decisively influenced by the development of modern medical science and technology. In fact, it can be argued that if not for the advances in medical technology between the early decades of the nineteenth century and the first half of the twentieth century, medical ethics as the discipline it currently is simply would not exist.

Doctor and Patient

The first set of issues of decisive interest in medical ethics are those having to do directly with the relationship between the physician (or other professional) and the patient. The most important of these concerns is that having to do with the informed consent of the patient to medical interventions. In the discussion of medical ethics since World War II the principle of informed consent has achieved universal, canonical status. One may not provide any care to otherwise competent patients without first explaining the situation and the options and securing patient agreement to proceed. This principle was first enshrined in medicine after World War II when the abuses of Nazi doctors in so called "experiments" came to light. The Nuremberg Code, formulated at the famous war crimes trial, enunciated the principle for researchers clearly: *The voluntary consent of the human subject is essential.* Later, in the 1960s, when it was discovered that some American physicians were ignoring this principle, renewed emphasis was placed on it in law and medicine.

The very emergence of this bedrock principle has been decisively shaped by technology. Prior to the twentieth century little could be done to actually treat most forms of illness and disease. What could be done required the active involvement of patients both in telling the doctor their symptoms, and their stories (travel, diet, lifestyle, etc.), and in following a therapeutic regimen of diet, rest, fluids, or other recommendations. An unconscious or unwilling patient would not reveal much nor cooperate in therapy. Pedro Laín Entralgo (1908–2001), the great medical historian of the premodern period, aptly called Greco-Roman medicine the "therapy of the word" in which the spoken word was crucial to diagnosis and treatment.

Consider now a patient who is brought unconscious into a twenty-first-century emergency room. The stethoscope can alert the physician to heart or lung problems, and scanning technology can reveal the presence of various brain injuries such as blood clots or strokes. Further scannings and laboratory techniques can reveal the precise source of problems from heart infections and heart attacks to pneumonia or drug abuse. Broken ankles and sprained ankles can be differentiated with technology, as can warts and melanoma.

Treatment can likewise be provided even if the patient refuses. Surgery, which is dominated by technologies, is performed on an anesthetized patient, not a conscious one. Prisoners can be treated for infectious diseases whether they wish it or not in the name of prison safety. Intravenous medication and hydration can be provided to the unconscious or the unwilling. Thus, the modern insistence on informed consent as a moral principle makes sense only in a world in which technology has decisively objectified the patient in the physician's hands and made possible medical care without patient involvement.

The same may be said of the importance of patient competency in contemporary medical care. The concept of competency is highly complex. The general idea is that in order for informed consent to be required patients must be capable of comprehending their medical situation and making choices about it. But competency is crucial only if one can, with technology, offer plausibly beneficial therapy to patients who are not competent. Competency and the associated questions regarding who should make decisions when patients cannot (for example, physicians, families, courts, committees) becomes a serious issue only when treatment is possible without the interpersonal word passing between doctor and patient. When therapies of the word are the only therapies possible, then any therapy presumes that the patient is plausibly competent. It is only when therapies of impersonal technology have surpassed therapies of the word that competency becomes an essential focus.

Technology has also profoundly altered the context in which one of the oldest principles of medical ethics, confidentiality, is viewed and defended. Though enshrined as early as the fourth century B.C.E. in the celebrated Hippocratic oath, and in the latest code from the American Medical Association, this concept has been decisively pressured if not altered by modern technology in three important ways. First, the early-twentieth-century growth of complicated technology such as clinical laboratories and X-ray machines caused a centralization of medical services in the modern hospital. Doctor's offices became appendages of the hospital often physically connected by tunnels or walkways. Records once kept confidential in a physician's office became centralized in the hospital and available for many more to see.

Second, technology led to increasing specialization both in medicine itself and in allied fields such as nursing, laboratory technology, physical and respiratory therapy, and more. Each of these specialists, from cardiac surgeons to cardiac rehabilitation technologists, has a legitimate need for access to a medical record both to document their care and to see what other care has been given. Thus, gone are the days of a specific private communication between two and only two persons: physician and patient. Now anonymous lab technologists who have just met a patient will know, and arguably need to know, that the patient from whom they are drawing blood has, for example, a bloodborne disease such as AIDS.

Third, advanced information technologies have become a standard way for storing information. They provide the most efficient means of data storage and retrieval both in hospital and out. The idea is that if a patient is brought to an emergency room thousands of miles from home the emergency room staff can have nearly instantaneous access to a patient's medical history, which they need to know to provide adequate care. But the very promise of easy access to sensitive information for professionals also suggests easy access for those with no need to know: reporters, hackers, angry relatives, titillated billing clerks, and nosy neighbors.

Life and Death

The second great set of issues in medical ethics are those having to do with the beginning and ending of life: abortion and the variety of issues dealing with euthanasia. Abortion has been an issue within medicine since Greco-Roman times. The Greek physician Soranus (second century C.E.), author of the first gynecological textbook, describes methods of producing abortion and then proceeds to criticize abortion for "cosmetic" reasons (for what he regarded as reasons of personal comfort or vanity, such as the fact that pregnancy altered one's looks or figure).

Though abortion has been a staple of medical ethics since, modern science and technology have decisively altered debates about the morality of abortion. It is often said that "science" believes or has "proven" that life starts at conception. Though technically correct now, the beginning of life at conception was discovered only in the early nineteenth century. Furthermore, contrary to the wishes of those who often make this claim, the claim itself does not lead to a moral conclusion unless one adds a moral principle such as "all human life of whatever sort should be preserved." Whether such a principle is sound is widely debated, but something like it must be added to the embryological claim to lead to a moral conclusion about abortion.

Furthermore, some of the most contested issues about selective abortion and partial-birth abortion exist only because of advances in medical technology. It was only in the late 1960s that the first process of prenatal diagnosis, amniocentesis, was developed to diagnose fetuses with chromosomal abnormalities such as trisomy 21 (Down syndrome), trisomy 18 or 13, fragile X syndrome, or broken chromosomes. In the early 1980s sonography (ultrasound) and blood screening technology advanced to the point that it could reliably diagnose in utero the second most common birth defect, spina bifida. In the future scientists hope to move beyond analysis of chromosomal abnormalities to genotyping of specific genetic abnormalities such as those that cause a variety of ills from blindness and Huntington's chorea to vaguer conditions such as tendencies to substance abuse and depression. To a limited extent this is already done in fertility clinics with preimplantation genetic diagnosis. Whatever the outcome, the issue of abortion for reasons of parental deselection of undesirable characteristics would not exist except for the technology that allows for the identification of such characteristics and the safe abortion of second-trimester fetuses or the existence of fertility clinics.

The same influence of technology is evident in the much contested situation of "partial-birth" abortions and/or very late term abortions. It is only because of advanced medical technology that late-term abortions are relatively safe, so the morality of taking the life of those fast approaching birth becomes an issue. Before the relatively recent past, abortion of any sort was preformed only infrequently because it was simply medically too dangerous for the woman.

The second cluster of life and death issues, those having to do with end-of-life care, have been even more decisively shaped by technological change. The first of these issues, that concerning the concept of death, would not exist but for the advancement of technology. Before the middle decades of the twentieth century the legal and moral definition of death was simple: complete and irreversible cessation of vital signs, specifically heartbeat and respiration. Physicians routinely called a person dead when the vital signs had ceased for a period of time that made them irreversible. In the 1950s technology decisively altered this framework. Respirator technology could pump air into a patient's lungs, forcing them out and weakly pumping blood to the heart and the body. Vital signs might never stop, and even the permanently unconscious might never "die." Technology seemed to promise longevity even to those whose conscious life had ended.

In this context, medicine and society were compelled to develop new understandings of death. Thus came the well-known concept of "brain death" in which persons could be considered brain dead if certain brain activities had ceased, even though other vital signs were artificially maintained. A debate has followed over different conceptions of brain death—centering on a cautionary "whole brain" formulation versus a broader "higher brain" formulation—but the important point here is that such a debate would not exist were it not for respirators, feeding tubes, and intravenous hydration and antibiotics that allow persistently unconscious human bodies to be kept alive indefinitely.

The same technological revolution brought out the importance of many other issues surrounding end-of-life care. How aggressive of an approach should be taken in keeping individuals alive who are gravely or terminally ill or severely brain damaged? The question of whether to go to extraordinary lengths to keep persons alive with advanced Alzheimer's disease or other brain deterioration is different from whether a doctor can just declare them dead. These questions have become crucial questions of end-of-life care. They become questions, however, only if there is a possibility of aggressive treatment of those who are gravely ill or severely handicapped. The morality of prolonging the life of the critically ill with technology becomes an issue only when the technology exists, such as respirators or dialysis machines, that will help preserve life.

A similar question involves when to resuscitate or not to resuscitate a patient who goes into cardiac arrest. Of course, one resuscitates in the emergency room and in cases of simple cardiac arrest in otherwise healthy persons. Furthermore, if patients have stated their wishes to be resuscitated, one honors them. But most hospitalized patients have never let their wishes be known. Should gravely ill persons in the intensive care unit routinely be revived even though data shows that such patients have very poor outcomes? The issue is widely debated, but the debate follows only from the existence of resuscitation technology such as defibrillators and heart-stimulating drugs.

So also does the agonizing debate since the 1970s about treatment for critically ill newborns follow from the advance of technology. Critically ill newborns may be saved with extensive interventions. But they may be left with severe handicaps as a result of many deficits. Parents and physicians are left with serious questions about when to intervene to save the life of such infants. Questions about the sanctity of all life, the quality of life, and when if ever life itself is not worth living swirl around these cases. Agonizing moral and legal debates both at the individual and policy levels have been involved. The debates, however, follow only from the dramatic advances in medical technologies that allow evermore fragile newborns to be saved.

Though issues of euthanasia and physician-assisted suicide have been around for millennia, as witnessed by the condemnation of euthanasia in the Hippocratic oath, they have taken decisive new turns in the modern period with the development of pharmacological means of causing death relatively painlessly and with a high degree of certainty. When suicide was limited to guns, knives, and poisons, the pain of the act was a deterrent. But when an injection of morphine and potassium chloride from a physician will end life quickly and painlessly, the issue takes on new dimensions. The same is true of the contested issues of physician-assisted suicide where doctors provide the means and patients take the action. This is hardly an issue when a person can buy a gun or rat poison at a hardware store. But with the advent of modern pharmacology, physicians can provide their terminally ill patients with strong painkillers such as Demerol and verbal instructions to enhance the power and speed with whiskey. Patients will then go unconscious and die without much suffering. Technology enhances the question: Should doctors ever do this?

Justice and Distribution

The third and final set of issues that has dominated the field of medical ethics in the last generation has been those related to access to and distribution of health care. One subset of issues here has to do with access to scarce lifesaving technology. In the early 1960s it was the development of dialysis, in the early twenty-first century it is organs for transplant. In the future it is likely to be new genetic technologies. Technologies change but issues of equitable access continue.

Basically there have been two broad contenders: (a) a merit-based selection or deselection scheme or (b) some form of randomization. Merit schemes are intuitively appealing but notoriously difficult to practice. Who is not moved by the plight of a mother of young children who needs a liver? Better she get it than a fifty-year-old who has grown children. Or who is not adversely affected by the thought of giving a liver transplant to someone, even as famous as the New York Yankees baseball star Mickey Mantle, who needed a new liver because drinking destroyed his original one? Though appealing, criteria of social worth are notoriously slippery. Perhaps Mantle stopped drinking years ago. Is he now to be thought of as less meritorious because of what he did as a younger person? Perhaps the fifty-year-old has a handicapped grandchild and her child care is much needed. Once carefully thought through, it seems that most people have merits and demerits in their lives. No one is so stellar that their case for new organs or other technologies shines clearly above the rest. Nor is anyone so completely unworthy that they can make no reasonable claim on a scarce medical resource.

Such considerations have led many to support some kind of randomization as a means of selection. The most common, especially in the case of transplants, is first come first served. In the case of transplants, patients are first screened medically to see if they are candidates for surgery—for example: Do they need a transplant? Could they survive such major surgery? And so on. Then they are broadly ranked according to medical need: How soon would they die without surgery? Finally, they wait their turn. When an organ becomes available that is tissue compatible, the person at the top of the list goes first. Though common this is not the only random method discussed in the literature. For example, though not often used, a lottery would be just as random and may have other advantages such as giving every needy person an equal opportunity to be served.

Finally the discussion of medical ethics has focused intensely on the question of whether there is a “right to health care” and if so how best to provide access to health care to those without it. It is now widely held that a society should provide basic medical care to all. Once this is granted two problems remain. First, how should the range of services to be provided be determined? Should services for some or all citizens be cut to free resources for those who do not have access? Plastic surgery might be an obvious cut, but what about expensive surgery that has very limited chances of success, such as treatment for some forms of cancer? For the person who needs the treatment as their only hope of survival, the question is answered one way. For the rest of society trying to find resources to provide prenatal care for poor women, the question might be answered differently.

Though this problem is difficult, a second sort of discussion has centered around how to provide access to basic services. Two broad approaches have dominated the discussion. The first is a government-run system in which doctors are paid by the government and tax revenues are used to provide health care for everyone. The second is to use tax revenues to move those without care into private health care plans. Each approach has its own difficulties. Government-run plans are often overused for minor problems and can result in long waiting lines for needed care. Private insurers can become bankrupt when they enroll too many sick persons at low rates. The problems are only compounded by the development of new technologies that increase the cost of health care in general.

For present purposes the most important points concern questions of access that follow advances in medical technology. One cannot talk about rationing access to dialysis or organ transplants until there are dialysis machines or transplant capabilities. Like other issues, this one too has been decisively shaped by the advances of medical technology.

Assessment

Medical ethics is representative of a larger field of professional and applied ethics in two important ways. First medical ethics involves the application of generally recognized principles in specific social, economic, and cultural settings. All cultures place a very high value on human life. But how that is balanced against quality of life and the use of scarce resources may vary in different settings. In a wealthy country such as the United States keeping someone alive at great expense may look very different than the use of scarce resources on a single life may look in a poor country with many public health needs. High technology may be afforded in one country but where even low technology is socially expensive the choices are much different.

Secondly, medical ethics combines both universal moral principles such as honesty and integrity with intra-profession principles or norms that are unique to that profession. Empathy is a highly valued virtue in medicine and less so in other professions such as engineering. Empathy is also a decisive virtue in modern times when technology can so easily separate doctor and patient. At other times such a virtue may require less effort.

Medical ethics, like medicine itself, has been profoundly shaped by modern science and technology. Without technology, the moral choices will look very different. However, without guidance from general principles such as respect for life and liberty technology may challenge the profession in uncharted ways.

RICHARD SHERLOCK

SEE ALSO *Abortion; Acupuncture; Aging and Regenerative Medicine; Bioengineering Ethics; Bioethics; Brain Death; Cancer; Complementary and Alternative Medicine; Death and Dying; DES (Diethylstilbestrol) Children; Drugs; Embryonic Stem Cells; Emergent Infectious Diseases; Genethics; Health and Disease; HIV/AIDS; Persistent Vegetative State.*

BIBLIOGRAPHY

Battin, Margaret P.; Rosamond Rhodes; and Anita Silvers, eds. (1998). *Physician Assisted Suicide*. New York: Routledge.

Bayertz, Kurt, ed. (1996). *Sanctity of Life and Human Dignity*. Dordrecht, Netherlands: Kluwer Academic.

Beauchamp, Tom L., and Robert M. Veatch, eds. (1996). *Ethical Issues in Death and Dying,* 2nd edition. Upper Saddle River, NJ: Prentice Hall.

Berg, Jessica W.; Paul S. Appelbaum; Charles W. Lidz; and Lisa S. Parker. (2001). *Informed Consent: Legal Theory and Clinical Practice,* 2nd edition. New York: Oxford University Press.

Brody, Baruch A., ed. (1989). *Suicide and Euthanasia*. Dordrecht, Netherlands: Kluwer Academic.

Buchanan, Allen E., and Dan W. Brock. (1989). *Deciding for Others: The Ethics of Surrogate Decisionmaking*. New York: Cambridge University Press.

Daniels, Norman. (1985). *Just Health Care*. New York: Cambridge University Press.

Daniels, Norman, and James E. Sabin. (2002). *Setting Limits Fairly: Can We Learn to Share Medical Resources?* New York: Oxford University Press.

Faden, Ruth R.; Tom L. Beauchamp; and Nancy M. P. King. (1986). *A History and Theory of Informed Consent*. New York: Oxford University Press.

Hursthouse, Rosalind. (1987). *Beginning Lives*. Oxford: Basil Blackwell.

Kamm, F. M. (1992). *Creation and Abortion*. New York: Oxford University Press.

Ramsey, Paul. (1978). *Ethics at the Edges of Life*. New Haven, CT: Yale University Press.

Reiser, Stanley Joel. (1978). *Medicine and the Reign of Technology*. New York: Cambridge University Press.

Steinbock, Bonnie, ed. (2002). *Legal and Ethical Issues in Human Reproduction*. Aldershot, UK: Ashgate/Dartmouth.

Weir, Robert F. (1989). *Abating Treatment with Critically Ill Patients*. New York: Oxford University Press.

MERTON, ROBERT

American sociologist considered to be the father of the sociology of science, Robert King Merton (1910–2003) was born in Philadelphia, Pennsylvania, on July 4, and died in New York City on February 23. His scholarly career spanned more than seven decades. Merton's contribution to ethics in science and technology was his elaboration of the social, and human, nature of scientific research.

After undergraduate study at Temple University, Merton attended Harvard University. He began his doctoral thesis in 1933 and completed it two years later with the title "Sociological Aspects of Scientific Development in Seventeenth Century England." In 1938 Merton's revised thesis was published in *Osiris: Studies on the History and Philosophy of Science, and on the History of Learning and Culture* as *Science, Technology and Society in Seventeenth Century England (STS)*. In this work, Merton explored the reciprocal relationships between the development of science and the religious beliefs associated with Puritanism. He concluded that cultural attributes, religious beliefs, and economic influences made it possible for science and its technical applications to flourish.

Merton later indicated that when *STS* was first published, it was generally ignored by sociologists (see Cohen 1990 and Chapter 20 by I. Bernard Cohen in Clark, Modgil, and Modgil 1990). More than three decades later, Merton's *STS* was published by a commercial publisher. By then, his reputation in sociology generally and in the sociology of science particularly was so broad that *STS* was widely studied and was considered a classic. It was both criticized and praised by historians, sociologists, and others.

After completing his doctorate, Merton taught at Harvard and published his most famous paper, "Social Structure and Anomie" (see Stephen Cole in Coser 1975). Merton's theory asserted that in the United States, people are taught to pursue the goal of economic success regardless of their location in the social structure. Yet the means to achieve success are not always available, resulting in a social condition conducive to deviant behavior.

After Harvard, Merton taught for two years at Tulane University. In 1941 he was invited to join the faculty at Columbia University; he remained affiliated with that university for the rest of his career. Soon after joining the faculty, he began to serve as associate director of the Bureau of Applied Social Research.

Merton published several articles from his thesis analyzing the social contexts of scientific advancement. In 1942, he described the normative structure of science in "Science and Technology in a Democratic Order" (reprinted in Merton 1973). He explains how the social institution of science involves a normative structure that works to support the goal of science—the extension of certified knowledge. Modern science has at least four norms or behavioral constraints that constitute its unique ethos.

Organized skepticism requires that any claim to new knowledge stand up to the same scrutiny, regardless of its source, before it becomes part of the accepted body of certified knowledge. *Universalism* requires that age, sex, race, or creed should not influence a decision about the acceptance or rejection of scientific information. Only the logical structure of the argument and the quality of the data are relevant. *Communism* (or *communality*) requires that once scientific information has been created or discovered and made public, the originator has no future intellectual claims to it. All scientists are free to use it in their work (with appropriate attribution). *Disinterestedness* requires scientists to be motivated to extend knowledge, not to seek personal gain.

This 1942 paper had a passing reference to a remark by Sir Isaac Newton stating, in effect, that if he had seen farther (in his work), it was by standing on the shoulders of giants. In the two decades that followed, Merton traced backward (and forward) the twelfth century origins of that phrase. *On the Shoulders of Giants* (1965) became a classic for its bibliographic erudition and style, and is recognized as a literary masterpiece.

Robert Merton, 1910–2003. Merton was a sociologist, educator, and internationally regarded academic statesman for sociology in contemporary research and social policy. He is considered the founder of the sociology of science. *(Archive Photos, Inc.)*

During the 1940s and 1950s, the Bureau of Applied Social Research provided unusual opportunities to collect data and conduct sociological analyses, and Merton developed a large body of theory that established his sociological talents. His new ways of seeing social realities invaded popular and official language. His work included such concepts as manifest and latent functions, self-fulfilling prophecy, goal displacement, local and cosmopolitan influentials, accumulation of advantage, the Matthew effect, theories of the middle range, sociological ambivalence, and obliteration by incorporation (Clark et al. 1990).

For two decades after Merton's 1938 contribution to the historical sociology of science, research by others in the sociology of science was largely dormant. In 1952, Merton explained why social aspects of science would be neglected by sociologists (Merton 1973). Most sociological research focuses on social problems such as deterioration of the family, political unrest, urban congestion, race relations, the media, and so on. Consequently, until either scientific knowledge or science as an institution is defined as a problem for society, scholarly investigators likely would not select science as the subject of social analysis.

In 1957, Merton's American Sociological Association presidential paper "Priorities in Scientific Discovery" continued his exploration of the developing sociology of science (reprinted in Merton 1973). That paper eventually became the most cited publication in the sociology of science (see Cole and Zuckerman's chapter in Coser 1975). It was full of ideas for further research, and provided a broad foundation for a growing interest in the sociology of science. During the 1970s, as science became to be perceived as a social problem, the number of scholars specializing in the sociology of science increased much faster than the growth of the field of sociology in general.

By the 1980s, Merton's influence was evident in the United States and in Europe. Colleges established courses and degree programs, and research centers focusing on social studies of science were created. Sociologists successfully organized specialty scholarly groups nationally and internationally. Although Merton was recruited to organize these societies, he mostly encouraged others and provided moral support.

During the last twenty years of the twentieth century, many competing ideas about the social nature of science developed. Controversies flourished about the foci of inquiries, research methodologies, and the validity of Merton's and other theories. These issues were debated internationally among historians, philosophers, sociologists, and others.

The Mertonian view of science based on the institution's normative structure was criticized as empirically invalid, especially by scholars outside sociology. Because social norms are not absolute, and compliance is rarely total, some deviance among community members is expected. Deviance among scientists, however, provided the basis for scholars to question Merton's perspective.

Merton was arguably the most influential sociologist in the twentieth century. Even scholars who did not see his scholarship as the final word on a subject nevertheless studied his work to create their own interpretations of the nature of society and the reciprocal relationships between science and society.

JERRY GASTON

SEE ALSO *Science, Technology, and Society Studies; Skepticism; Sociological Ethics.*

BIBLIOGRAPHY

Clark, Jon; Celia Modgil; and Sohan Modgil, eds. (1990). *Robert K. Merton: Consensus and Controversy*. London: Falmer Press. A critique of Merton's wide-ranging contributions across the entire field of sociology.

Cohen, I. Bernard, ed. (1990). *Puritanism and the Rise of Modern Science: The Merton Thesis*. New Brunswick, NJ: Rutgers University Press. An extensive discussion of the ideas developed in Merton's 1935 doctoral thesis.

Coser, Lewis A., ed. (1975). *The Idea of Social Structure: Papers in Honor of Robert K. Merton*. New York: Harcourt Brace Jovanich. Former students and colleagues discuss the breadth and depth of Merton's first forty years of scholarship and his career as teacher, collaborator, and colleague.

Merton, Robert K. (1965). *On the Shoulders of Giants: A Shandean Postscript*. New York: The Free Press. A literary exposition of the origin and persistence of the humble notion asserting that scientists are able to be creative because of the foundation laid by predecessors.

Merton, Robert K. (1970). *Science, Technology and Society in Seventeenth Century England*. New York: Howard Fertig. The 1935 doctoral thesis that first established comprehensively the sociological perspective of scientific development.

Merton, Robert K. (1973). *The Sociology of Science: Theoretical and Empirical Investigations*. Edited by Norman W. Storer. Chicago: University of Chicago Press. Major collection of Merton's papers on science as a social institution.

META-ANALYSIS

Meta-analysis is the quantitative review of the results of a number of individual studies in order to integrate their findings. The term (from the Greek *meta* meaning after) refers to analysis of the conclusions of the original analyses. The methodology can in principle be applied to quantitative studies in any area of investigation, but it has become a basic tool in healthcare research. It is part of the broader approach of *research synthesis*, which also includes qualitative aspects.

Evolution of Meta-Analysis

Gaining an overview of the outcomes of different experiments is the constant aim of science, and statisticians have been concerned with the combination of results since the emergence of formal statistical inference in the early twentieth century. The basic principles were established by the 1950s (Cochran 1954), and the need became clear with the subsequent rapid increase in research publications. The procedure was first developed in the social sciences, and the term meta-analysis introduced in the educational literature in 1976. The 1980s saw mounting interest in the combination of results of clinical trials, and since the early 1990s meta-analysis has experienced explosive growth in medical applications.

Although there seems little doubt that meta-analysis is here to stay, it has been fraught with controversy. There is the problem of the *quality* of individual studies, with their own biases, often small clinical trials with poor design and execution. There is the problem of *heterogeneity*, studies that measured different effects, used different populations, had different aims. A further problem is that of *publication bias*, the fact that studies with positive results are more likely to get published than those with negative outcomes, leading to an inflation of the effect estimate. Related to this is *Tower of Babel bias*, meaning that most meta-analyses identify only reports published in English.

An international conference on meta-analysis was held in Germany in 1994, to review problems and progress (Spitzer 1995). A strong opponent present called the method "statistical alchemy for the 21st century" (Feinstein 1995). But work has continued, with the development of guidelines for doing meta-analyses, emphasizing the need to identify unpublished studies, eliminate incomplete reports and those of flawed research designs, and include only quality studies that appear to address the same well-defined question. The gold standard is that of *Individual Patient Data* (IPD), where the original data are available for reanalysis in the combined context. *Cumulative meta-analysis* is the systematic updating of the analysis as new results become available. There is also extensive research on meta-analysis for observational studies.

The Cochrane Collaboration

An important, promising development is the vigorous Cochrane Collaboration, "an international nonprofit and independent organization, dedicated to making up-to-date, accurate information about the effects of health care readily available worldwide. It produces and disseminates systematic reviews of health care interventions and promotes the search for evidence in the form of clinical trials and other studies of interventions" (Cochrane Collaboration). The movement was inspired by Archibald Cochrane (1909–1988), the British epidemiologist best known for his 1972 work *Effectiveness and Efficiency: Random Reflections on Health Services*. Cochrane urged equitable provision of those modes of healthcare that had been shown effective in properly designed studies, preferably randomized clinical trials. He considered the latter among the most ethical forms of treatment, and he emphasized the need for systematic critical summaries, with periodic update by specialty, of all relevant randomized clinical trials.

The first Cochrane Center opened in the United Kingdom in 1992, followed by the founding of the Cochrane Collaboration in 1993. In November 2004 its web site listed twelve Cochrane centers worldwide (using six languages) that serve as reference centers for 192 nations and coordinate the work of thousands of investigators. The main output of the Cochrane Collaboration is the *Cochrane Library* (CLIB), published and updated quarterly by Wiley InterScience and available by subscription via the Internet and on CD-ROM. Its contents include the Cochrane Database of Systematic Reviews (CDSRs), over 3,000 reviews prepared by fifty Collaborative Review Groups (CRGs), the Cochrane Central Register of Controlled Trials, bibliographic data on hundreds of thousands of controlled trials, as well as methodologic information on the rapidly developing field of research synthesis, and critical assessment of systematic reviews carried out by others.

The Ethics of Evidence

Meta-analysis, an attempt to integrate the information already on hand from past studies, enhanced by guidelines that it be done on the highest professional level, fits into the framework of the *Ethics of Evidence*, a multidisciplinary approach proposed for dealing with the uncertainties of medicine (Miké 1999). The Ethics of Evidence calls for the development, dissemination, and use of the best possible evidence for decisions in healthcare. As a complementary precept, it points to the need to accept that there will always be uncertainty.

To explore the quality of evidence from meta-analyses, a 1997 study compared the results of twelve large randomized clinical trials (RCTs) published in four leading medical journals with the conclusions of nineteen previously published meta-analyses addressing the same questions, for a total of forty primary and secondary outcomes (LeLorier et al. 1997). The agreement between the meta-analyses and the subsequent large RCTs was only somewhat better than chance. A third of the meta-analyses failed to correctly predict the outcome of the RCTs, and would have led to adoption of an ineffective treatment or the rejection of a useful one. (The actual differences between effect estimates were not large, but that did not count in this adopt/reject type of analysis.) Then in 2002 the long-held belief that menopausal hormone replacement therapy offered protection against heart disease, a medical consensus supported by meta-analyses, was shockingly reversed by RCT evidence (Wenger 2003).

The Cochrane Collaboration, as a worldwide, integrated movement, has the great potential to promote cooperation on high-quality, controlled clinical trials. Systematic reviews of these, with regular update and dissemination, should help improve the evidence available for the practice of medicine. But it is important to keep in mind that even the best meta-analysis cannot take the place of original research. *Evidence-based medicine*, which makes heavy use of the results of meta-analyses, cannot apply evidence that does not exist. Scientists need to stay close to the primary literature, with an open mind, to get new ideas, seek new insights, and generate new hypotheses.

The public needs to have a cautious view of meta-analysis, judging each case in its proper context. For example, the meta-analysis showing that more than 100,000 Americans die each year from the side effects of legally prescribed drugs (Lazarou et al. 1998) merits serious concern, even if the estimate is not quite accurate. There is no substitute for being informed, getting involved, and taking personal responsibility.

VALERIE MIKÉ

SEE ALSO *Biostatistics; Statistics.*

BIBLIOGRAPHY

Bailar, John C., III. (1997). "The Promise and Problems of Meta-Analysis." *New England Journal of Medicine* 337: 559–560.

Cochran, William G. (1954). "The Combination of Estimates from Different Experiments." *Biometrics* 10: 101–129.

Cochrane, Archibald L. (1972). *Effectiveness and Efficiency: Random Reflections on Health Services*. London: Nuffield Provincial Hospitals Trust.

Feinstein, Alvan R. (1995). "Meta-Analysis: Statistical Alchemy for the 21st Century." *Journal of Clinical Epidemiology* 48(1): 71–86. Commentary by Alessandro Liberati, "A Plea for a More Balanced View of Meta-Analysis and Systematic Overviews of the Effect of Health Care Interventions," is included.

Lazarou, Jason; Bruce H. Pomeranz; and Paul N. Corey. (1998). "Incidence of Adverse Drug Reactions in Hospitalized Patients: A Meta-Analysis of Prospective Studies." *Journal of the American Medical Association* 279(15): 1200–1205.

LeLorier, Jacques; Geneviève Grégoire; Abdeltif Benhaddad; et al. (1997). "Discrepancies between Meta-Analyses and Subsequent Large Randomized, Controlled Trials." *New England Journal of Medicine* 337: 536–542.

Miké, Valerie. (1999). "Outcomes Research and the Quality of Health Care: The Beacon of an Ethics of Evidence." *Evaluation & the Health Professions* 22: 3–32. Commentary by Edmund D. Pellegrino, "The Ethical Use of Evidence in Biomedicine," also appears in this issue, pp. 33–43.

Moher, David. (2001). "QUOROM." [Quality of Reporting of Meta-Analyses] In *Biostatistics in Clinical Trials*, eds. Carol Redmond and Theodore Colton. New York: John Wiley & Sons.

Spitzer, Walter O., ed. (1995). *The Potsdam International Consultation on Meta-Analysis*, special issue *Journal of Clinical Epidemiology* 48(1): 1–172.

Stroup, Donna F., and Stephan B. Thacker. (2000). "Meta-Analysis in Epidemiology." In *Encyclopedia of Epidemiologic Methods*, eds. Mitchell H. Gail and Jacques Benichou. New York: John Wiley & Sons.

Thompson, Simon G. (2001). "Meta-Analysis." In *Biostatistics in Clinical Trials*, eds. Carol Redmond, and Theodore Colton. New York: John Wiley & Sons.

Wenger, Nanette K. (2003). "Menopausal Hormone Therapy and Cardiovascular Protection: State of the Data 2003." *Journal of the American Medical Women's Association* 58: 236–239.

INTERNET RESOURCE

Cochrane Collaboration. Available at www.cochrane.org. Web site of the organization.

MILITARY ETHICS

Military ethics can mean a wide range of things. It can encompass all aspects of military conduct, from writing performance reviews on subordinates, to relations of military personnel with their civilian leaders, to issues related to war. For the purposes of this entry, however, the discussion will be limited to ethical questions concerning the use of military force for the redress of political disputes. As war becomes increasingly dominated by high technology weaponry (at least in the developed countries), there is an intimate link between developments in science and technology and the questions of appropriate military use of those advances as addressed by military ethics.

Fundamental Issues

Traditionally military ethics has emphasized an approach to just war thinking that has roots in classical and early-Christian sources. In post-Reformation and post-Enlightenment Europe, this ethical and religious tradition found secular and legal codification in the Laws of Armed Conflict (both in international law and in the specific military law of individual nations).

Traditional just war analysis attempts to specify the scope and limits of morally acceptable uses of military force. Two independent sets of judgments are involved. The first, *jus ad bellum* (justice/right *toward* war) considers whether the use of force under a given set of political circumstances is warranted at all. The second, *jus in bello* (justice/right *in* war) frames issues regarding the conduct of military forces in combat.

Jus ad bellum (whether to go to war) questions the extent to which the use of force is justified at all by posing a series of tests. These gauge whether there is a just cause for war, whether there exists a legitimate authority to authorize the use of force, whether there is proportionality in the damage likely to be caused by the use of force measured against the political stakes of the conflict, and whether possibly effective non-military means of resolving the conflict have been exhausted (*last resort*). There is also a *reasonable hope of success* criterion, intended to rule out pointless violence. Because, paraphrasing the great philosopher of war Carl von Clausewitz (1780–1831), war is *politics by another means,* it is important to see whether the desired political result is likely to be attainable. In addition, for a war to be justified, it must be waged for the sake of returning to a better state of peace and conducted with that intention.

It is important to note that although decisions about use of force at this level are clearly military ethics insofar as they are ethical decisions about the use of the military instrument of national power, they are not decisions that involve many military personnel. With the exception of the most senior military advisers to civilian authority, most individuals involved in this level of discussion are the civilian leadership of the nation.

The *jus in bello* (how to conduct war) considers whether care is being taken to be *discriminant* (i.e., to attack directly only military objects and to take precautions against destruction of civilian individuals or objects) and *proportional* (i.e., to expend only the amount of destructive force on a given target that is justified by its believed military importance). Unlike the global assessment of justification and proportionality made at the highest levels of government about whether or not to go to war, these decisions are made at all levels of combat, from the smallest tactical decisions of a rifle squad to the decisions of a theater commander regarding the structure and targets of a strategic bombing campaign.

While both the *jus ad bellum* and the *jus in bello* decisions belong to individual leaders in their official capacities at all levels, the broader society can and does also engage in ethical discourse about those decisions. Especially in a democratic society with abundant technologically mediated public sources of information, citizens as individuals, members of the press, opinion leaders, and so forth all make independent assessments of the ethical quality of the decisions of political and military leaders. Leaders must persuade their citizenry of the justifications for the use of military force in the world, and individual actions of the nation's military (sometimes down to the lowest tactical level) can and do become objects of national scrutiny and ethical assessment. The strength of the connection of the military to the democratic society it serves is decisively influenced by the degree to which the military and the society share a common moral frame of reference and a sufficiently robust common understanding of the realities of military affairs.

An emerging challenge in the area of military ethics and society is that, in large-scale democracies that eschew compulsory military service, fewer members of the society have any direct experience with the military—including pivotal opinion leaders and civilian political leaders. This creates the risk of a diminishing realistic sense of the scope and limits of the capabilities of military power in the society at large and a commensurate risk that the military will be challenged to explain its choices and actions to fellow citizens.

Military Ethics and Technology

Practical military ethics is intimately connected with the military technology available to combatants. Further changes in available technologies have profound ripple effects in the ethical assumptions and accepted ways of behaving of the military—often in ways wholly unanticipated when the technology was introduced and applied. In a phrase commonly attributed to Immanuel Kant, *Ought implies can,* meaning that it is pointless to say someone ought to do something unless the person is possessed of the capability to do it. But in areas of ethics and military technology, at least in some cases, capability calls for use or that *Can implies ought*. As technology makes it possible for military operations to be conducted in novel ways, especially insofar as these come closer to honoring the sprit and letter of the just war criteria, the requirement to do so becomes more stringent. Once acceptable weapons and tactics may, at least for militaries that possess new capabilities, be considered objectionable. With increasing precision in the targeting of air bombardment, it is difficult to imagine militaries possessed of that capability reverting to less precise weapons in any but the most dire of circumstances.

One important theme of the just war tradition is the attempt to make war as humane as possible, even for the combatants. This is manifest in the elaboration of the Geneva Convention rules requiring that combatants who surrender be entitled to *benevolent quarantine* by their captors, including medical care, adequate food and housing, and more. Underlying these rules is the sense that combatant is a temporary status overshadowing the more fundamental common humanity of adversaries. When combatant status is lifted, humanitarian concerns with the suffering and welfare of the individual reassert themselves.

Humanitarian concern, even toward combatants, in the tradition of military ethics is evidenced by periodic attempts to rule out whole classes of weapon technology as inherently inhumane. Such efforts began with medieval Christian church efforts to ban the crossbow as being too accurate and deadly over too long a range. Later the bans on asphyxiating gas weapons, blinding lasers, and hollow-point (so-called *dum-dum*) bullets, and attempts to ban nuclear weapons, all reflected an impulse to identify unethical classes of technology.

A review of these efforts, however, points up their largely ineffectual and erratic character. When each technology first emerged, it presented as a novel and horrific new weapon system. Some bans (most notably that on asphyxiating gas) have held as a matter of customary practice among civilized nations. But it is hard in almost every case to say precisely why certain weapons are uniquely horrific in comparison to other weapons systems developed and deployed later. The ban on gas, for example, may continue in part because of the depth of the historical memory of World War I and the unique horrors gas weapons caused in that conflict, but also because they are not especially effective weapons systems in comparison to alternatives developed later. It is hard to see, from any objective moral perspective, how being shot with a hollow point bullet (deemed inhumane because of the gratuitous destruction of tissue caused by the tumbling bullet in contrast with the *clean penetration* of a rigid bullet) is less humane than being bombed with a fuel-air explosive that generates tremendous heat and overpressures, and kills by blast and by sucking oxygen out of the environment.

The link between military ethics and technology is not primarily in connections between specific technologies and guiding ethical principles. Specific, technology-by-technology restraints will always be piecemeal, sporadic, and difficult to justify or explain on the basis of a uniform set of moral principles. The connection between military ethics and technology is more subtle and complex. The development of air power is perhaps the clearest example, and worthy of extensive specific review, of the general issues in raised in this regard.

Between the two world wars, a number of air power thinkers developed a theory about the best strategic use of the airplane and bombing. Italian Giulio Douhet and American Billy Mitchell both speculated that long-range bombing would obviate the need for a frontline and trench warfare, both of which were required in World War I. Instead, they argued, the bomber would fly deep into enemy territory and bomb factories, transportation, and other infrastructure essential to the adversary's war effort. They also proposed (without always noting that this was quite another matter) bombing civilians and whole cities directly in the effort to so demoralize the population that the will to continue the war effort would collapse.

The latter proposal ignores, at the most fundamental level, the principle of discrimination that is a cornerstone of the *jus in bello* element of just war thinking. Before World War II, world leaders publicly declared that indiscriminate attacks on cities were completely outside the realm of military ethics and never to be ordered. The U.S. policy of so-called *daylight, precision* bombing was an attempt to maintain the principle of discrimination. Given the technology available at the time and the inherent inaccuracy of bombing from high altitude, it was an effort that had little practical meaning. At the end of the war, all pretense of discrimination was abandoned as the Allied air campaigns culminated in the *conventional* firebombing of Dresden and the atomic bombing of Hiroshima and Nagasaki.

One might have thought that the principle of discrimination in military ethics had effectively been rendered obsolete by this pattern of practice, but it was not. Nuclear weapons, and other weapons of mass destruction of the biological or chemical type would, if used, be impossible to justify under any reasonable interpretation of the just conduct of war. But on the more conventional side of war, the principles reasserted themselves after the end of World War II. The Vietnam era (1964–1975) practice of *free fire zones* in which it was declared that, after notice, all in a given area would be deemed combatants was at least a verbal and legalistic effort to maintain the distinction. More importantly, the introduction late in the Vietnam era of television-guided precision munitions hinted at a whole new connection between technology and military ethics just over the horizon.

In the opening hours of the air campaign of the Persian Gulf War in 1991, the world was introduced to a new manifestation of the link between technology and military ethics. The generation of precision guided munitions (PGMs) that was used held the prospect (only partially fulfilled in that conflict) of *one bomb, one target* accuracy, in which strategic bombing might be conducted even in urban areas with collateral damage to civilians limited to weapons malfunctions and intelligence failures in designating targets incorrectly.

Technologies have only continued to improve. PGMs requiring the risky and difficult laser designation by a pilot during the Persian Gulf War had, by the Kosovo conflict in 1999, been replaced with Global Positioning System-guided weapons that were virtually infallible in finding their targets, without requiring pilot supervision. Targeting mistakes still occurred, of course. But these were largely failures of intelligence and programming rather than of inherently inaccurate or indiscriminate weapons. The Chinese embassy in Belgrade was bombed with great precision, in that the bomb's coordinates were hit precisely; the mistake was in programming those coordinates. Successful conduct of just war has always depended to a large degree on intelligence, of course, because correct identification of legitimate targets rests on intelligence in all but face-to-face encounters between adversaries. However, in combat driven by precision stand-off and robotic munitions of great accuracy, perhaps intelligence will bear the brunt of the moral responsibility for discrimination and proportionality.

Air power is an appropriate focus for a discussion of the connections between military ethics and technology because it is has undergone the most dramatic technological evolution in the post-World War II period. Technological developments for land forces are driven by similar technological and ethical imperatives, however, more in the quest for technologically produced total situational awareness of the battlefield and precisely targeted weapons. Naval forces, too, are increasingly platforms for launch stand-off precision weaponry. The historical review of more than fifty years of the development of air power is instructive in a number of ways, not just for its own sake, but also for what it illustrates regarding the connection between military ethics and technology. Most of that history focused on the ethical test of discrimination. If World War II degenerated into an indiscriminate air war, it was partly out of a misguided strategic idea that bombing civilians would be effective in hastening the termination of conflict and partly from inherent technological limitations of the weapons and platforms available. Subsequent technological development increasingly provided the capability to conduct effective strategic level air bombardment, but to do so in an increasingly discriminate way. So at first glance, here is a clear example of technological development dramatically assisting the abilities of military forces to operate within the boundaries of established principles of military ethics. Further, regarding that development only from the perspective of the ability of the U.S. Air Force and Navy to conduct discriminate strategic air campaigns, technology has provided the capability to meet the requirements of military ethical principles.

The existence of the various technologies of PGMs has, however, generated a number of unanticipated ethical issues as well. Especially stand-off weapons (that is, weapons that can be fired from long distance, placing the operator beyond the range of enemy counterfire such as Air and Sea Launched Cruise Missiles) have already dramatically altered some *jus ad bellum* calculations. The ethical requirement that use of military force be a last resort was always supported by the fact that the decision of a political leader to use force inevitably involved putting the military forces of that nation at risk and almost certainly suffering some casualties. But stand-off weapons hold out the tantalizing prospect of using military force with complete impunity—thereby dramatically lowering the threshold to the use of force. Last resort remains a moral requirement. But without risk to a nation's own forces, the prospect of using missiles *to send a message* might be a political leader's course of action when it would certainly not have been if the possible deaths of aircrews or special forces units had factored into the decision.

The capability that PGMs provide generates ethical issues in another area as well. Because only the United States and a few major high-technology powers possess these capabilities, the entire war convention is challenged when such powers engage in conflict with less technologically advanced states. The Law of Armed Conflict that codifies just war principles is intended to apply equally to and to be observed equally by all combatants. Yet this capability creates a situation in which the United States can scrupulously observe those laws and conduct a highly discriminate air campaign against a lesser adversary that, if it follows those rules, faces only certain defeat. Understandably adversaries equipped only with lower technology weapons come to feel that U.S. forces lack honor in conducting war in this way. To the degree that the respect for the criteria of just war rests on a mutual sense that war can be conducted within those limits and still be a *fair fight*, precision munitions built to honor the principles of discrimination and proportionality may come to undermine respect for those very rules on the part of adversaries.

In practical terms, this asymmetry of capability provides a strong incentive for any adversary to find asymmetrical approaches to offset U.S. capabilities, even if those approaches strain or violate established ethical principles of military conduct. The Iraqis and the Serbs (examples of such lesser powers under attack) have illustrated the consequences of this asymmetry in their use of human shields (their own citizens, captured civilians of the attacking and allied powers, or prisoners of war), deliberate collocation of military and civilian objects (fighter aircraft parked next to mosques, schools, and hospitals), and perhaps dual-use of factories for production of baby formula and chemical weapons (although these cases are less certain).

It is hard to say what exactly follows from these points regarding the status and future of military ethics. It is ironic that weapons developed precisely to return air power to scrupulous respect for the ethical principle of discrimination have the unforeseen and unintended consequence of contributing to undermining the shared respect for those very principles on the part of adversaries. What is clear is the difficulty of predicting nonlinear relationships between developments in military technology and the law and practices of military ethics.

The more general point about the relation of technology and military ethics concerns not a single technology and its implications, but rather the aggregate effect of the overwhelming technological superiority of the United States and, to a much lesser degree, its allies in the whole panoply of military technologies. Taken together, they provide the tools for those militaries to intervene effectively and widely against less technically advanced powers—at least powers whose militaries are conventionally structured. The example of Vietnam and other guerilla wars suggest that some kinds of asymmetry are relatively immune to high-technology capabilities developed to date, although there too, improved sensor and surveillance technologies offer advantages for land forces as well.

The *jus ad bellum* requirement of just cause has, during the twentieth century come to be restricted to defense against the aggression of others. However, since World War II, a body of human rights law (starting with the Genocide Convention) has begun to sketch out a parallel body of international law that gives less weight to national sovereignty and suggests that the rights of human individuals and groups might provide a basis for legitimate intervention if the state failed to properly protect those rights. Kosovo provided a possible model for the future when the technologically superior powers intervened with relative impunity to protect human rights.

But the existence of the capability also suggests a danger: The superior powers may no longer be constrained by the risks to their own forces and may use their unmatchable technologically-based military power in ways that destabilize rather than stabilize the international system. At its roots, the relatively stable system of mutually respected military ethics developed among the European powers worked, insofar as it did, because powers felt that respecting the rules of military ethics still made it possible to have a fair fight. This asymmetry of capability may make it possible for the technologically superior to operate *in bello* in ways that adhere to the rules of discrimination and proportionality, but within a wider frame *ad bellum* of excessive interventionism.

The Historical Development of Military Ethics

In almost every culture, the warrior class develops some internal sense of appropriate military behavior. While it would be wrong to suggest that the rules are equivalent, the need warriors have to distinguish honorable from dishonorable conduct in war seems nearly if not completely universal.

The specific version of military ethics that evolved into the ostensibly universal principles embodied in the Hague and Geneva Conventions has specific roots. These principles may be traced back to ancient Roman thought and practice, as mediated through history by the European Christian Church and its secularized successors.

Although elements from pre-Christian Roman thought and practice (e.g., Cicero), feed into the origins of just war, the Christian writer Augustine's work is the origin of the unbroken stream of Christian military ethics that leads to the elaborated tradition that exists in the twenty-first century. Augustine wrote during a period when the Roman Empire was collapsing under the weight of barbarian advance and, unlike most of his Christian predecessors, he advocated Christian participation in the military defense of the Empire. While it was far short of Christian religious and ethical ideas, Augustine argued, use of military force to defend the *tranquility of order* provided by the Empire was a legitimate act of Christian love. Military struggle and even death in defense of that order was an act of love for one's neighbors who, if that order were to fall, would endure great suffering.

The Christian soldier is governed by restraints in combat. It is the enemy's misconduct rather than the soldier's wish that brings about the war. The Christian soldier goes to war *mournfully*, accepting the blessing of Jesus as the peacemaker struggling to restore order on behalf of the neighbor. But most importantly, the soldier recognizes the common humanity of the adversary and avoids personal hatred or animus.

Augustine lays the foundation for a tradition that accepts the necessity of coercion and even violent conflict in the name of maintaining order. But it also imposes rules of restraint and caution that are elaborated in subsequent Christian tradition. In the medieval period, for example, Thomas Aquinas and other scholastics developed and elaborated the intellectual framework for military ethics, even as the Code of Chivalry formed the basis of ideal military ethics among the warrior class. During the same period, the idea of a Law of Peoples (*jus gentium*) evolved: a concept that became *customary international law* in later versions of the tradition.

Although the major actors of the Reformation produced their own versions of just war and military ethics in the sixteenth century, the collapse of the unified Christian civilization of Europe and the encounter of Europeans with the inhabitants of the New World spurred the need for a less *religious* and Eurocentric understanding of just war and military ethics. Catholic thinkers such as Francisco Suarez and Franciscus de Vitoria argued that the indigenous peoples of the New World possessed rights. Hugo Grotius, Samuel Pufendorff, and Emmerich de Vattel laid the foundations for a non-religious framework of military ethics and just war, grounded in human reason that would be valid (as Grotius put it) *even if God does not exist*.

The European Enlightenment of the eighteenth century completed the work of secularization. Rationalist thinkers such as Kant argued that ethics generally must be grounded in the nature of human reason alone and that reason dictated a more rational system than war for the adjudication of international disputes. He envisioned a League of Nations, willing and able to provide world governance on principles better reasoned than the perpetual conflict of interstate rivalry. Such ideas set in motion the hope of a united global community operating in accordance with shared ethical and political principles—an endeavor manifest in the creation of the League of Nations and the United Nations in the twentieth century.

Abraham Lincoln's charge to Francis Lieber to create General Order 100 marked a milestone in the establishment of a state-mandated set of rules for military conduct. Military Codes of Discipline came to replace customary Chivalric Codes as official guidance for governing the conduct of military personnel of the various nations.

At the end of the nineteenth century, under the auspices of the Hague and Geneva Conferences, treaty law governing the conduct of military operations and the treatment of civilians, the rights of neutral powers, prisoners of war, and so on, began to grow. This body of law is the partial codification of the long moral tradition of military ethics, and constitutes customary international law for all states and their militaries.

At the conclusion of World War II, war crimes trials, held in Nuremberg and Tokyo, established the precedent of individual responsibility of commanders and soldiers for war crimes. Although criticized by some as *victor's justice*, they laid the foundation for the idea of individual culpability for war crimes that has evolved into ad hoc war crimes tribunals for Rwanda and the former Yugoslavia. In 1998 the United Nations adopted the Rome Statute calling for the establishment of a permanent standing war crimes court. That treaty received a sufficient number of national ratifications and entered into effect on July 1, 2002; the process of appointing members and establishing procedures was ongoing in the beginning of 2004.

In the early 2000s, the United States was among a small number of states opposed to the creation of the war crimes court due to fears that it would be dominated by political considerations rather than disinterested justice, and by awareness that U.S. forces are more widely deployed (and therefore more likely to be subject to the court's scrutiny) than those of other powers. It is too early to say what the effect of the war crimes court will be. But in intention, it represents the culmination of efforts over many years to give legal shape, form, and enforcement to the fundamental principles of military ethics.

MARTIN L. COOK

SEE ALSO *Airplanes; Baruch Plan; Biological Weapons; Chemical Weapons; Geographic Information Systems; International Relations; Just War; Missile Defense Systems; Limited Nuclear Test Ban Treaty; Weapons of Mass Destruction.*

BIBLIOGRAPHY

Bainton, Roland. (1960). *Christian Attitudes Toward War and Peace: A Historical Survey and Critical Re-Evaluation.* New York: Abingdon Press. The standard historical survey of Christian thought on ethics and war

Best, Geoffrey. (1994). *War and Law Since 1945.* Oxford and New York: Clarendon Press. A superb discussion of the evolution of international law since World War II. Especially helpful in tracing the development of humanitarian and human rights law as a parallel legal stream to the older state sovereignty-Westphalian legal framework.

Best, Geoffrey. (1980). *Humanity in Warfare: The Modern History of the International Law of Armed Conflicts.* London: Weidenfeld and Nicolson.

Christopher, Paul. (1994). *Ethics of War and Peace: An Introduction to Moral and Legal Issues.* Englewood Cliffs, NJ: Prentice-Hall.

Hartle, Anthony. (1989). *Moral Issues in Military Decision Making.* Lawrence: University of Kansas Press. A very useful ethical analysis by a distinguished U.S. army soldier-scholar.

Kelsay, John. (1992). *Islam and War: A Study in Comparative Ethics.* Louisville, KY: Westminster/John Knox Press. The best short discussion of Islamic thought on war in English.

Mendelsohn, Everett; Merritt Roe Smith; and Peter Weingar, eds. (1988). *Science, Technology and the Military.* Dordrecht, The Netherlands, and Boston: Kluwer Academic Publishers. An important collection of papers covering a broad range of topics.

Moorehead, Caroline. (1999). *Dunant's Dream: War, Switzerland, and the History of the Red Cross* New York: Carroll & Graf.

Nardin, Terry, ed. (1996). *Ethics of War and Peace: Religious and Secular Perspectives.* Princeton, NJ: Princeton University Press. A useful attempt to compare Islamic, Jewish, pacifist, feminist and realist ethical traditions to the standard categories of western just war analysis.

Smith, Merritt Roe. (1985). *Military Enterprise and Technological Change: Perspectives on the American Experience.* Cambridge, MA: MIT Press. The results of a discussion among historians of technology that helped initiate contemporary studies of war-technology relationships.

Walzer, Michael. (2000). *Just and Unjust Wars: A Moral Argument with Historical Illustrations,* 3rd edition. New York: Basic Books. The first edition of this influential book was published in 1977.

INTERNET RESOURCE

Mitcham, Carl, and Philip Siekevitz. (1989). "Ethical Issues Associated with Scientific and Technological Research for the Military." *Annals of the New York Academy of Sciences* 577. Available at http://www.annalsnyas.org/content/vol577/issue1/.

MILITARY-INDUSTRIAL COMPLEX

The *military-industrial complex* is one of a series of ideas that aim to critique the manner in which science, technology, and society have interacted with one another since World War II. The term itself was popularized by U.S. president and World War II general Dwight D. Eisenhower (1890–1969) in a farewell address to the nation on January 17, 1961, in which he warned the American people against "the acquisition of unwarranted influence, whether sought or unsought by [such a] complex" and the corresponding threat it posed to democracy. Although defined as "the conjunction of an immense military establishment and a large arms industry," its influence extends beyond industry and the military (Eisenhower). Often called the *military-industrial-congressional complex,* for instance, it comprises the *iron triangle* of Congress, the Pentagon, and defense industries. Additionally because the military and industry both support and depend upon academic research, another iron triangle has been dubbed the *military-industrial-university complex* (Hughes 2004).

Context and Emergence

The precise origins of the term military-industrial complex are obscure, but the idea is not. During the war, the U.S. government became increasingly dependent on both industrial corporations and scientific research for the production and development of military weapons. Military needs far exceeded those of previous wars. A typical U.S. army division, for example, required 225 times the mechanical horsepower required in World War I (Abrahamson 1983). In response, industry and the scientific enterprise shifted focus to help with the war effort.

Ford Motor Company, for example, manufactured jeeps, general purpose vehicles, and B-24 Liberator aircraft at a rate of one airplane per hour at the peak of production (Grudens 1997). Boeing Aircraft Company designed and built both the B-17 Flying Fortress and the B-29 Superfortress bombers at a rate of up to 362 planes per month. In total, companies produced 303,717 planes during the war—including 18,481 B24s and 12,761 B17s—at a price of $45 billion. According to Henry Stimson, secretary of war under both presidents Franklin D. Roosevelt and Harry S. Truman, "if you are going to try to go to war, or to prepare for war, in a capitalist country, you have got to let business make money out of the process or business won't work" (Higgs 1995, p. 1).

At the same time, the National Defense Research Committee, later the Office of Scientific Research and Development (OSRD), secured vast new resources for scientific research aimed at solving wartime problems. As a result, two new efforts allowed for increased collaboration between large numbers of scientists toward set goals: the centralization and creation of national laboratories, such as Los Alamos and Oak Ridge, and the targeted funding of research projects at universities, such as the Massachusetts Institute of Technology (MIT) Radiation Laboratory and the University of Chicago reactor research.

With the war, funding for large-scale scientific research shifted from industry to government and thus enabled *big science* projects such as the Manhattan Project. The architect of this shift, OSRD chair Vannevar Bush, began a trend to fund and direct scientific research through the military that would last well beyond the end of World War II. New scientific and industrial relationships and institutions begun during the war soon became fixed in U.S. economic and political life with the immediate emergence of the Cold War (1945–1989). It was this entrenchment that Eisenhower sought to highlight as a danger to political life.

Post-Cold War Revival

Throughout the Cold War, increasing military budgets were justified by the Soviet threat. When the Soviet threat disappeared, so too did the justification for large military budgets. Yet neither large military budgets nor the power of the military-industrial complex diminished, they simply reorganized (Hartung). According to Columbia University professor Seymour Melman, the United States has a permanent war economy, having "been at war—somewhere—every year, in Korea, Nicaragua, Vietnam, the Balkans, Afghanistan" since the end of World War II (Melman).

As a result, both scientific and industrial enterprises remain directed toward military ends. The fiscal year 2005 research and development (R&D) budget includes $75 billion for defense R&D and $57.2 billion for nondefense R&D. Defense R&D, therefore, comprises 56.7 percent of the total R&D budget (AAAS 2004). Additionally the fiscal year 2005 defense R&D budget is nearly $20 billion above what it was at the height of the Cold War, adjusted for inflation but not for growth in the economy.

Defense contractors have gained considerable power and influence because of mergers between previously competing contractors. Because of their size and power, specific contractors—such as Lockheed Martin, Northrup Grumman, and Raytheon—can secure support through sizable congressional contributions. They do so by supporting those candidates with power over their pet programs. Of the forty top recipients of defense contractor campaign donations, thirty-six are on either the congressional Appropriations Committee (the committee with authority over government funds) or Armed Services Committee (the committee with authority over defense programs). As a result, weapons programs, such as the Lockheed Martin F-22 fighter, the most expensive bomber ever built, are not likely to be terminated.

When President George W. Bush was first elected, he and Secretary of Defense Donald Rumsfeld promised a revolution in military affairs in which they would create new, more agile forces. Bush suggested that they might "skip a generation of technology" in certain systems, which would require the elimination of at least one big-ticket system such as the F-22 fighter (Hartung 2001, p. 3). As a testament to the power of the defense industries, this has not happened and in fact "the Pentagon has not shut down a single major weapons production line since the end of the Cold War" (Hartung).

Ethics and Policy Issues

Several scholars have raised concerns about the military-industrial complex throughout the years, including that it is a threat to democracy and to the free market. Lewis Mumford argues that the military-industrial complex threatens democratic processes, because it has become a *megamachine*, a rigid, hierarchical social structure with absolute powers and little outside input (Mumford 1964). In effect, he argues against the authoritarian nature of the military-industrial complex. This echoes Eisenhower's warning that the American people must remain alert and knowledgeable to ensure that the complex "does not endanger our liberties or democratic processes" (Eisenhower).

Seymour Melman argues that the military-industrial complex endangers the free market, because it actually creates a state economy. He contends that appropriations for physical infrastructure, health, and welfare are drying up, and thus "the idea that the U.S. can afford guns and butter without limit is proven false every day" (Melman).

GENEVIEVE MARICLE

SEE ALSO *Military Ethics; Science, Technology, and Society Studies.*

BIBLIOGRAPHY

Abrahamson, James. (1983). *The American Home Front.* Washington, DC: National Defense University Press.

Hartung, William D. (2001). "Eisenhower's Warning: The Military-Industrial Complex Forty Year Later." *World Policy Journal* 18(1): 1–7.

Hughes, Thomas P. (2004). *Human-Built World.* London: University of Chicago Press.

Mumford, Lewis. (1964). *The Myth of the Machine: The Pentagon of Power.* New York: Harcourt Brace.

INTERNET RESOURCES

American Association for the Advancement of Science (AAAS). "Defense and Homeland Security R&D Hit New Highs in 2005; Growth Slows for Other Agencies." AAAS. Available from http://www.aaas.org/spp/rd/upd1104.htm. Taken from the AAAS R&D Funding Update, November 29, 2004.

Eisenhower, Dwight D. "Farewell Radio and Television Address to the American People." Available from http://wikisource.org/wiki/Military-Industrial_Complex_Speech.

Grudens, Richard. "Henry Ford in WWII." History Net. Available from http://www.thehistorynet.com/wwii/blhenryford/index1.html. Article originally appeared in the January 1997 issue of the journal *World War II.*

Hartung, William D. "Military Industrial Complex Revisited: How Weapons Makers are Shaping US Foreign and Military Policies." Foreign Policy in Focus. Available from http://www.fpif.org/papers/micr/index.html.

Higgs, Robert. (1995). "World War II and the Military-Industrial-Congressional Complex." Independent Institute. Available from http://www.independent.org/newsroom/article.asp?id=141.

Melman, Seymour. "In the Grip of a Permanent War Economy." Bear Left. Available from http://www.bear-left.com/original/2003/0309permanent.html.

MILL, JOHN STUART

John Stuart Mill (1806–1873) was born in London on May 20. The son of the philosopher James Mill (1773–1836) and the godson of the philosopher Jeremy Bentham (1748–1832). John Stuart Mill was the most influential British philosopher of the nineteenth century, which saw science and technology transform society as significant contributions were made in metaphysics, logic, the philosophy of science, ethics, social and political philosophy, economics, the philosophy of religion, and the philosophy of education. The *System of Logic*

John Stuart Mill, 1806–1873. An English philosopher and economist, Mill was the most influential British thinker of the 19th century. He is known for his writings on logic and scientific methodology and his voluminous essays on social and political life. *(Hulton Archive/Getty Images)*

(1843) and the *Principles of Political Economy* (1848) became canonical textbooks in their fields. Mill died on May 8 in Avignon, France.

Logic

Mill understood his work in technical philosophy as providing a foundation for his social and political philosophy. The purpose of the discussion of the origins of knowledge in the *System of Logic* is to prepare the ground for the social sciences, and the discussion of the social sciences provides the grounds for Mill's moral, political, and economic views.

The first five books of the *Logic* are largely polemical, attacking the philosophical position known as intuitionism, which in the nineteenth century had served as the basis for political conservatism. Intuitionism takes the view that there are innate truths, including moral truths. Innate truths can be known independent of experience, and thus custom and tradition were elevated to the status of timeless truth impervious to empirical refutation. In contrast, Mill wanted to argue that customary practice is often no more than a historical accident or that although it may have been justified in earlier social circumstances, it had outlived its usefulness, and all practice should be subject to revision in light of changing circumstances.

Mill argued that almost every general principle in any domain was the result of an inductive process that began with individual experiences, although Mill conceded a few exceptions. For example, the general principle that nature is uniform seems to be an assumption that people bring to their experience insofar as there are many things people do not understand as examples of uniformity or for which they have no experience, although they continue to subscribe to this belief. There are diseases for which the cause or cure is not known, yet it is presumed despite the failure of past research that the hidden uniformity behind them will be discovered eventually. Mill insisted that these few exceptions had no moral or political implications.

Mill engaged in a protracted controversy with William Whewell (1794–1866), professor of moral philosophy at Cambridge, who had published a *History of the Inductive Sciences from the Earliest to the Present Time* (1837). Whewell coined the term *scientist* in recognition of the idea that traditional "natural philosophy" had become a new form of knowledge. Whewell was a critic of the philosopher Francis Bacon's (1561–1626) conception of the process of induction and wanted to redefine induction as the process by which scientific hypotheses are formulated. He considered this process a creative act rooted in history but not amenable to strict rules. In this he was close to the Kantian view that the most general principles of knowledge were not based on experience but instead were presuppositions. A successful hypothesis starts as a happy guess and evolves over time into a larger structure of thought incorporating both empirical and nonempirical elements. Whewell insisted on the historically evolving nature of scientific hypotheses and laws.

Mill objected on the grounds that Whewell was conflating induction with hypothesis formation and that what mattered was not the original happy guess but the subsequent inductive process by which the guess is confirmed by empirical observation. At this level Mill's dispute with Whewell was merely semantic.

Social Sciences and Technology

Mill contended that there can be a science of human nature and that its basic laws are the psychological laws of association. Moreover, the basic truths about human affairs, including questions of ends, are not part of the content of the psychological laws of association. To explain the basic truths of human action it is necessary to supplement the psychological laws of association with information about the circumstances in which those laws operate.

Human action, unlike physical interaction, cannot be explained in terms of current circumstances. Actions of human beings are not solely the result of their current circumstances but are the joint result of those circumstances and the characters of the individuals; the agencies that determine human character are numerous and diversified. Is it possible to give a systematic account of the circumstances, past as well as present? Mill at one time thought this possible. The science needed to discover and formulate the hypothetical laws of the formation of character he termed *ethology*.

Mill's views on technology are embedded in his historical account of the stages of economic growth. His view owes much to Scottish Enlightenment thinkers such as David Hume (1711–1776), Adam Smith (1723–1790), and Adam Ferguson (1723–1816). Economic and social progress is marked by three stages: savagery, barbarism, and civilization. By civilization Mill meant a modern industrial and commercial society with a liberal culture such as Great Britain. The rise and development of civilization are dependent on "the natural laws of the progress of wealth, upon the diffusion of reading, and the increase of the facilities of human intercourse" ("Civilization," *Collected Works*, Vol. XVIII, p. 127).

The third stage of *civilization*, as described in Mill's essay of that title, is marked economically by industry, politically by limited government and the rule of law, and socially by liberty. Mill saw examples of these combined features in military operations, commerce and manufacturing, and the rise of joint-stock companies. The consequences of the rise of civilization are economic, political, social, and moral. Economically, there has been a vast increase in wealth in which the masses and the middle class have been the primary beneficiaries. Politically, power is shifting from a few individuals to the masses.

Science, Technology, and Politics

Socially, the most important consequence has been the decline of individuality. The future of civilization depends on the masses exercising power in ways that allow the benefits of civilization to continue. Mill did not believe this would happen on its own. The masses must understand and appreciate the moral foundations of liberal culture.

Unlike both classical liberals such as the Philosophic Radicals Jeremy Bentham, James Mill, and orthodox Marxists, Mill was not an economic determinist. The moral world was not a product only of material forces. The functioning of the economy presupposed certain virtues. This explains Mill's economic position in the later *Principles of Political Economy*, the germ of the recommendations in *Representative Government* (1861), and the project that *On Liberty* (1859) would address. The social crisis created by the industrial revolution was class conflict. This crisis was exacerbated in Mill's thinking by the perceived coming of an increasingly democratic society.

Participation in a market economy informed by an individualist moral culture promotes different forms of virtuous behavior. Nevertheless, Mill insisted that there had to be a moral purpose to the technological project. The desire to employ the whole surface of the earth for the production of the greatest possible quantity of food and the materials of manufacture he considered to be founded on a mischievously narrow conception of the requirements of human nature. Among the many things Mill and his father had objected to most vehemently about the new industrial economy was the spoiling of the countryside by the many new and often duplicative railway lines. As hikers, they were sensitive to the destruction of natural beauty and the disappearance of solitude.

Mill also addressed the issue of the stationary state: an economy that no longer grows (a concern for classical economists but not neoclassical economists). Mill did not think that society had arrived at that state, and so more growth was probable. However, he did not consider a stationary state necessarily bad. Wealth is not an end in itself but a means to human fulfillment and individual liberty. Even if there were a stationary state of zero growth, freedom would not necessarily be lost.

Mill was the last major British philosopher to present an integrated view of philosophy and relate the theoretical and normative dimensions of his thought in a direct fashion. Book VI of the *Logic* remains the classic statement of what human science modeled after physical science might be, its limitations and qualifications, and the extent to which it may be useful. As a statement of the aims of and obstacles to the creation of the human sciences, it is unsurpassed.

NICHOLAS CAPALDI

SEE ALSO *Consequentialism; Liberalism; Locke, John; Scientific Ethics.*

BIBLIOGRAPHY

Capaldi, Nicholas. (2004). *John Stuart Mill: A Life*. New York: Cambridge University Press. This is the latest and only biography of Mill in print.

Cohen, Morris R. and Ernest Nagel. (1934). *An Introduction to Logic and Scientific Method*. New York: Harcourt, Brace and Company. The classic restatement of a Millian view.

Schwartz, Pedro. (1972). *The New Political Economy of J. S. Mill*. Durham, NC: Duke University Press. The best discussion of Mill's economics.

Skorupski, John. (1989). *John Stuart Mill*. London: Routledge. A good general discussion of the technical part of Mill's philosophy.

Skorupski, John, ed. (1998). *The Cambridge Companion to Mill*. Cambridge, UK: Cambridge University Press. A useful collection of secondary sources on Mill.

Wilson, Fred. (1990). *Psychological Analysis and the Philosophy of John Stuart Mill*. Toronto: University of Toronto Press. Wilson takes seriously Mill's project in the Logic to explain human beings scientifically.

MINING

From the moment humans discovered stone tools and salt, they have been extracting and using materials from the Earth. Every American will utilize approximately 2.4 million pounds of mined materials during their lifetime (calculated from Mineral Information Institute statistics). In spite of people's dependence on the products of extractive technologies and their associated sciences, mining is a highly controversial activity surrounded by ethical, political, social, and legal issues. Mining focuses attention on the metaphysical relationship of humans to the Earth, on the impact of their activities on the environment and other species, on issues of equity and sustainability, on human rights and democracy.

Mining is the extraction of metallic or nonmetallic materials from the Earth. The full cycle of mining involves exploration for the material required; mining *sensu stricto*, which is the physical removal of material from the Earth; processing, which is usually required to concentrate or clean the ore; the health, safety, and environmental issues associated with the full cycle of mining activities; and appropriate closure of the site when mining is completed (National Research Council 2002).

Surface mining, where material is separated directly from the surface of the Earth, is the oldest and most common method of mining. Underground mining, where the material is extracted via tunnels dug into the Earth, is used to work deeply buried ores. Mining technology has evolved greatly, but the basic concept of removing rock or minerals from the Earth has remained constant since prehistory. Nonentry mining, by which the valuable components of the rock are extracted without physically removing the surrounding rock, is still at an experimental stage.

The many ethical, social, and political challenges associated with mining can only be addressed within the context of the prevailing philosophical view of the relationship of human beings to the Earth and its resources. From prehistoric time through the sixteenth century, many cultures regarded Earth as animate. Ores grew and matured in the uterus of the Earth; mining was an interference with the natural order and was often accompanied by myths and rituals (Eliade 1962). In the Western world, the organic view of nature was superceded by a mechanical model during the Scientific Revolution: The Earth is inanimate, and its resources should be exploited for the benefit of humans (Merchant 1980). In the late twentieth century, scientists developed holistic syntheses that integrate humans, other living beings, and Earth in an all-encompassing, interdependent Earth system. Some philosophers emphasize the importance of the humanities in understanding the full dimensions of the human–Earth system relationship (Frodeman 2003). These cross-disciplinary concepts are the basis for most modern interpretations of the place and responsibilities of mining.

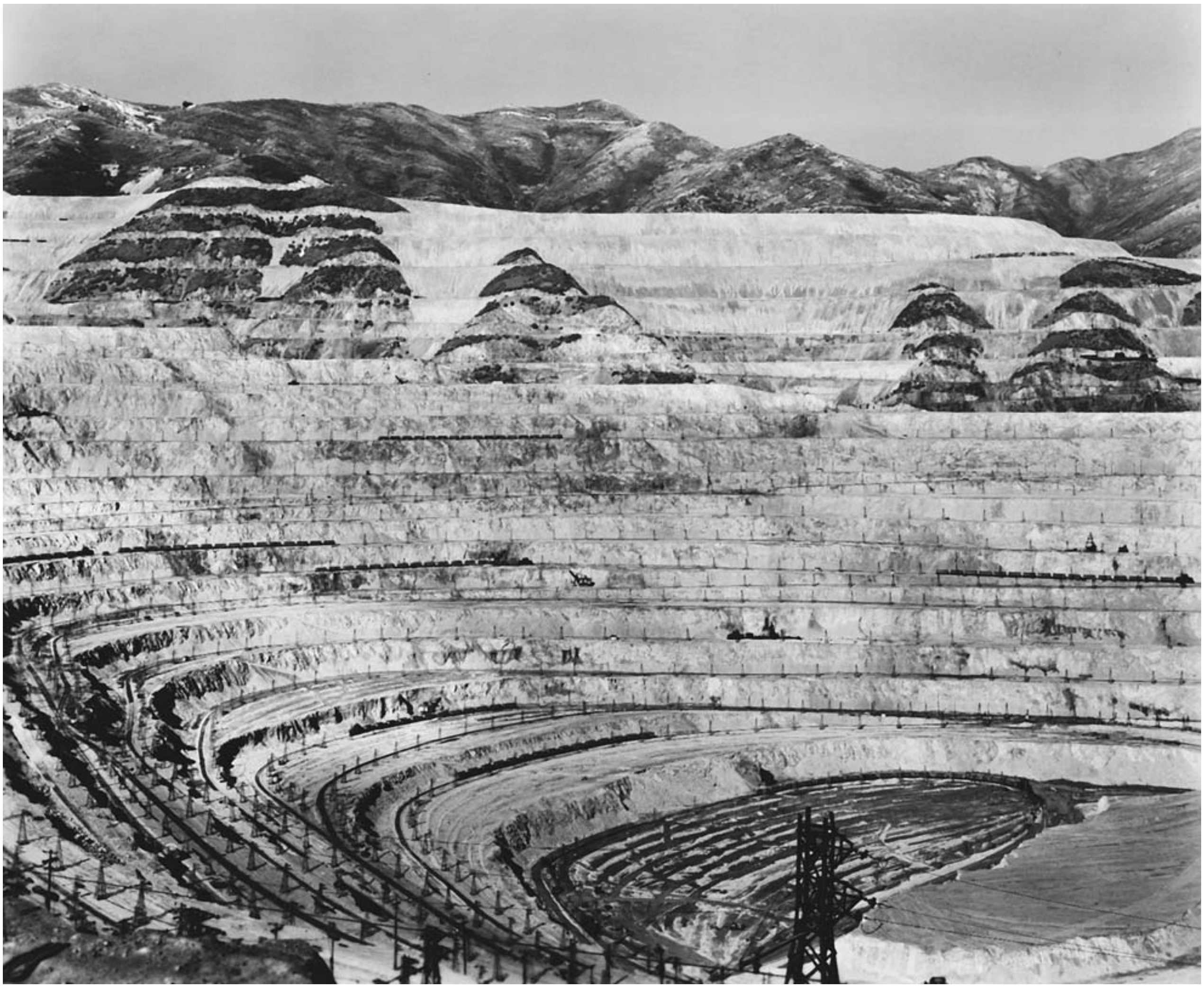
Polarized positions on the ethics of mining are strongly developed and there have been few true dialogs on the subject. One early-twenty-first century attempt to foster communication is the Mining, Minerals, and Sustainable Development Project, which concluded that economic, social, environmental, and governance issues must be addressed appropriately by all participants in order to meet the conflicting demands of society for the products of mining while still maintaining sustainability (International Institute for Environment and Development, and World Business Council for Sustainable Development 2002). Finding mechanisms whereby all the stakeholders can be involved in negotiating acceptable practices and compensation for mining has proved difficult. Some nongovernmental organizations and companies have promoted formal or informal democratic fora, but they have been difficult to implement in areas lacking good governance or a history of citizen participation.

Mining is inherently inequitable. Earth resources are not distributed evenly, and mines can only be located where there are suitable resources. Many of the social and environmental consequences of mining are concentrated at the mine site even if the consumer or ultimate beneficiary of the mine product, or the wealth it creates, is far away. Resolving these inequities are

Underground mining as depicted in Georgius Agricola's *De Re Metallica* (1556). *(© Bettmann/Corbis.)*

some of the major ethical and political challenges associated with mining.

A fundamental question concerns ownership and control of the mineral endowment. Does a nation, or a sovereign, or a dictator, own the mineral wealth of a country? Or is it instead the landowner, the owner of the mineral rights, the person or company who discovered the deposit, the artisan miners who may have worked the deposit, or the local community (however defined)? In many cases the owner of a mineral deposit is not competent to mine it. In capitalist societies the high financial risk of mineral exploration and mining is usually borne by corporations that also supply technical expertise, and in return expect a profit from their investment. Almost every country has devised a different formula for regulating mineral ownership and control, for calculating taxes, and for oversight of mining activities and their impact.



The Bingham Canyon copper mine in Tooele, Utah. This mine is the world's largest man-made excavation. Kennecott Utah Copper Corp. produces copper, molybdenum, gold, silver, platinum, and palladium from the century-old mine. *(© Bettmann/Corbis.)*

A mine may introduce large amounts of capital or people into an area, distorting the economic and social structure. Corruption may become a problem. Wars are fought over the control of resources, and illicit trade particularly in diamonds and columbite-tantalite has funded conflicts, such as those in Angola and Congo, in the twentieth and early-twenty-first centuries. Safeguarding the human rights of workers and local populations is also a concern. Disciplined and transparent governance by governments and companies is necessary to stabilize the impact of mining.

Economic analysis shows that the Earth is unlikely to run out of mineral resources in the twenty-first or twenty-second centuries, which is as far forward as such predictions can be made, but the total cost of mining (including environmental, social, and other external costs) may limit the willingness to produce minerals (Tilton 2003). The role of mining in sustainable development is controversial, and conclusions largely depend on what values or assets one wishes to sustain, and on the scale at which the question is examined. Tilton (2003) argues that mining can contribute to global sustainable development if the products and profits of present-day mining are used to provide other assets of equivalent or greater value to succeeding generations. Analyses that concentrate on preserving the lifestyle, economy, or environment of a particular location are more likely to conclude that mining is a temporary phenomenon which disrupts rather than sustains development.

Technological innovation may lessen the demand for mineral products and lower the environmental impact of mining, but intellectual innovation is also vital to resolve the social and cultural consequences of mining.

MAEVE A. BOLAND

SEE ALSO *Acid Mine Drainage; Development Ethics; Environmental Ethics; Sustainability and Sustainable Development.*

BIBLIOGRAPHY

Eliade, Mircea. (1978 [1962]). *The Forge and the Crucible: The Origins and Structures of Alchemy*, 2nd edition, trans. Stephen Corrin. Chicago: The University of Chicago Press.

Frodeman, Robert. (2003). *Geo-Logic: Breaking Ground Between Philosophy and the Earth Sciences*. Albany: State University of New York Press.

International Institute for Environment and Development, and World Business Council for Sustainable Development. (2002). *Breaking New Ground: Mining, Minerals, and Sustainable Development. The Report of the MMSD Project.* London: Earthscan Publications Ltd.

Merchant, Carolyn. (1980). *The Death of Nature: Women, Ecology, and the Scientific Revolution*. San Francisco: Harper & Row.

National Research Council. (2002). *Evolutionary and Revolutionary Technologies for Mining*. Washington, DC: Committee on Technologies for the Mining Industries, National Academy Press.

Tilton, John E. (2003). *On Borrowed Time? Assessing the Threat of Mineral Depletion*. Washington, DC: Resources for the Future.

INTERNET RESOURCE

International Institute for Environment and Development, and World Business Council for Sustainable Development. "Breaking New Ground: Mining, Minerals, and Sustainable Development. The Report of the MMSD Project." Available from http://www.iied.org/mmsd/finalreport/.

MISCONDUCT IN SCIENCE

Overview
Biomedical Science Cases
Physical Science Cases
Social Science Cases

OVERVIEW

In the United States the official definition of research misconduct is:

> . . . fabrication, falsification, or plagiarism in proposing, performing, or reviewing research, or in reporting research results. . . . Fabrication is making up of data or results and recording or reporting them. Falsification is manipulating research materials, equipment or processes, or changing or omitting data or results such that the research is not accurately represented in the research record. . . . Plagiarism is the appropriating of another person's ideas, processes, results, or words without giving appropriate credit. Research misconduct does not include honest error or differences of opinion. A finding of research misconduct requires that: There be a significant departure from accepted practices of the relevant research community; and the misconduct be committed intentionally, or knowingly, or recklessly; and the allegation be proven by a preponderance of the evidence. (Office of Science and Technology Policy 2000, p. 76262)

A somewhat broader definition of scientific misconduct has been put forward by the Wellcome Trust, the largest biomedical charity in the United Kingdom:

> . . . [t]he fabrication, falsification, plagiarism or deception in proposing, carrying out or reporting results of research or deliberate, dangerous or negligent deviations from accepted practices in carrying out research. It includes failure to follow established protocols if this failure results in unreasonable risk or harm to humans, other vertebrates or the environment. (Koenig 2001, p. 1411)

Germany (Bostanci 2002) and China (Yimin 2002) have also developed definitions of scientific misconduct that are somewhat broader than the U.S. version.

In all cases, core elements of the definition of misconduct in science (also known as scientific or research misconduct) include fabrication and falsification of research data, and plagiarism (FFP). This reflects both philosophy and history. Researchers depend on the reliability of the published work of others in order to determine how best to design and conduct investigations of research questions. Rather than reproducing all related experiments, investigators expect to be able to build on previous research, not only their own but also that of others. Thus fabrication and falsification undermine the fundamental and central tenets of the scientific enterprise. In addition, researchers expect to be recognized and held accountable for their contribution to a scientific body of knowledge. Plagiarism violates this expectation.

History

Although in retrospect the work of some earlier scientists has been the subject of debate (Broad and Wade

1982), during the seventeeth, eighteenth, and nineteenth centuries the only significant discussion of misconduct among scientists was an isolated work by Charles Babbage (1830), which identified three types of misconduct: *trimming* data to fit expectations; *cooking* data by discarding what did not fit expectation; and the outright forgery or creation of fictitious data. The most famous instance of scientific forgery occurred in the early-twentieth century with the *discovery* of Piltdown Man.

In the 1980s, blatant examples of research misconduct came to light (Broad and Wade 1982, Sprague 1993). As a result congressional committees responsible for oversight of various aspects of science and technology pressured funding agencies to develop policies to address what seemed to be the increasing incidence of scientific misconduct. These agencies, in particular the National Institutes of Health (NIH) and the National Science Foundation (NSF), developed policies designed to explicitly identify and address allegations of scientific misconduct.

In its initial policy, the NIH described misconduct as "serious deviation, such as fabrication, falsification, or plagiarism, from accepted practices in carrying out research or in reporting the results of research" (Public Health Service 1986, p. 2), a definition from which later definitions have derived (Buzzelli 1999). Fabrication, falsification, and plagiarism are clearly provided as examples and the *other serious deviation from accepted practices* (OSD) clause emphasizes the primary role of the scientific community in identifying and setting the ethical standards for its members (Buzzelli 1999). Thus the OSD clause reflects the widespread view that the scientific community has a collective responsibility for establishing and upholding the professional standards of the community (Chubin 1985, Frankel 1993). The OSD clause is a common element of definitions of scientific misconduct found in many policies developed by U.S. funding agencies, universities, and professional societies. Nevertheless, in defining scientific and research misconduct, in the United States, the scientific community has tended to focus on FFP and has opposed the OSD clause (National Academy of Science 1992, Buzzelli 1999).

In 1993 the Commission on Research Integrity (CORI) was formed to advise the U.S. Department of Health and Human Services (DHHS) on ways to improve the Public Health Service response to allegations of misconduct in biomedical and behavioral research. The Commission found that in spite of the community's seeming preference "for a narrow and precise definition centered upon 'fabrication, falsification and plagiarism (FFP)' 'FFP' is neither narrow nor precise" (CORI 1995, p. 8). CORI's report, "Integrity and Misconduct in Research" (1995) clarified the role of intent in research misconduct and reframed the definition in terms of *misappropriation* of words or ideas (specifically including information gained through confidential review of manuscripts or grant applications), *interference* in the research activities of others (i.e., intentionally taking, hiding, or damaging research-related equipment, materials such as reagents, software, writings, or research products), and *misrepresentation* of information so as to deceive, either intentionally or with reckless disregard for the truth (thereby covering both fabrication and falsification). They also identified as other relevant forms of professional misconduct obstruction of investigations of research misconduct and noncompliance with research regulations, and highlighted the need to protect from retaliation those who bring forward good faith allegations of misconduct (commonly known as whistle-blowers). In addition, the Commission emphasized the need for a proactive rather than reactive approach to misconduct in science and recommended that research institutions be required to provide education in research integrity.

Assessment

In the 1980s when concerns about the frequency of scientific misconduct were initially raised, the common response by senior members of the scientific community was that scientific misconduct is rare and in any case science is self-correcting. Given that FFP not only undermines but is inconsistent with the bedrock principles on which scientific research is based, it is not surprising that members of the scientific community would assume that genuine, authentic, and bona fide members of the community would not engage in such practices and that their occurrence would be rare. Indeed the frequency of misconduct continues to be debated. At the same time, it has become clear that the peer review process is largely incapable of detecting fabrication or falsification. What is not in doubt is the serious negative impact of even a single occurrence of misconduct not only for those involved and for those whose work is misdirected by fraudulent research, but also the negative impact on trust both within the scientific community and beyond (Kennedy 2000).

An apparent tension continues with regard to internal (i.e., within the scientific community) versus external governmental control of both the definition of scientific misconduct and of oversight of scientific research. However the tension may be more apparent than real since the scientific community is not homogeneous with regard to its views on research integrity and misconduct. As of 2002, the U.S. government policy regarding scientific misconduct continues to emphasize FFP and reflects vocal opposition by some segments of the scientific community to the OSD clause in spite of the obvious necessary reliance of the clause on the scientific community's own standards and assessment of *accepted practices*. It is nevertheless generally recognized that FFP does not encompass all of the serious deviations from accepted practice that are of concern to the wider scientific community. This is apparent from formal definitions of scientific misconduct like that advanced by the Wellcome Trust, educational programs at research institutions and professional scientific societies, and professional codes of ethics that identify and examine a wide array of other issues that arise in conducting and reporting scientific research, and in training science professionals. These issues include topics considered part of the responsible conduct of research (RCR) such as data management, humane treatment of research subjects whether laboratory animals or human volunteers, conflicts of interest, publication practices, peer review, and mentorship responsibilities. Moreover while the Office of Research Integrity (ORI) is responsible for addressing allegations of scientific misconduct either directly or by overseeing investigations conducted by research institutions, the agency relies on research institutions to conduct inquiries and investigations of allegations of research misconduct brought against their employees and students.

More to the point, the focus of concern both within the scientific community and in governmental agencies (exemplified by the ORI) is evolving (Mitcham 2003). Increasingly the ORI promotes research integrity through education and training in RCR (Pascal 1999). The scientific community, too, places less emphasis on misconduct and is more focused on research integrity and education (Institute of Medicine/ National Research Council 2002). While there is some consensus as to what constitutes the most egregious form of scientific misconduct (i.e., FFP) the concept continues to evolve both within the United States (as a result of the focus on the elements of RCR) and in other countries, for example China and Germany.

STEPHANIE J. BIRD

SEE ALSO *Accountability in Research; Research Integrity; Science, Technology, and Law.*

BIBLIOGRAPHY

Babbage, Charles. (1989 [1830]). "Reflections on the Decline of Science in England and on Some of its Causes." In *The Works of Charles Babbage*, Vol.7, ed. Martin Campbell-Kelly. London: Pickering.

Bostanci, Adam. (2002). "Germany Gets in Step with Scientific Misconduct Rules." *Science* 296: 1778.

Broad, William, and Nicholas Wade. (1982). *Betrayers of the Truth: Fraud and Deceit in the Halls of Science*. New York: Simon and Schuster.

Buzzelli, Donald E. (1999). "Serious Deviation from Accepted Practices." *Science and Engineering Ethics* 5: 275–282. A commentary on "Developing a Federal Policy on Research Misconduct" by Sybil Francis.

Chubin, Daryl E. (1985). "Misconduct in Research: An Issue of Science Policy and Practice." *Minerva* 23(2): 175–202.

Commission on Research Integrity (CORI). (1995). *Integrity and Misconduct in Research*. Washington, DC: U.S. Department of Health and Human Services, Public Health Services.

Frankel, Mark S. (1993). "Professional Societies and Responsible Research Conduct." In *Responsible Science: Ensuring the Integrity of the Research Process*, Vol. 2. Washington, DC: National Academy Press.

Institute of Medicine / National Research Council. (2002). *Integrity in Scientific Research: Creating an Environment That Promotes Responsible Conduct*. Washington, DC: National Academies Press.

Kennedy, Donald. (2000). "Reflections on a Retraction." *Science* 289: 1137.

Koenig, Robert. (2001). "Wellcome Rules Widen the Net." *Science* 293: 1411–1413.

Mitcham, Carl. (2003). "Co-Responsibility for Research Integrity." *Science and Engineering Ethics* 9: 273–290.

National Academy of Sciences (NAS). (1992). *Responsible Science: Ensuring the Integrity of the Research Process*, Vol. I. Washington, DC: National Academies Press.

Office of Science and Technology Policy. (2000). "Federal Policy on Research Misconduct." *Federal Register* 65: 76260–76264.

Pascal, Chris B. (1999). "The History and Future of the Office of Research Integrity: Scientific Misconduct and Beyond." *Science and Engineering Ethics* 5: 183–198.

Public Health Service. (1986). NIH Guide for Grants and Contracts 15(11). Special issue, July 18.

Sprague, Robert L. (1993). "Whistleblowing: A Very Unpleasant Avocation." *Ethics and Behavior* 3: 103–133.

Yimin, Ding. (2002). "Beijing U. Issues First-Ever Rules." *Science* 296: 448.

BIOMEDICAL SCIENCE CASES

Misconduct cases have been more prominent in the biomedical sciences than in the physical and social sciences. This may be because there are more people working in biomedical research than in physical or social science research or because misconduct in biomedical research is more likely to have direct, harmful effects on human beings. Several have been high-profile cases, attracting the attention of the scientific community, independent watchdogs, governmental agencies, and the public at large. The following four cases are some of the best-known instances of alleged misconduct and depict a variety of the ethical issues related to misconduct in biomedical research.

The Sloan-Kettering Affair

In 1974 William Summerlin was at the Sloan-Kettering Institute for Cancer Research, continuing work on a project that he and his supervisor, Robert Good, had begun while the two were at the University of Minnesota. Preliminary data from experiments there had suggested that some tissues, when incubated for several weeks in culture, cease to produce an immune response. If supported, that finding would have dramatic implications for transplantation science, allowing transplants between any two individuals without the risk of rejection.

Summerlin and his coworkers at Sloan-Kettering were having difficulty replicating the results of those initial studies, and as a result, Summerlin had little to show Good in a progress meeting in March 1974. In the elevator on his way to the meeting Summerlin used a marker to draw what appeared to be successful skin grafts on two of the laboratory mice and represented them to Good as successful transplants. Good failed to notice the fraud, but a laboratory assistant caring for the mice discovered the black spots later that day. When he was able to wash the spots away with alcohol, the assistant reported Summerlin. A review committee was established to look into the case.

In the investigations of the affair it was found that Summerlin's data from another transplant experiment conducted in the same period had been falsified. Summerlin had begun a study with two ophthalmologists that was designed to test the same hypothesis: that incubated tissues would not produce an immune response. The protocol required the ophthalmologists to transplant a fresh human cornea onto a rabbit's left eye and then transplant the donor's other cornea into the rabbit's right eye after it had been in tissue culture for several weeks. When Summerlin observed the rabbits, he saw unsuccessful transplants in the rabbits' left eyes and what looked to be successful transplants in their right eyes. He disseminated those remarkable results at several scientific meetings with confidence. In fact, however, the two ophthalmologists had not done the second transplant on any of the rabbits; therefore, what Summerlin interpreted as successful corneal transplants were actually the rabbits' own corneas. Summerlin later claimed that he was unaware that his coinvestigators had not completed the second half of the protocol.

The institute determined that Summerlin had misrepresented data in both cases. The review committee further concluded that Summerlin had been experiencing emotional problems and placed him on medical leave for a year rather than imposing official sanctions.

Subsequent testing of the only available mouse from the Minnesota laboratory that had undergone a successful skin graft and that had formed the basis for Summerlin's work at Sloan-Kettering revealed that the mouse was a genetic hybrid rather than a purebred mouse, as had been recorded. Because the purebred mouse would have been expected to reject the skin graft but the hybrid mouse would not have, this explains the success of the graft in that case. It is not known whether the hybrid mouse was selected deliberately or accidentally.

The Darsee Case

John Darsee was a prolific and well-liked postdoctoral fellow at the Brigham and Women's Hospital, an affiliate of Harvard Medical School. In May 1981 Darsee's coworkers observed him fabricating data by recording data gathered over several hours so that the data appeared to have been collected over a two-week period. Caught in the act, Darsee apologized and claimed that it had been an isolated incident.

An internal investigation led by Eugene Braunwald, Darsee's supervisor, was conducted, but the incident was not disclosed publicly until several months later, when the investigators uncovered data that Darsee had generated for a multicenter study funded by the National Institutes of Health (NIH). Inexplicable discrepancies between Darsee's data and the results from other participating institutions were found, precipitating an independent investigation and notification of the NIH.

The NIH then launched its own review of Darsee's research. The review committee found problems in five of the papers that Darsee had published and on which Braunwald had been a coauthor and recommended that Darsee be barred from eligibility to receive NIH funding for ten years. The panel condemned Braunwald's supervision of Darsee, stating that his hands-off approach had inhibited the discovery of Darsee's fabrication. In response Braunwald argued that he had followed standard laboratory practices.

Further investigation into work done previously by Darsee at Emory University and Notre Dame uncovered instances of data fabrication and falsification in at least twelve of Darsee's papers that were based on research he had conducted at those institutions.

Harvard Medical School was criticized for its handling of the case and subsequently revised its policies for responding to charges of misconduct. In particular the review committee claimed that the NIH had had a right to know that Darsee, who had continued work on NIH-sponsored research for six months after the incident, had been caught fabricating data.

The Gallo Probe

A well-known controversy involving the isolation of the acquired immune deficiency syndrome (AIDS) virus illustrates a third form of scientific misconduct: plagiarism. In May 1984 a series of four papers appeared in the journal *Science* written by Robert Gallo and his team at the National Cancer Institute, stating that they had identified the virus that causes AIDS and proposing a process for developing a blood test for the virus. Mikulas Popovic, working in Gallo's laboratory, had been able to grow the retrovirus in cells that could survive infection with the virus, a cell line that he called H9. It later was revealed that the H9 cell line had not been developed by Popovic but instead had been cloned from a cell line called HUT78 that had been given to the Gallo laboratory by John Minna's team at the Veterans Administration. Minna's group was not credited in the *Science* papers for that significant contribution.

A second and more high-profile dispute accompanied the Gallo group's accomplishment. In July and again in September 1983 Luc Montagnier's team at France's Pasteur Institute had sent a sample of a viral isolate called LAV to Gallo's laboratory. In spring 1984 Popovic used the H9/HUT78 cell line to grow an AIDS retrovirus, which Montagnier's laboratory had been unable to do because it did not have a cell line that could survive infection with the virus. Gallo was able to produce sufficient quantities of the virus, which he named HTLV-III, to develop a method for testing for the presence of the virus in blood. It was discovered later that HTLV-III and LAV were the same virus, although Gallo had not acknowledged the contribution of the Pasteur Institute. Gallo claimed that the use of LAV was unintentional and must have contaminated his cultures accidentally.

The NIH's Office of Scientific Integrity (OSI) conducted an investigation and found Popovic guilty of four counts of misconduct but held Gallo responsible only for exhibiting a lack of collegiality. In a later investigation by the OSI's successor, the Office of Research Integrity (ORI) at the Department of Health and Human Services (DHHS), Gallo was found guilty of intention to deceive the scientific community about the origin of the materials used to isolate and replicate the AIDS virus. In 1993, however, a federal appeals board cleared Popovic and therefore Gallo of the misconduct charges, citing a lack of evidence that the virus had been stolen.

The Gallo case was significant not only because of the recognition and prestige associated with receiving credit for a discovery of this magnitude. The patent on the blood test for AIDS virus antibodies was lucrative, producing millions of dollars in royalties. It eventually was agreed that those royalties would be split evenly between the United States and France.

The Baltimore Case

Perhaps the most infamous instance of alleged misconduct in the biomedical sciences was the affair that would come to be known as the Baltimore case, even though David Baltimore, for whom the case is named, was not accused of fraud. Baltimore did, however, staunchly defend Thereza Imanishi-Kari against claims that she had fabricated data in a paper on which he was a coauthor. When the accusations were made, Baltimore was a professor of biology at the Massachusetts Institute of Technology (MIT) and the director of the Whitehead Institute. He had been awarded a Nobel Prize in 1975 for his work in virology. Imanishi-Kari was working with Baltimore on a complex project investigating the mechanisms behind the immune response.

Margot O'Toole took a postdoctoral fellowship in Imanishi-Kari's laboratory in 1985, and the two clashed from the beginning. O'Toole was having difficulty getting results consistent with Imanishi-Kari's data and had some problems with the experimental method. When she approached Imanishi-Kari with her concerns, she was dismissed and told that the discrepancies were due to incompetence. While attempting to understand the discrepancies between Imanishi-Kari's results and her own, O'Toole came upon evidence that she believed showed that data in a 1986 *Cell* paper coauthored by David Baltimore had been misrepresented.

O'Toole brought her concerns to senior scientists at both MIT and Tufts University, where Imanishi-Kari had taken a position. Informal investigations were conducted at both institutions. Errors were found in the paper, but the investigators believed that O'Toole's problems with the paper were scientific disagreements and did not demonstrate misconduct. O'Toole and a former graduate student of Imanishi-Kari's continued to push the issue, notifying NIH scientist's Walter Stewart and Ned Feder. In doing so, they sparked parallel investigations by the NIH and by the congressional subcommittee on oversight and investigation with jurisdiction over the NIH that continued for the next six years.

In 1994 a report by the ORI found Imanishi-Kari guilty of numerous counts of fabricating and falsifying data and banned her from receiving NIH funding for a period of ten years. However, two years later the DHHS's Research Integrity Adjudications Panel exonerated Imanishi-Kari of fraud. The panel made note of the many errors in the *Cell* paper as well as the sloppiness of Imanishi-Kari's bookkeeping but stated that solid evidence of intentional misrepresentation was lacking. That was the second ruling by the ORI that had been overturned by an expert panel (the first had been the Gallo ruling), shedding doubt on the office's ability to police scientific misconduct.

The Baltimore case also raised questions about the treatment and protection of whistle-blowers. Throughout the ten years of the ordeal O'Toole was alternately ostracized and praised for her actions and was unable to find work in science. Her experience and the similar experiences of others sparked a movement that resulted in improved protections for whistle-blowers.

Results and Changes

These four cases illustrate a variety of the difficult issues related to scientific misconduct. They raise questions about the high expectations placed on researchers and about authorship requirements, supervision of laboratory work, appropriate attribution of credit, collegiality, transparency of data recording, and treatment of whistle-blowers. These cases also demonstrate that the distinction between honest errors or omissions and intentional fraud is not an obvious one. Significant improvements in the process used to negotiate the murky waters of scientific misconduct have come out of these experiences.

In some cases, a rapid and transparent response to revelations of misconduct may minimize the damage done by those revelations. In 1996, Francis Collins, head of the human genome project at NIH, became aware that data had been falsified by one of his graduate students in five papers that he had coauthored. Collins promptly confronted the student, informed researchers for whom the information would be relevant, retracted two of the papers and corrected sections of three others. Although this case differs from those above in that the researcher accused of misconduct did not deny the allegations, it may illustrate the advantages of dealing with instances of misconduct quickly and openly.

JANET MALEK

SEE ALSO *Bioethics; Medical Ethics.*

BIBLIOGRAPHY

Anderson, Christopher. (1993). "Popovic Is Cleared on All Charges; Gallo Case in Doubt." *Science* 262(5136): 981–983.

Cohen, Jon, and Eliot Marshall. (1994). "NIH-Pasteur: A Final Rapprochement?" *Science* 265(5170): 313.

Culliton, Barbara J. (1974). "The Sloan-Kettering Affair: A Story without a Hero." *Science* 184(4137): 644–650. First part of a review of the Sloan-Kettering affair.

Culliton, Barbara J. (1974). "The Sloan-Kettering Affair (II): An Uneasy Resolution." *Science* 184(4142): 1154–1157. Second part of a review of the Sloan-Kettering affair.

Culliton, Barbara J. (1983). "Coping with Fraud: The Darsee Case." *Science* 220(4592): 31–35. Review of the Darsee case and its fallout.

Culliton, Barbara J. (1990). "Inside the Gallo Probe." *Science* 248(4962): 1494–1498. First part of a review of the Gallo probe.

Hamilton, David P. (1991). "NIH Finds Fraud in Cell Paper." *Science* 251(5001): 1552–1554.

Kaiser, Jocelyn, and Eliot Marshall. (1996). "Imanishi-Kari Ruling Slams ORI." *Science* 272(5270): 1864–1865.

Kevles, Daniel J. (1998). *The Baltimore Case*. New York: W. W. Norton. Detailed history and analysis of the Baltimore case.

Marshall, Eliot. (1996). "Fraud Strikes Top Genome Lab." *Science* 274(5289): 908.

Palca, Joseph. (1992). "'Verdicts' Are in on the Gallo Probe." *Science* 256(5058): 735–738.

Rubenstein, Ellis. (1990). "The Untold Story of HUT78." *Science* 248(4962): 1499–1507. Second part of a review of the Gallo probe.

PHYSICAL SCIENCE CASES

In the year 2002, two cases of scientific misconduct by physicists received prominent attention. One involved a young scientist at Bell Laboratories named Jan Hendrick Schön, and the other a researcher at Lawrence Berkeley National Laboratory (LBNL) named Victor Ninov. This was a surprising development because nearly all cases that had arisen prior had been in biology, biomedicine, and related fields. The questions arose: Why had the physical sciences previously seemed immune to this kind of misbehavior, and what had suddenly changed?

Qualifications

Before responding to these questions, it is important to consider the scope of misconduct and some charges of historical significance. Misconduct is a narrower concept than ethics in science. There are many ethical issues having to do with conflict of interest, not properly sharing credit, not hyping results or prospects in grant applications, covering up misconduct, reprisals against whistleblowers or malicious allegations of misconduct, violation of due process in handling misconduct cases, treating graduates students fairly, and so on, that are not part of scientific misconduct in the strict sense. During the 1980s and 1990s, after considerable debate, scientific misconduct was carefully defined as fabrication, falsification, or plagiarism (FFP) of results. It is this FFP definition that is most appropriate to bring to bear on considering misconduct in science because, without a well-crafted understanding, many activities can unfairly be called misconduct when they should more properly be called moral weaknesses or improper behavior. This is not to downplay the importance of a host of ethical issues, but simply to be clear in discussion.

Until the two physics cases arose, the fabrication and falsification type of misconduct seemed to be confined to biology and related sciences. A considerable number of such cases surfaced during the 1980s and 1990s. From those cases a pattern emerged of preconditions for such misconduct. First the scientists who commit misconduct are under career pressure. Of course all scientists are almost always under career pressure, but the point is they engage in misconduct for motives more subtle than simple monetary gain. Second scientists do not purposely insert falsehoods into the scientific record, but rather fabricate or falsify data, giving a result they believe to be true without taking the time to do the science properly. In other words, this kind of misconduct is always a violation of the scientific method, never purposely a corruption of the body of scientific knowledge. Such is almost certainly the case because even corrupt scientists believe that science is self-correcting, and a wrong result will eventually be found out. Finally misconduct occurs in fields where reproducibility is not very precise. This last point explains why the physical sciences seemed immune to such behavior while biology did not. If two organisms as identical as they can be made, for example, two transgenic mice, are exposed to the same carcinogen under the same conditions, they are not expected to produce the same tumor, at the same time, in the same place. This is an example of what is known as biological variability. Experiments in biology are not as precisely reproducible as those in physics generally are supposed to be, so a biologist disposed to cheat does not fear that someone else repeating the same experiment will find it out quickly. The two physics cases that arose in 2002 pose a severe test of this pattern.

Ninov Case

Dr. Victor Ninov was a leader of the Berkeley Gas Filled Separator (BGS) group at LBNL. Ninov had joined LBNL in 1997 after a stint at the rival GSI, German acronym for the Laboratory for Heavy Ion Research, in Darmstadt. The BGS is a device designed to sort through the debris of nuclear collisions between a stationary target, and particles that are accelerated in the LBNL 88-inch cyclotron. The Berkeley laboratory has a distinguished history of discovering heavy, radioactive elements by this means. However, although even heavier elements were believed to be possible, it was widely thought that this so called *cold fusion* method of producing new elements had pretty well run its course and entirely new approaches would be needed. This would not have come as good news to Dr. Ninov and the BGS group.

The possibility of a reprieve from this situation arose when a theory published by Robert Smolańczuk predicted a highly enhanced probability of creating superheavy element 118 if projectiles consisting of an isotope of krypton were fired with the right energy into a lead target. The signature of such an event would be a chain of subsequent events, in which the original nucleus shed alpha particles at times and with energies predicted by the theory. This was just the kind of experiment the BGS was designed to do. In May 1999, a paper was submitted for publication, and a few days later a press release was issued by LBNL, both announcing that three instances of decay chains characteristic of element 118 had been observed.

By international agreement, new elements are not official until their discovery has been reproduced. The GSI in Germany and a research group in Japan immediately undertook to reproduce the new result, but both failed. The BGS group did a new series of experiments, and in 2001, produced a fourth signature decay chain. But by now, suspicions had been aroused. A series of investigations ensued determining that the data for all four significant decay chains had been fabricated, and that Ninov was the only person in a position to have done it. The entire BGS group was criticized for not checking the raw data more carefully in what would have been a major scientific discovery, but Ninov alone was found guilty of scientific misconduct. Furthermore the investigations uncovered that in the earlier discovery of element 112 at the GSI in Darmstadt, a discovery that was real and that had been reproduced, data had nevertheless been fabricated, and Ninov had been a member of the group at the time. Ninov was fired by LBNL.

Schön Case

The other physics case involved Jan Hendrick Schön, a young superstar who had recently arrived at Bell Laboratories in Murray Hill, New Jersey, after completing his Ph.D. at the University of Konstanz in Germany. Schön, a postdoctoral member in the research group of a well known and highly respected physicist named Bertram Batlogg, did experiments in which an intense electric field drew electrons to the interface between a semiconducting material and an insulating layer. Such devices are known as MOSFETs (metal-oxide semiconductor field effect transistors) and, using conventional semiconductors such as silicon, they had been the mainstay of the electronics industry for years. The Batlogg group's work involved substituting exotic materials such as organic crystals for the silicon, and using the field effect to alter their properties. Schön's results seemed truly spectacular. In a period of only two years, together with a total of some twenty collaborators, he turned out eighty research papers announcing remarkable breakthroughs that many others had attempted but failed to achieve.

Then questions arose. In some cases, the data just looked too good to be true. In other cases, completely independent curves had identical noise, little glitches in the data that are inevitable in any real experiment, but that should be random, meaning no two experimental curves should be identical to one another. These anomalies and others were reported to the management of Bell Laboratories, which, in May 2002, announced that it had appointed a committee, headed by Malcolm Beasley of Stanford University, to investigate. It also announced that the committee's report would be made public. By contrast, the report of the committee that investigated the Ninov case at LBNL is regarded as a confidential personnel matter, and has not been released to the public.

The Beasley committee, whose report was issued at the end of September 2002, chose to investigate some twenty-four specific allegations, and found that Schön had committed misconduct in at least sixteen of them. They also decided that Schön alone, and none of his collaborators, was responsible. The insulating layer in the MOSFET was the key to the whole affair. The process by which the insulating layer is laid down on the semiconductor is called sputtering. Schön, who started his collaboration with Batlogg when he was still a graduate student, had tried his hand at sputtering an insulating layer on to one of the group's exotic samples in a very modest apparatus at his university, in Konstanz. The insulating layer proved to be much more robust than those that others were able to make. It allowed stronger electric fields to be applied, producing results that no one else could achieve. Because sputtering involves complex processes that are not well understood or controlled, it seemed believable to Schön's collaborators that for unknown reasons, the apparatus in Konstanz could make better insulating layers than could be made anywhere else. Thus it was believable that Schön could get experimental results no one else could produce. People and samples shuttled back and forth between Murray Hill and Konstanz, but all the sputtering was done in the magic machine at Konstanz and Schön alone made nearly all the measurements. The results were, literally, too good to be true. When the Beasley report came out, Schön was immediately fired by Bell Laboratories.

Assessment

The two physics cases of 2002 can be analyzed in light of the pattern, described above, that had emerged from previous cases of scientific misconduct. The three necessary (but certainly not sufficient) factors that seemed to be present whenever misconduct occurred were career pressure, belief in knowing the answer before the experiment was performed, and the expectation that the experiment was not easily and precisely reproducible. All three factors were unmistakably present in the Schön case. The atmosphere at a place like Bell Laboratories puts great pressure on scientists to succeed. The effects that Schön and his collaborators reported were widely believed to be possible, even though no one else had managed to obtain them yet. In fact, in an addendum to the Beasley report, Schön admits that he made some mistakes, but says he still believes all the effects he reported were real. And finally, the field is notorious for its lack of reproducibility. The problem lies not only in the sputtering, but also in the difficulties of preparing good samples of the exotic materials involved. If an experiment fails to reproduce a given result, it does not necessarily show the result was mistaken, it just means the experiment was performed on an imperfect sample Thus a failure to reproduce has no significance at all.

The Ninov case is more subtle, and requires some speculation as to cause. Certainly Ninov and the BGS group were under pressure to produce something new because their measurement technique seemed to have run its course, giving them less leverage to get expensive beam time on the 88-inch cyclotron and perhaps even threatening the continued existence of the group itself. The theory by Smolańczuk gave the group new hope, and quite possibly, Ninov came to believe in it because he needed to. The question of reproducibility appears to pose a contradiction, though, because the field is one in which results must be reproduced before they are official. Ninov seems to have turned the irreproducibility factor upside down. If he believed that element 118 existed, he also must have believed that its discovery could be reproduced, and, when that happened, that he and his group would get credit for the original discovery. This, of course, is exactly what occurred in the discovery of element 112, an experiment he had also been involved in; data had been faked, but the discovery turned out to be real.

These cases demonstrate that the physical sciences never were immune to FFP misconduct, and that nothing has suddenly changed. The necessary factors may line up less often than in some other areas of science, but when they do, misconduct can follow just as in other fields.

DAVID L. GOODSTEIN

BIBLIOGRAPHY

Beasley, Malcolm R., et al. (2002). "Report of the Investigation Committee on the Possibility of Scientific Misconduct in the work of Hendrik Schon and Coauthors." Unpublished.

Broad, William, and Nicholas Wade. (1982). *Betrayers of the Truth*. New York: Simon and Schuster.

Goodstein, David. (1994). "Pariah Science—Whatever Happened to Cold Fusion?" *American Scholar* 63(4): 527–541.

Goodstein, David. (2001). "In the Case of Robert Andrews Millikan." *American Scientist* 89(1): 54–60.

Goodstein, David, and James Woodward. (1996). "Conduct, Misconduct and the Structure of Science." *American Scientist* 84(5): 479–490.

Vogt, R., et al. (2002). "Report, Committee on the Formal Investigation of Alleged Scientific Misconduct by LBNL Staff Scientist Dr. Victor Ninov." Unpublished.

SOCIAL SCIENCE CASES

Issues of scientific misconduct in the forms of fabrication, falsification, or plagiarism (FFP) tend to be most prominently reported in the biomedical area, where fraudulent data may lead to serious consequences for patients receiving treatment. Nevertheless, scientific misconduct in the social sciences may also cause considerable damage—not the least being the undermining of public trust in a scientific endeavor that aims to be of benefit to social decision-making. Among the cases that have been most prominent in this area are those associated with anthropologists and psychologists.

Anthropology Cases

The American anthropologist Margaret Mead (1901–1978) in her famous 1928 study, *Coming of Age in Samoa*, described adolescence in those islands in glowing terms with little cultural competition and easy and frequent sexual activities among teenagers that was not condemned by Samoan society. The only problem with this book, which received high acclaim, was that it was based on a myth, as later documented in detail by Derek Freeman (1983). Reasons for such a vast and almost complete misinterpretation of the facts of the culture, according to Freeman, include the following: Mead could not speak the Samoan language; she lived with an American family while on the islands; she was denied access to the chiefs who determined the laws and customs; she simply overlooked contradictory data to her favorite theories. Freeman's criticisms of Mead have, however, been challenged; for a review of the controversy, see James E. Côte (2000).

Other cases have involved charges that anthropologists have on occasion aided and abetted the mistreatment of indigenous peoples or illegitimately conspired with national governments. Patrick Tierney (2000), for example, charged that during the 1960s the anthropologist Napoleon A. Chagnon was complicit in the fomenting of violence among the Yanomami, a tribal people living in remote areas of Brazil and Venezuela. (He also charged Chagnon's associate, the geneticist James V. Neel, with administering measles vaccine to the Yanomami according to protocols that were not in their best interest.) An American Anthropological Association (AAA) investigation did not sustain the most grievous charges, and in fact argued that Tierney himself, through misrepresentation and sensationalism, failed to practice responsible journalism. Nevertheless, it did admit that the Yanomami are now in such danger as to encourage "anthropologists to reflect deeply upon the ways in which they conduct research" (AAA 2002).

The AAA has also reported on a number of other ethics cases. Among these are the outrage of Franz Boas (1858–1942) at the use of anthropology as a cover for espionage during World War I and debates about the authenticity of the autobiography of the 1992 Nobel Peace Prize winner, the Guatemalan peasant activist Rigoberta Menchú.

Psychology Cases

In psychology, cases are both more numerous and more contentious than in anthropology. One commonly discussed early case in psychology involved the work of John B. Watson (1878–1958), who espoused a strong form of behaviorism. Some people vigorously question the quality of his study, known as Little Albert, that supposedly showed conditioned fear of a stuffed toy rabbit in a baby (Cohen 1979). Whatever the final settlement of the argument regarding Watson's work, there is no doubt that later, starting in the 1980s, such cases would have been judged scientific misconduct by social scientists.

It should be noted, however, that many social scientists were working in biomedical areas. The first such publicized case was that of Stephen E. Breuning, a psychologist studying the effects of psychoactive medications on the behavior of a vulnerable population, the institutionalized mentally retarded, people societies typically strongly protect. Neuroleptic medications, commonly known as tranquilizers, are often given to the mentally retarded to control aggressive and self-injurious behavior. Breuning was conducting studies on these neuroleptic medications, but was collecting little data. Instead he was fabricating data indicating that such medications were harmful to the patients' learning and behavior. Thus, he was strongly suggesting on the basis of fabricated data that removing medications from these vulnerable patients might be helpful to them.

In December 1983 Robert L. Sprague reported Breuning's fraud to the appropriate federal agency that was funding his research, the National Institute of Mental Health. The agency began an investigation that moved with glacierlike speed even in this crucially important health area. Although there were publications in the scientific press about the slowness of the investigation in this important case (Holden 1986), the agency did not issue its first report until April 1987—more than three years after receiving smoking-gun evidence of scientific misconduct (NIMH 1987). Breuning was the first independent scientist with his own federal research grant to be indicted, tried, and found guilty of fraud in federal court. Considering the seriousness of his offenses, his sentence was light; he served no jail time, but was confined to a halfway house for sixty nights and fined $11,352 (Wilcox 1991).

Another important case in psychology was that of Marion Perlmutter, a psychologist at the University of Michigan who plagiarized the research proposals of Carolyn Phinney, also at Michigan. When confronted with an accusation by Phinney, Perlmutter denied any wrongdoing and the university officials initially supported her (Gordon 1991). When Phinney could not obtain justice through university channels, she was the first victim of scientific misconduct to turn to the courts for relief (Gordon 1993). After a trial in Ann Arbor, Michigan, Phinney was awarded $1 million in damages for theft of intellectual property and research proposals. University officials unwisely followed Perlmutter's request to appeal. The appellate court upheld the trial court and added to the damage award interest because of the years of delay while the appeal process took its course, increasing the award to $1.6 million (Hilts 1997).

Assessment

These are only a few of the more than 300 cases on which data have been collected by Sprague since his discovery and disclosure of the Breuning fraud. Drawing on these and other cases in the social sciences, it is possible to argue three points. First, it is likely that there are more cases of misconduct in the biomedical sciences than in the social sciences (Shamoo and Resnik 2003). One reason for this discrepancy may be that large profits are often involved in research leading to new medications, which is seldom the case in the social sciences. The potential for making large profits seems to bring out the worst in human beings, including scientific researchers.

Second, during the 1990s universities were sluggish in recognizing misconduct problems among their faculty and slow in taking corrective actions. This was as true in the social as in any other sciences.

Third, times have changed, and the situation has improved in the social sciences as elsewhere—though the situation could hardly be termed ideal. There is hope for continued improvement with federally mandated training for graduate students and federal requirements that universities maintain written policies addressing scientific integrity. Furthermore, there has been a sharp increase in the awareness of scientific misconduct among researchers.

Despite this increased awareness, one must be careful to distinguish cases of misconduct in the social sciences from research that is simply controversial. Twin studies, IQ studies, and race studies, for instance, are sometimes mentioned as cases of scientific misconduct. But although research in these areas may have been very controversial, this does not mean that they involved scientific fraud or misconduct. They may have poorly designed or unwise. Still, misconduct and controversy must be distinguished.

ROBERT L. SPRAGUE
CARL MITCHAM

SEE ALSO *Sociological Ethics.*

BIBLIOGRAPHY

American Anthropological Association (AAA). (2002). *Final Report of the AAA El Dorado Task Force.* Arlington, VA: Author. Also available from http://aaanet.org/edtf/index.htm.

Arias, Arturo, ed. (2001). *The Rigoberta Menchú Controversy.* Minneapolis: University of Minnesota Press.

Cohen, David. (1979). *J. B. Watson: The Founder of Behaviourism.* London: Routledge and Kegan Paul.

Côte, James E. (2000). "The Mead–Freeman Controversy in Review." *Journal of Youth and Adolescence* 29(5): 525–538. The introduction to a theme issue on the Mead–Freeman controversy that includes four other articles and some historical documentation.

Freeman, Derek. (1983). *Margaret Mead and Samoa: The Making and Unmaking of an Anthropological Myth.* Cambridge, MA: Harvard University Press.

Gordon, G. (1991). "Academic Fraud Charged at U-M." *Detroit News* 3A, 5A. Newspaper report on the Perlmutter case.

Gordon, G. (1993). "Misconduct Costs U-M $1 Million." *Detroit News.* Another newspaper report on Perlmutter.

Hilts, Philip J. (1997). "University Pays $1.6 Million to Researcher." *New York Times* August 10, p. 10.

Holden, Constance. (1986). "NIMH Review of Fraud Charge Moves Slowly." *Science* 234: 1488–1489. A report on the Breuning case.

"Jury Awards $1.1 Million to Researcher." (1993). *Ypsilanti (Mich.) Press.* On the Perlmutter case.

Mead, Margaret. (1928). *Coming of Age in Samoa: A Psychological Study of Primitive Youth for Western Civilisation.* New York: Morrow.

National Institute of Mental Health (NIMH). Panel to Investigate Allegations of Misconduct. (1987). *Report and Recommendations of the Panel.* Author.

"Psychologist Pleads Guilty to Research Fraud." (1988). *Psychiatric Times,* 21. On the Breuning case.

Shamoo, Adil E., and David B. Resnik. (2003). *Responsible Conduct of Research.* Oxford: Oxford University Press.

Sprague, Robert L. (1993). "Whistleblowing: A Very Unpleasant Avocation." *Ethics and Behavior* 3(1): 103–133.

Tierney, Patrick. (2000). *Darkness in El Dorado: How Scientists and Journalists Devastated the Amazon.* New York: Norton.

Wilcox, B. (1991). "Fraud in Scientific Research: The Prosecutor's Approach." *Accountability in Research: Policies and Quality Assurance* 2: 139–151.

MISSILE DEFENSE SYSTEMS

Experts have long debated the idea of defending national territory against airborne strategic attack. These debates often conflate feasibility, morality, strategy, and politics, so that each observer must independently weigh such factors even in arguments that seem to be purely technical.

BMD (ballistic missile defense) supporters tend to draw on early strategic theory developed by Wohlstetter (1958) and others from the RAND Corporation (for example Kahn 1970). They generally suggest the following: Nuclear strategy is neither easy nor impossible. It requires repeated analysis and improvement. It should serve national policy, such as deterring enemies (or the nation should change its policy). National leaders have a commitment to preserve and protect the people and the political system as well as they can, which no technical advice can abrogate. Deterrent systems should maximize human control over weapons. Deterrence based on the threat of retaliation against civilians is immoral if targetting enemy weapons is possible. Furthermore, the strongest supporters of BMD tend to have more faith in large-scale technology development and system predictability and performance.

BMD critics, in contrast, generally believe the following. Nuclear weapons are so awful and so difficult to stop that their development should freeze in place and that arms control diplomacy should be relied on to reduce them. Even one or a very few nuclear weapons detonated in war would be as bad as many, so that targeting a few against cities is enough to threaten assured destruction (AD) to any potential attacker, thereby achieving deterrence and stability. No defense is likely to prevent some attackers from getting through to cause unacceptable damage.

In this view, offense dominates defense. Defenses undermine stability and encourage useless competitive arms procurements ("arms races"). Measures to reduce the consequences of nuclear war will only encourage it. These critics accept mutual deterrence based on the threat of retaliation, to the point in the 1970s of considering a policy of [immediate] "Launch-On-Warning" or "Under Attack" (Garwin 1989, pp. 189–198). Therefore, they advocate cooperating with adversaries against a greater and common enemy, the danger of nuclear war, by accepting mutual vulnerability (Carter and Schwartz 1984).

Whatever the value of any of these views on either side, they often have combined technical, strategic, political and ethical beliefs in ways difficult for observers to evaluate. This problem caused one professional society to conduct a formal—and critical—review of the professional standards at work (ORSA 1971).

Historical Development of Arguments

While the debate from the 1960s to the present has focused on ballistic missile threats, strategic defenses may target any air-borne attacker. Strategic defense may use active means such as interceptor weapons and passive means such as hardening (protecting), hiding, and dispersing assets against enemy targeting. After German dirigibles bombarded London during World War I, thinkers from the English writer and futurist H. G. Wells to the U.S. Army Air Corps predicted that future wars would be dominated by air power, which would be "strategic" more than "tactical": It would aim at national will, not forces, by attacking the enemy cities to force the population to demand that its government sue for peace. Defenses could not stop "the bomber always getting through," and only a few bombs would be enough to achieve the strategic goal. Therefore, nations should ignore defenses and rely for security on their own bombers to threaten retaliation. Yet in 1940 the Battle of Britain saw Royal Air Force fighter defenses stop enough German bombers to defeat their strategic purpose, even if many bombs indeed "got through."

The atomic bomb revived the idea that devastating attack was unavoidable, and therefore the only means of stabilizing relations was to threaten retaliation. Some even argued that the *analysis* of the military use of nuclear weapons was immoral and "unthinkable" because it might make nuclear war seem rational.

After World War II, many technologists involved in the development of atomic weapons helped pioneer this debate (Kimball Smith 1965). Radar expert Louis Ridenour, in a collection (Masters and Way 1946) for the nascent Federation of American Scientists immediately after the war, described the great difficulty of countering each aspect of an airborne attack, making defense hopeless. Such arguments have become standard, as in those made by leading assured destruction theorists and BMD critics such as Richard L. Garwin (1989) and others (for example UCS, 1984).

This view reached its peak in 1972, when the United States and the Soviet Union pledged in the Anti-Ballistic Missile Treaty (ABMT) not to defend against each other's missile threat, arguably making further offensive weapon development superfluous. The two powers accompanied the ABMT with a Strategic Arms Limitation Agreement capping offensive forces at some 1,700 U.S. missiles and almost 2,500 Soviet missiles, numbers that diplomats expected to reduce in future negotiation.

These missile levels were more than enough for AD theorists. They saw the only rational use of strategic forces as pure deterrence (threatening cities, if not expecting actually to attack them). They saw military use (targeting forces) as irrational. Cities were good targets because the destruction of enemy cities was easy and of our own, unacceptable. This scenario eliminated both the targeting side's temptation to upgrade its weapons and the targeted side's temptation to make useless, yet still provocative, defenses. A balance of deterrence ensued—"mutual assured destruction" (MAD). Neither side could envision a nuclear war scenario from which it could escape intact. While leaders' acceptance of vulnerability, especially of civilians, might turn ethical traditions on their head, proponents believed they had a better analysis of the dynamics of nuclear peace. With the election of Jimmy Carter to the Presidency in 1976, these views achieved their peak in U.S. policy.

The Soviets, however, frustrated expectations. By 1979, Harold Brown, President Carter's Defense Secretary, told Congress that "Soviet spending has shown no response to U.S. restraint—when we build they build; when we cut they build" (Brown 2003). The Soviets also improved the accuracy of their warheads, which they now mated to their very large boosters. The combination raised the possibility of a disarming first strike—against not U.S. cities but the land-based deterrent forces themselves. Few enough might survive that retaliation would then fall to the submarines and the bombers, in which defense supporters (but not the AD theorists) saw major problems.

BMD Proposals

In 1980 the election of Ronald Reagan to the Presidency signaled a new U.S. skepticism on arms control and assured destruction. President Reagan accepted advice that new technologies based, for example, on directed energy, might create systems that could destroy Soviet missiles, and thereby move zthe basis of deterrence away from mutual threat, toward mutual security. In March 1983, he supported BMD by asking, "Would it not be better to save lives than to avenge them" by countering "the awesome Soviet missile threat ... before they reached our own soil or that of our allies"? Was it not "worth every investment necessary to free the world from the threat of nuclear war?" (Reagan 1983).

Despite strong Reagan Administration support, BMD development programs did not receive similar priority from Congress, the military services, or the subsequent presidencies of George H. W. Bush and (especially) Bill Clinton. In December 2001, however, President George W. Bush announced U.S. withdrawal from the ABM treaty and the intention to develop layers of short-, medium-, and long-range interceptors—air-, sea- and space-based—and the systems to manage them (White House 2001).

BMD nevertheless continued to be controversial. U.S. technical experts, pro- and especially anti-BMD, have often demanded that any BMD system reach extremely high levels of effectiveness. Yet often beneath their arguments there lurk basic questions of technology (will it work?) mixed with policy (should it?). These should be made explicit. For example, BMD "effectiveness" makes sense only in terms of some policy goal. A 100-percent-effective shield may be impossible but also strategically excessive. Alternatively, a defense of three independent layers of say 50-percent effectiveness each, defending retaliatory forces, might make any incoming attack prohibitively expensive if not suicidal. It depends on the strategy.

Attitudes outside the United States

The Russian, Chinese, and North Korean governments oppose BMD because it reduces their threat to the United States and its allies. Beginning in the early 1990s Japanese governments, perhaps as worried by their own pacifists as by China and North Korea, engaged in a delicate and muted dance of cooperative BMD development efforts. The problem is that, if Japan lacks both defenses and a tie to a United States that can credibly defend it, it may well face a choice of acquiescence to its neighbors or developing its own retaliatory forces. Either could be a global disaster.

European experts worried that a U.S. defense system might "decouple" the United States from NATO, make nuclear war more thinkable, or remove constraints on conventional war. Yet lacking a Soviet threat to deter in Europe, the United States relies more on conventional forces to support stability, globally. At the same time rogue states and terrorists have pursued their own mass destruction weapons to deter the Unites States from using its forces. Further European objections to U.S. defenses, therefore, seem more related to intra-alliance political jockeying, resentment at the association of BMD with Presidents Reagan and George W. Bush (neither popular in Europe), and a belief that the ABM treaty is worth preserving as a precedent for arms control.

It nevertheless appears that U.S. BMD work will continue, if only to deny future missiles—from China, North Korea, or anywhere else—an unimpeded ride into the United States. Whatever the validity of AD theory that governed U.S. policy during the cold war, the United States is unlikely to continue to pursue that course alone. While seeking peaceful relations with other powers, it is difficult to see how U.S. leaders will not consider protection against the possible worst case, if only to make it less likely. Missile defenses cannot solve all problems. That they nevertheless try to address some significant ones is likely to capture the attention of leaders.

If these trends hold, the role of the scientists and engineers who have challenged BMD will be essential to ensure that missile defense programs achieve technical, programmatic, and strategic soundness. If both the hopes of BMD supporters and the critiques of BMD detractors are more task-focused and less millennial, their debates will be more transparent, professional, and indeed ethical.

THOMAS BLAU

SEE ALSO *Computer Ethics; Military Ethics.*

BIBLIOGRAPHY

Brown, Harold. (2003). *Paul C. Warnke Lecture In International Security*. New York: Council on Foreign Relations.

Carter, Ashton B., and David N. Schwartz, eds. (1984). *Ballistic Missile Defense*. Washington, DC: Brookings Institution. See Leon Sloss, "The Strategist's Perspective," 24–48.

Garwin, Richard L. (1989). *Richard Garwin on Arms Control*, ed. Kenneth W. Thompson. Lanham, MD: University Press of America.

Kimball Smith, Alice. (1965). *A Peril and a Hope*. Chicago: University of Chicago Press.

Kahn, Herman. (1963). *Thinking About the Unthinkable*. Croton-on-Hudson: Hudson Institute.

Kahn, Herman. (1970). *Why ABM?* New York: Prentice-Hall.

ORSA [Operations Research Society of America]. (September 1971). *Operations Research* 5. "Guidelines for the Practice of Operations Research."

Ridenour, Louis. (1946). "There Is No Defense." In *One World or None,* ed. Dexter Masters and Katharine Way, 33–38. New York: Whittlesey House, McGraw-Hill.

UCS (Union of Concerned Scientists). (1984). *The Fallacy of Star Wars,* ed. John Tirman. New York: Random House.

White House. (2001). *ABM Treaty Fact Sheet: Statement by the President. Announcement of Withdrawal from the ABM Treaty*. Washington, DC: White House Office of the Press Secretary.

INTERNET RESOURCES

Reagan, Ronald. (1984). Announcement of the Strategic Defense Initiative. Available from http://www.nuclearfiles.org/redocuments/1984/841228-reagan-sdi.html.

Wohlstetter, Albert. (1958) "The Delicate Balance of Terror." P-1472. Santa Monica: The RAND Corporation. Available from www.rand.org.

MODELS AND MODELING

Models are abstractions of reality, and modeling is the process of creating these abstractions of reality (Wallace 1994). Models take a variety of forms based upon their function, structure, and degree of quantification (Tersine and Grasso 1979). For example the functions of a chart of an organization is to describe and does not provide any predictions or recommendations; a sales forecast predicts the future based upon a particular business strategy; and a procedural manual for a manufacturing process is normative in that it provides advice on how to manage a process. The structure of a model can be symbolic (represented by equations), analog (using graphs to model physical networks), or iconic (physical representations such as scale models). Models are usually thought of as being quantitative, and able to be represented mathematically. However, qualitative models are far more common. For example, mental models play a very important role in the conceptualization of a situation (Crapo, Waisel, Wallace and Willemain 2000) and verbal and textual models are used in the process of communicating mental models. Because reality is near-infinitely complex, all data needs to be processed, which involves a movement from information to knowledge. Models are forms of codified knowledge.

Science can be seen as a model-building enterprise, because it attempts to produce abstractions of reality that help scientists understand the world (Little 1994). Technological advances in computing allow for the development of complex computer-based models in a wide range of fields. These models can be used to describe phenomena observed in the world as well as to provide structure to real or hypothetical experiences described or postulated by individuals or groups. Models play a very important role in formalizing and integrating theoretical principles from science that pertain to the phenomena being studied. For example, the computational models used for weather forecasting integrate scientific principles from a variety of the physical and natural sciences.

As the role of models within society increases, the significance of ethical issues related to the development and use of models also rises. Models are generally designed by experts who may hold privileged positions, yet model users and those affected by models may cover a wide demographic range. Thus, it is ethically imperative that researchers consider the relationships among the modeler(s), the model, the user(s), and those affected by the model.

Models may be developed for a range of purposes, in a variety of domains, including research, education, and applications. This entry begins with a brief overview of the ethics of modeling in each of these domains. The next focus is on ethical issues that span all three domains. Finally, the conclusion provides an assessment of the current status of the ethics of modeling.

Ethics of Modeling in Research

Models play an important role in scientific and engineering research. Scientific researchers seek to better understand the world, and models can serve as a way for them to create these understandings. Engineers try to improve the world by creating new technologies, and modeling allows them to explore their ideas in the abstract before moving on to the concrete. Computer aided design is one example. This technology allows an engineer to create a model design and view the resulting product in a three-dimensional graphical representation. This creative process can be repeated many times with various participants before the physical prototype is produced. In both science and engineering, models serve as tools for understanding the world and the ways in which people can improve that world.

One important ethical issue of modeling in research is the relationship between modeling and the norms of science. John Allison and colleagues (1994) argue that the fundamental ethic of science is an assumption of openness and access to data and methodology that fosters repeatability and verifiability. Yet, they point out that science increasingly relies on proprietary databases that do not allow others to repeat or verify the studies, such as economic analyses that use corporate financial data. They assert that models in this context may pose a danger to society, unless their data and methodology are kept open, as has been overwhelmingly the case over the long history of scholarly scientific research. Thus, it is important to consider not only the ends to which modeling is used in research but also the means through which it is used.

One way to ensure that models for research are used ethically is to develop a code of ethics for modeling within a particular domain of research. Saul I. Gass (1994) explores the codes of ethics for various research fields and organizations. He concludes that a uniform code of ethics should be developed so that researchers within a wide range of specialties can benefit from it.

Ethics of Modeling in Education

Another important use of modeling is for instruction. In education, models can be used to help students better understand a problem. Manipulation of the model—whether it is a formula, a plastic mock-up, or a computer simulation—helps students develop a better understanding of the problem at hand. Similarly, models can be useful in training, potentially allowing trainees to practice techniques and skills in a relatively risk-free environment.

Barbara Y. White and John R. Frederiksen (2000) argue that computer-based models are particularly important in education because they make scientific inquiry potentially accessible to all students. They assert that computer-based models can help students develop the conceptual models necessary for scientific inquiry. These tools allow students to experiment with models in order to better understand naturally occurring relationships captured by theories in physics or other academic subjects. White and Frederiksen further argue that students should be able to use computers not only to learn to apply models but also to create models and understand the principles behind modeling natural systems. Modeling in education can thus include both learning to build models and learning to use models.

Perhaps one of the most ethically intriguing applications of modeling is the use of virtual reality in education and training. Virtual reality models have been used to train and evaluate doctors, pilots, and other professionals. The goal of such models is to provide a safe environment that mirrors the work environment in potentially all ways except the consequences of the actions taken in the simulated environment. One issue requiring further study is the role that consequences play in affecting actions, and consequently, the potential utility of such environments. Another issue is that virtual reality environments may become so realistic that it becomes difficult or impossible to distinguish between the actual situation and the model of it. In such cases, transparency may be one way to avoid ethical dilemmas. Thorough documentation of the model, delineation of the assumptions the model makes about reality and values, and an explicit representation of the components of the model and how they are linked are all ways to help ensure the transparency of the model.

Ethics of Modeling in Applications

Modeling may also be used in a wide range of applications. Computational models have contributed to developments such as Dupont's discovery and use of ozone-friendly chemicals (Hoffman 1995), structures than can better withstand earthquakes (Booker 1994), and innovations in nanotechnology (Bozman 1993). Computational models are also increasingly being used for public policy-making (Kollman et al. 2003), and as a result they are receiving an increasing degree of attention in the popular press (see for example Ashley 2003). One major application of models is as aids for decision-making. Models used for decision-making may be either primarily descriptive or prescriptive—that is, they may attempt to portray reality as it is or reality as it should be. Neither of these tasks is as simple as it might seem. The design of both descriptive and prescriptive models is influenced by the perspectives of the participants, and thus it requires transparent communication and consensus between the builder(s) of the model and the user(s) of the model (Wallace 1994).

The relationship between the model builder(s) and model user(s) is inherently problematic. John D. C. Little (1994) describes six pitfalls for modelers to avoid:

(1) The user already knows the answer and wants to use the model as a justification for it.

(2) The user wants quick answers and does not give the modeler time to do a thorough study.

(3) The user does not understand the basis for the modeler's results and thus is uncomfortable about using the model.

(4) The user wants a defined, black-and-white outcome from the model.

(5) The user is allowed to put her or his own personal judgments into the model.

(6) The user does not realize that all models are incomplete.

Modelers must find ways to avoid these pitfalls that result from misinformed or misbehaving users.

Deborah G. Johnson and John M. Mulvey (1995) identify three types of relationships between modelers and users. First, they discuss a paternalistic relationship in which the modeler acts as an unquestionable expert with total control of the relationship. Next, they explore a second way of understanding this relationship, the agency model, in which the user has the upper hand in the relationship, and the modeler is merely an implementer of the user's will. They reject both of these views as being unbalanced and failing to ensure that both sides strive to fulfill their roles. They conclude that the fiduciary model is the ideal model for the relationship between the modeler and the user, because under this model, the user and the modeler work together to construct the model and the user's expectations for the model.

Ethical Issues that Connect Modeling in Research, Education, and Applications

In each of these three domains of research, education, and applications, models can be used to either help or replace humans. Models used in research may either assist researchers or take over for them. Educators may either use models or be supplanted by them. Finally, in applications such as decision-making, models may either support human decision makers or automate their roles. Given this stark choice, it is important to consider the ethical implications of both models that help humans and models that replace humans.

Mulvey (1994) argues that models that are used to replace humans, which he refers to as "computerized decision procedures," are ethically problematic because they can easily be misused or abused. Intentional manipulation of a model may be used to serve the will of those that control it, who are often the elites within a society. Thus, models intended to replace humans may be used in antidemocratic and authoritarian ways.

Vincent P. Barabba (1994) points out, however, that models used by humans can also be misused and abused. A model can, for example, be oversold, so that limitations in the accuracy, precision, or scope of the model are underemphasized or completely ignored. In this way, models used by humans may also be used by elites to ensure that their will is achieved.

It is thus important to consider the power dimensions of models and modeling. As discussed above, there are a range of possible relationships between modelers and users, and the best type of relationship appears to be a fiduciary relationship whereby modelers and users each have both responsibilities and expectations as part of the modeling process. It is important that steps are taken to regulate this relationship, to avoid unethical behavior on either side of the transaction, and to ensure the best outcomes for both modelers and users, as well as for those affected by the model (Leet and Wallace 1994).

Models also present other ethical challenges. Models are designed to make reality more easily understandable, yet these same models may, intentionally or unintentionally, distort reality in important ways. Models may be used to make very value-laden decisions appear "scientific" and "objective." In building and using models, it is thus important to understand their limitations as well as the cultural specificity of the knowledge content and values that are explicitly and implicitly embedded in models (Leet and Wallace 1994).

Assessment of Ethics of Modeling

Richard O. Mason (1994) argues that modelers, as a part of their fiduciary relationship with users, have a professional responsibility for the models they build. To meet this professional responsibility, a modeler must fulfill two covenants: a covenant with reality and a covenant with values. The covenant with reality involves technical and social elements: The faithfulness of a model to reality often depends on highly technical decisions by the modeler, yet it is also a fundamental part of the relationship between the modeler and the user. According to the covenant with values, a modeler must understand and incorporate the user's values into the model in an effective way. These covenants are particularly important because a successful model may become a standard that affects a wide range of users and people affected by the model (see also Carrier and Wallace 1994).

In addition, it is important for the modeling process to be as transparent as possible. Because models always reflect the social and cultural context in which they are created, in both their knowledge content and values, it is most helpful if the model is open and honest about these influences. Models that contain assumptions should make these assumptions clear, rather than masking them as fact. Similarly, the extent to which a model is descriptive or prescriptive should be made immediately obvious to the user. Importantly, allowing the user to see clearly into the model is a way for the modeler to share control and responsibility with the user, allowing the user to make informed decisions based on all relevant data, rather than placing blind faith in a black box.

These three covenants—the covenant with reality, the covenant with values, and the covenant with transparency—can all help modelers and users communicate optimally so that they can mutually benefit from the process of modeling. All three covenants are important, because they make clear what users should be able to expect from designers, allowing designers and users to work as partners. Such cooperation ensures that modeling will be used for ethically responsible uses within the domains of science and technology.

WILLIAM A. WALLACE
KENNETH R. FLEISCHMANN

SEE ALSO *Georgia Basin Futures Project; Operations Research.*

BIBLIOGRAPHY

Allison, John; Abraham Charnes; William W. Cooper; and Toshiyuki Sueyoshi. (1994). "Uses Of Modeling in Science and Society." In *Ethics in Modeling,* ed. William A. Wallace. Tarrytown, NY: Pergamon. These authors address the question of the contribution and interpretation of models affects decisions.

Ashley, Steven. (2003). "Alloy By Design." *Scientific American* 289(1): 24. This brief article documents how the use of computational models led to the invention of a new class of titanium-based alloys, which are now used in medical implants, eyeglasses frames, and spacecraft parts.

Barabba, Vincent P. (1994). "The Role of Models in Managerial Decision Making—Never Say the Model Says." In *Ethics in Modeling,* ed. William A. Wallace. Tarrytown, NY: Pergamon. Barabba propounded Barabba's Law ("Never say the model says!") and discusses ways to limit model builders from making excessive claims for their models.

Booker, Ellis. (1994). "Working Toward a Quake-Proof Design." *Computerworld* 28(5): 86. Describes how computational modeling in an interdisciplinary environment is being applied to the problem of predicting the damage that can result from earthquakes.

Bozman, Jean S. (1993). "Tiny Technology: The Small World of Nanotechnology Opens Possibilities for Molecular Computing." *Computerworld* 27(31): 28. Touches on applications of computational modeling to nanotechnology.

Carrier, Harold D., and William A. Wallace. (1994). "An Epistemological View of Decision Aid Technology with Emphasis on Expert Systems." In *Ethics in Modeling,* ed. William A. Wallace. Tarrytown, NY: Pergamon. Discusses the philosophical foundations of statistics, operations research, and expert systems. Presents a framework to aid decision makers in choosing an appropriate decision technology for solving a particular problem.

Crapo, Andrew; Laurie B. Waisel; William A. Wallace; and Thomas R. Willemain. (2000). "Visualization and the Process of Modeling: A Cognitive-Theoretic View." In *Proceedings KDD-2000: The Sixth ACM SIGKDD International Conference on Knowledge Discovery and Data Mining, Boston, MA,* ed. Raghu Ramakrishnan, Sal Stolfo, Roberto Bayardo, and Ismail Parsa. New York: Association of Computing Machinery. This paper provides a description of the process of modeling and, based upon theories of cognition, shows how visualization can assist in developing computational models for very large, high dimensional datasets.

Gass, Saul I. (1994). "Ethical Concerns and Ethical Answers." In *Ethics in Modeling,* ed. William A. Wallace. Tarrytown, NY: Pergamon. Offers guidelines for professional behavior by modelers.

Hoffman, Thomas (1995). "Making A Difference: Say Goodbye To Ozone-Wrecking Chemicals." *Computerworld* 29 (23): 105. Explains how computational modeling techniques have been used since the 1970s to explore the environmental impacts of ozone-depleting chloroflurocarbons.

Johnson, Deborah G., and John M. Mulvey. (1995). "Accountability and Computer Decision Systems." *Communications of the ACM* 38(12): 58–64. Focuses on the issue of accountability in the design of computer decision systems. Argues that it is important for the designers of computer decision systems to develop and adhere to a set of standards in order to increase public trust in these systems.

Kollman, Ken; John F. Miller; and Scott E. Page, eds. (2003). *Computational Models in Political Economy.* Cambridge, MA: MIT Press. Contains a variety of applications of computational modeling to the fields of political science and economics.

Leet, Edith H., and William A. Wallace. (1994). "Society's Role in the Ethics of Modeling." In *Ethics in Modeling,* ed. William A. Wallace. Tarrytown, NY: Pergamon. Discusses the proposition that values are inherent in any model, and offers suggestions on how to ensure users are cognizant of this fact.

Little, John D. C. (1994). "On Model Building." In *Ethics in Modeling,* ed. William A. Wallace. Tarrytown, NY: Pergamon. Reviews the process of modeling and notes several "pit falls" that can waylay the model builder.

Mason, Richard O. (1994). "Morality and Models." In *Ethics in Modeling,* ed. William A. Wallace. Tarrytown, NY: Pergamon. Presents three covenants that should guide the relationship between the model builder and the user.

Mulvey, John M. (1994). "Models in the Public Sector: Success, Failure, and Ethical Behavior." In *Ethics in Modeling,* ed. William A. Wallace. Tarrytown, NY: Pergamon. Focuses on the interpretation of models and the fact that lack of understanding of the techniques used in modeling hinders a user's ability to ascertain the values inherent in the models.

Tersine, Richard J., and Edward T. Grasso. (1979). "Models: A Structure for Managerial Decision Making." *Industrial Management* 21(2): 6–11. Presents a very comprehensive classification scheme for models.

Wallace, William A., ed. (1994). *Ethics in Modeling.* Tarrytown, NY: Pergamon.

White, Barbara Y., and John R. Frederiksen. (2000). "Technological Tools and Instructional Approaches for Making Scientific Inquiry Accessible to All." In *Innovations in Science and Mathematics Education: Advanced Designs for Technologies of Learning,* ed. Michael J. Jacobson and Robert B. Kozma. Mahwah, NJ: Erlbaum. The authors use

the example of physics education to explore how modelng can shape student involvement in science.

MODERNIZATION

Modernization is a slippery term with manifold relations to science and technology. In a narrow sense, it is often synonymous with bringing more advanced science or technology to bear, as in modernizing a construction process or production plant. In a broader sense, social scientists describe modernity as a particular form of culture or society dependent on and supportive of science and technology, with the process of creating such a society defined as modernization. (Related concepts are *urbanization,* the concentration of population into cities, and *secularization*, the recasting of society from a basis in religious beliefs to one based on rationality, science, and technology.)

Insofar as modernization in the broader sense connotes an undermining of traditional values and is presented as a program with its own normative character, it is also of ethical significance, and has been assessed in both positive and negative terms.

Modernization is a somewhat more neutral term for a concept known in the nineteenth century as the "civilizing" process, and during the first half of the twentieth century as "Westernization." The term gained widespread currency in the 1950s, but began attracting substantial criticism during the 1960s.

Positive Assessments

In social, economic, and political theory, modernization is characterized by the achievement of industrialization, high urbanization, secularization, and rationalization. In a 1983 essay submitted for a symposium on Cultural Identity and Modernization in Asian Countries at Japan's Kokugakuin University, Robert M. Bellah analyzed the tension between tradition and modernization, then noted that when these forces successfully collaborate, the results may be remarkable: "A viable tradition should continue to guide individuals and societies in their quest for what is truly good, and modernization should simply supply more effective means for that quest" (Bellah 1983, Internet site). Bellah concludes that although the marriage of tradition and modernization is often over-stated, "the amazingly successful economic modernization" of Japan and the Pacific Rim countries is largely due to "[t]he spirit of the people, their work ethic, their social discipline, their ability to cooperate . . . all . . . more or less rooted in one or another aspect of the tradition."

The Cold War vision of modernization as a weapon against the spread of Communism strongly differed from this vision of a consensual and beneficial partnership between tradition and the modern. In an influential 1968 article, Samuel Huntington urged "forced-draft urbanization and modernization which rapidly brings the country in question out of the phase in which a rural revolutionary movement can hope to generate sufficient strength to come to power." Rather than basing modernization on the consent of the governed, Huntington posited that less developed nations could be dragged into modernity—an approach applied in the Strategic Hamlets Program in Vietnam, where populations were forcibly removed at gunpoint to new "modern" surroundings, and their old homes burned.

Thus, proponents of modernization saw the process in two entirely different lights: one as a good that could be forced on subjects regardless of their wishes, and the other as a consensual step, greatly desired by the participants, toward participation in "a world of industrial, competitive nations interacting in a capitalist, free-trade, global framework" (Adas 2003, p. 37).

Critical Assessments

While modernization sounds more neutral than a phrase such as "Westernization," critics complain that it nonetheless carries with it substantial Western baggage. Modernization assumes that the sole criteria of success of a society are gross national product (GNP) and the degree of industrialization. Underlying the theory of modernization is an almost entirely unexamined premise that all other nations should seek to imitate the West, and particularly the United States.

The process of modernization has been described as a cover for the introduction of capitalism without regard for the well-being of local populations. Rather than elevating all nations to equal opportunity participation in free markets, thereby lifting their citizens to higher living standards, critics say that modernization leads perversely to increased impoverishment and greater dependency of former colonies. "Modernization and development have previously been built on considerable exploitation of certain segments of the society and have involved a degree of ruthlessness. Imperialism aided them substantially" (Dube 1988, p. 5). Modernization, of course, also brings with it the glitches experienced by Western capitalist nations, including cycles of recession, inflation, and unemployment.

Other critics question whether it is really an absolute good to eliminate diversity and make people the same everywhere. Ironically, modernization, like Marxism, holds that there is a universal historical process in which "a single modernity" will eventually emerge (Gilman 2003, p. 56).

Modernization has also been said to be based on the premise that science and technology can solve all human problems, rendering unnecessary any specific consideration of ethical implications of their introduction. Yet high technology may lead to high unemployment in third world countries, and therefore modernization theory needs to be modified by the addition of an ethical element, wholly lacking from the work of most writers on the topic. One view is that science and technology should specifically be used to address "social needs . . . tempered with distributive justice" (Dube 1988, p. 32).

The countervailing forces to modernization include fundamentalism, anomie, violence, decay of norms, and the dysfunction of social institutions. Aslam Siddiqi offers an interesting critique from a Third World and Islamic perspective in a 1974 work; he says that modernization is an essentially materialistic concept lacking higher ethical value. "Human personality has no sanctity . . . Abundance of goods is its greatest achievement, and hedonism is the proper way of life" (p. 13). Siddiqi does not propose the rejection of science and technology, but instead says that it is necessary to "identify the framework for society and to find accommodations between modernization and Islamic requirements" (p. 194).

Conclusion

The term modernization is invested with meanings that are better unpacked and examined individually, to see what assumptions are necessary to support them. While in the early twenty-first century, few people argue that a decentralized, agrarian, low-technology way of life is preferable, there is a consensus that development has moral implications that require close analysis and planning.

JONATHAN WALLACE

SEE ALSO *Building Codes; Development Ethics; Enlightenment Social Theory; Green Revolution; Industrial Revolution; Secularization; Sustainability and Sustainable Development; Urbanization.*

BIBLIOGRAPHY

Adas, Michael. (2003). "Modernization and the American Revival of the Scientific and Technological Standards of Social Achievement and Human Worth." In *Staging Growth: Modernization, Development, and the Global Cold War,* ed. David C. Engerman et al. Amherst: University of Massachusetts Press.

Dube, S.C. (1988). *Modernization and Development: The Search for Alternative Paradigms.* Atlantic Highlands, NJ: Zed Books.

Gilman, Nils. "Modernization Theory, the Highest Stage of American Intellectual History." In *Staging Growth: Modernization, Development, and the Global Cold War,* ed. David C. Engerman et al. Amherst: University of Massachusetts Press.

Huntington, Samuel (1968). "The Bases of Accommodation." *Foreign Affairs* 46(4): 642–656.

Siddiqi, Aslam. (1974). *Modernization Menaces Muslims.* Lahore, Pakistan: Sh. Muhammad Ashraf.

INTERNET RESOURCE

Bellah, Robert M. (1983). "Cultural Identity and Asian Modernization." Available from http://www2.kokugakuin.ac.jp/ijcc/wp/cimac/bellah.html.

MONDRAGÓN COOPERATIVE CORPORATION

The Mondragón Cooperative Corporation (MCC) is composed of a group of industrial, retail, service, and support cooperatives primarily in the Arrasate-Mondragón valley in the Basque country in Spain. Many scholars have studied Mondragón as a strong example of an industrial cooperative with a longstanding and successful history. From the beginning the MCC has, in its own words, strived for: (1) openness to all; (2) democratic organization; (3) recognition of the importance of work; (4) making capital instrumental and subordinate (people over capital); (5) participatory management; (6) minimal salary differentiation; (7) cooperation with other cooperatives; (8) transformation of society; (9) nondiscrimination in terms of gender, religion, and political affiliation; and (10) education and training for all.

It is a widespread belief among sociologists and economists that an association of producers that tries to develop an alternative to the capitalist model is destined to abandon democratic principles or fail economically. The success of Mondragón challenges this view. Since the first Mondragón cooperative was founded in 1956, the group has grown and continuously increased its profits. In the process it has maintained its cooperative structure almost unchanged. In 2002 the MCC was the seventh largest business group in Spain with a net worth of more than 15 billion euros. In 2003 it

employed more than 66,000 people in 120 firms of three types: financial, industrial, and distribution. The financial group includes the banking activities of Caja Laboral and a social welfare entity, Lagun Aro. The industrial group includes seven divisions: automotive, components, construction, industrial equipment, household appliances, machine tools, and engineering capital goods. The distribution and sales group consists of consumer cooperatives such as Eroski.

History

The project started in 1943 when a newcomer to the area, a young and unorthodox Catholic priest, José María Arizmendiarreta, decided to create a technical school in Mondragón in order to offer new opportunities to young people who had no access to that type of education. Arizmendiarreta never became a member of a cooperative but took part in most of the crucial decisions regarding the MCC project. The technical training school was registered legally in 1948. Eleven of the students in the first class went to the University of Zaragoza to study industrial technical engineering. In 1955 five of them bought a bankrupt firm that had produced heaters and stoves in Vitoria and moved that firm to Mondragón a year later. The firm eventually became Fagor, which was converted to a cooperative in 1958 and in the early twenty-first century is the largest producer of household appliances in Spain.

In 1959 the Caja Laboral Bank was formed with a double aim: to promote savings and to channel funds into other developing cooperatives. In the same year the social welfare entity Lagun Aro was set up to solve the problem of pensions. Because the government considers them owners, not workers, members of cooperatives cannot be covered by Spain's social security system.

In 1969 the technical school officially became an industrial technical engineering school. The distribution cooperative Eroski was formed in that year. Ikerlan, the first technological research center of the MCC, was started in 1974.

In the late 1970s the organization became more complex, setting up so-called local groups, which bring together sets of cooperatives to do combined activities and optimize results. Beginning in the 1980s, the group increased exports and formed trade missions, and by 2003 it had constructed factories in sixteen other countries. The Caja Laboral has expanded throughout Spain, and Eroski commercial centers and megastores compete successfully with those of multinational firms. In 1990 the group officially became a corporation, and the businesses were organized by sectors rather than geographically.

Throughout its history an important value for Mondragón has been education, both technical and cooperative. In 1997 the University of Mondragón was established, combining all the cooperatives devoted to education: the three industrial technical engineering schools (Mondragón, Txorrieri and Lea-Artibai); Eteo, which is dedicated to business management and administration; and the University College for Teaching.

Another goal of the MCC is to produce its own technological knowledge. In addition to the university the MCC has formed several research centers: Ikerlan, Ideko, Maier Technology Center, Ahotec, Orona EIC, the Business and Organizational Management Research Center (MIK), Modutek, Koniker, and Lortek. In 2002 the Garaia Project developed a research network linking the university, the research centers, and the firms. The objective was to foster the kind of technological knowledge that the cooperatives consider key to their success.

Critical Reactions

Many scholars have tried to explain the extraordinary success of the Mondragón project from different perspectives. Some have seen Arizmendiarreta as a far-sighted leader whose decision-making ability was crucial. Others have pointed to a prior industrial and cooperative tradition in the area. As a result of these and other specific aspects Mondragón often has been presented as a unique experience that would be impossible to reproduce in other places.

A controversial aspect of Mondragón is its supposed relationship with the Basque nationalist movement. The Mondragón area is, along with many others in the Basque country, markedly nationalist, and for this reason it often has been suspected that the MCC has received favorable, protectionist treatment from the regional Basque government, which has always been in the hands of the nationalists. These suspicions have never been substantiated, and it is important to remember that the MCC first developed and achieved economic success during the earlier Spanish dictatorship.

An important problem has resulted from the growth of the cooperatives: Some of them, especially Eroski, require an increasing number of hired employees who are not members of the cooperative. This clearly contravenes the original ideals of the MCC and could be interpreted as leading to a transformation of the cooperatives into firms with a less democratic structure. However, MCC researchers are studying ways to incorporate those workers into the cooperative system.

ANA CUEVAS BADALLO

SEE ALSO *Affluence; Business Ethics; Work.*

BIBLIOGRAPHY

Bradley, Keith, and Alan Gelb. (1983). *Cooperation at Work: The Mondragón Experience*. London: Heinemann Educational Books. Economic analysis.

Kasmir, S. Sharryn. (1996). *The Myth of Mondragón: Cooperatives, Politics, and Working-Class Life in a Basque Town*. Albany: State University of New York Press. Argues that democratic government is not as ideal as claimed.

Whyte, William Foote, and Katheleen King Whyte. (1991). *Making Mondragón: The Growth and Dynamics of the Mondragón Cooperative Complex*, rev. edition. Ithaca, NY: ILR Press. Best source, by a well-known sociologist and his wife.

INTERNET RESOURCE

Mondragón: Corporación Cooperativa. Available at http://www.mcc.es. Translations include English, French, Spanish, and German.

MONEY

The term *money* derives from the Latin *moneta*, meaning mint or coin, and is most often defined as a medium of exchange and measure of value. Even from its earliest use as a replacement for barter, money was often a technologically produced metal coin and thus associated with developments in the science of metallurgy and metal technology. In the *Nicomachean Ethics* (350 B.C.E.), Aristotle (384–322 B.C.E.) offers a first glimpse of the ethical implications of money as technology when he rejects moneymaking as the proper end of human life on the basis that it has only instrumental value. With the rise of modern scientific economics came efforts to formulate monetary policies for states, and the use and management of money became more closely associated with science, technology, and normative issues. All this is underscored by the German philosopher-sociologist Georg Simmel (1858–1918) who identifies money as the pivotal technological tool that paved the way for the modern technological approach to the world.

Historical Considerations

One of the earliest forms of money was cowrie shells (c. 1200 B.C.E.); based metal (1000 B.C.E. in China) preceded precious metal (700 B.C.E. in the Middle East) coinage. At least as early as Aristotle, whose views have influenced classical and modern discourses on the topic, money was recognized as a medium of exchange and measure of value. Initially simple bartering had sufficed because the goal was subsistence. But even in barter, precise equivalences between bushels of wheat and a cow or a physician's services are difficult to determine, so that questions arose about how to determine a fair exchange or just price. Again in the *Nicomachean Ethics*, Aristotle contends that the just price of a technological product is determined by proportion, with the anchor of proportionality being the status of the producers, as when the shoemaker's product is to the farmer's as the farmer is to the shoemaker. In the *Politics* (350 B.C.E.), he describes how money, usually in the form of precious metals, facilitated exchanges between parties who could not engage in direct transactions. This function of precious metals was further enhanced when they were minted and embossed to attest to their monetary value—generally in excess of the use-value of the metals themselves. With paper or representative money, the disparity between use-value and monetary or exchange value becomes even more pronounced. For Aristotle, the use of money is *contrary to nature* when the exchange is for profit rather than subsistence. The function of money is distorted when it becomes an end-in-itself and the primary measure of wealth.

In the modern period, Adam Smith (1723–1790) continues to distinguish between money and genuine wealth, but goes on to argue that the desire for profit and personal advantage promote private and public good. The profit motive, free competition, and an advanced division of labor that includes the development and use of technology, work together to increase productivity and fuel a "universal opulence which extends itself to the lowest ranks of the people" (Smith 2000, p. 12).

Influenced by Smith, David Ricardo (1772–1823) initially agrees that advances in machine technology benefit all parties—landholders, capitalists, and laborers—but is less sanguine about the alleged advantages for laborers. He eventually concludes that machine technology and labor are in competition and that increased use of the former is often detrimental to the latter. This is by itself insufficient reason to jettison *laissez-faire* principles, for, as Ricardo sees it, government intervention to curtail the use of machine technology to fend off unemployment actually has the opposite effect of driving capital investment offshore and eventually destroying the domestic labor market.

Karl Marx (1818–1883) agrees with Aristotle that legitimate exchange binds human beings together, whereas the profit motive drives them apart. He goes beyond Aristotle, however, when he insists that money is an insurmountable obstacle to genuine human community. In his *Economic and Philosophic Manuscripts of 1844* (1932), Marx argues that money alienates human beings from themselves, from the fruits of their labor, and from each other. In short, money subverts the natural order of things and turns the world upside-down. A return to an authentic mode of human (that is, communal) existence requires the rejection of both private property and money. Only then can one take an optimistic view of the impact of technology on human life. After all, technology has the potential to liberate energy normally expended to obtain the material necessities of life—energy that, once freed, may be redirected toward human cultivation and refinement.

The appearance in 1936 of *The General Theory of Employment, Interest, and Money* by John Maynard Keynes (1883–1946) precipitated a revolution in economics by assigning government a significant role in the economic affairs of free-market states. While the *laissez-faire* approaches of Smith and Ricardo allowed for modest and minimal government involvement in economic matters, Keynes articulated a theory whereby government bears major responsibility for the overall economic health of a nation. According to Keynes, adroit and judicious government intervention in setting fiscal and monetary policies, spending on public works to boost a sluggish economy, and supporting technological innovation would, generally speaking, stabilize the economy, increase productivity, and foster full employment. The implicit conviction is that eliminating involuntary unemployment and poverty would reduce, if not cure, many of the social ills endemic to failed economic environments.

Keynes's intention was to improve the "technique of modern Capitalism," and he did not challenge the capitalist "dependence upon an intense appeal to the money-making and money-loving instincts of individuals as the main motive force of the economic machine" (Keynes 1963, p. 319). Keynes nonetheless speculates about a day when economic issues will no longer matter. The basic needs of human existence will be met, leisure will be filled with noneconomic activities, and the "love of money as a possession—as distinguished from the love of money as a means to the enjoyments and realities of life—will be recognised for what it is, a somewhat disgusting morbidity, one of those semi-criminal, semi-pathological propensities which one hands over with a shudder to the specialist in mental health" (Keynes 1963, p. 369). With this assessment of the *true value* of money, Keynes, who was arguably the most influential economist of the twentieth century, joined forces with Aristotle and to some extent Marx.

Building on but criticizing Keynes, Milton Friedman (b. 1912) developed a theory of money that argues for measured control of the money supply as a better means than stimulus over the long term. Of course, for both Keynes and Friedman money has become an increasingly abstract phenomenon, far removed from the traditional technologies of coinage and representative money into fiat and credit money that are tied up with new technologies of plastic, computers, and information transfers.

Money and Technology

With the Industrial Revolution, money began to play a central role in the production, exchange, and consumption of all goods and services. During the same period, economic growth became increasingly dependent on and intertwined with technological developments requiring significant capital investment. In other words, money must not lie fallow. The supply of money must be directed at consumption and/or investment. The question is whether money, as a means to an end, is simply a benign technological device requiring no special caution by the user.

Simmel's consideration of money as the *purest form of the tool*, a *pure instrument*, is instructive here. His *Philosophy of Money* (1900) seeks to extrapolate from the "surface level of economic affairs a guideline that leads to the ultimate values and things of importance in all that is human" (Simmel 1978, p. 55). To that end, Simmel pursues two lines of inquiry—the subjective preconditions of economic life and the consequences of using money as the medium of exchange. In this latter inquiry, Simmel formulates his critique of modern technological society.

For Simmel, money enhances human freedom, but this freedom has a price. The overvaluation of money engenders a means-ends reversal whereby money is elevated to the status of an absolute end, while things that are ends-in-themselves are treated merely as means. It is not until money fails to function properly—for example, when money cannot even buy bread—that one remembers which of them has intrinsic value. Simmel also sees a causal connection between money and the modern technoscientific tendency to translate all qualities into quantities so that they can be quantitatively measured and assessed. "The ideal of numerical calculability has been made possible in practical and perhaps even in intellectual life only through the money economy" (Simmel 1978, p. 445). In other words, money is not neutral, and, like all technological artifacts, its use has both positive and negative consequences.

Despite the earlier connections between the exchange value of money and the material substances serving as money, the true nature of money and its socioethical implications cannot be derived from the material in which it is embodied. Just as money was introduced to facilitate bartering, paper money, checks, bank drafts, and credit cards were introduced to facilitate the use of money in commercial transactions. The socioethical implications of money derive from the impact that its use has on people's inner lives and their perceptions of the world.

Like Simmel, who argues that money transforms every quality into a quantity, Jacques Ellul (1912–1994), for instance, maintains in *L'Homme et l'argent* (Money and power) (1953) that the spiritual power of money transforms every relationship—be it to oneself, to others, or to the world—into one of buying and selling.

Whereas both Aristotle and early modern economists couched their analyses of the use and value of money in ethical and political terms, the view of economics as positive science often appears to treat technical economic issues independently of the broader ethicopolitical dimensions of social life. By embracing the goal of scientific objectivity, economics may obscure how the management of economic systems is never value-neutral. Of course, free market economists such as Friedman argue forcefully for a positive connection between money and freedom. Money, like all technological artifacts, has important ethical implications. While few in the early twenty-first century would seriously advocate its abolition, one should bear in mind that money surreptitiously shapes self-understanding and valuations of the world.

Naturally, there are people in the field of technology studies who defend the thesis that technology and, *mutatis mutandis*, money are inherently neutral with regard to ethicopolitical values. On this view, technologies are neither good nor bad and are steered in one direction or the other by values that are external to the technologies themselves. And even if one concludes that technologies are value laden, it does not necessarily follow that the relevant values and their consequences are negative.

JOHN E. JALBERT

SEE ALSO *Affluence; Business Ethics; Class; Work.*

BIBLIOGRAPHY

Davies, Glyn. (2002). *A History of Money: From Ancient Times to the Present Day*, 3rd edition. Cardiff: University of Wales Press. A thorough treatment of the history of money with interesting chapters on its early forms and uses. The author emphasizes the need for a broad understanding of money that includes its social and psychological dimensions.

Ellul, Jacques. (1984). *Money & Power*, trans. LaVonne Neff. Downers Grove, IL: InterVarsity Press. English translation of the 1953 French language *L'Homme et l'argent*.

Friedman, Milton. (1992). *Money Mischief: Episodes in Monetary History*. New York: Harcourt Brace Jovanovich.

Friedman, Milton, with Rose D. Friedman. (1962). *Capitalism and Freedom*. Chicago: University of Chicago Press.

Keynes, John Maynard. (1963). *Essays in Persuasion*. New York: W. W. Norton & Company. The general theory is arguably the most significant work in the history of modern economics. Keynes criticizes *laissez-faire* economics and argues for government intervention in the economic affairs of nations. Keynes's economic principles are put to work in the essays on public policy and political economy assembled in essays in persuasion. All are written in nontechnical language and easily accessible.

Keynes, John Maynard. (1997). *The General Theory of Employment, Interest, and Money*. Amherst, NY: Prometheus Books.

Marx, Karl. (1975). "Economic and Philosophic Manuscripts of 1844." In *Collected Works of Marx and Engels*, Vol. 3: 1843–1844. New York: International Publishers.

Marx, Karl. (1996). *Collected Works of Marx and Engels*, Vols. 35–37: *Capital*. New York: International Publishers. *Das Kapital* is required reading, if for no other reason than it is perhaps the most unyielding and influential critique of capitalism to date. In *Kapital,* Marx formulates his labor theory of value and explains profit in terms of the exploitation of laborers.

Ricardo, David. (1996). *The Principles of Political Economy and Taxation.* Amherst, NY: Prometheus Books.

Simmel, Georg. (1978). *The Philosophy of Money*, trans. Tom Bottomore and David Frisby. Boston: Routlege and Kegan Paul. A much neglected work that focuses on the influence of a money economy on social and cultural life. It supplements and provides helpful alternatives to Marx's interpretations of history, value, and alienation. It also directs attention to the positive relation between money and human freedom.

Smith, Adam. (2000). *The Wealth of Nations.* New York: Modern Library. No study of political economy is complete without the inclusion of smith's classic treatise on the subject. Anyone who wishes to understand the development of modern capitalism and the origins of *laissez-faire* economics would do well to begin here. Smith argues that an unregulated economy benefits all of the parties involved in the production, exchange, and consumption of goods.

MONITORING AND SURVEILLANCE

Monitoring is a general term that refers to the systematic, continual, and active or passive observation of persons, places, things, or processes. By contrast *surveillance* is used to indicate targeted monitoring of activities by police or security officials for specific evidence of crimes or other wrongdoing. Surveillance focuses on individuals, buildings and properties, or vehicles deemed suspicious on the basis of credible information that they are connected in some way to illegal or otherwise inappropriate activity. Surveillance operations carried out by investigators may: (1) be stationary or mobile in nature and require various types of monitoring technologies to enhance the visual or hearing capabilities of officers or operatives doing the surveillance; (2) involve recording of events, locations, days or times, and patterns of behaviors or activities; and (3) include monitoring of telephone or in-person conversations, as well as electronic correspondence such as E-mail or instant messaging notes exchanged between individuals or groups of people. Surveillance is usually carried out in covert ways and with legal authority.

Monitoring typically involves routine recording of activities to warn of trouble or for accounting purposes. Open public spaces such as airports, shopping malls, and other places where large numbers of people gather are monitored to help assure public safety and security. Surveillance is the targeted monitoring of people suspected of committing crimes or other civil wrongdoings. Examples of monitoring tools are smoke detectors and turnstile counters used to determine the number of subway passengers. In contrast, electronic building-access cards have a surveillance element because individuals can be held accountable for improper use of the device. Monitoring systems that are used also as surveillance devices include video cameras in commercial and public spaces. Electronic listening devices that are placed to record conversations of targeted people are surveillance tools. Point-of-sale systems that monitor inventory and customer buying habits may be ethically problematic, but the function of those devices does not have a surveillance aspect as that term is used in this entry.

Spying combines the arts and technologies of monitoring and surveillance along with active intelligence gathering and analysis in order to advance a government or corporate interest. Spying is often commissioned by secretive government agencies in the interest of national security, or by unscrupulous corporations intent on illegally discovering the secrets of competitors. Spying is covert in nature and, if exposed, may have negative legal, political, or financial repercussions for the agencies, corporations, firms, or individuals involved.

The differences between monitoring, surveillance, and spying mostly concern the purposes and sponsors of the activities, and the degree to which they are carried out in relatively covert versus overt ways. The same technologies that are used for monitoring (such as binoculars, night-vision equipment, and listening and recording equipment) can also be used for surveillance and spying. In general, monitoring technologies are used in relatively overt ways in many sectors of society, whereas in surveillance and spying, technologies are used primarily in covert investigations.

Monitoring Technologies in Society

Humans develop their knowledge of monitoring techniques and their skill in using monitoring technologies with age, experience, and training. From childhood, throughout adolescence, and into adulthood, humans combine cognitive skills with sensory perceptions in order to observe, monitor, interact with, and generally function within their environments. In so doing, people learn to decipher patterns, trends, and anomalies and thereby recognize what is ordinary versus unusual regarding places, things, and processes.

Safety and security, as well as efficiency and effectiveness (as in manufacturing processes), are premised on people knowing when things are out of place. For this reason, people are often monitored while driving in traffic, waiting in airports or train and bus stations, working in their places of employment, shopping in malls or detached retail stores, or as they are depositing or withdrawing money from automatic teller machines (ATMs) located at banks or other locations.

Monitoring technologies are combinations of simple and complex tools and techniques that facilitate routine and systematic observation, recording, and analysis of activities or processes in specific locations. Essentially they help people understand what is going on in a given environment. Monitoring technologies encompass a variety of communications, computing, electromechanical, imaging, robotics, and sensing devices and systems. These include but are not limited to closed-circuit television (CCTV) systems, global positioning and tracking devices, and metal or contraband detection devices. Monitoring technologies such as these may also include or integrate various combinations of alarms and warning systems that signal when something unusual occurs, or when a desired state or condition has been met.

Monitoring technologies are used by government agencies; by manufacturing, service, and other businesses; and in fields as disparate as agriculture (for crop and livestock monitoring), astronomy (to track movements of planets, comets, or asteroids), and meteorology (for monitoring and forecasting of weather and climatic patterns). They are used to observe many types of human activities and processes, such as vehicular traffic congestion on public roadways and commercial and military aircraft flight patterns, and to detect malfunctions in manufacturing processes. In medical fields, monitoring technologies are used to check the status of patients on treadmills and to signal problems experienced by those recovering from major surgery (Abrami and Johnson 1990).

Monitoring technologies are employed extensively in security and criminal justice situations (National Institute of Justice 2003). For example, law enforcement officers use all-weather camera systems to observe and record, and also to aid in dispatched responses to, suspicious activities. Intrusion and motion detectors are devices used to detect and signal several conditions. For example, excessive heat or cold indicator devices and warning alarm systems for foreign substances such as smoke, carbon dioxide, and radon are all used to promote safety and security. Virus detection software applications, which are often used in combination with firewalls, help insure computer privacy and security.

Similarly police use cameras mounted in their vehicles to remotely monitor or record interactions between themselves and motorists during traffic stops. Global information system monitoring technologies are used to keep track of the locations of emergency vehicles, or to monitor specific locations and movements of prisoners inside detention facilities or those on supervised release programs. These are just some examples of the various types of monitoring technologies and what they can be used for. In all these situations, monitoring technologies are intended to facilitate detection and warning of unusual and potentially unsafe or threatening behaviors, conditions, or developments.

History of Surveillance

Surveillance is the close observation of a person or group. While technology is not necessary to surveillance, certain technologies greatly facilitate it. Video and computer technologies, for instance, have made surveillance an important feature of modern societies. In many cities—London stands out—the average citizen is captured on video many times each day. Many shops use closed-circuit television to videotape customers and staff and to record transactions. Workplace surveillance is becoming common as well: According to an American Management Association (AMA) survey, "In 2003, more than half of U.S. companies engage in some form of e-mail monitoring of employees and enforce e-mail policies with discipline or other methods. . . . 22% of companies have terminated an employee for e-mail infractions" (AMA 2003, p. 1).

Following the lead of Michel Foucault (1977), many critics see modern societies as *panopticons*, tending toward Jeremy Bentham's model prison design in which each prisoner is kept under observation by invisible watchers. This metaphor reveals something about the history of surveillance as well as its ethics.

Historically, surveillance has been a labor-intensive undertaking. Bentham's prison was designed to enable a single guard to oversee many prisoners. Short of the severe constraint of a prison environment, this ratio is difficult to attain. For instance, following someone undetected on the street requires a team of several trained agents. Thus widespread covert surveillance of a population would be extremely expensive without technological augmentation. This is also true for reading large volumes of handwritten mail. In both cases, technology has offered possibilities. The automated searching of text, for example, has made it economically practical to read the E-mail of every employee in a firm.

The path of technological development can be expected to influence whether one is exposed to surveillance at a given time. Text is still easier to search than voice or video images. The situation is fluid, however, because technological development is rapid, especially given the widespread security concerns that followed the terrorist attacks of September 11, 2001.

Ethics of Monitoring

Increasingly affordable, interoperable, and compact technologies make possible and help to perpetuate the human desire and willingness to engage in the monitoring of virtually any activity, location, or process. In other words, monitoring technologies make ubiquitous watching possible. George Orwell popularized the fear of omnipresent monitoring and surveillance in his classic novel, *Nineteen Eighty-Four* (1949). Since the book was published, people in developed nations, particularly Americans (who have always been concerned about protecting privacy rights), have become increasingly anxious about the technology-enabled monitoring capabilities of their governments. But, notwithstanding concerns about privacy, widespread and even routine use of monitoring technologies for numerous purposes has become the norm. Indeed given growing worldwide concerns about crime and terrorism, use of sophisticated technologies to support legal surveillance by security and law enforcement officials, and even spying by government intelligence agencies, is often welcomed, if not actually deemed necessary, as a means of enhancing security and safety and reducing fear in both public and private places (SPIE 2002).

While responsible use of monitoring technologies is generally acknowledged as sensible and, therefore, is often encouraged in private property situations, the same is not true for public domains. Law enforcement use of monitoring technologies to observe open spaces is often met with strong criticism from the people who the police or security officials are trying to protect. Resistance to government watchfulness is rooted in the belief that even passive monitoring of public spaces impinges on the privacy and other rights of individuals and groups who are legally present or assembled and are doing nothing wrong.

The controversy and ethical dilemma is twofold. First, will the use of monitoring technologies in public spaces create a social-psychological atmosphere of intimidation versus promoting safety or well-being (Goold 2002)? Second, will increasing legal use of monitoring technologies by authorities lead to collective endorsement of such tactics that, if taken to the extreme, will create conditions resembling a high-tech police state akin to the Big Brother atmosphere conceived by Orwell in *Nineteen Eighty-Four*?

Ethics of Surveillance

Foucault's panopticon metaphor reveals something about the ethics of surveillance:

> The major effect of the panopticon was to induce in the inmate a state of conscious and permanent visibility that assures the automatic functioning of power. So to arrange things that the surveillance is permanent in its effects even if it is discontinuous in its action; . . . this architectural apparatus should be a machine for creating and sustaining a power relation independent of the person who exercises it. (Foucault 1997, p. 201)

Thus surveillance creates a new power relationship because those subject to it must always behave as if someone is watching, even if no one is.

While properly focusing on the strategic element in surveillance and pointing out the power differences between watcher and watched, this assessment exaggerates the situation. Though it is true that surveillance need not be continuous to be effective, those being watched have counterstrategies. The simplest is for them not to act as if they are always being watched.

Because surveillance is a dynamic process, unexpected consequences are likely. Consider, for example, radar for monitoring automobile speed, an early form of electronic surveillance. Naively one might think that equipping police with radar would lead all drivers to obey speed limits. But this expectation ignores the strategic element in the situation. Not every road that has a "Speed Controlled by Radar" sign is actually monitored—the police typically follow a mixed strategy and patrol only some of the signed roads. Drivers know this and do not always obey the speed limits. In addition, there are technological countermeasures: Sophisticated radar detectors are cheap and widely used. This situation leads to two kinds of ethical question. First, is this *technological arms race* efficient, once the cost of countermeasures and the failure to control speed completely is taken into account? Second, is surveillance radar fair? Does it catch anyone other than those too poor or naive to participate in the strategic game played out by law enforcement and drivers with antiradar equipment?

Other examples of counterstrategies include obstruction of video surveillance devices and using language ambiguities to confound text-based surveillance. Once the potential of counterstrategies is taken into account, the logic of surveillance goes beyond the panopticon. Most populations are not as confined as prisoners. Most surveillance, to be effective, needs the support of the majority of its subjects (Danielson 2005).

Consider how this plays out in three typical surveillance venues.

STATE AND PUBLIC SURVEILLANCE. Surveillance by agencies of the state is the most familiar model of surveillance. However the Big Brother image is probably out of sync with the practice in many modern technological societies where private surveillance is more prevalent.

State surveillance in democratic states requires public acquiescence. This tends to be forthcoming when events make a security rationale salient, as in states that fear a terrorist attack or experience a great deal of crime. Without this impetus, public outcry has forced liberal states to remove public cameras (e.g., Canada) or subject them to strict regulation (e.g., the United Kingdom).

THE WORKPLACE. Workplace surveillance is distinguished by two features. First, employees are contractually related to employers, so consent, or broad doctrines of implied consent, permit surveillance in the workplace that would be controversial in public places. There are, of course, conflicts over the line between permitted workplace surveillance and protected privacy at work. Surveillance of washrooms and other private spaces has caused controversy, as has intercepting and logging E-mail and personal web browsing.

Second, more computerized jobs expose more workers to surveillance. Computerized surveillance is inexpensive and indiscriminate. New, cheap technologies tend to get overused, beyond their practical and ethical justification. Practically, unwelcome surveillance can undermine employee morale, destroying organizational goals. Ethically, privacy is the value most at risk. For example, widely deployed wireless surveillance cameras effectively broadcast whatever information they pick up, creating an opening for outside interception. This threat is increased by the recent introduction of inexpensive web-based and cell-phone-based cameras.

COMMERCIAL AND INDIVIDUAL SURVEILLANCE. Examples of commercial, individual applications range from the convenience store video camera to the *nanny-cam* installed to watch children and caregivers. Because the technology deployed in these contexts is quite primitive, there are additional risks to privacy and other values. In addition, the increased use of surveillance technology in the home challenges traditional lines between public and private spaces (Nissenbaum 1997). People expect to be observed in public and at work—and adjust their behavior accordingly—but this expectation does not exist for private spaces.

Assessment

The ethics of surveillance is best developed for the workplace. Overall there are three main lessons. First, legitimacy makes a difference by avoiding unwelcome surveillance and lowering the costs of countermeasures. Consent and, as a precondition, education about the technology are obvious ways to increase legitimacy. Second, the ethical risks of surveillance should be conveyed to would-be users, which, hopefully, would limit use to more serious cases. Third, more explicit norms against the incursion of surveillance technology into private spaces may be necessary.

People who object to increased monitoring suggest that quality of life will be unduly, negatively affected by the mere presence of cameras and tracking and recording devices, and that even if people do not have a legal right and expectation of privacy in open spaces, social interactions, unfettered spontaneity, and being able to feel as though one is not being watched are qualities of life that ought not be compromised. Further, if left unchecked, increasing use of monitoring technologies will undermine the freedoms of speech, movement, association, assembly, and religion. Supporters of monitoring usually point out that such devices provide effective deterrence against crimes or other inappropriate conduct, as well as a means to respond to, interdict, and if legally appropriate, apprehend violators. Supporters also point out that the mere presence of cameras and recording devices can make people feel safer, and that persons obeying the law have nothing to hide or fear because police and security officials exist to provide protection and can be held accountable for illegal or inappropriate use of their powers.

Ethical use of monitoring technologies by anyone hinges on circumstances under which people have an expectation of privacy. In general, U.S. courts have ruled that citizens and residents have constitutionally based privacy protection in their homes and other privately owned places. People have considerably less, or no, expectation of privacy, however, as students in private or public schools, in places of employment, or in open spaces or other public places. Proper use of monitoring technologies by private individuals, firms, corporations, or government authorities can improve or lessen quality of life from the standpoint of privacy versus safety and security, and also enhance the quality of manufactured products. Ultimately what constitutes proper use of monitoring technologies is a matter to be resolved on ethical, legal, social, and economic grounds.

SAMUEL C. MCQUADE III
PETER DANIELSON

SEE ALSO *Internet; Privacy; Telephone.*

BIBLIOGRAPHY

Abrami, Patrick F., and Joyce E. Johnson. (1990). *Bringing Computers to the Hospital Bedside: An Emerging Technology.* New York: Springer Publishing.

Bentham, Jeremy. (1969). "Panopticon Papers." In *A Bentham Reader,* ed. Mary Peter Mack. New York: Pegasus.

Constant, Mike, and Philip Ridgeon. (2000). *The Principles and Practice of* CCTV, 2nd edition. Borehamwood, England: Paramount Publishing.

Danielson, Peter. (2005). "Ethics of Workplace Surveillance Games." In *Electronic Monitoring in the Workplace: Controversies and Solutions*, ed. John Weckert. Hershey, PA: Idea Group Publishing.

Foucault, Michel. (1977). *Discipline and Punish: The Birth of the Prison,* trans. Alan Sheridan. New York: Pantheon.

Goold, Benjamin. (2002). "Privacy Rights and Public Spaces: CCTV and the Problem of the 'Unobservable Observer.'" *Criminal Justice Ethics* 21(1): 21–27.

Hunter, Richard. (2002). *World without Secrets: Business, Crime, and Privacy in the Age of Ubiquitous Computing.* New York: Wiley.

Lyon, David, and Elia Zureik, eds. (1996). *Computers, Surveillance, and Privacy.* Minneapolis: University of Minnesota Press.

National Institute of Justice. (2003). "CCTV: Constant Cameras Track Violators." *National Institute of Justice Journal* 249: 16–23.

Nissenbaum, Helen. (1997). "Toward an Approach to Privacy in Public: The Challenges of Information Technology." *Ethics and Behavior* 7(3): 207–219. Develops the public/private distinction.

Orwell, George. (1949). *Nineteen Eighty-Four: A Novel.* London: Secker and Warburg. The classic surveillance dis-utopia. Note that the source of recent surveillance has shifted from governments to include corporations and individuals.

Society of Photo-optical Instrumentation Engineers (SPIE). (2002). *Sensors, and Command, Control, Communications, and Intelligence (C3I) Technologies for Homeland Defense and Law Enforcement.* Bellingham, WA: Author. Conference proceedings of the SPIE, April 1–5, Orlando, Florida.

INTERNET RESOURCE

American Management Association (AMA). (2003). "E-Mail Rules, Policies, and Practices Survey." Available from http://www.amanet.org/research/pdfs/Email_Policies_Practices.pdf. An accessible survey of corporate e-mail surveillance practices in the United States.

MONTREAL PROTOCOL

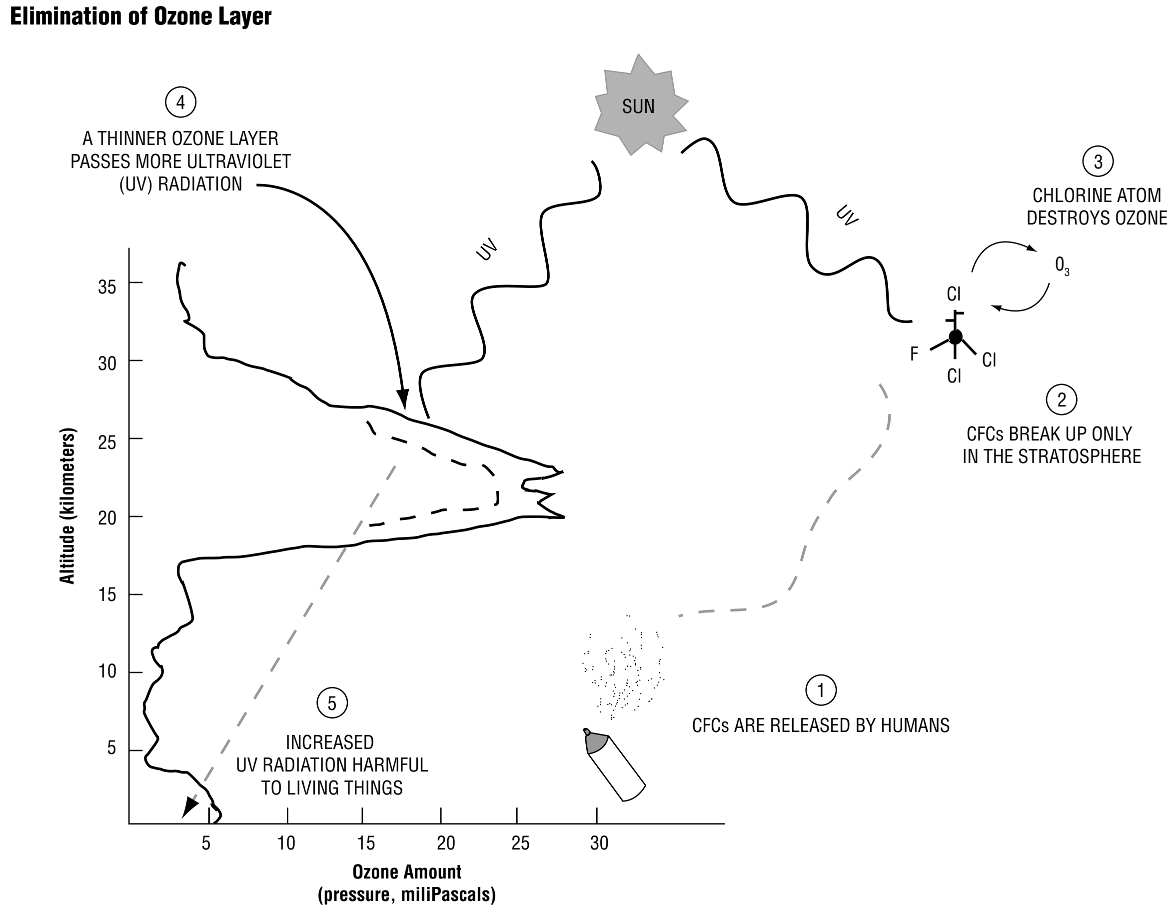
The Montreal Protocol on Substances that Deplete the Ozone Layer (MP) of 1987 is an international agreement to protect the stratospheric ozone layer from harmful synthetic chemical compounds. The targets of the MP are synthetic chemical substances that destroy an upper level protective ozone layer of the Earth and whose destructive behavior persists over decades if not centuries, depending on the chemical compound. The MP is considered an exemplary case of science-based policy making, adroit diplomacy, innovative treaty language, and regulatory collaboration, and is the most successfully implemented global environmental treaty in history. It is also the best example to date of global action based on the *precautionary principle*.

The Issue and Efforts Leading to the Montreal Protocol

Ozone is a bluish gas, harmful to breathe, that is composed of three atoms of oxygen. Nearly 90 percent of the planetary ozone is in the stratosphere, an atmospheric region above the troposphere extending from about 10 to 50 kilometers in altitude. In the 1930s, scientists Dorothy Fisk and Charles Abbott discovered how to measure atmospheric ozone, and described the critical role an *ozone layer* plays as a global sunscreen. Stratospheric ozone absorbs a band of ultraviolet radiation (UVb), preventing most of it from reaching the ground where it is particularly harmful to living organisms (causing skin cancer and cataracts, interrupting food chains, and more).

Chlorofluorocarbons (CFCs), now recognized as ozone depleting substances (ODS), were hailed for being safe, friendly, and widely applicable when first invented about the same time that the benefits of the ozone layer were discovered. Besides their original application in refrigeration—where they were both safer and more efficient—CFCs were manufactured for an extremely wide variety of uses: flexible urethane foams (for carpeting, furniture, and automobile seats); rigid polyurethane foams (as insulation for buildings and refrigeration units); blowing agents in non-urethane foams (polyurethane sheet products, foam trays, fast-food wrappers); and refrigerants in automobile air conditioners, and industrial and commercial air conditioners known as chillers. CFCs became an important solvent for the electronics and aerospace industries as a cleaning agent for circuit boards and scientific instruments. Halons, another set of haloge-

FIGURE 1



SOURCE: National Oceanic and Atmospheric Administration. "Stratospheric Ozone." Available from http://www.ozonelayer.noaa.gov.

nated hydrocarbons, were widely used as flame suppressants in firefighting. Carbon tetrachloride, methylene chloride, and the agricultural chemical methyl bromide used as a soil fumigant and to protect stored agricultural products from pest-related deterioration, are implicated as well.

In the 1970s natural scientists (notably, Richard Stolarski, Ralph Cicerone, Sherwood Rowland, and Mario Molina) questioned whether these chemical compounds were benign in the stratosphere. When CFCs reach the stratosphere, ultra-violet radiation causes them to decompose releasing a chlorine atom that in turn destroys ozone molecules. They concluded that a single chlorine atom released in the stratosphere could eliminate thousands of ozone molecules through a catalytic chain reaction; that this reaction would continue for the life of the chemicals (40–150 years); and that CFC concentrations in the ozone layer could be expected to reach one to thirty times their current levels with disastrous consequences for the integrity of the ozone layer.

For the next ten years, debates over the science of ozone depletion raged, reflecting different industrial, political, and scientific worldviews and the symbolic resources brought to bear on the issue (Dotto 1978).

Much of the early empirical evidence of a "hole" in the stratospheric ozone layer was discounted by scientists who simply assumed that the extremely low Dobson instrument measurements were due to technical malfunctions. Indeed, the 1982 ozone measurement devices aboard the Nimbus 7 satellite had been programmed to flag low values as erroneous (Gribbin 1988). By the mid-1980s, however, scientists such as Shigeru Chubachi and Susan Solomon provided empirical evidence of stratospheric ozone depletion (Andersen and Sarma 2003). Consensus that an *ozone hole* was swiftly developing left open to debate whether the hole was caused by nature or by invented chemicals. Nevertheless, and importantly, even in the face of continuing uncertainty, the world moved from demands for more research to demands for precautionary regulation in a relatively short period of time.

In 1985, under the auspices of the United Nations Environment Programme (UNEP), Executive Director Mostafa Tolba led Australia, Canada, Finland, Germany, New Zealand, Norway, and the United States to adopt the Vienna Convention (VC). This was the first official version of international understandings and responsibilities regarding the protection of the stratospheric ozone layer. The MP, signed in September 1987, followed (Benedick 1991). By 2003, 184 nations had ratified the MP.

Implementation and Evolution of the Montreal Protocol

Parties to the MP agreed to use national consumption/production figures as a baseline from which to measure targets for phaseout, permitting flexibility so that each nation could determine how best to meet its national phaseout commitment. Article 6 established periodic reviews by scientific and technical experts so that the treaty could be adjusted with the benefit of fast-paced developments in science and technology. With amendments of the MP, the twin principle of *differentiated responsibility/capability* was adopted. Funds, expertise, and technology transfer supported developing countries that were not major contributors to the problem and whose domestic economic priorities were not in line with phaseout. (Article 5 lists 136 such nations in 2003.) The Global Environment Facility took responsibility for helping Countries-With-Economies-in-Transition (high ODS, economically troubled), typically members of the former Soviet Union.

Originally the treaty committed parties to reduce, by 1996, the use of CFCs by 50 percent, using their national 1986 baseline values. Failure to sign the treaty imposed import/export restrictions that encouraged wide participation, especially given that total, worldwide phaseout of the harmful substances meant that non-parties without production capability would not have access to supplies. This also prevented companies seeking to avoid controls on ODS from moving their production facilities to non-parties and exporting back into the countries controlled by the MP (Brack 1996).

By the time the treaty went into force on January 1, 1989, there was already a strong push for amending it, as anticipated. In 1990 the London Amendments provided for a total ban of CFCs by the end of the twentieth century, added other ODS to the list of controlled substances, created the Multilateral Fund (MLFund) to help developing countries phase out, instituted a ten-year grace period for developing country compliance, mandated technology transfer from rich countries, and reclassified hydrofluorcarbons (HCFCs) as *transitional substances*. The Copenhagen Amendments (1992) accelerated the compliance schedule, confirmed the MLFund permanently, and suggested new compounds for the control list, notably HCFCs and methyl bromide. Subsequent adjustments (Montreal 1997, Beijing 1999) replenished the MLFund and tightened control measures.

Administratively the treaty established the MP Secretariat (Nairobi) with K. M. Sarma as the first Executive Secretary and, after 1990, the MLFund Secretariat (Montreal), first headed by Omar El-Arini. The MLFund Executive Committee is composed of equal numbers of developed and developing countries. Four United Nations agencies support the phaseout through activities such as training, information sharing, institutional strengthening, conferences, and consultant services. Each Article 5 country has established a National Ozone Unit; these are strengthened by regional networking activities of the UNEP.

Three autonomous advisory panels—in Science, Environmental Impacts, and Technology and Economic Assessment (TEAP)—report directly to the parties. These volunteer expert review panels are the primary source of the confidence with which the parties have frequently amended the treaty in light of new, credible science and technology.

Over the first decade of the MP implementation, the TEAP, under the collaborative leadership of Stephen O. Andersen and Lambert Kuijpers, rose to preeminence as the worldwide authority on technically credible, economically possible options for speedy phaseout. Other than the Economic Options Committee, the TEAP was organized by industrial sector, and includes divisions such as the Technical Option Committee (TOC) for aerosols, foams, halons, methyl bromide, refrigeration, and solvents. The TEAP found and created new product designs, innovative practices, and industry-wide alterations in production processes that were harmful to the ozone layer.

The TEAP was built on the principle of dynamic collaboration across sciences, technologies, industries, governmental ministries, and citizen groups from around the world. Industries from Canada, Brazil, China, Germany, India, Japan, the Netherlands, Sweden, the United Kingdom, and the United States, among others, contributed more than 50 percent of the approximately 700 TEAP members.

TEAP experts were not required to share the epistemology of precaution. However they were expected to work with disregard of national or industrial interests and toward global solutions with a can-do spirit. They did this by developing strong social bonds of trust and respect (a tight community) and by forging collaborative norms of problem solving, boundary spanning, and information sharing. The effective regulatory community that emerged from the TEAP—largely the result of collaborative leadership as well as linkages to broader constituencies in government, industry, and the academy—became valuable and necessary resources in the creation and transfer of knowledge so essential to MP success (Canan and Reichman 2002).

The one area where phaseout has lagged is addressing the issue of methyl bromide, in which commitment to planetary concerns has not overridden industrial interests and national politics. Nominations for Critical Use Exemptions for methyl bromide have used criteria that differ from the criteria for other ODS. For other ODS, an *essential* use is defined as one that "is necessary for the health, safety or is critical for the functioning of society (encompassing cultural and intellectual aspects)" (Decision IV/25 of the Parties, cited in DeCanio and Norman, 2003). An oft-cited example was the exemption for CFC use for Metered Dose Inhalers (MDIs) having life-and-death criticality. However the MP allows nominations for *critical use exemptions* to the methyl bromide phaseout based on claims that alternatives are not *economically feasible* or that the phaseout would cause *significant market disruption*. As a result, some parties have requested exemptions for a range of methyl bromide applications, including tobacco, pet food, flowers, and golf courses (DeCanio and Norman 2003).

Despite the tremendous progress that has been made accelerating phaseout dates, banning additional chemicals, and identifying, creating, and adopting alternative technologies, the long life of ODS means that restoring the earth's protective stratospheric ozone layer will remain a serious challenge throughout the twenty-first century.

PENELOPE CANAN
NANCY REICHMAN

SEE ALSO *Global Climate Change; International Relations.*

BIBLIOGRAPHY

Andersen, Stephen O., and K. M. Sarma. (2003). *Protecting the Ozone Layer: The United Nations History*. London: Earthscan. An authoritative and exhaustively documented history of the science and diplomacy that led to the Montreal Protocol; contains a detailed account of the contribution of business, industry, and government to develop environmentally sound alternative technologies to restore the ozone layer. Provides a careful record of the role of the media and non-governmental organizations in evolving the global response to the destruction of stratospheric ozone. It is the official UN history of the Montreal Protocol.

Benedick, Richard. (1991). *Ozone Diplomacy: New Directions in Safeguarding the Planet*. Cambridge, MA: Harvard University Press. Provides a detailed account from the perspective of the senior U.S. negotiator of the Montreal Protocol. Features interpretations of the bargaining motivation and stratagems of other countries. Stimulated many others to tell the story from their own perspective.

Brack, Duncan. (1996). *International Trade and the Montreal Protocol*. London: Earthscan. Covers the role of trade as a governing principle for international agreements and how variable national economic positions view trade sanctions as impetus for participation and compliance.

Canan, Penelope, and Nancy Reichman. (2002). *Ozone Connections: Expert Networks in Global Environmental Governance*. Sheffield, UK: Greenleaf. A sociological analysis of the extent and effectiveness of a small number of experts, organized in communities of practice, were instrumental in protecting the ozone layer. Looking systematically at the connection between technology, global environmental policy, and the social connections of experts, the authors focus on the Technology and Economic Assessment Panel of the Montreal Protocol. By combining formal network analysis, biographical interviews and participant observation, they demonstrate that treaty implementation relies on social relations, trust and the collaborative leadership of institutional entrepreneurs.

Dotto, Lydia, and Harold Schiff. (1978). *The Ozone War*. New York: Doubleday and Company. The most comprehensive early account of conflict among scientists, citizens, industry, and political activists. It was published during the decade when UENP and national environmental ministries were created and environmental law was invented, but long before there was much hope of stratospheric ozone protection.

Gribbin, John R. (1988). *The Hole in the Sky: Man's Threat to the Ozone Layer*. New York: Bantam. Documents the triumph of science and diplomacy in securing the Montreal Protocol.

INTERNET RESOURCE

DeCanio, S. J., and C. S. Norman. "Economic Aspects of Nominations for *Critical Use* of Methyl Bromide Under Terms of The Montreal Protocol." Included in UNEP Report of the Technology and Economic Assessment Panel, May 2003 Progress Report. Available at http://www.econ.ucsb.edu/~decanio/papers/MB-UK9r.pdf. A

sophisticated analysis of the economics of critical uses of ODS revealing the politics of changing definitions risk.

MORE, THOMAS

Thomas More (1478–1535) was born in London on February 7 and executed on Tower Hill, London on July 6. He was a lawyer and royal councilor who rose to be Lord Chancellor of England (1529–1532) before falling afoul of Henry VIII over the matter of the king's divorce. Of his voluminous writings, the only one that has anything to say about science and technology is *Utopia* (1516), his vastly influential Latin book about an imaginary island republic somewhere off South America.

To More and those of his fellow humanists who understood the Greek etymology, of the word that he coined for this title *utopia* meant simply *noplace* (*ou* + *topos*): the word, that is, did not originally have the meaning—an ideal society, or a fictional work about one—acquired in the book's aftermath. Indeed the fundamental interpretive question about the work is whether More intends Utopia as his ideal society. At the least, though, the Utopian commonwealth includes a number of institutions that he clearly regarded as preferable to those of sixteenth-century England and Europe.

The Utopian institutions toward which the book embodies a clearly favorable attitude do not for the most part involve science or technology: England had to wait until 1627, when Bacon's *New Atlantis* appeared, for its prototypical scientific utopia. More finds the principal means to human betterment not in scientific and technological advances but in wiser political, religious, and educational institutions. There are, however, several passages focusing on science and technology, and in all but one the attitude toward these subjects is unreservedly positive.

The account of Utopia is narrated by a fictitious character named Raphael Hythlodaeus, who is supposed to have sailed with Amerigo Vespucci and who now speaks to More and his friend Peter Giles. Just before the account, Hythlodaeus attempts to convince his auditors of the superiority of Utopia to Europe by an historical anecdote. Utopia had had, in about 300 C.E., a previous encounter with Old World visitors, in the form of a company of shipwrecked Romans and Egyptians. The Utopians, Hytholodaeus approvingly observes, profited greatly from this chance event, learning "every single useful art of the Roman empire either directly from their guests or by using the seeds of ideas to discover these arts for themselves . . .This readiness to learn is, I think, the really important reason for their being better governed and living more happily than we do, though we are not inferior to them in brains or resources" (1995, p. 107; 2002, p. 39, 40). Later, discoursing again on the Utopians' passion for learning, Hythlodaeus notes that they are "wonderfully quick to seek out those various skills which make life more agreeable" (1995, p. 183; 2002, p. 76). In this instance, having heard in general terms about printing and paper-making from Hythlodaeus and his companions, the Utopians rapidly develop these technologies and use them to reprint the classical Greek and Roman books that Hythlodaeus's group had with them.

Among the ancient books, Hythlodaeus notes, the Utopians were especially pleased to receive works of Hippocrates and Galen, because in Utopia medical science is held in great esteem. In general, the Utopians find science a source not only of practical benefits but of keen intellectual pleasure. Hythlodaeus singles out for special praise their mastery of astronomy, in the pursuit of which "they compute with the greatest exactness the course and position of the sun, the moon and the other stars that are visible in their area of the sky" (1995, p. 157; 2002, p. 65). (For astrology, they have only contempt.) They also regard the exploration of the secrets of nature as a form of worship. God, they suppose, "created this beautiful mechanism of the world to be admired—and by whom, if not by man, who is alone in being able to appreciate so great a thing?" (1995, p. 183; 2002, p. 76).

Another area in which the Utopians are said to be especially inventive is the design of weapons. There is no hint of disapproval in the passage on this subject. (The Utopians avoid war whenever possible, but when it is unavoidable, they excel at it.) Only one passage in More's book intentionally raises the possibility that technological advance may not always be an unmixed blessing. Before reaching Utopia, Hythlodaeus and his companions have occasion to introduce their native South American hosts to the magnetic compass and its navigational benefits. Previously, the natives had "sailed with great timidity, and only in summer." Now, however, they put such trust in the loadstone that "they no longer fear winter at all, and tend to be careless rather than safe." Thus "there is some danger that through their imprudence this device, which they thought would be so advantageous to them, may become the cause of much mischief" (all quotes 1995, p. 49; 2002, p 12). This is as close as More comes to the topic of the ethical

Sir Thomas More, 1478–1535. The life of this English humanist and statesman exemplifies the political and spiritual upheaval of the Reformation. The author of *Utopia*, he was beheaded for opposing the religious policy of Henry VIII. *(The Library of Congress.)*

implications of science and technology—a topic that was, however, to be a major focus of many of the hundreds of utopias (and, latterly, dystopias) that have their prototype in his subtle little book.

GEORGE M. LOGAN

SEE ALSO *Utopia and Dystopia.*

BIBLIOGRAPHY

Baker-Smith, Dominic. (1991). *More's "Utopia."* Unwin Critical Library. London and New York: HarperCollins Academic.

Guy, John. (2000). *Thomas More*. Reputations (series). London: Arnold; New York: Oxford University Press.

Manuel, Frank E., and Fritzie P. Manuel. (1979). *Utopian Thought in the Western World.* Cambridge, MA: Harvard University Press.

More, Thomas. (1995). *Utopia: Latin Text and English Translation*, eds. George M. Logan, Robert M. Adams, and Clarence H. Miller. Cambridge, UK: Cambridge University Press.

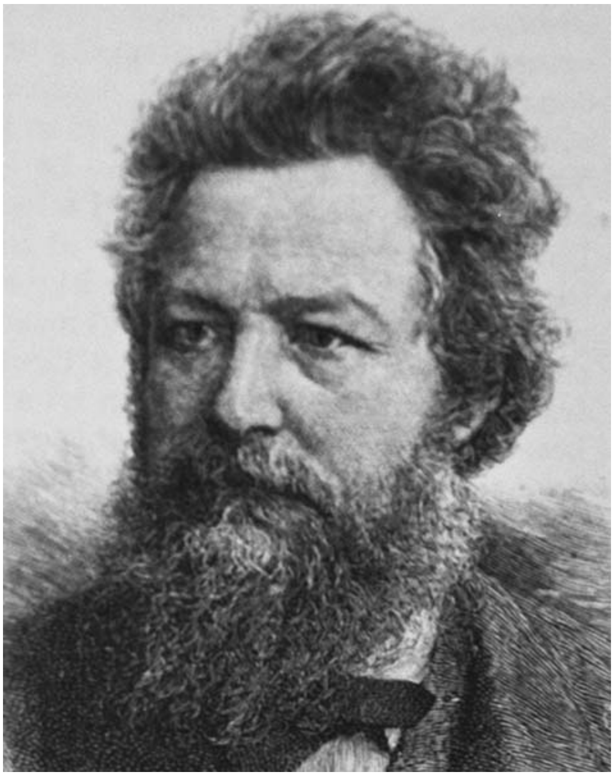
More, Thomas. (2002). *Utopia,* rev. edition, eds. George M. Logan, and Robert M. Adams. Cambridge Texts in the History of Political Thought. Cambridge, UK: Cambridge University Press. This edition contains the English translation only (plus annotations and an introduction), omitting the Latin original. While the 1995 edition cited above is the scholarly standard, this 2002 version, a widely-used teaching edition with the same translation, is far handier.

MORRIS, WILLIAM

William Morris (1834–1896) was born in Walthamstow, now part of London, on March 24 and died at Kelmscott House, Hammersmith, London on October 3. During his own lifetime he was best known as a poet, but while his reputation as a poet has continued, his work as a designer with his own firm and as a politically active socialist has been even more enduring. An early love of the Middle Ages helped shape all his activities. He rejected what he saw as the cheap and shoddy ideas and goods of the modern age.

At first Morris thought that social reform was possible through the Anglican ministry. But influenced by the work of social commentator and art critic John Ruskin (1819–1900), especially the fifth chapter of *Stones of Venice* (1851–1853), "On the Nature of Gothic," he turned to art instead. Ruskin convinced him of the need for workers to have a sense of pleasure in their work and surroundings. Morris considered being an architect, then a painter. Moving to London he found no furniture to his liking so he designed his own. He found no house he wished to live in. Turning to his friend Philip Webb, Morris had him design the influential Red House in Bexleyheath outside of London in a simplified red brick Gothic. He formed a design firm to work on the inside of the house and it became a commercial operation.

It was through his work as a designer and a businessman that Morris confronted issues of technology and ethics. He felt that much of the design of the time was ugly and false to nature. Its purpose was not beauty but to advertise the wealth of its purchaser; it was not true to its form; it was not true to Ruskin. Morris believed in talent, not genius, and felt he demonstrated this himself by working in all areas of his firm's production. To modern eyes, many of Morris's designs appear elaborate; in their own time they represented a move toward simplicity. He designed furniture, wallpaper, stained glass, textiles, tapestries, tiles, carpets, and toward the end of his



William Morris, 1834–1896. Morris, one of the most versatile and influential men of his age, was the last of the major English romantics and a leading champion and promoter of revolutionary ideas as poet, critic, artist, designer, manufacturer, and socialist. *(The Library of Congress.)*

life, books for his last enterprise, the Kelmscott Press. His aim, as he wrote in *Arts and Crafts Exhibition Society Catalogue of the First Exhibition,* was "to combine clearness of form and firmness of structure with the mystery that comes of abundance and richness of detail" (p. 27). He wished, in his own words, "to give people pleasure in the things they must perforce *use,* that is the one great office of decoration; to give people pleasure in the things they must perforce *make,* that is the other use of it" (Morris 1882, p. 4).

Morris was aware of being caught in a technological conundrum. He hated what he saw as the low quality of machine products. He is frequently seen as being anti-machine. He certainly did not admire the machine but he was perfectly willing to use it as a way of producing his wallpapers and chintzes at lower cost, although his firm's finer work was done by hand. He increasingly came to feel that the reliance on technology was becoming an ethical and political matter and that, to use the modern term, corporate interests would demand cheaper and shoddier production. For instance, he hated the new chemical dyes and insisted on using natural ones. He became more and more active in politics because he felt that the only way the ordinary person could make and have truly beautiful and useful objects was if socialism were introduced and the economic arrangements of society transformed. He became a convinced Marxist. This did not result in his changing his business methods. Though his workers were well paid, it was not a firm in which he shared the profits. To charges of hypocrisy, he pointed out that his one individual case would not change society and he needed his income to achieve political reform, indeed revolution, for all.

Morris devoted a great deal of his considerable energy to political agitation. The various political groups with which he was associated were the precursors of the British Labour Party, much as he would have disliked it. In his view, society needed to be totally transformed politically if it were to serve the best scientific, technical, and ethical needs of its members. He outlined his utopia in his most famous prose work, *News from Nowhere* (1890). Though he fought for total change, at the same time he had an important influence on contemporary capitalist society. He launched the modern preservation movement through the founding of the Society for the Protection of Ancient Buildings (1877), and he helped create a sensitivity in favor of preserving and protecting the environment. Although in practice he made compromises, he left a legacy of belief in simplicity of form and truth to materials that has had a profound effect on the look, usefulness, and technology of the modern world.

PETER STANSKY

SEE ALSO *Science, Technology, and Literature; Socialism; Utopia and Dystopia.*

BIBLIOGRAPHY

Arts and Crafts Exhibition Society Catalogue of the First Exhibition. (1888). London: London New Gallery.

Briggs, Asa, ed. (1984). *William Morris: News from Nowhere and Selected Writings and Designs.* Harmondsworth: Penguin.

Kelvin, Norman, ed. (1984–1996). *The Collected Letters of William Morris,* 4 vols. Princeton, NJ: Princeton University Press.

MacCarthy, Fiona. (1995). *William Morris: A Life for Our Time.* New York: Knopf.

Morris, May, ed. (1910–1915). *The Collected Works,* 24 vols. London: Longman, Green & Co.; (1973) New York: Oriole Editions.

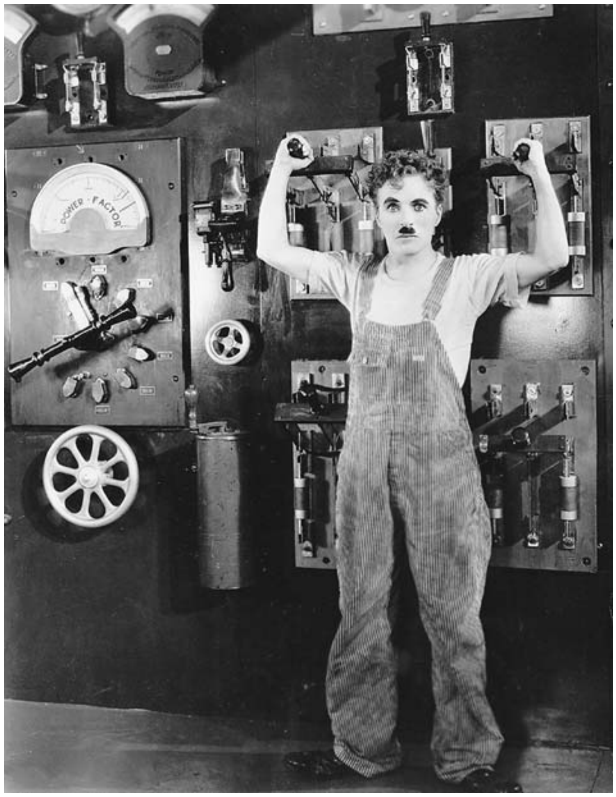
Morris, William. (1882). *Hopes and Fears for Art.* London: Ellis & White.

Stansky, Peter. (1985). *Redesigning the World: William Morris, the 1889s, and the Arts and Crafts*. Princeton, NJ: Princeton University Press.

Thompson, Edward Palmer. (1976). *William Morris: Romantic to Revolutionary*. New York: Pantheon.

MOVIES

Motion pictures are one of the most pervasive contemporary technologies, and, since their invention, have been continuously engaged with ethical issues. From the beginning, movies have been accused of corrupting children and adults by communicating godless, overtly sexual, and perverted values. The result has been extensive attempts to control movie content. Even commentators who are against censorship have argued that, independent of any particular content, movies have a morally significant influence. Finally as a new technological medium, films have explored the ethical challenges of new technologies.



Charlie Chaplin in a scene from the 1936 film *Modern Times*. The movie explores automation and its repercussions for human beings. *(The Kobal Collection. Reproduced by permission.)*

Background

In January 1894 inventor Thomas Edison filmed his assistant, Fred Ott, sneezing. Early proponents of the new medium soon began shooting the first fiction films, consisting of only a few scenes. *The Great Train Robbery* (1903) was a milestone, using montage and the point of view of the camera to excite and frighten the audience. By 1907 there were 1 million daily viewers of nickelodeons in the United States. In 1910 the nation had 10,000 movie theaters. Hull House reformer Jane Addams said that "what they [children] saw on the screen was directly and immediately transformed into action." Reverend Wilbur Crafts saw the early cinema as "offering trips to hell for a nickel" (Black 1994, pp. 6, 10). *The Jazz Singer* (1927) popularized the new technology of synchronized sound, allowing actors to speak and sing and writers to create more complex, morally nuanced, and provocative stories.

Later technological developments have not been quite as earthshaking as the addition of sound. Cinemascope, a wide-screen color format introduced in 1953, brought audiences back to the movie theater by creating an experience television could not rival. 3-D films, another 1950s attempt to draw viewers from television, quickly became associated with schlock horror and science fiction efforts and was a mere technological detour rather than a lasting development. The huge-screen IMAX 3-D movies may represent a technological apex, but the use of digital video instead of film has been more significant in reducing costs of entry for small filmmakers in both the United States and abroad. The digitization of Hollywood films for distribution and projection also reduces costs and makes moviegoing more consistent, eliminating such memorable experiences as the scratchy print and film that breaks during the crucial scene.

Film has long served as a means of advancing scientific understanding, particularly by capturing events that occur too quickly or slowly for the human eye to see (a cheetah running or the growth of a flower), and by archiving scientific information. It has also popularized science to the masses, via such media as IMAX films shown in museums.

Censorship

Attempts to protect citizens by censoring the cinema began at the local level in the United States soon after the nationwide introduction of popular films; states and cities set up their own boards of censorship to determine what could be shown in local theaters. In *Mutual Film Corp.* v. *Ohio Industrial Commission* (1915), the Supreme Court denied First Amendment protection to movies, finding them to be "a business, pure and simple" and therefore not "part of the press" or "organs of public opinion" (*Mutual Film Corp.* v. *Ohio Industrial Commission,* p. 244).

In 1922 production companies launched a preemptive strike against increasingly pervasive state and local censorship by founding the Motion Picture Producers and Distributors Association of America, headed by William Harrison Hays, former postmaster general and chairman of the Republican National Committee. That spring, more than 100 movie censorship bills had been introduced in the legislatures of thirty-seven states. Hays served as a buffer between the producers and public opinion. The studios wanted to police themselves so as to avoid more rigorous censorship from outside. The first *Hays code* prohibited profanity, nudity, drug trafficking, and white slavery, and urged good taste in presenting criminal behavior, sexual relations, and violence.

Compliance with the code was initially voluntary, and Hays frequently threatened public embarrassment as a means of persuading producers to follow his views. Soon enough, the owners of movie theaters would not show films without the seal of approval of the office, making the system mandatory for studios that hoped for national distribution. It was not until the 1950s that films, such as *The Moon Is Blue* (1953) and *The Man with the Golden Arm* (1955), began to be nationally distributed without the seal of the Hays office.

Early in the sound era, Hollywood moved to secure the rights to several popular but controversial novels by respected authors such as Ernest Hemingway, William Faulkner, and Sinclair Lewis, triggering an ethical debate as to whether movies are an art form, mirroring the world like novels, or have a special responsibility to function as "twentieth century morality plays" illustrating "proper behavior to the masses" (Black 1994, p. 39). The Hays office fought to prevent the studios from filming Hemingway's *A Farewell to Arms* (1929), released as a film of the same name in 1932, and Faulkner's *Sanctuary* (1931), filmed as *The Story of Temple Drake* (1933). Failing in these efforts, Hays's people successfully pushed the producers to tone the films down, delete controversial material, and add plot developments or commentary illustrating the negative consequences of *antisocial* behavior.

Until then movie censorship had been primarily a Protestant affair, but in 1930 the Catholic Church proposed its own movie code, which was adopted in large part by the Hays office (Walsh). The possibility of federal censorship of movies was looming. The Catholic-inspired revision of the code, taken literally, "forbade movies from ever questioning the veracity of contemporary moral and social standards" (Black 1994, p. 41). Producers including Jack Warner and Irving Thalberg rebelled. Movies, they said, are "one vast reflection of every image in the stream of contemporary life." As such, they should be able to present "any book, play or title which had gained wide attention" (Black 1994, p. 41). In 1934 the Hays office was once again reorganized, and code enforcement became much tougher.

The studios were often able to subvert the code by presenting glamorous gangsters and loose women, only to have them pay for their sins by dying at the end of the picture. The *Nation* magazine amusingly referred to this trend as "five reels of transgression, followed by one reel of retribution" (Black, p. 45). The Hayes office intervened in the making of popular gangster films such as *Scarface* (1932), ensuring that the protagonist would die cravenly, not bravely as he did the original script.

Propaganda

During the 1940s, Hollywood and the government entered into partnership for the first time. The Office of War Information asked all filmmakers to consider seven key questions regarding movies made during wartime. The first and most important was, Will this picture help win the war? (Basinger 1998). Hollywood responded enthusiastically with movies calculated to encourage and reinforce patriotic feelings, and engender contempt and hatred for the enemy—in effect, political advertising or propaganda.

An interesting feature of these movies is that they represent the first time Hollywood had both an opportunity and incentive to represent the diversity of American society. Most portrayed a squad or other military group "made up of a mixture of ethnic and geographic types, most commonly including an Italian, a Jew, a cynical complainer from Brooklyn, a sharpshooter from the mountains, a Midwesterner (nicknamed by his state, Iowa or Dakota), and a character who must be initiated in some way (a newcomer without battle experience) and/or who will provide a commentary on the action as it occurs (newspaperman, letter writer, author, or professor)" (Basinger 1998).

The Hays Office nevertheless continued to be an important force in Hollywood into the 1950s, a period during which congressional investigations into communism exerted significant influence over the content of American movies. The Hollywood Ten, directors and screenwriters who went to prison for refusing to name names, and many other writers, directors, and actors saw their careers ruined or, at best, put on hold for many years until the atmosphere changed. Many blacklisted writers continued to work under pen names or through *fronts* (Navasky 1991). Most Hollywood films stayed even more resolutely away from subject matter which could be construed as political; the 1950s was the era of the uncontroversial, extremely traditional, family-centered romance or comedy.

Hollywood, in a second, smaller collaboration with the government, also produced a number of overt propaganda films including *I Married a Communist* (1950), *I Was a Communist for the FBI* (1951), and *My Son John* (1952).

Ratings for Consumer Choice

One important development during the 1950s was the Supreme Court's reversal of the almost forty-year-old decision in *Mutual Film Corp. v. Ohio Industrial Commission*. In the case of *Joseph Burstyn Corp*. v. *Williams* (1952), the Court granted movies full First Amendment protection. Weakened by new legal protections against state and federal censorship and overwhelmed by the cultural and sexual revolutions of the 1960s, the Hays office was finally discontinued in 1966 and replaced by a new ratings system.

Under the new system, the Motion Picture Association of America (MPAA) assigned an X, R, M or G to every movie. X meant the content of the film was highly sexual or violent; R indicated that the film should be restricted to viewers above a certain age; M advised that the film was appropriate only for mature audiences; and G signified that the film was approved for all audiences. Minors (under 17) could not attend X-rated films, and could only see R-rated ones if accompanied by an adult. In 2005 the revised rating system consists of NC-17 (over 17 years old only); R (under 17 years old only if accompanied by a parent or guardian); PG-13 (may not be appropriate for viewers under 13); PG (parental guidance suggested); and G (general audiences).

From the start, opponents contended that the ratings system was biased: Sexually explicit movies tended to get an X-rating, whereas extremely violent ones frequently received only an R, suggesting a cultural acceptance of violence and disapproval of sex. The ratings system has also been described as a mechanism of political control by the major studios that participate in it. "It's no coincidence that the films given Xs and NC-17s over the years have tended to come from independents, minorities, foreign filmmakers, and women—those outside the fold of the seven major studios who are members of the MPAA" (Keough 1999 Internet site).

Influence of the Medium

Since the demise of the Hays office, films have become far more explicit than they were, routinely showing nudity, simulated sex, and increasingly inventive forms of graphic violence (while earning nothing more restrictive than R ratings). F. Miguel Valenti notes that violence and sex sell tickets. An epigraph frequently quoted in film criticism, and usually attributed to Jean-Luc Godard, holds that all that is needed for a movie is a gun and a girl. The debate about whether movies promote violence, immoral or unsafe sexual behavior, or other undesirable acts continues. But some film industry representatives and many consumers deny that movies are a medium of moral expression.

In fact, all films communicate moral ideas, simply by telling stories: ideas about the propriety of certain kinds of social behavior, including sexual and romantic acts, truthfulness and lying, the acceptability of violence; and the mutual rights and responsibilities of various social groups, including wealthy and poor, or police and citizens. Revenge movies, including many Westerns, thrillers, and cop films, show that it is sometimes acceptable to take the law into one's own hands. Many films communicate the idea that those in law enforcement cannot fight crime effectively without disregarding the strictures of the U.S. Constitution.

Thrillers promote a jaundiced or even fearful view of the world. "[T]hey portray a world in which crime, deceit, avarice, intrigue and betrayal are the norm rather than the exception, a film noir world even grimmer than our grimmest perception of daily life" (Dickstein 1981, p. 49). These films may promote "mean world" syndrome, "the feeling instilled in viewers that they live in a dangerous environment" (Valenti 2000, p. 14). However the underlying moral structure renders these films entertaining to audiences. "It is the exposition of moral significance that keeps the audience watching, not the quantity and quality of pyrotechnics on the screen" (Hicks 1995, pp. 106–108).

Peter Bogdanovich, director of *The Last Picture Show* (1971), believes that movies have a profound influence on behavior: "The trouble with portraying any way of life on the screen is that there cannot fail to be an inherent glorification of it, no matter how seamy" (Valenti 2000, Introduction). By contrast, film critic Judith Crist believes that movies have too long a lead time to have much of an influence on American popular

Harrison Ford as Rick Deckard in a scene from the 1982 film *Blade Runner*. The movie explores the definition of humanity in a machine-dominated world. *(The Kobal Collection.)*

culture; because it takes three to five years to make one, "it simply can't be that movies set patterns. They reflect our society" (Thayer 1980, p. 49).

Films aimed at juvenile audiences are widely thought to have a special responsibility to communicate socially acceptable values. Analee R. Ward notes that writers and animators at The Walt Disney Company are aware of their role in forming children's values, but have blind spots. "The role of a female in *The Lion King* is largely that which is associated with love, either romantic or motherly" (Ward 2002, p. 127). She notes possible racism in the portrayal of the hyenas as jive-talking blacks, and homosexual stereotypes in the behavior and mannerisms of the villain, Scar.

Others argue that by giving in to self-censorship, filmmakers often make bland, uninteresting movies. Pediatrician Perri Klass observed that "[I]f children's entertainment is purged of the powerful, we risk homogeneity, predictability and boredom, and we deprive children of any real understanding of the cathartic and emotional potentials of narrative" (Ward 2002, p. 29). Carter Burwell, writing about adult movies, has similarly said that "[I]f people's buttons are pressed in completely predictable fashion, you're depriving them of the opportunities to have novel and perhaps enlightening experiences" (Valenti 2000, p. 36).

Some critics have noted that movies give a distorted view of historical events. Stephen Fjellman wrote, "What Disney does, perhaps, is kill the *idea* of history by presenting it as entertainment" (Ward 2002, p. 117). Historian Mark Carnes said that films "make the past speak to us with . . . complete crystal clarity, so that it speaks to our time. Of course, historians, when they go to the past, don't find that clarity. They find a muted voice in a different language echoing through vast expanse of time" (Public Broadcasting System 1995).

The most provocative criticism, however, is that independent of any particular content, motion pictures have distinctive social and cultural effects that call for ethical assessment. For instance, media analyst Marshall McLuhan's thesis that the *medium is the message* might suggest that because film deals with rich visuals and sounds disembedded from their full physical contexts, it cannot help but make any violence it depicts somewhat attractive. Moreover motion pictures would also seem to have a strong tendency to induce in those who sit in a dark room in front of a large screen the kind of dreamy rootlessness described in Walker Percy's novel *The Moviegoer* (1961). Remarkably, however, there has been little scientific research on the psychological impact of movie watching—certainly nothing like the degree of empirical research devoted to the psychological influence of television.

Movies Examining Science and Technology

From the silent days to the era of huge screens and Dolby sound, films tell stories about new technologies, often in a fantasy or science fiction context. Fritz Lang's *Metropolis* (1927) portrayed a world in which evil rulers used technology to manipulate workers, and in which a woman was impersonated by an evil robot doppelganger. Charlie Chaplin's *Modern Times* (1936) examined the alienation caused by automation. These movies raised the central questions considered by later efforts: What happens when powerful technology evades human control, and what is human as opposed to *other* (Telotte 2001).

The apocalyptic genre (Shapiro 2002) which began in the 1950s with movies such as *Godzilla* (1954), *Them* (1954), and *The Beast From 20,000 Fathoms* (1953) was based on the premise that *there are some things man was not meant to know*. Typically the threat in these movies was a mutant created by radiation from an atomic blast. The *Alien* films (originating in 1979) similarly show humans trying to manipulate forces (the rapacious aliens) that quickly evade their control, with deadly results. The *Terminator* series (originating in 1984) recapitulates a theme, first expressed in movies such as *2001* (1968), *The Demon Seed* (1977), *Colossus: The Forbin Project* (1970), *Westworld* (1973), and *War Games* (1983), in which computers become powerful enough to destroy humankind. More subtle thrillers such as *Minority Report* (2002) portray a future in which humans are punished for overreliance on technology, which never works exactly as planned (the pre-cogs' infallible view of the future can be manipulated).

For McLuhan the popularity of techno-horror and vampire movies reflects more than the simple dominance of science and technology in contemporary culture. Instead they are a collective unconscious articulation of the sense in electronic culture of feeling taken over by technology. "*The Exorcist* [1973] is an account of how it feels to live in the electric age, how it feels to be completely taken over by alien forces and hidden powers" (McLuhan 2004).

But perhaps it is *Blade Runner* (1982) that, though a flawed movie, asks the most interesting question: In a world of machines that can imitate human behavior, even to the point of being indistinguishable from people, how is *human* redefined? Philip K. Dick's *Do Androids Dream of Electric Sheep* (1968), on which the movie was based, answered that the irreducible difference is that humans feel compassion, and machines do not. This powerful idea was drowned out in the movie's pyrotechnics, which transformed it into a more clichéd Hollywood story about eliminating the other.

The fact that so many of these films, which use cutting edge technologies to create their special effects, take an antitechnology stance may be partly due to the requirements of storytelling. A screenplay involves a threat to the protagonist that must be overcome. Though there have always been some films in which a misunderstood hero champions an initially disregarded technology (1930s and 1940s films about inventors and medical innovators; *Lorenzo's Oil* (1992) is a more recent example), audiences prefer stories with more at stake. Technology provides weapons for really frightening villains, or it may actually play the role of the evil adversary. Susan Sontag says that science fiction films are "fundamentally about disaster, which is one of the oldest subjects of art," but which involves an "extreme moral simplification" (Sontag 1986, pp. 213–215).

International Perspectives

The highly influential cinemas of other nations have faced similar ethical challenges. The French New Wave, which introduced a new kind of moral storytelling, set a youth ethic against the morality of an older generation portrayed as hidebound and hypocritical (Marie). New Wave films such as *Breathless* (1960) and *The 400 Blows* (1959) glorified rebels, outsiders, and gangsters. The New Wave continues to resound, almost fifty years later, in the films of contemporary American auteurs including Martin Scorsese and Quentin Tarantino.

Whereas the films of all nations struggle with some degree of government censorship, Soviet cinema developed in an environment in which dissent could mean exile, imprisonment, or even death. Soviet film artists nonetheless evaded censorship by telling stories set in past centuries, sometimes based on the unassailable works of pre-Soviet masters such as Tolstoy and Chekhov, or through movies, such as *Solaris* (1974), based on a novel that is so heavily coded that it escaped the criticism of simpleminded censors. During the upbeat socialism of the Brezhnev era, Soviet films enjoyed a new freedom to portray humans as "inwardly torn by doubt, failing to accomplish anything in life other than the destruction of that which [they] held dear" (Gillespie 2003, p. 18). In the early-twenty-first century, Russian filmmakers, deprived of their former political and social context, are struggling to create a new identity based on shared cultural values and the country's "awesome historical legacy" (Gillespie 2003, p. 122).

Unfamiliar to most Americans and Europeans, India has developed its own powerful cinematic tradition of leisurely told romance and suspense stories interspersed with musical numbers. Colloquially known as Bollywood, the Indian film industry produces 800 films per year, which are shown in 13,000 cinemas and average 11 million viewers daily nationwide. Vijay Mishra notes that Bollywood cinema knits together a widely dispersed Indian diaspora in Western Europe and North America. Expatriate Indians, who through hard work have joined the comfortable middle classes of their adopted countries, inhabit "the desired space of wealth and luxury that gets endorsed, in a displaced form, by Indian cinema itself" (Mishra, p. 236). Bollywood has been "crucial in bringing the 'homeland' into the diaspora ... creating a culture of imaginary solidarity" reaching across India's numerous ethnic groups (Mishra, p. 237).

Conclusion

Movies are simultaneously a reflection of human life and a distraction from it. As such, they are intimately involved with ethics, drawing from and influencing people's views. It is unlikely that any extensive history of the events, mood, or ethics of any modern era will be written without reference to movies of that period.

JONATHAN WALLACE

SEE ALSO *Entertainment; Information Ethics; Popular Culture; Science, Technology, and Literature; Special Effects; Technocomics; Violence.*

BIBLIOGRAPHY

Black, Gregory. (1994). *Hollywood Censored: Morality Codes, Catholics and the Movies*. Cambridge, MA: Cambridge University Press.

Dickstein, Morris. (1981). "The Morality of Thrillers." *American Film* July–August: 49–52, 67–69

Gillespie, David. (2003). *Russian Cinema*. Harlow, England: Longman.

Hicks, Neill D. (1995). "'Fill Your Hand, You Son of a Bitch': The Underlying Morality of Action Adventure Films." *Creative Screenwriting* 2(4): 106–108.

Joseph Burstyn Corp. v. *Williams*, 393 U.S. 495 (1952).

Keough, Peter. (1999) "An Immodest Proposal: It's Time to Give the Ratings System an X-it." *Boston Phoenix*, August 30. Also available from http://weeklywire.com/ww/08-30-99/boston_movies_1.html.

Marie, Michel. (2002). *The French New Wave: An Artistic School*. Oxford: Blackwell.

McLuhan, Marshall. (2004). "Man and Media." In *Understanding Me: Lectures and Interviews*, eds. Stephanie McLuhan and David Staines. Cambridge, MA: MIT Press.

Mishra, Vijay. (2002). *Bollywood Cinema: Temples of Desire*. New York: Routledge.

Mitchell, Charles P. (2001). *A Guide to Apocalyptic Cinema*. London: Greenwood Press.

Mutual Film Corp. v. *Ohio Industrial Commission*, 236 U.S. 230 (1915).

Navasky, Victor S. (1991). *Naming Names*. New York: Penguin Books.

Shapiro, Jerome F. (2002). *Atomic Bomb Cinema: The Apocalyptic Imagination on Film*. London: Routledge.

Sontag, Susan (1986). *Against Interpretation*. New York: Doubleday.

Telotte, J. P. (2001). *The Science Fiction Film*. Cambridge, MA: Cambridge University Press.

Thayer, Lee, ed. (1980). *Ethics, Morality and the Media: Reflections on American Culture*. New York: Hastings House.

Valenti, F. Miguel. (2000). *More Than a Movie: Ethics in Entertainment*. Boulder, CO: Westview Press.

Walsh, Frank. (1996). *Sin and Censorship: The Catholic Church and the Motion Picture Industry*. New Haven, CT: Yale University Press.

Ward, Analee R. (2002). *Mouse Morality: The Rhetoric of Disney Animated Film*. Austin: University of Texas Press.

INTERNET RESOURCES

Basinger, Jeanine. (1998). "Translating War: The Combat Film Genre and Saving Private Ryan." American Historical Association. Available from http://www.theaha.org/Perspectives/issues/1998/9810/9810FIL.CFM. Published in *Perspectives Online: The Newsmagazine of the American Historical Association*, October 1998.

Motion Picture Association of America. "Voluntary Movie Rating System." Available from http://www.mpaa.org/movieratings/.

"The Motion Picture Production Code of 1930." Artsreformation.com. Available from http://www.artsreformation.com/a001/hays-code.html.

Public Broadcasting System. (1995). "Interview with David Gergen and Mark Carnes, December 26, 1995." Public Broadcasting System. Available from http://www.pbs.org/newshour/gergen/carnes_12-26.html.

"Red Scare Filmography." The All Powers Project. http://www.lib.washington.edu/exhibits/AllPowers/film.html.

MULTIPLE-USE MANAGEMENT

Multiple use is a form of natural resource management with ethical dimensions that may have additional implications for other aspects of science and technology by its interdisciplinary nature. In the present case the focus nevertheless remains on natural resource management.

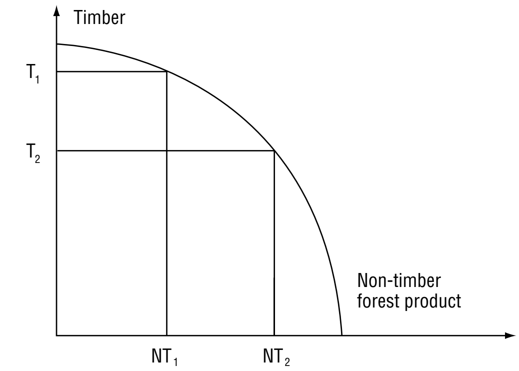
Multiple-use natural resource management is a way of using resources to produce more than one good or service simultaneously. In the U.S. Forest Service this commonly implies managing national forests for such diverse ends as timber production, recreational activities, and environmental protection. Such multiple use easily leads to ethical dilemmas for decision makers. For example, many people living near forests in developing countries make a livelihood out of harvesting timber and non-timber forest products such as honey, nuts, and wild animals on a small scale. Commercial timber operations also have the potential to extract these resources for profit, but only by excluding, at least to some extent, the small-scale harvesters. Decision makers must decide what is the best use of resources: Produce non-timber products to ensure livelihood of communities living near forests? Produce timber to stimulate regional or national economies? Developed nations face similar dilemmas, often compounded by public concern for nearly immeasurable forest benefits, such as recreation, aesthetic beauty, and contribution to global biodiversity.

What Is Multiple Use?

Goods and services produced through a multiple-use management strategy can be complementary, supplementary, or competitive. For example, in Figure 1 the harvest of both timber and non-timber forest products from the same forest are shown to be competitive; the use of standing forest resource to produce timber limits the opportunity to produce non-timber products requiring management decisions. If decision makers decide that timber, for example, is very important and should be harvested at a high level (T1), then by following the curve one can see that non-timber forest products will be harvested at a relatively lower level (NT1). On the other hand, if decision makers think that benefits from non-timber forest products are more important, a management plan might use the NT2 value at the expense of timber interests. A private resource owner could choose a mix of timber and non-timber products that gives the greatest profit. In the context of a public

FIGURE 1

Competitive Multiple-Use Management Strategy



SOURCE: Courtesy of Janaki R.R. Alavalapati and Jensen R. Montambault.

The competing relationship between timber and non-timber forest products in a multiple-use forest management scenario.

resource, however, once single-faceted, often arbitrary, management strategies are abandoned, a variety of involved economic, cultural, political, technological, spatial, and temporal factors raise socioeconomic and ethical dilemmas in multiple-use management.

Socioeconomic, Environmental, and Ethical Issues in Multiple Use

Each forest presents its own medley of site-specific considerations challenging the decision maker to question the fairness of a management plan in terms of how it directly and indirectly affects a variety of stakeholders. Several socioeconomic and environmental justice theories can be applied to exploring the different facets of these issues.

Many ethical problems arise when there is no standard scale for comparing competing issues. For example, it is fairly easy to calculate consistent monetary values for timber. While non-timber forest products are sometimes harvested for a specialized global market, more often they are harvested for household use or local trade in situations in which there exists no market value for these articles. Markets for non-timber forest products, where they do exist, tend toward instability or limited scope. Therefore, taking Figure 1 again as an example, if the management goal is to maximize the monetary gain from a forest, timber would have a distinct advantage over non-timber forest products. In many developing (and some developed) countries, however, non-timber forest products are a major source of income for marginalized or impoverished communities. According to the philosopher John Rawls's theory of social justice (1971), no amount of overall gain is acceptable if it is at the expense of the most disadvantaged. On the other hand, unequal distribution of social goods (rights and liberties, powers and opportunities, income and wealth) is justified if it will help this disadvantaged group. In the case of forest policy, this may mean that a multiple-use strategy is implemented to include both timber and non-timber forest product harvesting at the expense of monetary efficiency because it benefits an otherwise marginalized group.

Basic liberties are not limited to those who are most disadvantaged. Natural resource conflicts frequently arise when the government tries to restrict access by local communities in an area to protect a public good such as biodiversity or the headwaters of a river. This might mean that a local community would lose their livelihood from non-timber forest products or the cultural tradition of family picnics by the river. If communities have a legitimate customary right to use these resources, according to Robert Nozick's theory of social justice (1974), any transfer or exchange is acceptable only if voluntary or without violation of rights. If the communities agree to forego harvesting non-timber forest products or hold their picnics in another area, either out of a sense of altruism or in response to compensation, then it is fair to restrict access to the forest.

The theory of customary rights sometimes conflicts with Aldo Leopold's land ethic philosophy (1949), which argues that all living species and environmental elements, including soils and rivers, for instance, have a basic right to exist at least to some extent in their natural condition. Managers place disproportionate weight on human needs, often ignoring the role these natural functions play in support of the human species. If a community refuses to restrict access to the forest around a river headwater, it might harm the water supply for a much larger human, plant, and animal community downstream. In this case, it becomes difficult to distinguish which is the most disadvantaged group. Followers of an ecocentric philosophy might argue that those species with no voice in the management argument and at great potential risk are actually what Rawls would describe as the most disadvantaged.

Multiple-use natural resource management attempts to address issues of equitability in sharing the benefits supplied by forests, waters, and other resources. The issue of implementing a fair policy, however, is subjective and complex. Economically efficient and ethically acceptable multiple-use management options would be ideal, but very few options pass these criteria simultaneously. In order to ensure a more egalitarian society, it is critical to use these social and ethical principles as binding constraints to maximize efficiency through multiple use of public natural resources.

JANAKI R. R. ALAVALAPATI
JENSEN R. MONTAMBAULT

BIBLIOGRAPHY

Bowes, Michael D., and John V. Krutilla. (1989). *Multiple-Use Management: The Economics of Public Forestlands.* Washington, DC: Resources for the Future. Analyzes Forest management on public lands from an economic perspective to explore the application of multiple-use scenarios.

Leopold, Aldo. (1949). *A Sand County Almanac.* New York: Oxford University Press. This classic text falls into the readable genre of nature writing and also presents seminal arguments for the intrinsic value of wilderness and land ethics.

Nozik, Robert. (1974). *Anarchy, State, and Utopia.* New York: Basic. Focusing on his theory of entitlement, Nozik examines appropriate limits to the function of the state in order to guarantee liberties.

Rawls, John. (1999 [1971]). *A Theory of Justice.* Cambridge, MA: Harvard University Press, Belknap Press. "Liberty" and "difference" principles are discussed in the context of Rawls's moral philosophy.

MUMFORD, LEWIS

Historian and social philosopher Lewis Mumford (1895–1990) produced a broad critique of modern technology complemented by studies of art, architecture, and urban life. Born in Flushing, New York, on October 19, Mumford studied at the City College of New York (CUNY) but contracted tuberculosis and was forced to leave before earning a degree. In 1919 he became associate editor of the *Dial,* and he later worked as architectural critic for the *New Yorker.* His first book, *The Story of Utopias* (1922), was a literary survey that examined the place of technology in society. This became the main theme in *Technics and Civilization* (1934), which was a founding work in the social history of technology. Although he voiced critical attitudes that sometimes anticipated wider cultural shifts (Hughes and Hughes 1990), Mumford also saw science and technology as positive forces in history. In 1936 he and his wife Sophia settled in rural Amenia, New York, where he died on

January 26 more than half a century later, after a lengthy period of dementia.

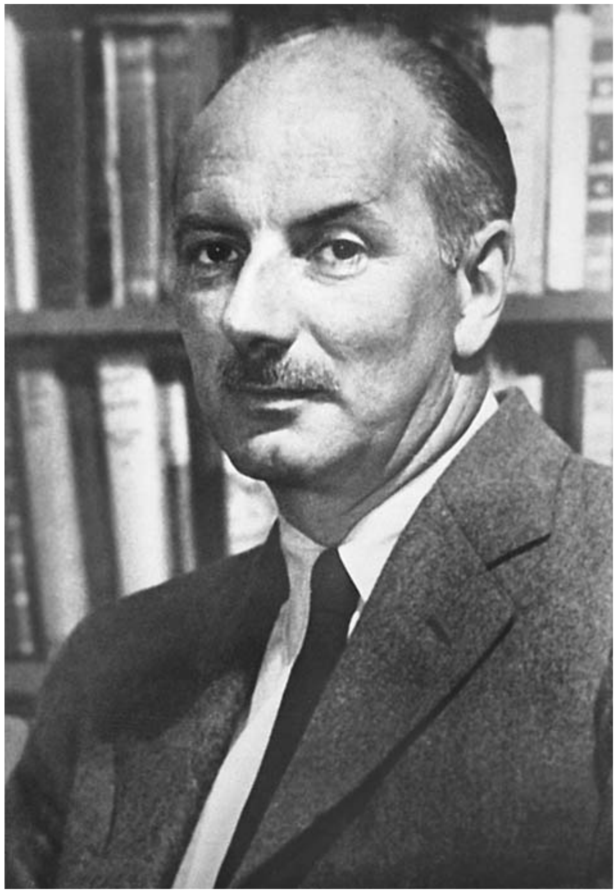
Life in Context

In 1915 Mumford discovered the writings of Scottish philosopher Patrick Geddess (1854–1932), from whom he learned to see the built environment and social processes as reciprocal influences. With others he hoped that technology would usher in an era of material abundance, but maintained that such promise would be fulfilled only if technology were subject to social democracy and wise regional planning. Mumford thus fostered a regionalist vision in which the automobile, electricity, and other new technologies would help transform congested cities into balanced and decentralized communities. The Great Depression, however, raised grave doubts, in response to which he argued for new institutions and revitalized values to redirect technology to human ends.

Mumford was an early advocate of World War II, but the loss of his son in the war, the dropping of atomic bombs on Hiroshima and Nagasaki, and the ensuing nuclear arms race left him a fading hope "that a moral transformation may alter the fateful course of technological development" (Hughes and Hughes 1990, p. 6). Many of his later works betrayed a growing pessimism that science and technology were fundamentally irrational and dangerous, which led him to challenge the equation between rationality and modernity. Despite this his stubborn optimism and refusal to lose sight of the human element and submit to technological determinism in the massive waves of sociotechnical change prompted many to consider Mumford one of the last great humanists (Stunkel 2004).

At times, however, Mumford appeared to despair that his cautious utopian vision of an *organic culture* was at odds with an increasingly mechanistic post-World War II society. He rebuked scientists for their alliance with capitalists and the military, but his books in this era received poor reviews. This can be partially explained by his unabashed interdisciplinary holism, which threatened many narrowly specialized academics. As Russell Jacoby noted, he was "a thinker and writer who addresses a literate and general audience about questions and issues undefined or categorized by conventional academic and professional disciplines" (Hughes and Hughes 1990, p. 11). He also remained fiercely independent, declining all employment in institutionalized academia except visiting professorships.

Mumford resolved to react to what he saw as the negative drift of history by analyzing and promoting the positive personal and communal forces more in line with his vision. In this work, he influenced U.S. literary studies, architecture, and urban development studies. Unlike John Dewey (1859–1952), Mumford did not emphasize political action as a means of transforming society, but maintained that communities were formed and reformed at the levels of family, church, and workers' associations. His later years were characterized by his ambivalent position that science and technology presented both peril and hope and his determined optimism that the necessary moral and religious transformation could happen and thus alter the course of scientific and technological development. His critique of science and technology continues to influence work in several fields, and his vision for urban renewal and transformation lives on in the Lewis Mumford Center for Comparative Urban and Regional Research, established at the University at Albany, State University of New York (SUNY), in 1988.



Lewis Mumford, 1895–1990. Mumford, an American social philosopher and architectural critic, analyzed civilizations for their capacity to nurture humane environment. He emphasized the importance of environmental planning. *(The Library of Congress.)*

Philosophical Anthropology

Mumford is part of the U.S. tradition of this-worldly romanticism that first flowered with Ralph Waldo Emerson (1803–1882) and Walt Whitman (1819–1892). The tradition demonstrates a concern for the preservation of nature and the harmonies of urban life, while insisting that physical matter is not the final explanation of organic activity, especially in its human form. In this sense Mumford represents an even older tradition (stretching back to Aristotle) of a humanities philosophy of technology (Mitcham 1994).

In 1930 Mumford proposed that the machine be considered in terms of both its psychological and practical origins and appraised not just by technical considerations but in ethical and aesthetic terms. This thesis was the germ of *Technics and Civilization*, which sought to integrate the examination of the practical with the good, the true, and the beautiful. The book broke new ground by summarizing technical history for the previous thousand years of European civilization in a way that revealed the reciprocal and many-sided relationships between social values and institutions and the work of inventors, engineers, and industrialists. One popular example is Mumford's treatment of the clock, which is a "piece of power-machinery whose 'product' is seconds and minutes" (Mumford 1934, p. 15). Like Henri Bergson (1859–1941), Mumford saw alienating dangers in the regulating of time by the mechanical clock.

In *Technics and Civilization*, Mumford described the psychological and cultural origins of the machine, explained its material and efficient causes, and outlined a history of machine technics in three overlapping phases: intuitive technics using water and wind (to about 1750); empirical technics of coal and iron (1750–1900); and scientific technics of electricity and metal alloys (1900 to the early-2000s). The last part of the book evaluates social and cultural reactions: "We have seen the machine arise out of the denial of the organic and the living, and we have in turn marked the reaction of the organic and the living on the machine" (Mumford 1934, p. 433). Other civilizations had reached high degrees of technical proficiency and possessed machines, but only the Europeans adapted their entire mode of life to the pace and capacities of *the machine*. Technics (his term for technology) has thus been transformed from mere hardware into a complex sociotechnical system that embodies a way of thinking and being.

Mumford's subsequent writing, insofar as it was an elaboration of *Technics and Civilization*, culminated in the two-volume *Myth of the Machine* (1967, 1970). In it Mumford argued that humans are not fundamentally to be understood as *Homo faber*, because the human essence is not making but interpreting. The interpretive mind, not the manipulative tool, is the basis of humanity:

> If all the mechanical inventions of the last five thousand years were suddenly wiped away, there would be a catastrophic loss of life; but man would still be human. But if one took away the function of interpretation . . . man would sink into a more helpless and brutish state than any animal; close to paralysis. (Mumford 1950, p. 8–9)

The elaboration of symbolic culture through language "was incomparably more important to further human development than the chipping of a mountain of hand-axes" (Mumford 1967, p. 8).

Kinds of Technology

On the basis of his philosophical anthropology, Mumford distinguished two basic kinds of technology: polytechnics and monotechnics. The former is the primordial form of making, which is "broadly life-oriented, not work-centered or power-centered" (Mumford 1967, p. 9). Like *appropriate technologies*, polytechnics harmonizes with the many aspirations of human life and functions democratically. Monotechnics is directed toward production, expansion, military superiority, and power.

Although modern technology exemplifies monotechnics, Mumford traced its origins back 5,000 years to the discovery of the *megamachine*, or rigid, hierarchical social organization. Examples include the work crews that built the Pyramids or the Great Wall of China. The center of authority in these ancient megamachines lay in the absolute ruler, whereas in the modern bureaucratically administered megamachine it resides in the system itself. The megamachine and monotechnics produce great material benefit but at the expense of a dehumanizing limitation of human aspirations and the pervasive belief in *the myth of the machine*, or the notion that monotechnics is irresistible and ultimately beneficent. In the 1950s, for example, forecasts predicted that by the year 2000 technology would shorten the workweek to twenty hours. Newly formed institutes of leisure pondered how to spend the resulting free time (Lightman 2003). But in 1990 the average American was actually working 160 hours longer than twenty years earlier (Schor 1991). For Mumford this phenomenon illustrates the enthrallment to the myth of the machine.

But the megamachine can be resisted, especially because it is not ultimately beneficial. Mumford attempted to demythologize monotechnics and to make a plea against losing sight of humanity, its purposes, and its dreams. He called for a reevaluation of the machine in order to master it and put it to work in the service of life. Technology should be promoted when it enhances human meaning and the *personal* aspect of existence, but not when it restricts life in the service of power.

Mumford explored as well the positive technologies of art and urban life, and his *The City in History* (1961) won a national book award. The second volume in his four-volume *renewal of life* series (1954) championed a technology modeled on patterns of human biology and a *biotechnic economy*. In *Art and Technics* (1952) Mumford contrasted art as a symbolic communication of inner life with technology as a power-manipulation of external objects. He did not seek a simpleminded rejection of technology but wanted to complement the Promethean myth of human beings as tool-using animals with the story of Orpheus. The animal became human "not because he made fire [a] servant, but because he found it possible, by means of his symbols, to express fellowship and love, to enrich [a] present life with vivid memories of the past and formative impulses toward the future, to expand and intensify those moments of life that had value and significance" (Mumford 1952, p. 35).

CARL MITCHAM
ADAM BRIGGLE

SEE ALSO *Science, Technology, and Society Studies.*

BIBLIOGRAPHY

Hughes, Thomas P., and Agatha C. Hughes, eds. (1990). *Lewis Mumford: Public Intellectual.* New York: Oxford University Press. Sixteen papers by an assortment of scholars, plus a synoptic introduction by the editors. Reveals the breadth of Mumford's interdisciplinary social criticism.

Lightman, Alan. (2003). "The World is Too Much with Me." In *Living with the Genie: Essays on Technology and the Quest for Human Mastery,* ed. Alan Lightman, Daniel Sarewitz, and Christina Desser. Washington, DC: Island Press. Explores the intangible human losses from the fast-paced nature of modern life.

Miller, Donald L. (1989). *Lewis Mumford: A Life.* New York: Weidenfeld and Nicolson.

Mitcham, Carl. (1994). *Thinking through Technology: The Path between Engineering and Philosophy.* Chicago: University of Chicago Press. Some material from the analysis of Mumford, on pages 40 through 44, has been adapted for this article.

Mumford, Lewis. (1922). *The Story of Utopias.* New York: Boni and Liveright.

Mumford, Lewis. (1934). *Technics and Civilization.* New York: Harcourt, Brace. A 1963 reprint includes a new introduction by the author plus corrigenda.

Mumford, Lewis. (1950). *Man As Interpreter.* New York: Harcourt, Brace.

Mumford, Lewis. (1952). *Art and Technics.* New York: Columbia University Press.

Mumford, Lewis. (1954). "Technics and the Future of Western Civilization." In *In the Name of Sanity.* New York: Harcourt, Brace. This is a lecture presented at the 100th anniversary meeting of the American Association for the Advancement of Science (AAAS) in 1948.

Mumford, Lewis. (1961). *The City in History: Its Origins, Its Transformations, and Its Prospects.* New York: Harcourt, Brace & World.

Mumford, Lewis. (1967, 1970). *The Myth of the Machine,* 2 vols. New York: Harcourt Brace & World.

Mumford, Lewis. (1973) *Interpretations and Forecasts: 1922–1972: Studies in Literature, History, Biography, Technology, and Contemporary Society.* New York: Harcourt Brace Jovanovich. Forty-two selections from his work, by the author.

Mumford, Lewis. (1982). *Sketches from Life: The Autobiography of Lewis Mumford.* New York: Dial Press. The first volume of an unfinished autobiography. See also Mumford's more schematic *My Works and Days: A Personal Chronicle* (New York: Harcourt Brace Jovanovich, 1979).

Schor, Juliet B. (1991). *The Overworked American: The Unexpected Decline of Leisure.* New York: Basic Books. Chronicles the increased workloads and stress faced by U.S. citizens since World War II.

Stunkel, Kenneth R. (2004). *Understanding Lewis Mumford: A Guide for the Perplexed.* Lewiston, NY: Edwin Mellen Press. Organized by concept such as *architecture* and *megamachine.*

MURDOCH, IRIS

Philosopher and novelist (Jean) Iris Murdoch (1919–1999) was born in Dublin, Ireland on July 15 and educated at St. Anne's College, Oxford, where she also taught from 1948 to 1963. She won the 1978 Booker Prize for her novel *The Sea, The Sea,* which provocatively opens with the protagonist's project of "learning to be good, after a life of egoism, art and power." Murdoch is especially renowned for reviving the classical humanistic philosophy of Plato. She makes Plato's philosophy of ideal truth, beauty, and goodness timely and accessible to general readers, articulating a view of human life as love's labor in journeying from illusion to truth. This vision is especially challenging in a world dominated by scientific reason and technological

Iris Murdoch, 1919–1999. The works of this novelist and philosopher portray characters whose warped and often dreamlike perceptions of reality create suffering among those whose lives they attempt to dominate. *(The Library of Congress.)*

pursuits of material goods. Murdoch died on February 8 in Oxford, England.

Murdoch's uniqueness as a twentieth-century novelist-philosopher is found in *Acastos* (1987), her two Platonic dialogues on love and religion. Like Plato, Murdoch writes philosophically about aesthetics and moral values, arguing that close connections between facts and values in the creative arts and the sciences are necessary to enable humans to live better and more wisely. For Murdoch, the critical difference between creativity in the arts versus the sciences is that the arts, especially literature, represent humanity in the world of relationships, reflected through the creative mind in play with the unlimited, unconscious self. In Murdoch's writings, individuals aim to refine human desires and longings for unreachable goodness through their interpersonal relations of love, and are not satisfied with the more abstract beauty and goodness prominent in the sciences. In thus reinventing literary art and ethics, Murdoch explores the quest of the passionate self for a goodness beyond any individualistic center of self. This indefinable, sublime good that humans seek can become destructive when desires and relationships are based more upon obsessive loves and fantasies about oneself and others, than upon moral and spiritual goodness and love. Unlike basically selfish, egotistical humans, goodness represents a necessary, ideal *otherness* that transcends the human ego.

For self and society to move toward the good is to be rescued from vices of deception and self-deception in the search for beauty, truth, and the virtues of self-knowledge, humility, and compassion. Beauty is the one good to which humans are attracted as if by instinct, and is what galvanizes the creative pursuits of new technologies as well as arts. Yet without developing a purer sense of self, and humility based on knowledge of oneself and others, humans fail in their creativity to find or experience the very things they yearn for, love and happiness, acceptance and understanding.

Murdoch draws inspiration not only from Plato, but also from related philosophers such as Immanuel Kant (1724–1804). For Plato, the ideal forms are distinct from the physical universe, and the form of the Good is even "beyond being" (*The Republic,* Book VI, 509b). For Kant, the dualism lies in the contrast between the rational free will and the determinism of the natural world known by sense experience and laws of causality. Murdoch drew further influence from central twentieth-century philosophers such as the existentialist Jean-Paul Sartre, on whom she wrote the first book in English, and the philosopher of language Ludwig Wittgenstein, with whom she shared a mistrust of written words and language as unable to express full wisdom. With Sigmund Freud she also shared the view that the source and impetus toward knowledge and achievement is sexual.

Murdoch's achievements as both novelist and Platonist argue the importance of living well, ethically, and wisely. By breaking away from barriers to female philosophers and novelists in her own time and place, Murdoch reinvigorated the Idea of the Good for an era dominated more by laws and rules than by the creative works of arts and sciences, to reveal and embody material progress toward ideal truth, beauty, and goodness.

MARY LENZI

SEE ALSO *Consequentialism; Deontology; Virtue Ethics.*

BIBLIOGRAPHY

Bayley, John. (1999). *Elegy for Iris*. New York: St. Martin's Press. Also see the film *Iris* (2001), based on her husband John Bayley's memoir of Murdoch's struggle with and death from Alzheimer's disease.

MacIntyre, Alasdair. "Which World Do You See?" *New York Times Review of Books*, January 13, 1993. A review of *Metaphysics As A Guide to Morals*, by Iris Murdoch.

Murdoch, Iris. (1983). *The Philosopher's Pupil*. New York: Viking Penguin Press, Inc.

Murdoch, Iris. (1987). *Acastos: Two Platonic Dialogues*. New York: Viking Penguin Press.

Murdoch, Iris. (1992). *Metaphysics As A Guide to Morals: Philosophical Reflections*. London and New York: Allen Lane Publisher.

Murdoch, Iris. (1998). *Existentialists and Mystics: Writings on Philosophy and Literature*, ed. Peter Conradi. New York: Penguin Books.

The Ontario Science Centre in Toronto. Since opening its doors in 1969, the center's 600-plus exhibits have fascinated more than 37 million visitors. *(© Dave G. Houser/Corbis.)*

MUSEUMS OF SCIENCE AND TECHNOLOGY

Science and technology museums have the power to inspire and educate millions of visitors each year. As mediators between expert scientists and the general public, museums have the responsibility to provide informed and balanced exhibits. Ethics are embedded in museum decisions, from determining what objects to collect to what exhibits to mount and what to say about them. This discussion examines the long history of science and technology museums and raises some of the ethical questions museums face, particularly how an educational mission is defined by the competing tensions of representation, political influence, funding, and entertainment.

From Cabinets of Curiosities to Science and Technology Centers

As showcases for scientific discoveries, technological marvels, and natural wonders, museums became popular across Europe during the sixteenth and seventeenth centuries. These palaces of the muses began as private collections for acquiring physical knowledge and became displays of individual wealth and power. As explorers brought back new curiosities from around the world, these collections were a systematic attempt to organize the explosion of new knowledge. A complete cabinet of curiosity would have one of everything in the world, organized and displayed in a continuum from the ordinary to the exotic, sometimes even including the imaginary.

Natural history dominated scientific representation in museums for several centuries. From the mid-eighteenth century, collections of ornithology, entomology, paleontology, and geology formed the basis for large public museums. These museums were organized by Linnaean classification with hierarchal representations of human progress. When curators began including technology exhibits in museums in the late nineteenth century, the exhibits were also organized as a reflection of human progress. A typical framework included *synoptic series* that traced the evolution of a particular technology—for example, a series on sailing from rafts to steamships.

In addition to permanent museum facilities, the public had opportunities to see the latest in science and technology at temporary shows and traveling exhibits. The "great exhibition of the works of all industry of all nations" opened in 1851 at the Crystal Palace in London and ushered in an age of world's fairs. Cities sponsored these year long celebrations to showcase top standards in industry and national pride in technical achievement. In the early twentieth century, several companies turned their exhibits into traveling shows that toured cities after the fairs closed, allowing even more people to see their wares. Many factories even offered tours of their facilities, giving visitors an inside look at working in different industries.

In 1969, the year a human being first walked on the moon, an innovation in science and technology museums occurred: the launch of the first hands-on science and technology centers. San Francisco's Exploratorium and Toronto's Ontario Science Centre forged a new path for exhibiting science. Frank Oppenheimer, a Ph.D. physicist who worked on the Manhattan Project (headed by his brother J. Robert Oppenheimer), founded the exploratorium to supplement science curricula. He wanted to combine invention and play in order to encourage students to look at science from a new perspective. Science and technology were no longer tied to national or history museums, and curators began interpreting objects using new exhibiting techniques in a variety of non-traditional museum settings. In the 1980s industrial archaeology gained momentum, displaying technology in the physical spaces of abandoned factories.

As the notion of what constituted a museum expanded, traditional methods of exhibiting objects also changed. Throughout the twentieth century, museums began showing science and technology within social and cultural contexts. Natural history exhibits began placing animals in realistic groups representing predator-prey relationships and biodiversity within the environment. Technology ceased to be represented as a forward march of progress, and the complicated relationships among science, daily life, and the environment began to be explored. These changes in exhibit practices set the stage for the ethical questions for museums of science and technology.

Ethical Questions of Museum Exhibitions

Museum practitioners are well aware of the ethical dilemmas posed by every acquisition or exhibition. The museum studies literature often raises extended blocks of questions, such as Sharon Macdonald's introduction to *The Politics of Display*, a collection of essays addressing ethics in science and technology museums:

> Who decides what should be displayed? How are notions of "science" and "objectivity" mobilized to justify particular representations? Who gets to speak in the name of "science," "the public" or "the nation"? What are the processes, interest groups and negotiations involved in constructing an exhibition? What is ironed out or silenced? And how does the content and style of an exhibition inform public understanding?

The museum community has not reached a reasonable consensus on any of these questions.

The literature in the field has traditionally addressed these questions through case studies, but the analysis of individual museums or exhibitions does not often lead directly to changes in collection and exhibition practices. The difficulty in assessing effective exhibitions and implementing guidelines for future directions is that the ethical dilemmas museums face are a tangled knot of competing interests. Frequently, each new exhibit struggles with the same fundamental questions, hoping to maintain a balance among the diverse tensions of exhibit design.

At the core of the debate is the fundamental question: What is the purpose of museums? For many museums this can be generally answered under the aegis of education. Most museums exist to collect and share information, but how this mission is interpreted highlights the ethical dilemmas museums face: What should be collected? How should the objects be displayed? Who is the intended audience? What should they learn?

Although many science and technology centers have similar exhibits demonstrating scientific principles, are these fair representations of scientific practice? Science is a coordinated practice of trial and error: state a hypothesis, create trials, collect data, analyze the results, draw conclusions, and repeat as necessary. However, museums often display science as a finished product. Where are the experiments? Where are the failures? Even the popular hands-on interactive exhibits do not reflect the dynamic nature of science because they fail to show the evolution of scientific thought and practice.

Interactive science centers frequently push the boundaries of an educational environment. Techniquest in Cardiff, Wales, is billed as the largest hands-on science center in Great Britain, but the cacophony of children running in every direction raises the question: Is any active learning taking place? Advocates for science centers argue that stimulation of multiple senses encourages learning. They also argue that interacting with science in a fun and entertaining manner encourages students to continue studying science at more advanced levels. As funding for school trips to science centers grows, teachers must ask at what point does the balance shift from education to entertainment, and museums must make their positions clear.

In developing countries where non-scientific world views persist and significant portions of the population remain illiterate, do science museums have different education responsibilities? Armalendu Bose, retired director of the National Council of Science Museums in India, sees museums as having "the responsibility of educating the masses—literate, semiliterate, or even illiterate—about the social benefits of science and the need to imbibe a value and [to] practice a way of life imbued with scientific outlook." This brings an explicit value judgment to bear on exhibit design, raising a host of new questions: Where should museums position themselves along the spectrum of education to avocation? Do museums have the responsibility to explain the effects of policy decisions on scientific research? Should they be forums for debate? Can they be advocates for policy change? These questions in turn become questions of representation and interpretation.

Museums make choices at each stage in designing an exhibit. From what objects to include to what descriptions to write, curators craft a specific experience for the museum visitor. Until the end of the twentieth century, the voice of interpretation was the anonymous museum authority, but in the mid-1990s two exhibitions by the Smithsonian Institution brought the question of museum authority to center stage. The highly controversial exhibits *Science in American Life* and *The Crossroads: The End of World War II, The Atomic Bomb and the Origins of the Cold War* garnered international attention and sparked what would become known as the "history wars." Science in American life, which was funded in part by the American chemical society, explores the interaction between science and society. Criticism of the exhibit came from scientists who felt that it trivialized scientific achievements while emphasizing negative outcomes of scientific research. The debate over the crossroads exhibit centered on the Enola Gay, the airplane that dropped the atomic bomb on Hiroshima. Should a museum attempt to ask critical questions of wartime actions, as original plans for the exhibit did with a section describing the aftermath of the bombing? Or should museums allow interested parties, such as veterans groups or members of congress, to write a heroic narrative of the events? The debate, amplified by the media, eventually led to the cancellation of the exhibit. The battle over the exhibits sparked debate over who controls the information presented to the public. Is it the museum? Is it the donor? Is it the person or company featured in the exhibit? Is it the media? Is it a political party? Is it a scientific expert? Who speaks for science in history museums? How do you represent a heterogeneous group of scientists? These questions forced the museum community to reflect on the purpose of museums and their ethical responsibilities to the variety of audiences they serve.

As a reaction to the controversies, many museums have shied away from politically sensitive exhibits. This limits the amount of contemporary scientific research that is exhibited to visitors and makes museums artifacts of science history. One suggestion for mounting exhibits without offering potentially controversial interpretations is to let the objects speak for themselves. Unfortunately, this presents a dilemma leading back to the educational mission of museums. Lacking any explanations, museum visitors may not understand the exhibit's content unless they are already informed on a particular subject matter. Another approach is to allow all interested parties a platform for explaining their views, but this can make an exhibit cumbersome and likewise confuse the visitors.

Tied to questions of representation and interpretation are questions regarding museums' responsibilities to their donors. Museums operate on a precarious business model; proceeds from visitors rarely cover operating expenses. Museums rely on grants, donations, and government funds to maintain and expand their collections, and these monies rarely come with no strings attached. Should donors have any input into the content of an exhibit? Historically, this has not been an ethical dilemma. In the 1910s the Smithsonian's curator of mineral technology built the collection by soliciting corporate donations and relinquishing control of exhibit labels to company copyeditors, making it explicitly clear that the company's name "would be conspicuously present." But as critics began noticing the increased advertising in museums during the 1990s and suggested that corporations had undue influence on exhibit development, museum directors began reforming exhibit policies. Curators in the early 2000s attempt to make clear breaks between funding and content, acknowledging financial contributions but attempting to limit influence on exhibit design.

Possibilities for the Future

It is unlikely that any of the questions raised here will be resolved decisively. Rather, museums will continue to attempt to balance the competing internal tensions inherent in exhibit design. As institutions of learning, museums need to evolve to reflect changes in current scientific practices while being mindful of their histories. In tackling current ethical questions and uncovering fresh ones, here are a few suggestions for possible directions for future exhibits at science and technology museums.

- Museums should reflect current scientific practice. Boston's Museum of Science has started the Current Science and Technology Center to highlight leading edge research and science in the news. Following this model, museums could become educational centers for sharing scientific research with the public, and museums could position themselves as forums for debate.
- Museums should tackle complex scientific problems. If museums are intended to be institutions for life-long learning, they should not be built exclusively for children. Exhibits should aim for a range of intellectual audiences, ranging from the uninformed novice to the educated non-expert.
- Museums should highlight the multifaceted and interdisciplinary nature of modern science. Science is no longer neatly divided into disciplines, and museums should not be either. An example would be exhibits showing the interactions among biologists, engineers, and doctors in the development of new medical devices. Exhibits could also

explore the relationships between science and other disciplines, such as the law or business. Both of these intersections would be shown in an exhibit on technology and the patent system.

- Museums should take advantage of new technologies to share their collections with a wider audience. Visitors used to have to travel to museums to see wonders, but the Internet has brought these wonders into the home, office, and classroom. The Science Museum of London has started an ambitious program to catalogue its collection online. If other museums follow suit, the diffusion of knowledge could reach tremendous numbers of people.

ALLISON C. MARSH

SEE ALSO *Activist Science Education; Education; Interdisciplinarity; Science, Technology, and Society Studies.*

BIBLIOGRAPHY

"America's Museums." (1999). *Daedalus: Journal of the American Academy of Arts and Sciences* 128(3): entire issue; contains 15 essays.

Conn, Steven. (1998). *Museums and American Intellectual Life, 1876–1926*. Chicago: University of Chicago Press.

Findlen, Paula. (1994). *Possessing Nature: Museums, Collecting, and Scientific Culture in Early Modern Italy*. Berkeley: University of California Press.

Henderson, Amy, and Adrienne L. Kaeppler, eds. (1997). *Exhibiting Dilemmas: Issues of Representation at the Smithsonian*. Washington, DC: Smithsonian Institution Press.

Lilenthal, Edward T., and Tom Engelhardt. (1996). *History Wars: The Enola Gay and Other Battles for the American Past*. New York: Henry Holt.

Macdonald, Sharon, ed. (1998). *The Politics of Display: Museums, Science, Culture*. London: Routledge.

Society for the History of Technology. (1965). *Technology and Culture* VI(1).

Spaulding, Julian. (2002). *The Poetic Museum: Reviving Historic Collections*. Munich: Prestel.

MUSIC

The history of Western music involves a transition from music understood as reflecting the harmony of the cosmos to the industrial production of desegregated sounds. From classical antiquity until the sixteenth century, music was a way to cultivate the senses for the good of a specific ethos. Politicians and physicians still talked about music when they searched for the right mixture of powers in politics or the right mixture of bodily humors in medicine. But with the demise of cosmological harmony manifested in Pythagorean proportionality, music became the disembedded art of sound production. Since the nineteenth century, modern music has been influenced substantially by scientific progress and its technological fallout. The technogenic production of sound reflects the disappearance of the traditional deep ethical relevance of music.

Music and Ethics

From ancient times to the sixteenth century, philosophers, musicians, physicians, and politicians understood music as an art intimately associated with ethics. In Greece as in other cultures, music and dance were significant threads in the fabric of every day life. Hymns were sung to praise and address the gods of its ethos. Outside religious rituals, music accompanied weddings, funerals, harvests and wars: Most social occasions not only had their own time but also were marked by their own musical instruments and modes. Authors such as Plato (*Republic*), Aristotle (*Politics*), Boethius (*De musica*), and Isidore of Seville (*Etymologiae* [Etymologies]) considered the influence of specific modes of music, rhythms, and musical instruments on body and soul (Anderson 1966, West 1992). It was believed that music not only mirrored the cosmos but also influenced the constitution of both individuals and society (Lippman 1992). Plato in *The Republic* describes different modes and rhythms with regard to their ethical effects (books 2, 3, and 7) and stresses their importance for education. Along with arithmetic, geometry, and astronomy, *musiké* was used as a sensible route to the appreciation of appropriate correspondences: "musical training is a more potent instrument than any other, because rhythm and harmony find their way into the inward places of the soul. . . . he who has received this true education of the inner being will most shrewdly perceive omissions or faults in art and nature" (Book III, paragraph 401).

The demonstration of the harmonic order of the cosmos with the help of a monochord, a rectangular sound box with a single stretched string, was the cornerstone of Greek ethical education. Teacher introduced pupils to the proportions of the musical consonances. According to one legend, it was Pythagoras of Samos who discovered the connection between the first four numbers and the musical consonances (octave 2:1, fifth 3:2, and fourth 4:3) and thus became the founder of music. For Pythagoras and his successors, musical consonances mirrored the harmonic order of the world. The first four numbers, the so-called *tetraktys*, were considered harmonic because they symbolized the four seasons, the four directions, and the four humors. This doctrine was handed down to the Middle Ages through Boethius's *De musica*, which distinguishes between *musica instrumentalis* (music that can be heard), *musica mundana* (music of the heavens), and *musica humana* (harmonic mixture of the bodily humors).

The Disembedding of Music

In the sixteenth and seventeenth centuries, the notion of music as the reflection of a given harmony started to fall apart. Doubts about the authority of the Pythagorean legend and new technologies such as musical printing questioned the millennia-old assumption of the embeddedness of music in a cosmological order and its ethical relevance. In a diverse range of treatises such as Gioseffo Zarlino's *Le istitutioni harmoniche* (1558; The harmonic foundations) and Johannes Kepler's *Harmonices mundi* (1619; The harmony of the world). *musica instrumentalis* is still considered an echo of the music of the spheres and the body. But at the same time, authors appear who complain that music has lost its power to form an ethos: Antonio de Ferraiis' s *De educatione* (1505) and Richard Pace's *De fructu qui ex doctrina percipitur* (1517; The benefit of a liberal education), for example, on the education of princes, follow the tradition of Plato and Aristotle by emphasizing the ethical value of a musical education. But they lament the loss of the sense for harmony, a sense that, from the pre-Socratics to their contemporaries, was fundamental to recognition of the good.

For music that was played in the Middle Ages, the technique of musical notation was understood as a memory aid for its performance. This changed during the sixteenth century when the German composer Nikolaus Listenius (dates unknown) claimed that a composition should be an *opus perfectum et absolutum*, an independent piece of art. He rejected the traditional notion of composition as the expression of God's creation (Kaden 1992). Notation did not serve as a blueprint for musical performance, but for the production of an autonomous, timeless piece of art made of composed tones. The Swiss scholar Henricus Glareanus (1488–1563) explicitly declared notated musical tones the foundation of music. The technological invention of musical printing in the late fifteenth century fostered this new understanding of composition as the production of a piece of art and made possible its conservation and reproduction. The musical artifact, namely, musical tones aesthetically arranged according to the tastes of the time, became the quintessence of music. Music now was understood as an art that fosters the individuality of its creators.

At the same time, philosophers and mathematicians, such as Giovanni Benedetti, Galileo Galilei, Marin Mersenne, and Isaac Beeckman, made the musical tone and its acoustic foundations an object of empirical research. These figures were the first to examine the validity of the canonical tradition of Pythagoras, rather than seeking to demonstrate its truth. Their experiments refuted the doctrine that the *tetraktys* was the harmonic foundation of music. In his *Discorsi e dimostrazioni matematiche, intorno a due nuove scienze* (1638; Dialogues concerning two new sciences), Galileo proved that the traditional assumption that the same ratios produce musical consonances when they "expressed relative weights of hammers, weights attached to strings, or the volume enclosed in bells or glasses" was wrong (Palisca 1961, pp. 128–129). What before had been considered a universal law reflecting a universal harmony was suddenly demystified as an empirical fact true only "for strings with the same thickness, length, and quality, and stretched to the same tension" (pp. 128–129). In his *Harmonie universelle* (1636; Universal harmony), Mersenne developed a mathematical formula for calculating the relation between the frequency of oscillation and the pitch of a string. By replacing the length of a string segment (e.g., 2:1 for the octave) with the frequency of oscillation (1:2), he anticipated the shift from cosmology to science (Cohen 1984).

Music as an Object of Scientific Research

The invention of measuring devices in the eighteenth century transformed musical qualities to calculable quantities. The tuning fork, developed by the trumpeter and lutenist John Shore in 1711 and Étienne Loulie's *chronomètre* (1696) gave a technological impetus to the quantification of pitch and tempo. Loulie's apparatus was almost 2 meters high, and although considerably improved by the French mathematician Joseph Sauveur at the beginning of the eighteenth century, was used only by music theorists and scientists. But in 1816 Johann Nepomuk Maelzel began manufacturing his version of the metronome (invented circa 1812 by Dietrik Nikolaus Winkel). With Maelzel's successful commercialization of the metronome, which was soon adopted by Beethoven (who retroactively marked metronome beats in his compositions, though these are sometimes questioned) and other composers, timekeeping became common in musical practice. The Italian tempo indication (for example, adagio, allegro, or presto), common since the seventeenth century, had determined the characteristics of a piece. The metronome fixed those characteristics to defined units per minute, replacing the description of qualities with quantifiable measurements of speed.

At the beginning of the eighteenth century, Sauveur founded the science of acoustics, a discipline designed to explore sound the same way optics analyzed light. Unlike his predecessors Mersenne, Kepler, or Galileo, who still searched for the harmonic principles of music, Sauveur did not distinguish between music and noise; he treated both as kinds of physical sound. This new scientific perspective on music created the foundations for musical acoustics, which, within one and a half centuries, would transform musical theory. In his *Génération harmonique* (1737; Harmonic generation), the French composer Jean-Philippe Rameau became the first to use Sauveur's research to support his own musical theory by referring to its acoustical foundations (Palisca 1961). Jean Jacques Rousseau (1712-1778), the French philosopher, introduces "acoustics" into the terminology of music with his dictionary of music. Whereas instrument makers used discoveries in the field of acoustics to improve musical instruments such as the piano and the violin; musicians, composers and musical scholars mostly neglected the importance of acoustics for their own work.

During the nineteenth century, music became the object of systematic scientific research in the laboratories of physicists and physiologists. In order to exchange and compare results within the scientific community, they had to develop standardized parameters. The acoustical examination of the tone required a universal point of reference. In 1834, following a suggestion of the German acoustician Johann Heinrich Scheibler, a convention of physicists in Stuttgart adopted Scheibler's standard pitch of A above middle C = 440 hertz. Fifty years later an international committee agreed on a standard pitch with global validity. A professionally defined and bureaucratically prescribed standard did away with the diversity of pitches that had been characteristic of each place and its ethos. The millennia-old art of attuning oneself to the appropriate and good of a certain place was replaced by submitting to experts' guidelines.

The German physiologist Hermann von Helmholtz (1821–1894) was the towering figure in acoustical research on music in the second half of the nineteenth century. In his study *On the Sensations of Tone* (1863), he reformulated the Pythagorean interpretation as a scientific problem and presented his new physiological, psychological, and physical foundations of musical theory. Helmholtz was an advocate of "objectivity," a new scientific paradigm of his time that was based on the use of scientific instruments. By developing scientific instruments that made not only the analysis but also the technical synthesis of sounds of different musical instruments possible, he revolutionized the understanding of music. Since Helmholtz, the axioms and technological fallout of the acoustical laboratory frame the understanding and meaning of musical instruments, hearing, consonance, and tone.

Music as the Production of Sound

At the beginning of the twentieth century, Helmholtz's laboratory notion of music as sound production became an everyday assumption. Without his acoustical research, the inventions of the phonograph by Thomas Edison in 1877 and the telephone by Alexander Graham Bell in 1875 would have been unthinkable (Peters 2004). The phonograph was commercially exploited by organizing concerts where real musicians had to compete with the machine. The audience was supposed to recognize that the machine was able to mimic musicians (Thompson 1995). In the early telephone days—the late nineteenth and early twentieth centuries—the new technology of analyzing and synthesizing sounds was primarily used to transmit concerts, operas, and variety shows to marketplaces, bars, hotels, or the parlor. Radio, which debuted in 1920, replaced the telephone as a device for broadcasting music.

At the same time new technologies made music an industrial product, the sound of industrial machines such as airplanes and trains entered theaters and concert halls. Arthur Honegger's *Pacific 231* (1923), a musical dedication to the then strongest American Locomotive Kurt Weill's *Der Lindberghflug* (1929; The Lindbergh flight), or Frederick Converse's *Flivver Ten Million* (1926), praising the 10 millionth Ford car, document how music reflected the industrial age and its technological innovations (Braun 2002). The Italian futurists even used the noise of steam engines and other machines together with conventional musical instruments in order to create industrial soundscapes. Electronic instruments gave birth to innumerable new sounds. The aetherophone, or theremin (1921) by Leon Theremin, the Sphräophon (1926) of Jörg Mager, and Maurice Martenot's Ondes Martenot (1928) produced artificial sounds that were enthusiastically welcomed by concert and movie audiences. Machines for synthezising sounds were introduced in 1929 and became commercially viable with the synthesizer invented by Robert Moog in 1964.

The invention of the triode vacuum tube by the American inventor Lee de Forest in 1906 and of the transistor in 1947 opened up the possibility of amplifying and modifying sounds. It was the avant-garde of popular musicians who, in the 1950s and 1960s, were fascinated by the new technological potential and started to use amplifiers, microphones, and loudspeakers. With the help of electrified musical instruments such as the electric guitar, music groups invented and produced their own characteristic sounds, that is, their individual "trademark sound," which facilitated commercialization in popular as well as in classical music. Since then, sound engineers behind the scene have become the ones who produce the sounds adapted to the taste of different consumer groups. Technicians operating recording machines, filters, and mixers determine the musical output on records and in concert halls. Musicians and composers used machines such as the tape recorder, the vocoder, the synthesizer, or the sampler to design new sounds or to imitate the sound of musical instruments. Computer programming, tape recording, the "playing" of turntables or musical instruments were equally used as means for sound production.

The technological imperative of contemporary music was discussed controversially among composers, philosophers, and musicologists after World War II. In "Music and Technique" (1959), Theodor W. Adorno expressed disapproval of contemporary composers who incorporated technology into their works. He called their search for a new kind of music based on the electronic generation of sound a banality that would raise engineers to composers and lower composers to technicians. According to him, music without notation and interpretation would be nothing but a technogenic production and reproduction of something audible. In contrast to Adorno, apologists of electronic music such as Karlheinz Stockhausen (b. 1928), John Cage (1912–1992), and Pierre Schaeffer (1910–1995) praised its new forms of expression that overcame the outdated limits of traditional music. They sought a new kind of music that would provide the technological society with its appropriate musical expression.

In the 1980s the computer ushered in the era of boundless possibilities of sound production. In the early twenty-first century new sounds are generated, conventional ones are simulated, and all types of sounds are mixed arbitrarily regardless of their historical and cultural meanings (Théberge 1997). With little fanfare, sound designers and artists use noises and artificial sounds as well as plainchants venerating the Madonna or pop songs by the American singer Madonna as a resource for their artistic productions. Be it songs of African shamans in the supermarket or classical symphonies in a parking lot—disembedded sounds have become the background music of a technogenic society.

MATTHIAS RIEGER

SEE ALSO *Entertainment; Popular Culture; Science, Technology, and Society Studies.*

BIBLIOGRAPHY

Adorno, Theodor W. (1999). "Music and Technique." In *Sound Figures,* trans. Rodney Livingstone. Stanford, CA: Stanford University Press. Translation of "Music und Technik," originally published, 1959. A collection of articles originally published in the 50s and 60s on the social aspects of musical experience. In the last essay, music and technology, Adorno discusses the impact of the electronic production and reproduction of music on its aesthetics.

Anderson, Warren D. (1966). *Ethos and Education in Greek Music*. Cambridge, MA: Harvard University Press. Surveys the contribution of musicians and music-making in Greece from archaic to the graeco-roman periods. Covers topics such as musicians' dress, affinities with shamans and gods, musical instruments, notation and scales. Other cultural musical practices are cited as suggestive parallels.

Braun, Hans Joachim, ed. (2002). *Music and Technology in the Twentieth Century*. Baltimore and London: John Hopkins University Press. A collection of articles by musicologists and historians of technology. Covers the area of electronic music and instruments, the history of sound recording, aesthetics, education and the echo of technological inventions such as the railroad and the airplane in twentieth century music.

Cohen, H. Floris. (1984). *Quantifying Music: The Science of Music at the First Stage of the Scientific Revolution, 1580–1650*. Dordrecht, Netherlands: D. Reidel. Main study on the transition from the scientific analysis of music in terms of numbers to an approach on an essential physical basis, covering the acoustical research of Galilei, Beeckman, Descartes and Kepler.

Helmholtz, Hermann von. (1954 [1863]). *On the Sensations of Tone as a Physiological Basis for the Theory of Music,* trans. Alexander J. Ellis. New York: Dover Facsimile edition of the translation by Ellis (1875), which offers a comprehensive introduction into musical acoustics as well as into nineteenth century musical aesthetics and music history.

Kaden, Christian. (1992). "Abschied von der Harmonie der Welt" [Farewell to the harmony of the world]. In *Gesellschaft und Musik: Wege zur Musiksoziologie* [Society and music: approaches to the sociology of music], ed. Wolfgang Lipp. Berlin: Duncker und Humblot. Discusses the shift from a cosmological understanding of music to the modern notion of music as an independent art that developed between the fifteenth and the seventeenth centuries.

Lippman, Edward A. (1992). *A History of Western Musical Aesthetics*. Lincoln: University of Nebraska Press. Provides a brief introduction into the role of music concerning ethics in antiquity and the middle ages. Focuses on musical aesthetics from the sixteenth century (music as fine art) to the twentieth century.

Palisca, Claude V. (1961). "Scientific Empiricism in Musical Thought." In *Seventeenth Century Science and the Arts*, ed. Hedley H. Rhys. Princeton, NJ: Princeton University Press. Deals with the transformation of music from an ethical art to aesthetics. Referring to the main scientific discoveries in musical acoustics in the sixteenth and seventeenth centuries, Claude describes the influence of scientific thinking on musical theory taking the example of the theories of overtones and the sympathetic vibration of strings.

Peters, John Durham. (2004). "Helmholtz, Edison, and Sound History." In *Memory Byte: History, Technology, and Digital Culture*, ed. Lauren Rabonovitz and Abraham Geil. Durham: Duke University Press. Examines the influence of Helmholtz's acoustical work on Edison and Bell's inventions.

Plato. *The Republic*. Books 1–5, trans. Paul Shorey. Cambridge, MA: Harvard University Press 1930.

Sauveur, Joseph. (1984). *Collected Writings on Musical Acoustics*, ed. Rudolf Rasch. Utrecht, Netherlands: Diapason Press. Collection of writings by Joseph Sauveur on different aspects of musical acoustics such as harmonics, beats, tuning and standard pitch.

Sterne, Jonathan (2003). *The Audible Past: Cultural Origins of Sound Reproduction*.Durham, NC: Duke University Press. Explores the cultural origins of sound production and reproduction in the nineteenth century; covers the social and historical preconditions for the invention of technical devices such as the telephone, microphone, phonograph, and radio.

Théberge, Paul. (1997). *Any Sound You Can Imagine: Making Music, Consuming Technology*. Hanover, NH: Wesleyan University Press. Offers a sustained analysis of social conditions of technological innovations in the design of music technologies, focusing on digital technologies in the production of popular music.

Thompson, Emily. (1995). "Machines, Music, and the Quest for Fidelity: Marketing the Edison Phonograph in America, 1877–1925." *Musical Quarterly* 79(1): 131–171. Describes the marketing of the Edison phonograph by competitions between the phonograph and live music.

West, Martin L. (1992). *Ancient Greek Music*. Oxford: Clarendon Press. Introduces different aspects of ancient Greek music such as instruments, rhythms, scales, notation, and the role of music in religious and everyday life.

N

NAGASAKI

SEE *Hiroshima and Nagasaki.*

NANOETHICS

Nanoscience, nanoengineering, and nanotechnology involve the study, design, and manipulation of natural phenomena, artificial products, and technological processes at the nanometer level. Because a nanometer is one-billionth of a meter (10^{-9} meter), this effectively means research, design, and operations at the atomic and molecular levels. Nanoethics aims to promote critical ethical reflection in this relatively new field. It complements other efforts to explore the moral dimensions of the scientific and technological transformations in human action such as nuclear ethics (dealing with very large scale power generation and its challenges), biomedical ethics (focusing on the bio-scientific and bio-technological aspects of medicine), and computer ethics (emphasizing the technological redefinition and processing of information).

Background and Prospects

Early inspiration and vision for the pursuit of nanoscience and nanotechnology is widely credited to physicist Richard P. Feynman's (1918–1988) talk "There's Plenty of Room at the Bottom" at the 1959 annual meeting of the American Physical Society. He concluded that speech with a financial challenge, offering $1,000 to the "first guy who can take the information on the page of a book and put it on an area 1/25,000 smaller in linear scale in such a manner that it can be read by an electron telescope" (http://www.its.caltech.edu/~feynman/plenty.html). In 1982 Gerd Binnig and Heinrich Rohrer invented the scanning tunneling microscope (STM), which made Feynman's challenge technically feasible and essentially marked the technological beginning of nanoscience and nanotechnology research. International Business Machines (IBM) patented the invention, and demonstrated the microscope's incredible power by writing the initials *IBM* with thirty-five individual xenon atoms.

Thirty years after Feynman's talk, President Bill Clinton, at a 2000 appearance at Feynman's home institution, the California Institute of Technology, announced the U.S. National Nanotechnology Initiative. Other initiatives were subsequently launched in many other countries indicating significant political and economic motivations to promote this new area of scientific knowledge and to accelerate nanoscale technical understanding and control of the physical world. Together with private funding from corporations and venture capital investors, support for nanoscience and nanotechnology initiatives is anything but small.

K. Eric Drexler's *Engines of Creation* (1990) provided the one of the first dramatic visualizations of possible nanotechnology futures general overview of nanotechnology. Subsequent developments led to the production of rapidly produced nano-scaled devices, such as nanoscale storage and nanotube transistors; molecular transistors and switches; atomic force microscopes; focused ion and electron beam microscopes; novel materials; nanowires and nanostructure-enabled devices; non-volatile RAM, nano-optics, nanoparticle solubilization, and nano-encapsulation for drug delivery. Products already on the market by the early 2000s included sunscreens, fabrics, sports equipment, house paint, and medical devices.

A report by the National Science and Technology Council claims that "the emerging fields of nanoscience and nanoengineering are leading to unprecedented understanding and control over the fundamental building blocks of all physical things. This is likely to change the way almost everything from vaccines to computers to automobile tires to objects not yet imagined is designed and made" (http://www.wtec.org/loyola/nano/IWGN.Public.Brochure/IWGN.Nanotechnology.Brochure.pdf). Endorsements of the U.S. National Nanotechnology Initiative refer to the possibilities of miniaturized drug delivery systems and diagnostic techniques, positive environmental impacts through drastic reductions in energy use and the rebuilding of the stratosphere, extending and repairing deficits in the human senses, and security systems smaller than a piece of dust. One nanotechnology visionary, whose ideas are controversial, Drexler envisions that molecular assemblers could make possible low cost solar power; cures for cancer and the common cold; cleanup of the environment; inexpensive pocket supercomputers; accessible space flight; and limitless acquisition and exchange of information through hypertext.

Concerns and Criticisms

Some dismiss these claims as *hype,* not grounded in scientific reality. Nobel Laureate in chemistry (1996) Richard Smalley disagrees with Drexler about the ability to create self-replicating, self-assembling devices. Harvard University chemist George Whitesides concurs, arguing that there exists no concept of how to design a self-sustaining, self-replicating system of machines. There is a great deal of speculation and debate over future applications, and no one knows if the machines created will be able to do the things hoped for, such as to remove molecules from their environments, cause them to reproduce themselves in new environments, and use them to create devices such as molecular robots for engineering purposes.

Extreme reactions, such as those expressed in Michael Crichton's novel *Prey* (2002), where swarms of nanobots aggressively and intelligently seek to eat human flesh, reflect fear that scientists will not have complete control over the products of nanotechnology. These opinions call for moral reflection about the inevitability of nanotechnology development, the risks and harms imbedded in precise, atomic manipulation by humans, and potential inability to undo harmful technological advances. Aside from the more dramatic concerns expressed in science fiction (such as nanobots) are questions pertaining to (a) equity and access; (b) environmental safety; (c) irreversible and mysterious changes to food, water and air; (d) privacy and security; and (e) the philosophical considerations of introducing mechanical systems into biological organisms.

One cause of concern that ensued early in the emergence of nanotechnology developments was over the idea of grey goo; the possibility that nanoscaled robots (nanobots) originally designed for specific manufacturing processes might make copies of themselves, atom by atom, replicate endlessly and consume large areas of matter, even the world. Although the debate over grey goo has lessened over time, the idea still occasionally surfaces in public debates and science fiction.

The Canadian based Action Group on Erosion, Technology and Concentration (ETC), a nanotechnology watchdog organization, is concerned that nanotechnology development is moving too quickly, without any real oversight regarding environmental safety, public heath, and other societal concerns. The ETC identifies three phases of nanotechnology development. The first (which is already well underway) involves bulk production of nano-scale particles for use in products such as sprays, powders, coatings, and fabrics. In these applications, nanoparticles contribute to lighter, cleaner, stronger, more durable surfaces and systems. In the second phase, scientists seek to manipulate and assemble nanoscale particles into supra-molecular constructions for practical uses. The third phase would be mass production, possibly self-replicating nanoscale robots, to manufacture any material, on any scale. Ultimately, according to the ETC, nanomaterials will be used to affect biochemical and cellular processes, such as for engineering joints, performing cellular functions, or combining biological with non-biological materials for self-assembly or repair.

Ethical Issues and Analysis

The rapid development of nanoscience and nanotechnology is not simply a technological initiative, but has social aspects as well. While fueled by scientific ingenuity, it is also motivated by political pressures, competition for new international markets, venture capital ambitions, and competing conceptualizations of the public good. There is a sense of urgency that because of potential dangers (such as freely migrating carbon nanotubes penetrating plant, animal, and human cells, or uncontrollable self-assemblers) science must learn how to respond effectively and proactively to avert any consequential and irreversible social and environmental harms.

In this vein, some have called for implementation of a precautionary principal and a moratorium on further nanotechnology pursuits. Bill Joy reflected upon the potential dangers of genetics, nanotechnology, and robotics, and stated that "These possibilities are all thus either undesirable or unachievable or both. The only realistic alternative I see is relinquishment: to limit development of the technologies that are too dangerous by limiting our pursuit of certain kinds of knowledge" (Joy 2001, p. 11).

Joy's writing unleashed vigorous debate, and was strongly criticized by nanotechnology proponents such as Christine Peterson of the Foresight Institute. In the interest of providing safe opportunities for the development and commercialization of molecular manufacturing, the Foresight Institute has written a set of self-regulation guidelines for the development of nanotechnology, and argues that, if adopted by research scientists and the industries involved, those guidelines should suffice in addressing ethical concerns over the development of nanotechnology. Others defend the continued pursuit of nanoscience, nanoengineering, and nanotechnology on moral grounds, contending that they are relatively benign enterprises, representing a good and natural evolution in scientific inquiry, and further, that any restraint on development of nanotechnology will inhibit the improvement of humankind. Many important questions remain unanswered regarding the prevention of potential environmental accidents and abuses, or threats to human health and safety that may result from the release of nano-scaled devices into the atmosphere, waterways, the food chain, and medicine.

The use of nanotechnology to design improved surveillance systems raises the issue of the privacy rights of individuals. The potential of nanotechnology to produce powerful and precise new weapons calls into question the purposes of advanced and redefined forms of military combat and intervention. Miniaturization and hybridization of commonly used electronic devices tests the assumption that faster and cheaper is equal to better, and demands examination of how market imperatives could supercede other social goods and respected human values.

Scientists have a moral responsibility to be conscientious in their research because nano-scaled science and engineering fundamentally entail risk taking with novel, unpredictable, relatively untested new materials and devices in the realm of public and environmental safety. Of course, as with any new technology, responsibility for the ethical development of nanotechnology also lies with those who make public policy and society in general. The more philosophical questions will be answered not by scientists, but in the public domain: How does society identify what is *the good* or *the harm?* What new materials and processes should society be exposed to? What values can be sacrificed in the attempt to achieve precise human control and manipulation of matter?

Policy Responses

Matters to be resolved include how government is to be held accountable for funding stipulations that influence actual nanoscience research, timeline and reporting of results, the ethics of basic research questions that grantees study, and the technologies they are asked to develop. Provisions for access to education and technical training in this new field is also a matter of public policy. Who will pay for and provide the specialized retraining needed for teachers, or for the equipment, facilities and supplies needed for the schools? How will society assure democratic inclusion and full public access in this fast moving new initiative?

In the United States, the NSF has taken a leadership role in consideration of social and ethical issues in the development of nanotechnology. The NSF sponsors major conferences and panels for the purpose of considering the societal and ethical issues involved in nanotechnology. It allocates funding for individual researchers, and has established major centers of research. The European Commission regularly releases sponsored reports on issues related to nanotechnology health and safety. The European Parliament has held public hearings on nanotechnology, and sponsored various other public forums for widespread discussion of the emerging concerns. Yet because nanoscience and nanotechnology are still in an early stage of development, there is a significant lack of international consensus over distinctions of fact and fiction in their potential, and few clearly agreed upon articulated nodes of ethical concern.

There are multiple questions to be considered and new policies to be debated regarding who will receive the benefits of nanotechnology developments, and at what cost and to whom. Ownership, power, and control issues regarding devices and processes that are fundamentally invisible to the human eye present interesting ethical challenges both legally and socially. Some political rhetoric uses the language of competition, describing the international climate of nanoscience initiatives as a race. The very notion of a race raises the questions of why science is in such a hurry and to what end. The issues of who will *win* this race, and how world powers will implement and control the applications of nanotechnology have not as yet been effectively examined. Public policy must also respond to the potential for private individuals to gain access to the raw materials of nanotechnology, such as carbon nanotubes, or eventually, assemblers. Who, then, will oversee or control the use individuals make of those materials, such as for the building of experimental devices or weapons of mass destruction? To protect society from possible harm, external controls may have to be put in place to regulate and govern the types of nanotechnology that corporations can develop. Moral responsibility dictates that corporations adhere to rigorous self regulation, abide by widely adopted rules, principles and codes, such as those proposed by the Foresight Institute, and/or become involved in public policy, citizen review groups, and the like.

Public policy must also address the management of nano-related toxicity, release and control of nano-scaled, self-replicating artifacts, subtleties of nano-scaled surveillance mechanisms, inequities in access to power, and other unpredictable nano-related implications for society.

Conclusion

Through the tools now available, extensions of human hands and eyes (such as the atomic force and atomic probe microscopes) allow scientists to observe and manipulate atoms directly, move them, rearrange them, and reconfigure them. The resultant potential, to create atomically built hybrids of synthetic, mechanical, and biological components and turn them into novel devices, suggests that society is embarking on an incredibly powerful, tremendously exciting, but possibly dangerous undertaking. The development of nanotechnology could mean fundamental and beneficial changes to our relationships with the physical world, as human beings gain greater power to manipulate their bodies and environment. Where might such awesome abilities lead? What will happen when nanoscience and nanotechnology advance enough to achieve the results aimed for by scientists? What society does with this new knowledge may determine the changing substance of the physical, social, cultural, economic, moral, and perhaps even spiritual lives of humankind. Are people fully cognizant of and fully prepared to accept and adapt to those changes? Are science and the public in general proceeding with conscientious commitment? The ethical challenges are as daunting as the technical ones.

ROSALYN W. BERNE

SEE ALSO *Bioengineering Ethics; Biotech Ethics; Environmental Ethics; National Science Foundation; Posthumanism; Science Fiction.*

BIBLIOGRAPHY

Crichton, Michael. (2002). *Prey*. New York: Harper Collins.

Crandall, B. C., ed. (1999). *Nanotechnology: Molecular Speculations on Global Abundance*. Cambridge, MA: MIT Press.

Drexler, K. Eric; Chris Peterson; and Gayle Pergamit. (1990). *Engines of Creation: The Coming Era of Nanotechnology*. New York: Anchor Books.

Drexler, K. Eric; Chris Peterson; and Gayle Pergamit. (1991). *Unbounding the Future: The Nanotechnology Revolution*. New York: William Monroe and Co.

Editors at Scientific American, eds. (2002). *Understanding Nanotechnology*. New York: Warner Books, Inc.

Gross, Michael. (1999). *Travels to the Nanoworld: Miniature Machinery in Nature and Technology*. New York: Plenum Trade.

Kaku, Michio. (1997). *Visions: How Science will Revolutionize the 21st Century*. New York: Anchor Books.

Mnyusiwalla, Anisa; Abdallah Daar; and Peter A. Singer. (2003). "Mind the Gap: Science and Ethics in Nanotechnology." *Nanotechnology* 14(3): R9–R13.

Nelson, Max, and Calvin Shipbaugh. (1995). *The Potential of Nanotechnology for Molecular Manufacturing*. Santa Monica, CA: Rand.

Ratner, Mark, and Daniel Ratner. (2003). *Nanotechnology: A Gentle Introduction to the Next Big Idea*. Upper Saddle River, NJ: Pearson Education, Inc.

Regis, Edward. (1995). *Nano: The Emerging Science of Nanotechnology*. Boston: Little, Brown and Company.

Roco, Mihail C., and William S. Bainbridge. (2001). *Societal Implications of Nanoscience and Nanotechnology*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Smalley, Richard E. (2001). "Of Chemistry, Love and Nanobots." *Scientific American* 285, no. 3 (September): 76–77.

Stephenson, Neil. (1995). *The Diamond Age*. New York: Bantam Books.

Whitesides, George. (2001). "The Once and Future Nanomachine." *Scientific American* 285, no. 3 (September): 78–83.

INTERNET RESOURCES

ETC Group. Home page at http://www.etcgroup.org/.

Feynman, Richard P. (1959). "There's Plenty of Room at the Bottom." Available at http://www.its.caltech.edu/~feynman/plenty.html.

Foresight Institute. (2000). "Foresight Guidelines on Nanotechnology." Available at http://www.foresight.org/guidelines/current.html.

Joy, Bill. (2000). "Why The Future Doesn't Need Us." *Wired Magazine*, issue 8.04. Available at http://www.wired.com/wired/archive/8.04/joy.html

NANOTECHNOLOGY ETHICS

SEE *Nanoethics.*

NATIONAL ACADEMIES

The U. S. National Academies are a consortium of four organizations. They are composed of the National Academy of Sciences, the National Academy of Engineering, the Institute of Medicine, and the National Research Council.

History and Structure

The National Academy of Sciences (NAS) was founded in 1863 to provide scientific and technical advice to the government. It is a membership organization of leading scientists, and new members are selected by the current membership. The membership decides how many total members to admit, and the number as of 2004 was about 1,800. In 1916 NAS realized that it could not meet the demand for advice from its members alone and therefore organized the National Research Council (NRC) to make it possible to enlist the larger scientific and technical community in its mission of providing expert advice to government. The National Academy of Engineering (NAE) was formed in 1964, and the Institute of Medicine (IOM) in 1970. Like NAS, NAE and IOM are membership organizations of the most respected engineers and medical professionals respectively. NAE has about 1,900 members, and IOM has approximately 1,200. The three organizations jointly manage NRC, which is the operating arm of the Academies.

The National Academies are not government organizations. The federal government chartered NAS, but the Academies are private organizations. The Academies do, however, receive federal funds to conduct studies at the request of Congress or federal agencies. State governments, foundations, and private companies also support studies, but industry can provide no more than 50 percent of the cost of a study. NAS, NAE, and IOM can each conduct studies independently, but NAS with support from NAE conducts most of its studies through the NRC. IOM is not a formal part of the structure of NRC, but its program must be approved by the NRC Governing Board and its reports must meet the requirements of the NRC Report Review Committee. The NRC issues about 250 reports per year, and at any given moment has roughly 6,000 volunteers serving on 600 study committees. In 2003 the National Academies had a staff of 1,200 and a budget of about $225 million.

The National Academies have a long and distinguished history of involvement in a wide range of activities related to science, technology, and ethics. The typical process for any Academies activity begins with a request from the federal government to conduct a study and issue a report on a specific topic. The Academies then select a committee of experts from relevant disciplines to perform the study. Once the committee members are named, there is a period of public comment to make certain that there is no bias or conflict of interest within the committee. Then the committee is formally appointed. The committees usually include some NAS, NAE, or IOM members, but most committee members are not members of these institutions. The expertise needed for these studies include law, ethics, and other nonscientific disciplines, and the individuals come from think tanks, advocacy groups, and industry as well as the universities. All committee members are volunteers; they are assisted by Academies staff.

The committees usually work for about eighteen months to produce a consensus report. All reports are subjected to rigorous review by the Report Review Committee, which appoints reviewers who are independent of the institution, have had no role in preparation of the report, and are unknown to the committee. Once the study committee has satisfied the reviewers that the report is fair and accurate, the report is published by the National Academies Press and is available for public purchase.

A list of sample NRC studies follows:

Science and Human Rights (1988)

The Responsible Conduct of Research in the Health Sciences (1989)

Shaping the Future: Biology and Human Values (1989)

Extending Life, Enhancing Life: A National Research Agenda on Aging (1991)

The Social Impact of AIDS in the United States (1993)

Women and Health Research: Legal and Ethical Issues of Including Women in Clinical Studies (1994)

Society's Choices: Social and Ethical Decision Making in Biomedicine (1995)

Biotechnology: Scientific, Engineering, and Ethical Challenges for the 21st Century (1996)

Xenotransplantation: Science, Ethics, and Public Policy (1996)

Non-Heart-Beating Organ Transplantation: Medical and Ethical Issues in Procurement (1997)

Cells and Surveys: Should Biological Measures Be Included in Social Science Research? (2001)

Integrity in Scientific Research: Creating an Environment That Promotes Responsible Conduct (2002)

Research Ethics in Complex Humanitarian Emergencies: Proceedings of a Workshop (2002)

Responsible Research: A Systems Approach to Protecting Research Participants (2002)

Scientific and Medical Aspects of Human Reproductive Cloning (2002)

The Experiences and Challenges of Science and Ethics: Proceedings of an American-Iranian Workshop (2003)

Guidelines for the Care and Use of Mammals in Neuroscience and Behavioral Research (2003)

Unequal Treatment: Confronting Racial and Ethnic Disparities in Health Care (2003)

Ethics Related Activities

In addition to producing studies at the request of others, the Academies sometimes use their endowment funds to prepare studies and organize activities at their own initiative. One such project began in the 1980s when there were a number of prominent cases of scientific fraud. NAS decided that it had a responsibility to make certain that all scientists understood the rules and responsibilities of scientific research. In 1989 NAS published *On Being a Scientist: Responsible Conduct in Research*, which provides a detailed discussion of the norms governing the proper behavior of scientists. More than 200,000 copies were distributed, and an expanded version was published in 1995. NAS distributed 70,000 copies of the new edition free to graduate students.

The Academies also operate the Joseph Henry Press, which publishes books by independent authors on a variety of scientific subjects. One title is *The Common Thread: A Story of Science, Politics, Ethics, and the Human Genome* (2002) by Georgina Ferry and 2003 Nobel laureate John Sulston. IOM also publishes books by independent authors, such as *Science and Babies: Private Decisions, Public Dilemmas* (1990) by Suzanne Wymelenberg.

Finally NAS publishes the scholarly journal *Proceedings of the National Academy of Sciences* (1914–present) and co-publishes with the University of Texas at Dallas the quarterly policy magazine *Issues in Science and Technology* (1984–present). *Proceedings* includes scientific research articles, but some of these touch on ethical as well as scientific concerns. An example is Paul R. Ehrlich's "Intervening in Evolution: Ethics and Actions" (2001). *Issues* is an independent magazine that provides a forum where individuals can express their views on a wide range of subjects. It regularly publishes articles and book reviews that address ethical and social concerns.

Although NAS conducts most of its activities through the NRC, it maintains direct control of the Committee on Human Rights, which was formed in 1976 to protect human rights, particularly of scientists, throughout the world. NAE and IOM became cosponsors in 1994. The committee uses the prestige of the institutions to defend scientists, engineers, and health professionals who are unjustly detained or imprisoned for behavior that is protected by the Universal Declaration of Human Rights. The committee investigates suspected violations, appeals directly to governments when appropriate, offers moral support to prisoners and their families, and works to make the public aware of the need to protect human rights. The committee serves as the secretariat for the International Human Rights Network of Academies and Scholarly Societies, which includes organizations from fifty countries. The committee has had numerous successes in obtaining the release of people being unfairly detained.

Because of their reputation and renown, the Academies are able to attract leaders from government, academia, and industry to events that provide a forum for discussion of controversial issues. The NAS Building in Washington, DC, is the site of numerous workshops, conferences, and symposia at which experts and decision makers debate the critical ethical issues related to science and technology. Examples include a series of workshops on regulatory issues in animal care and use as well as several meetings about human reproductive cloning and the treatment of human subjects in research.

The National Academies have enormous influence in all aspects of science and technology because of their long history of providing guidance to government, the rigorous review process through which all reports must pass, and the widely recognized expertise of committee members. NRC reports are regularly featured in the popular press, and committee chairs are often invited to testify before Congress or to brief administration officials. The full text of all reports is available for free on the Academies Internet site, which makes the site a valuable source of information for scholars, journalists, and government officials.

KEVIN FINNERAN

SEE ALSO *National Institutes of Health; National Science Foundation; Royal Society.*

BIBLIOGRAPHY

Cochrane, Rexmond C. *The National Academy of Sciences: The First Hundred Years, 1863–1963*. Washington, DC: National Academy Press, 1978.

Committee on the Preparation of the Semi-Centennial Volume. *A History of the First Half-Century of the National Academy of Sciences: 1863–1913*. Washington, DC: National Academy Press, 1913.

INTERNET RESOURCE

The National Academies: Advisers to the Nation on Science, Engineering, and Medicine. Available from www.nationalacademies.org.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

The National Aeronautics and Space Administration (NASA) is the principal civilian space agency in the United States, and the leading space science agency in the world. Its scientific and technological activities pose a variety of ethical issues, from setting program priorities to environmental impacts and risk–safety tradeoffs. NASA decisions, however, rarely turn on explicitly ethical considerations (see, for example CAIB 2003, PCSSCA 1986). Common influences on NASA decisions include interest-group lobbying, Congressional politics, and intra-agency competition for resources.

NASA's Mission and Other Space Activities

Legislation created NASA in 1958, building on existing civilian aviation research activities of the National Advisory Committee for Aeronautics (NACA). The core of NASA's mission is space exploration, divisible into human exploration and space science. Human exploration includes, for example, the space shuttle and the International Space Station (ISS) in Earth orbit and the Apollo missions to the Moon. Space science includes astronomy and robotic planetary exploration missions; the Hubble Space Telescope (HST) is the most visible example of the former, while the Mars rover missions of 2004 exemplify the latter. Exploration and science overlap: Astronauts installed instruments on the Moon, and scientific experiments are conducted on the ISS and shuttle. Other NASA programs include earth science (satellites that look down at the earth) and practical applications such as communication satellites. In 2004 President George W. Bush called for human planetary exploration.

Other U.S. agencies with space activities include the National Oceanic and Atmospheric Administration (NOAA) and the Department of Defense. NOAA operates satellites to gather data in support of its missions (weather forecasting, for example). The Defense Department and intelligence agencies support their missions with satellites for surveillance, communication, and navigation. Private commercial activities, some virtually independent of NASA, include launch services and satellites for communications and Earth observation.

As an independent agency, NASA reports directly to the U.S. president. Although managed from a Washington, DC, headquarters its operations are decentralized in two ways: First, the great majority of NASA employees work at eight field centers such as the Johnson Space Center near Houston, Texas. Second, private-sector contractors do most of NASA's work, and most of its scientific research is conducted through grants to universities. In 2002 the NASA budget was around $15 billion, supporting 18,000 civil service employees and a contractor workforce several times as large.

NASA's involvement with science and technology is extensive: Virtually all its missions embody advanced technology (although some long-lived missions use yesterday's state-of-the-art technology). It developed the Saturn launch vehicle for Apollo, and the shuttle as a general-purpose, reusable launch vehicle. It created the HST, perhaps the most productive scientific instrument ever, and its series of missions to other planets were the basis for the new field of planetary science.

Ethical Issues

Broadly speaking, many justify space exploration primarily in terms of human adventure and scientific knowledge. A strong version of this position is that humans have an innate need to explore and learn about the world around them. In this view, humans leaving Earth is a straightforward extension of the species' past spread across Earth. Further in this vein, certain images from space, such as Earth seen from *Apollo 11* and the violent galaxies captured by HST, show how fragile and lonely this beautiful planet is, inspiring efforts to preserve it. A somewhat more modest justification holds that, regardless of human history, today humans want to go into space essentially because they can.

Against this background, and to some extent because of it, NASA activities raise a diverse set of ethical issues. These run from whether space exploration can or need be justified in terms of human history, anthropology, and psychology, to the dangers of planetary cross-contamination, risks to astronauts, and honesty in justifying and describing particular programs.

The possibility of life on other planets has animated reflection across much of human history. Search for evidence of life is an important aspect of many planetary missions. But if missions that land on Mars carry with them microbes from Earth, the Earth microbes may confuse the results. Future generations may be misled. Humankind may have "polluted" another planet. (Against this possibility NASA sterilizes spacecraft before launch.)

Further, many scientists want to bring back to Earth a Mars sample for study more complete than can be done remotely on Mars. If life exists there, a returned sample or dust on the returning spacecraft might contain organisms threatening to life on Earth. The threat is remote because NASA will take steps to isolate any returned spacecraft and sample, but given human ignorance it still raises the issue of whether NASA programs might cross-contaminate planetary life-forms. NASA recognizes the issue and therefore ended the Galileo mission in 2001 by crashing it into the atmosphere of Jupiter, which was intended to extinguish all Earth-life aboard it. If humans "colonize" Mars, however, cross-contamination is probably inevitable.

Another form of contamination is the debris missions leave in orbit. A collision with even a small object can disable a spacecraft. Thus early missions leave risks for following ones. Debris in low Earth orbit will slowly reenter because of residual atmospheric drag, but debris in higher orbits remains for centuries. The vastness of space dilutes the risks, but they remain real. Recognizing this, NASA and the world's other space agencies are working to minimize debris from future missions.

Risks to Life

The loss of life in space transportation accidents dramatically raises questions of risks. For example, what purposes justify risking astronaut lives in space missions? In the *Challenger* and *Columbia* space shuttle disasters risk became loss.

In the past NASA dismissed the risks of shuttle flight, claiming at one time that the accident rate would be one shuttle lost in 100,000 flights. Empirically it is roughly 2 in 100. Reliability of 98 percent is good for a launch vehicle—perhaps the best possible, and perhaps acceptable for professional astronauts on valuable missions. What about amateurs: a "teacher in space," members of Congress, scientists? Do the experiments done on the ISS justify the risk to astronauts tending them? Is returning the HST to the Smithsonian Institution at the end of its life worth the risk of a shuttle mission to retrieve it? Do seven astronauts have to be sent up for this mission? Perhaps the science done by the HST justifies the risk of the missions flown to keep it operating, but a mission to retrieve it for the Smithsonian seems questionable.

The death of seven astronauts in each of two shuttle accidents makes clear that one way to reduce the potential loss is to reduce the number of crew on each mission. The first accident involved a "teacher in space" who was to inspire young students. In order to decide if the risk she took was appropriate, one would have to ask hard-to-answer questions such as whether inspiration was likely, and whether students most needing inspiration would be positively affected. Another dimension is whether an amateur could give adequately informed consent to the risk.

Risk issues become entangled: The HST will eventually reenter Earth's atmosphere. Being massive, it will not burn up; large pieces are expected to reach the ground, presenting an involuntary risk to people on Earth. Guiding the HST down to a remote ocean area would greatly reduce that risk, but it has no capability for a guided reentry because NASA originally planned for shuttle retrieval. A mission to install a reentry package could also service HST to lengthen its scientifically productive life. Several incommensurate considerations are thus involved: The risk to professional astronauts, the risk to bystanders on Earth, and the value of HST science. Balancing these risks calls for ethical discussion. One proposed solution involves the use of robots to service HST.

Promoting and Justifying Programs

A different ethical problem arises in the description and justification of programs. NASA began as a geopolitical response to the Soviet Union's launch of *Sputnik I*, to demonstrate that U.S. technical capability was superior to that of the USSR. The program, however, was promoted as space exploration—as the realization of humanity's drive to explore and gain knowledge. In reality space exploration was the means for the end of demonstrating U.S. prowess. From the beginning there has been a mix of motives, of ends and means. The ISS is variously justified and described as space exploration and as a science laboratory in space. But these are both problematic: As the station goes around and around Earth, the incremental exploration on additional orbits becomes vanishingly small, while the risk to astronauts remains the same. Second, there are questions as to whether the science on the ISS is worth what it costs. That is, if the justification is scientific, one must ask whether the same funds could support better science, for example in space astronomy (SSB 2003).

Similarly, NASA's justification of a program to develop a nuclear power reactor in space is questionable. The public justifications are that nuclear power would enable new activities, including scientific missions. Nuclear power is probably necessary for missions outside the solar system, and perhaps for extended human exploration missions within the solar system. Nevertheless, to justify the nuclear program a scientific mission to study Jupiter's moons, which had been endorsed by the scientific community and which could be done without nuclear power, has been adopted as the nuclear program's first mission, to give the technology development a clear target. The adopted mission had to be redesigned to require nuclear power; a scientific mission became a nuclear mission. That is, from the time of adoption forward the criteria for making decisions about the mission became nuclear first, science second. Scientific questions no longer drive the mission; rather the driver is developing and demonstrating nuclear power in space—science is a stalking horse. It would be more honest to call this a nuclear program using a science mission to demonstrate possibilities.

Of course a program to put a nuclear reactor into space faces all the ethical problems of nuclear programs on Earth, if in a different form. First are the hazards in the development program and the hazards of launching fissile material. Further, when its fuel is exhausted the reactor will become both another bit of nuclear waste and another bit of space debris. Where and how will it be "disposed of"? Typically, such questions are considered technical, not ethical.

RADFORD BYERLY, JR.

SEE ALSO *Apollo Program; Space Exploration; Space Shuttle Challenger and Columbia Accidents; Space Telescopes.*

BIBLIOGRAPHY

Bilstein, Roger E. (1989). *Orders of Magnitude: A History of the NACA and NASA, 1915–1990*. Washington, DC: National Aeronautics and Space Administration. NASA history as seen from the inside.

McDougall, Walter A. (1985). *The Heavens and the Earth: A Political History of the Space Age*. New York: Basic. The best general history of space activity.

National Research Council. Space Studies Board (SSB). (2003). *Factors Affecting the Utilization of the International Space Station for Research in the Biological and Physical Sciences*. Washington, DC: National Academies Press. Scientists describe the scientific usefulness of the space station.

U.S. Columbia Accident Investigation Board (CAIB). (2003). *Report of the Columbia Accident Investigation Board*, Vol. 1. Arlington, VA: Author. The official, comprehensive report.

U.S. Presidential Commission on the Space Shuttle Challenger Accident (PCSSCA). (1986). *Report of the Presidential Commission on the Space Shuttle Challenger Accident*. 5 vols. Washington, DC: Author. Comprehensive report from the executive branch.

INTERNET RESOURCES

National Research Council. Space Studies Board (SSB). "On Scientific Assessment of Options for the Disposal of the *Galileo* Spacecraft." Available from http://www7.nationalacademies.org/ssb/galileoltr.html. Letter, June 28, 2000, from SSB Chair Claude Canizares and Committee on Planetary and Lunar Exploration Chair John Wood to Dr. John Rummel, NASA planetary protection officer. Describes efforts to prevent planetary contamination.

National Research Council. Space Studies Board (SSB). "Factors Affecting the Utilization of the International Space Station for Research in the Biological and Physical Sciences." Available from books.nap.edu/openbook/NI000492/html/.

U.S. Columbia Accident Investigation Board (CAIB). "The CAIB Report." Available from http://www.caib.us/news/report/.

U.S. Presidential Commission on the Space Shuttle Challenger Accident (PCSSCA). "Report of the Presidential Commission on the Space Shuttle Challenger Accident." Available from http://history.nasa.gov/rogersrep/51lcover.htm.

NATIONAL GEOLOGICAL SURVEYS

National geological surveys provide scientific knowledge about a nation's lands, natural resources, and natural hazards within particular political, social, and legal contexts. At any given time, the work done by a geological survey reflects the public good as governmentally defined. Regardless of specific activities, however, geological survey scientists have special responsibilities as public scientists to maintain high standards of scientific inquiry and to remain credible irrespective of shifting priorities and pressures. Historical review of the U.S. Geological Survey (USGS) illustrates how one major national geological survey has sought to address priorities of the public it serves and to contribute to the common good.

Historical Review

During the nineteenth century, many nations recognized the importance of understanding the nature and distribution of their natural resources and thus established national geological surveys. The British Geological Survey (BGS, established 1835) and the Geological Survey of Canada (GSC, established 1842) were the earliest of these organizations that have operated continuously since their founding. Initially, the BGS, the GSC, and subsequent sister geological surveys in other countries focused on supporting the mineral needs of industrialization. Because countries equated their security and standing in the world with economic viability, the ability to locate raw materials for industrial development became the first major justification for beginning or continuing national geological surveys.

In the United States, mapping and science explorations, reconnaissances, and surveys sponsored by the federal government began in 1804 and continued thereafter under the aegis of the War Department, the Treasury Department, and/or the Department of the Interior (established in 1849), which was responsible for the stewardship and management of federal lands and their resources. In 1879, Congress and the President discontinued three competing mapping and science surveys of the public domain (Rabbitt 1979); their activities in biology passed principally to the Commissioner of Agriculture. In place of these surveys, Congress and the President established the USGS as a bureau of practical geology within the Department of the Interior to respond to pressing national needs for minerals for construction and currency.

The USGS was made responsible for "the classification of the public lands and examination of the geological structure, mineral resources, and products of the national domain" (U.S. Statutes at Large, v. 20, p. 394, March 3, 1879), but its operations were confined to the 1.2 billion acres in the public domain lands, most of which was acquired during westward expansion of the nation and lay west of the 100th meridian. The General Land Office, established in 1812 and transferred to Interior at the Department's founding in 1849, continued its land-parceling (cadastral) surveys and classifications—including mining, grazing, timbering, and agriculture—as the basis for disposition and title as a source of revenue and public good. To conduct the *scientific* classification of the public domain, USGS Director Clarence King planned a series of land maps to provide information for agriculturists, miners, engineers, timbermen, and political economists (Rabbitt 1980). In 1882, Congress implicitly extended USGS responsibilities to include the entire country, not just public lands, when it authorized preparation of an improved geologic map of the United States and by necessity a national geographic base map (Rabbitt 1980, Nelson 1999).

By the last decade of the nineteenth century, the increasingly recognized consequences of the rapid exploitation of lands and their resources spawned the first significant conservation movement in the United States. The USGS responded to these concerns between 1888 and 1902 by gaining statutory approval to study surface and ground water (which led to a national stream-gauging network), to map forest reserves, and to conduct reclamation investigations.

Studies by the USGS in support of the exploitation of natural resources continued well into the twentieth century, work spurred by concerns for economic growth, public needs, and national defense. The mineral industry had supplanted agriculture as the U.S. principal business activity in 1859. Raw materials needed during the Civil War, postbellum national development, and the emergence of the United States as a world power between 1898 and 1918 justified the view that resource studies were critical to the economic well-being and security of the nation (Rabbitt 1980, 1986; Cloud 1980). Beginning in 1938 and 1939, the USGS increased its critical- and strategic-minerals program for national defense. During World War II, the USGS increased its minerals and water-resource investigations and its mapping for military purposes; the agency also founded a Military Geology Unit for terrain-intelligence studies at home and in combat theaters. These activities, along with energy programs and the study of uranium and other radioactive materials also begun during World War II, continued and expanded during the subsequent Cold War based on much the same rationale: providing the nation with a better understanding of these resources as aids to exploration and development for economic and military security (Rabbitt 1989).

After World War II, it was generally believed that good science automatically created societal benefits (Sarewitz 1996), and USGS scientists pursued research goals within broad programmatic guidelines to generate new science to apply. At the same time, the USGS responded directly to societal needs as they arose by adding new missions. By the mid-1960s, for example, USGS personnel studied the effects of underground nuclear explosions, mapped the Moon, helped to train astronauts for the manned space program, and established long-term cooperative projects with government agencies in Brazil, Pakistan, Saudi Arabia, and other countries (Rabbitt 1989).

The environmental movement of the 1970s also influenced the direction and scope of USGS activities. Land-use choices no longer were viewed from a wholly exploitative standpoint. The USGS response to environmental issues included a greater emphasis on water quality (including the development of a toxics-hydrology program and the implementation of a National Water-Quality Assessment), investigation of the environmental effects of resource extraction such as acid mine drainage, and studies of climate change, including global assessment of changes in glaciers and the monitoring of permafrost. USGS studies of uranium in the 1970s focused on deposit models and assessment of resources, but the research emphasis later shifted to addressing the appropriate disposal of low- and high-level radioactive wastes at sites such as Yucca Mountain in Nevada. The USGS had provided the nation and the world with classic work in ore-deposit modeling (thereby advancing exploration, development, and science), but society's concerns shifted to the consequences of extraction and the USGS responded by modifying the emphasis of its mineral-resource activities.

Toward the end of the twentieth century, several national and global trends combined to influence USGS priorities and change its role and that of earth scientists. The rapid development of information technology fueled societal expectations for more information. At the same time, population growth in the United States affected regions previously sparsely settled, and ever-larger segments of society were exposed to the dangers of coastal storms, earthquakes, floods, landslides, volcanic eruptions, and wildfires. It became clear to the USGS that its studies of the impact and causes of these events would have to be linked more closely to emergency response needs and yield more rapid results. To have the most significant influence on decisions of public safety, the information needed to be available in a timely manner and thus required a response capability of twenty-four hours per day, seven days per week. The availability of real-time data expanded the public and municipality demand for innovative products. By using rainfall amounts and stream-gauging hydrographs, the USGS has predicted the severity and duration of flood events for emergency response efforts. Emergency managers and industry began to use USGS products that showed them the intensity of ground shaking within minutes of an earthquake, enabling them to make quick-response decisions. The engineering community began to use these same products to assess the behavior of structures during earthquakes and to develop more precise building codes.

Remote sensing and satellite operations such as Landsat and their archives became major activities within the USGS. The development of the Internet and the digital revolution enabled the USGS to respond to public demand for a diversity of real-time data, geospatial products, and scientific interpretations through use of the World Wide Web. In the early 2000s, the USGS implemented *The National Map*, an effort to make up-to-date digital topographic maps available to the public via the Internet.

In 1996, the National Biological Service, founded within the Department of the Interior three years earlier, became part of the USGS. This broadened the mandate of the USGS beyond the geographic, geologic, and hydrologic sciences. The USGS became a natural science organization, unique among the national geological surveys of the world because of the breadth of capabilities within the agency. The USGS began to focus on a more integrated approach to its scientific work to address the complex issues facing society.

Global Cooperation

National geological surveys are increasingly aware of the global nature of their efforts. This awareness is manifested through their increasingly global activities and through organizational partnerships and alliances. In the 1990s, the International Consortium of Geological Surveys (ICOGS) was formed to address the public perception that the missions of the national surveys were completed and that their services were no longer needed in the twenty-first century. ICOGS has worked to increase awareness of the importance of the earth sciences for the public and for policymakers. The International Union of Geological Sciences (IUGS) and the United Nations Educational, Scientific, and Cultural Organization (UNESCO), as well as numerous professional societies, have also addressed the awareness issue through major education campaigns. In addition, individual national surveys have formed a number of strategic alliances that improve their quality and effectiveness. One example is the partnership among the USGS, the GSC, and the Consejo de Recursos Minerales (CRM) of Mexico that has resulted in continental-scale efforts and products of mutual interest, such as geophysical maps, standards, geochemical surveys, and the geologic map of North America. Other groups such as the Coordinating Committee for Geoscience Programmes in East and Southeast Asia (CCOP) and the Circum-Pacific Council also reflect an emphasis on addressing earth science issues through a collaborative process of multiple national surveys, academia, and the private sector.

The program activities of most national geological surveys are also adopting a more global view. The BGS, the Australian Geological Survey Organisation (AGSO), the French survey (BRGM), the South African Council for Geoscience, and the USGS all have active programs providing earth-science support to the developing world. In addition to these dominantly cost-sharing activities, there is an increase in global assessments and information gathering. For example, the USGS operates a global seismographic network that provides high-quality information on seismic events to researchers and the public. Because resources such as minerals, oil, and gas are such vital commodities and have profound economic implications, the USGS conducts global assessments of these resources. In addition, the USGS reports on the demand for more than 100 mineral commodities, both domestically and internationally for approximately 180 nations. The USGS also receives and processes data from the Landsat satellites and provides images of the earth available to all biweekly. National surveys are also playing an expanded role in diplomacy. The USGS has cooperated with the Geological Survey of Ireland and the BGS on a possible mineral assessment in the border area of Ireland and Northern Ireland, has collaborated with nations in the Middle East relative to the region's seismic hazards, and has worked in Cyprus relative to hydrologic and seismic-hazard issues.

Future Directions

Population pressures challenge Earth's capacity to sustain a viable human society without deleterious effects. The common good has, over time, been redefined to include other values in addition to economic growth, and the public arena is fraught with competing and often conflicting values. Appropriate choices by decision makers and society require scientific insights about complex natural systems and the probable consequences of any proposed decision. Society demands pertinent and reliable scientific information in forms useful for decision-making. Science alone, however, is not the determining factor in most decisions—social, economic, and aesthetic values enter in as well. The tradeoffs inherent in societal choices, and the variable confidence in which knowledge is held at any given juncture, also need to be communicated. In the early twenty-first century, the USGS began a focused effort to improve and expand the use of its scientific results to inform the public and support decision making at all levels of society by exploring the problem of incorporating science into value-laden societal decisions. Ultimately, society will decide which tradeoffs are acceptable based on the its values, but the USGS can provide the critical scientific understandings that can help inform the nation about these choices.

As scientists strive to define their research goals by focusing on the decision context of the information needed, many recognize that it will be difficult to sustain their impartiality and integrity. Before the twenty-first century, many research scientists maintained a significant distance between their research and the decisions that might be based on their results. The challenge will be to bridge the gap between scientists and decision makers without compromising impartiality. The law that established the USGS in 1879 required that "the Director and members of the Geological Survey shall have no personal or private interests in the lands or mineral wealth of the region under survey, and shall execute no surveys or examinations for private parties or corporations" (U.S. Statutes at Large, v. 20, p. 394, March 3, 1879). These ethical requirements remain important ones, as society looks to the USGS for honest, impartial, and useful analyses of difficult choices ahead. All societies need the insight of public earth scientists and their engagement in issues of great societal importance.

Throughout their history, national geological surveys, including the USGS, have reflected the priorities and values of the nations they serve. Although the issues that determine the scope of their missions change over time, three principal activities are conducted: (1) long-term monitoring of the earth and its processes; (2) assessment and applied studies; and (3) basic research and understanding of physical, chemical, and biological processes. In the future, the national geological surveys will face societal challenges that increasingly involve the complex interactions of humankind and the natural world. Among the most important challenges will be the mitigation of natural hazards; an increased demand for water, mineral, and energy resources; the consequences of human activities with respect to earth's ecosystems; and the implications of climate variability. As people expand their definition of quality of life to include human and ecosystem health, decision makers will need insights based on the most reliable knowledge to make informed choices.

P. PATRICK LEAHY
CHRISTINE E. TURNER

SEE ALSO *Expertise; Geological Information Systems; Modernization; Science Policy.*

BIBLIOGRAPHY

Cloud, Preston. (1980). "The Improbable Bureaucracy: The United States Geological Survey, 1879–1979." *Proceedings of the American Philosophical Society* 124(3): 155–167. A brief overview of the history of the U.S. Geological Survey and the scientific leaders who contributed significantly to the development of the agency.

Nelson, Clifford M. (1999). "Toward a Reliable Geologic Map of the United States, 1803–1893." In *Surveying the Record: North American Scientific Exploration to 1930,* ed. Edward C. Carter II. Philadelphia: Memoirs of the American Philosophical Society 231: 51–74. A history of the national portrayal of U.S. geology from four geognostic maps published between 1803 and 1832 to ten geologic maps issued between 1834 and 1893, with a brief review of subsequent maps through 1974.

Rabbitt, Mary C. (1979). *Minerals, Lands, and Geology for the Common Defence and General Welfare,* Vol. 1. Washington, DC: U.S. Government Printing Office. A detailed history of public lands, federal science and mapping policy, and the development of mineral resources in the United States to the founding of the U.S. Geological Survey in 1879.

Rabbitt, Mary C. (1980). *Minerals, Lands, and Geology for the Common Defence and General Welfare,* Vol. 2. Washington, DC: U.S. Government Printing Office. A detailed history of geology in relation to the development of public-land, federal-science and mapping policies, and the development of mineral resources in the United States during the first twenty-five years of the U.S. Geological Survey.

Rabbitt, Mary C. (1986). *Minerals, Lands, and Geology for the Common Defence and General Welfare,* Vol. 3. Washington, DC: U.S. Government Printing Office. A detailed history of the period 1904–1939 in the U.S. Geological Survey and the relation of geology to the development of public-land, federal-science and mapping policies, and the development of mineral resources in the United States.

Sarewitz, Daniel. (1996). *Frontiers of Illusion: Science, Technology, and the Politics of Progress.* Philadelphia: Temple University Press. A perspective on modern science policy in terms of what types of science should be pursued, who makes such choices, and how science can be evaluated in the context of broader social and political goals.

INTERNET RESOURCE

Rabbitt, Mary C. (1989). "The United States Geological Survey, 1879–1989." *U.S. Geological Survey Circular* 1050. Available from www.usgs.gov. A brief history of the relation of geology during the first 110 years of the U.S. Geological Survey to the development of public-land, federal-science and mapping policies, and the development of mineral resources in the United States.

NATIONAL INSTITUTES OF HEALTH

The National Institutes of Health (NIH) is the biomedical research agency of the U.S. federal government. Located in Bethesda, Maryland, a suburb of Washington, DC, the NIH funds intramural (federal employee) scientists and extramural (outside the federal government) researchers across the country. Eighty percent of the NIH budget goes to grants to outside universities and laboratories. Research conducted at the NIH or with NIH funds leads to a more complete understanding of human health and to developing preventions, cures, and therapies for disease. At the same time, the agency has been forced to address and respond to ethical questions regarding research subjects, research topics, and scientific conflicts of interest.

From the Marine Hospital Service to the Hygiene Laboratory

In 1798 President John Adams signed legislation that started the United States on a long road of funding health-related activities by creating a Marine Hospital Service (MHS), an agency that would fund hospitals in ports to care for military personnel when they fell sick at sea. However the U.S. government did not support health-related research for much of the nineteenth century.

Widespread acceptance of the germ theory in the 1870s led to an increase in the number of American scientists doing research on disease. The basic idea that one specific germ caused one specific disease led to an explosion of new studies on microbes, immunity, and vaccines. Scientists began to trace diseases back to a particular *vector* such as water, milk, insects, or healthy human carriers. The government began to organize and enforce quarantines to curb epidemics—and such measures worked. Scientists soon identified the bacteria that caused diphtheria, tuberculosis, typhoid fever, anthrax, and malaria.

In the 1880s, the government decided to expand the role of the MHS to include bacteriological research. A laboratory was set up at the MHS facilities in Staten Island, New York, and Joseph Kinyoun was appointed to run it, since he was one of the few MHS officers who had studied the new science of bacteriology. Kinyoun called his facility a *laboratory of hygiene* and it soon became known as the Hygienic Laboratory. Kinyoun's first paper described his methods for making a positive diagnosis of cholera using his microscope and bacteriological methods.

In 1891 the laboratory moved to a more prestigious government location: near the U.S. Capitol Building in Washington, DC. Kinyoun and his associates began to manufacture vaccines and antitoxins (known collectively as biologics) for diphtheria, rabies, and smallpox. After a tragedy caused by contaminated diphtheria antitoxin in St. Louis, Congress passed the 1902 Biologics Control Act, putting the Hygienic Laboratory in control of regulating biologics for the entire country.

In 1902 Congress expanded the Marine Hospital Service to the broader Public Health and Marine Hospital Service and reorganized the laboratory. The four new divisions were Pathology and Bacteriology, Zoology, Chemistry, and Pharmacology. Ph.D.s were hired alongside the M.D.s, introducing new scientific techniques and expertise. In 1912 the name Marine Hospital Service was dropped entirely. Activities of the newly conceived laboratory included exploring noncontagious diseases and conducting studies of dairies, pollution, and water filtration systems to identify causes for disease. Scientists showed that their research could assist public health officials in preventing epidemics and keeping the public safe.

Epidemiology became an important function of the Hygienic Laboratory in the early twentieth century. Scientists would be dispatched to a location where there was an outbreak of a disease such as yellow fever or typhoid. They would investigate the cause of the disease by finding the vector that passed it along or identifying problems of diet or pollution. Joseph Goldberger, for example, traveled across the South for many years doing studies on populations with outbreaks of pellagra. By closely observing the people who had the disease, experimenting with different diets, and exhaustively searching for possible causes among the populations of small towns, institutions, orphanages, and prisons, he correctly identified the disease as a dietary deficiency, rather than a contagious disease. Goldberger's discovery eventually led to the elimination of pellagra as a dangerous disease that once plagued an entire region.

The staff of the Hygienic Laboratory grew. Rocky Mountain spotted fever studies spawned a new outpost in Montana to better study the insect vector in that region. While the Pathology and Bacteriology division researched diseases such as typhoid fever, the Zoology division studied a new species of hookworm known to cause disease and the Chemistry division studied the role of stomach acid and the chemistry of blood. The Pharmacology division studied toxicity of alcohols and the effect of certain drugs on blood pressure.

NIH: 1930s to 1950s

In 1930 Congress approved more funding for a new building and expanded the role of the Hygienic Laboratory—renamed the National Institute of Health by Senator Joseph Ransdell—to fund scientists in new fields such as the study of chemicals used in warfare. As the Great Depression further eroded private support of scientific research, scientists increasingly looked for help from the federal government. The Ransdell Act of 1930 ushered in a new era of expanded government support for scientific research.

Cancer became the first disease to generate enough public panic to build support for legislation funding scientific research. In 1937 every senator in Congress cosponsored a bill creating the National Cancer Institute (NCI), which would (in 1944) become a subset of the NIH. The 1937 bill was important for another reason: It authorized the NCI to award grants and fellowships to outside scientists conducting research. This granting (extramural) program would become a fundamental part of the NIH's work.

With more responsibilities came the demand for more space. In 1935 the government accepted a gift of land from suburban estate owners Luke and Helen Wilson. The original plan was to use the land for the growing number of animals used in research, but by 1941 all the scientists had packed up their laboratories and joined the animals in a newly built complex of six brick buildings.

During World War II NIH scientists studied many problems among workers in the war-related industries in the United States. For example, they studied the levels of toxicity incurred by people working in industries such as synthetic rubber, ships, tanks, munitions, and airplanes. Disease research focused on malaria, yellow fever, and typhus, all of which proved devastating to the troops abroad. NIH scientists also studied the oxygen needs of pilots at certain altitudes.

In 1944 Surgeon General Thomas Parran and NIH Director Rolla Dyer helped pass a new law, the Public Health Service (PHS) Act, which revitalized the NIH. The act authorized more granting authority to the NIH and also allowed for spending on clinical research. Additionally the NIH was required to prepare public materials to inform the general public about its research and how that research affected people's health.

The next decades were a period of rapid growth for the NIH. Based on the success of the National Cancer Institute, many of the new institutes focused on the study and cure of certain diseases. During World War II many recruits were deemed unfit for service due to poor mental health or poor dental health, leading to the creation of new institutes to ease the effect of these problems in the population. These included the National Heart Institute, the National Institute on Mental Health, and the National Institute of Dental Research.

In 1953 the promise of clinical research was realized in the NIH Clinical Center, then the largest research hospital in the world with 540 beds. The special design of the Clinical Center ensured that the scientists and physicians kept in close contact while studying the effects of certain drugs or therapies on patients. Doctors referred many of the patients to the Clinical Center from all over the country. Other patients were *normal volunteers*, whose participation in studies produced baseline information about how healthy people reacted to proposed therapies. This data could then be compared with that from ill patients.

The clinical center was opened in the shadow of Nazi medical experiments. Its initial ethics rules, guided by the Nuremburg code, mandated informed consent from the human subjects of research and instituted an internal review process. In 1974, after the abuses of the Tuskegee syphilis study were made public, congressional action required the creation of Institutional Review Boards (IRBs) to oversee human research projects and an office of protection from research risks at NIH to oversee the IRBs.

In the decades after World War II, the proliferation of institutes—most of them still linked to a particular disease or body part—brought hundreds and then thousands of scientists, laboratory technicians, and support staff to the Bethesda campus, which also grew to accommodate more buildings.

NIH: 1960s to 2000s

Virus research was one major area of study at the NIH in the 1950s and 1960s. Developing new ways to grow and identify viruses, scientists identified dozens of new virus strains, leading to better and more effective ideas for curbing outbreaks.

One major line of research that has carried through in dozens of NIH laboratories in the second half of the twentieth century is genetics. In the late 1950s and early 1960s, scientists working with Marshall Nirenberg deciphered the genetic code. Building on this basic research, researchers in the 1960s and early 1970s learned how to cut and recombine DNA. In the 1980s the Human Genome Project was launched with the goal of charting the human genome, a goal that was reached in 2003 by scientists at the National Human Genome Research Institute. NIH scientists have also been leaders in experimental clinical research such as gene therapy.

In the 1970s, fields such as genetics research advanced rapidly because of new molecular biology techniques and instrumentation. The scientific competition that resulted also led to misconduct by some scientists. Beginning in the early 1980s, NIH led investigations into this issue. It also sponsored studies on how to ensure research integrity and programs to incorporate ethics training in the graduate education of scientists.

Research on chronic disease has been a mainstay of NIH research, from the earliest days of cancer and heart research to diseases such as diabetes, arthritis, and drug and alcohol addiction. A long-term NIH-funded study in Framingham, Massachusetts, provided evidence about heart health that has led to major education campaigns about the importance of exercise, low-fat eating, and smoking cessation. Dental research led to the mass fluoridation of water as it was shown to reduce the number of dental caries in children. In the 1980s infectious disease again took center stage when NIH researchers began studying AIDS.

In the 1990s the NIH continued to expand. New institutes funded studies of the aging population and the effects of nursing on patient care. Thousands of NIH scientists conduct research on the main campus in Bethesda, and at outposts such as the National Institute of Environmental Health Research in North Carolina and the Rocky Mountain Laboratory in Montana. In 1998 Congress voted to double the NIH budget over five years, and this money funded scientists all over the country and even around the world.

The NIH is proud to claim five Nobel Prize winners who did their major work on the Bethesda campus. In addition, dozens of members of the National Academy of Sciences have worked at the NIH. Over 100 scientists based at other institutions won the Nobel Prize based on research conducted with NIH funding in fields as varied as chemistry, physiology, medicine, and economics.

Several centers founded in the 1980s and 1990s complement the basic science at the NIH. For example, the Center on Research in Women's Health tracks the inclusion of women in clinical trials of drugs and disease therapies, and the Office of Technology Transfer encourages partnerships between scientists and industry. The National Center on Minority Health and Health Disparities monitors the NIH and works to eliminate health disparities. The National Center for Research Resources helps link scientists with the resources they need to make their projects work. These and other components of the NIH help ensure that the mandate to inform and protect the public from disease is carried out.

Ethics and Politics

In 1977, the NIH added a bioethicist to its staff. In 1995, bioethics was expanded to an entire program that supports training of new bioethicists and conducts research that seeks to inform public policy in health research. Though many argue that disease knows no politics, the NIH has had to deal with many issues that have divided bioethicists and the agency's supporters along political lines. Certain choices about which diseases to study and which patients to admit (such as AIDS patients in the 1980s) aroused controversy. Stem cell research worried many Americans and Congress members in the late 1990s and at the turn of the twenty-first century. New allegations in 2003 about NIH scientists accepting funding from pharmaceutical companies led to congressional calls for stricter rules about consulting and stock ownership. The regulations, similar to those imposed on scientists at regulartory agencies, sharply curtailed participation by NIH scientists on boards, committees, and participation in professional associations as well as their ownership of health-related stocks. In 2005, the new rules led to intense debate among NIH staff and scientists, who feared that they would result in driving top people away from federal service. Though for the most part scientists can work quietly in their laboratories without worrying about politics, institute directors must testify before Congress about how they are spending taxpayers' money. In 2005 with 27 institutes and centers and an annual budget of $27.9 billion, the NIH would be barely recognizable to Joseph Kinyoun, its first director.

SARAH A. LEAVITT

SEE ALSO *Complementary and Alternative Medicine; Health and Disease; National Academies; Research Integrity.*

BIBLIOGRAPHY

Harden, Victoria A. (1986). *Inventing the NIH: Federal Biomedical Research Policy, 1887–1937*. Baltimore: Johns Hopkins University Press. This volume describes the research conducted at the Hygeinic Laboratory and the expansion of its research program in the early-twentieth century before the NIH moved to Bethesda.

Kraut, Alan M. (2003). *Goldberger's War: The Life and Work of a Public Health Crusader*. New York: Hill and Wang. This engaging work explores the epidemiological work of Dr. Joseph Goldberger, a PHS scientist who solved the mystery of the cause of pellagra in the early twentieth century. The book outlines the policies and research goals of the early Hygeinic Laboratory scientists in Washington, DC.

Park, Buhm Soon. (2003). "The Development of the Intramural Research Program at the National Institutes of Health After World War II." *Perspectives in Biology and Medicine* 46(3): 383–402. This article outlines the research plans of the NIH as it grew astronomically in the decades after World War II. New goals are examined, the work of particular scientists is explored, and the overall mission of the NIH in this period is explained.

Hannaway, Caroline; Victoria Harden; and John Parascandola, eds. (1995). *AIDS and the Public Debate: Historical and Contemporary Perspectives*. Amsterdam and Washington, DC: IOS Press. This edited volume includes an essay by former Surgeon General C. Everett Koop in which he describes his positions on AIDS-related sexual education topics in the 1980s. The volume is an important addition to the story of how U.S. scientific and medical communities responded to the AIDS epidemic and how the NIH was influential in the early years of research and clinical studies.

INTERNET RESOURCE

National Institutes of Health. Available from www.history.nih.gov. This web site links visitors to a brief illustrated history of the NIH, along with more specialized web exhibits on certain research initiatives, such as genetics research, particular individual scientists such as Martin Rodbell and Marshall Nirenberg, and particular scientific achievements at the NIH. The site also provides bibliographies, copies of unpublished and out-of-print sources on NIH history, and much more.

NATIONALISM

Nationalism is a dominating political concept while being at the same time theoretically and practically problematic. In relation to science and technology, it is common to talk about national styles—French science and engineering are more rationalist, English science and engineering more empirical—and to see science and technology as having different national impacts. Certainly the scientific community in United States is able to marshal a greater percentage of gross domestic product (GDP) for research investment than similar communities in any other developed country, and U.S. culture is the most high-tech saturated in the world. Nationalism both energizes scientific and technological communities and has served as a justification for behavior that has been argued to violate scientific standards of conduct with regard, for instance, to research involving human subjects and to the sharing of knowledge. The scientific community has on occasion also seen itself as opposed to nationalism (and able to replace it with the "republic of science"), while nation-states have suspected scientists of disloyalties and seen them as a threat to national security. The following analysis of nationalism is thus designed to provide a basis for further exploration of such issues.

Nationalism as Theoretical Enigma

Nationalism is among the most problematic concepts in the social sciences. At the core of this enigma is the frequently observed discrepancy between the emotive and politically mobilizing *power* of nationalism and its flimsy or minimal *content* when analyzed as a political ideology. Primarily because nationalism is a political "ism," it is readily classified alongside other political/ideological isms, such as conservatism, liberalism, and socialism. But in contrast with adherents of these other ideologies, nationalists do not seem to be required to take on many, or indeed any, substantive intellectual commitments (Anderson 1983). One popular definition of nationalism, for example, holds that it is the doctrine "that the boundaries of the state and of the nation should always be congruent" (Gellner 1983, p. 1), but apart from this being minimalist in the extreme, there are still many enthusiastic nationalists in states that *long ago* realized such a doctrine But this does not appear to have diminished the nationalist enthusiasms and commitments that still emerge in such states from time to time.

This discrepancy between the appeal and content of nationalism has led some theorists to argue that it is not a political ideology at all, but a more emotive phenomenon, closer to religion than to politics. Others, while not endorsing this view, have suggested that its intellectual vacuity is precisely the secret of its mobilizing power. For while other political ideologies, precisely because of the substantive commitments they entail, will necessarily *divide* populations, nationalism *unifies*, through its broad emotivism, people who would otherwise differ—whether by socioeconomic status and interests, ethnicity, gender, or philosophical and value commitments.

Nationalism and Identity

Such an observation, while true and important, still does not explain the broad, unifying emotive appeal of nationalism. The response most favored by scholars of nationalism is that nationalist politics are a form of *identity politics* and that the emotive power of nationalism comes from its being one of the most common ways, at least in the modern world, in which people identify themselves and others. Because a threat to personal identity is one of the most profound, it is therefore not surprising that nationalist conflicts often call up deep, even hysterical, emotions in those involved.

The sociology and psychology of identity, while assisting in explaining the emotive power of nationalism, generates its own difficulty. It is a commonplace of the literature on identity that any human being always possesses *multiple* identities, of which a national identity is but one. Thus a person may be an American, a Christian, a woman, a feminist, a wife, a Democratic voter, a computer programmer, a keen basketball fan, and an enthusiastic gardener; which identity she emphasizes at any moment will depend on the context and situation. In certain circumstances (say, when she is traveling abroad, or when America is at war) her American identity may be uppermost. But it remains to be explained why people will kill and die for a national identity more readily than a gender, religious, or domestic political identity, or any other numerous possible identities. It is in addressing this question above all that theorists of nationalism divide into two broad groups or camps.

Modernist Theories of Nationalism

The great debate in the literature on nationalism concerns both the historical antiquity and the fundamental roots or sources of its appeal and power. Modernist theorists argue that national identities are of relatively recent origin and political construction. In essence, they maintain that since the late eighteenth century states or state elites have politically constructed national identities among the mass of their populations. For modernist theorists the two seminal historical events in the construction of nationalism as a political ideology and identity were the American (anticolonial) Revolution of 1776 and the French (antimonarchical) Revolution of 1789. These two events were seminal because between them they dethroned the predominant principle of political legitimacy of the premodern period (the divine right or divine status of hereditary rulers) and installed the modern democratic principle (rule in the name of, and with the assent of "the People") in its stead. In both these revolutions the boundaries of the legitimacy-bestowing "People" were taken to be coterminous with the boundaries of "the Nation." That is, "the People" who made up the new democratic citizenry were generally defined as those living within a certain geographical space, speaking a certain language, and sharing a common culture (Hobsbawm 1992, Gellner 1983).

Nevertheless, while the above was the core of the mobilizing and legitimizing ideology of both these modern revolutions, in practice the actual people—the population—occupying the geographical territories involved (the thirteen American colonies, the former kingdom of France) were often *not* possessed of the characteristics with which they were predicated in the noble rhetoric of "the People." Thus many were illiterate, quite a number did not support their respective revolutions at all, and in France many did not even speak French, at least not the Parisian variety in which the revolution was conducted. Thus in the postrevolutionary situation state elites set about *turning* populations into "The People" through the imposition of mass education systems using a single language or (in the French case) a particular regional version of a language. Such education systems not only turned "peasants into Frenchmen" (Weber 1976) or American colonists into Americans, they also specifically introduced the newly educated masses to the national symbols of identity and loyalty (flags, anthems, and constitutional principles) and inculcated them with a nationalist version of history in which they could find a sense of pride in their new identity.

These state-led "nation-building" practices became even more vital when, in the later years of the nineteenth century, France began its own industrial revolution and millions of non-English-speaking European and other immigrants flooded into the industrializing United States. The need of industrializing countries for a skilled and literate labor force, and the emergence of other economic and social institutions to shape that force (large industrial towns and cities, modern mass communications and infrastructure), gave further impetus to this state-directed process of "nationalizing" the masses. On this account the creation of national identities and identifications is simply part of the political and economic modernization of states and their populations, a process that introduces this new political identity (that of being a free and equal "citizen" of a "nation-state") as it also introduces a range of other new economic, occupational, and social identities (Gellner 1983).

Whatever its historical merits, this "modernist" theory of nationalism still leaves certain crucial questions unanswered. First, while it can and does account for the creation of "mass" nationalism, it has to assume the preexistence of a state elite nationalism that it does not itself explain. This is especially a problem in the case of English nationalism, which, as an elite or upper-class phenomenon, predates both the American and French Revolutions by a hundred years (Colley 1992, Newman 1997), and is therefore radically anomalous in the modernist account (Smith 1998). Second, precisely insofar as modernist theory emphasizes that national political identities are only *one* of the identity changes brought about in human populations by modernization, it still leaves unexplained the singular emotive power of national political identities specifically, relative to the many other modern identities ("worker," "employer," "liberal," "socialist," "feminist," "Yankees fan") created in the course of modernization.

One "modernist" attempt to deal with the latter question is found in Benedict Anderson's seminal book *Imagined Communities* (1983). Anderson suggests that it is significant that nationalism both borrows a great part of its emotional power from religious feelings and symbolism, and that it originated in a place and time when conventional religious belief was coming under widespread and systematic challenge. Anderson emphasizes the role of religious or quasi-religious symbols in national identification (cenotaphs, tombs of unknown soldiers, hymnlike national anthems). He also suggests that nationalism provides a sort of secularized version of immortality to replace explicitly religious notions coming under challenge. Thus, though any individual citizen lives and dies, "the Nation" itself lives on, and, in making the "ultimate sacrifice" for his or her nation on the field of battle, the individual citizen ensures the continuity/immortality of the national collective.

Although suggestive, such an interpretation is hardly conclusive. First, the late-eighteenth-century origin remains assumed. Second it is not clear that nationalism *did* replace or supplant conventional religiosity. It is true that conventional religious belief came under widespread challenge in the eighteenth-century Enlightenment, in certain restricted circles. But it nonetheless remained powerful and important as a mass phenomenon, and many who have killed and died for their nation have *also* seen themselves as killing and dying for God. That is, nationalist sentiment seems far more often to combine with, or even coattail upon, conventional religious conviction as to supplant it.

Antimodernism and "Ethnicity"

The essential view shared by all antimodernist theorists is that, in some way or another, modern nationalism is a "politically transformed" version of a much older, even primordial, phenomenon in human life, ethnicity. This latter concept is not without its problems, but in its original meaning at least, ethnicity is a biological or putatively biological concept. An "ethnic group" is a group of people claiming descent from a common ancestor, with such groups varying considerably in size and having many and various names in different languages. In English terms such as *tribe, clan,* and *family,* and indeed *nation* itself, are all terms with such an original biological or "kinship" meaning. Historically, people who have claimed a common biological descent have also shared a common language and have often had important customs and beliefs (religious, magical, sexual, etc.) in common.

In essence then, antimodernist theorists of nationalism claim that the creation of nationalism is best conceived as the modern "political transformation" of much older ethnic identities. Nationalism turns group identities that people possess but are not conscious or aware of (ethnic identities) into conscious, self-aware political identities (national identities). On this account there have for centuries been people who were ethnically English living in the geographical space known as England, but they became consciously, politically English only sometime in (most likely) the seventeenth century. Likewise, there have for millennia been people who were ethnically Chinese in the area of the world known as China, but they became consciously, politically Chinese only sometime in most likely the late nineteenth or early twentieth century (Smith 1986).

The clear advantage of this concept (which can embrace language, religion, and culture as well as biology) is that it explains why it was relatively easy for state elites to create mass nationalist loyalties (they were "only" making conscious what in some sense or other had long existed) and why (conversely) it may be difficult to create fervent, self-identifying nations across boundaries of biology, language, or culture. It also explains where "elite nationalists" come from. Elite nationalists are just the first people *within* an old ethnic group to make their ethnic identity a conscious political identity. This is a feat made easier by certain aspects of elite privilege (for example, greater leisure time and education and greater capacity to travel—and thus to see other peoples and cultures *and* to see them as "other" than "their own").

But antimodernist theories of nationalism are not without their problems. First, the existence and flourishing of such immigrant-based nation-states as the United States, Canada, Australia, New Zealand, and (indeed) Brazil or Argentina demonstrates that, while it may be more difficult to create national identities and solidarities across ethnic/cultural boundaries, it is by no means impossible to do so, given enough time and the appropriate political will. While most modern nation-states may indeed be dominated by a politically transformed ethnic core nation, not *all* are. This in turn implies the following: *All* modern nation-states that are now ethnically plural as the result of global population movements will not necessarily be imperiled by ethnic divisions between old host ethnic core groups and new arrivals. This may happen, as the result of political failures of one sort or another, but the relatively successful creation of the above-mentioned multiethnic, immigrant-based "nation-states" of the nineteenth century suggests that there is nothing inevitable about it.

Second, as the more sophisticated antimodernist theorists readily admit, ethnic identities are not themselves in any way fixed, static, or "unchanging" (Smith 1986). Human beings can, and have, changed even their biological group characteristics (physiogamy, skin tones, etc.) very considerably over long historical periods through interbreeding. Moreover, although ethnic groups usually *claim* to be biological entities, virtually none of them are, or are exclusively. That is, virtually all social anthropologists and historians who have studied large or largish human kin-based groupings (past and present) have emphasized that they operate through what is called "fictive" as well as real (biological) kinship. Slaves, war captives, or simple peaceful adoptees may be incorporated into a kinship group by the use of kinship terminology (by being treated as "uncles," "brothers," "cousins," etc.), and then, over time, this original adoption is forgotten and the people in question both claim to be and are accepted as "real" kin. (They or their descendents may even become so through interbreeding.)

Third, the above observations imply that *no* human ethnic groups existing today are in fact ethnic groups in the narrow biological sense (that is, actual biological descendents from a common ancestor). All of them are really linguistic and (to an extent) cultural groupings and therefore more or less open to any adoptees who are accepted into them. Therefore, although there *is* a linguistic and cultural "ethnic nation" of English people in England, they long ago ceased to be a biological descent group. (They are in fact a mélange of many such groups including Celts, Angles, Saxons, Normans, Danes, and others.) Moreover, although these composing groups "happen" to share broadly "Caucasian" physiogamies and skin tones (so that ethnically English people are "white" people), there is no reason why, in the future, this shared biological fact may not change markedly as the result of widespread interbreeding with non-Caucasians. What is true of the English ethnic nation is equally true of the Chinese, French, German, or any other ethnic nation.

Ethnic versus Civic Nationalism

These are not merely abstract historical considerations. They have vital contemporary implications. Because in a world of massive global population movements, the central political issue now facing all states is that of the relationship between civic national identities and ethnic national identities. While an ethnically Chinese person who settles in (say) Australia can readily, even "instantly," become a *civic* Australian citizen by going through a "naturalization" ceremony, being issued an Australian passport, and so on, this person will become *ethnically* Australian only by learning the English language well, adopting Australian cultural mores, and so on. All historical and contemporary evidence suggests that converting civic national identities into ethnic national identities (if that is what the people in question wish to do) will be a *much* slower process than formal civic incorporation—a process possibly requiring many generations to occur. But such evidence also suggests that there is nothing impossible about it, if the right "open" political and cultural conditions exist. Moreover, if the right conditions exist civic nationality can be turned into cultural or ethnic nationality quite quickly, as for example in the United States.

Nationalism and Globalization

This review of the major modern theories of nationalism has done little to dispel its enigmatic quality. All its theorists and theories are able to do *some* justice to this extraordinarily slippery phenomenon, while none do it *total* justice The reason may be relatively simple. It may be that *any* theorization of human identity in general (and not just of national identity) must come to terms with an important but frequently overlooked paradox. This is that (1) all human identities are parasitic upon notions of "difference" or "otherness"—for example, "male" identity on "female" identity, "white" identity on "colored" or "black" identity, and "liberal" identity on "conservative"—which are structurally "fixed," or apparently fixed, over relatively short historical periods. This semantic parasitism of identity on otherness has the possibility of conflict built into it, if the right (or wrong) political and historical conditions arise during those periods. (2) Despite this, all human identities are also, to a greater or lesser degree, plastic or changeable in the long run. Thus, human identity differences that at one historical moment can seem both immutable and inherently conflictual can (and indeed have) come at another time either to cease to exist altogether or to be regarded as perfectly and peacefully compatible, even mutually enriching. In this perspective then, ethnicity theories are strong in telling why national identities are slow to change but weak in explaining how and why they *have* changed over long periods and will no doubt continue to change. Conversely, modernist theories are good at laying out one important means and mechanism of change (manipulation by political elites) but weak in explaining why *some* identities seem much easier for such elites to manipulate than others.

If this is the case, then the central question facing all theories of nationalism concerns what political and institutional conditions tend to fix or "reify" the currently existing global pattern of ethnic/cultural differences and what political and institutional conditions tend to encourage the change or mutability of that pattern. When the matter is put this way, its implications for both bodies of theory are clear. At a certain period in modern history (roughly from the eighteenth century onward), a given global pattern of human ethnic grouping was (as both the modernists *and* the antimodernists assert) made conscious (through political mobilization by state-related elites), then further fixed and reinforced by such measures as the laying down of spatially exact and controlled state borders, the issuing of passports and citizenship papers, and the creation of a single "national" education system in a single "national" language.

In a word, some ethnic nations were "statized"—turned into so-called nation-states—whereas others were enforcedly incorporated into these state-dominant ethnicities or simply subordinated, as "second-class citizens," within these states. In many of the latter cases such subordinated groups also had their own demands for statehood denied or suppressed. Seen from a contemporary perspective this historical statization of *some* ethnicities was an enormously powerful force in politically fixing a particular historical ethnic pattern and making it seem both "natural"—the only possible pattern—and difficult, if not impossible, to change.

In a world that is globalizing rapidly—not only economically and technologically but also, to a degree, culturally—this political "fixing" of identity by statization may now be the central problem facing humans. There is no doubt that statizing (some) nations has made it more difficult (more difficult, that is, than would other more open and flexible political arrangements) for all human beings—whether members of dominant or "statized" ethnicities or not—to deal effectively with the unique problems posed by globalization *and* more difficult for all of them to take full and proper advantage of the economic and other opportunities it affords. This is because the principal socioeconomic and cultural differences and disparities that globalization creates are *not* ethnic or national differences at all, but differences that deeply cut across both ethnicity and nationalism. And there is strong reason to believe that those human beings who recognize this first, and act accordingly, will therefore be (and indeed already are) those who benefit most from globalization, whereas those who remain mired in ethnicity and national identity (and through the early twenty-first century this is the vast majority of humankind) will also be those least well equipped either to take advantage of globalization's opportunities or to solve its problems (Kitching 2001).

Conclusion: Nationalism, Science, and Technology

As indicated at the beginning, nationalism, science, and technology exists in some tension with each other. As an enigmatic form of identity that is dependent on otherness and historically plastic, nationalism has also been able to oppose and be opposed by various forms of science and technology. Obvious examples of opposition have involved the Nazi German rejection of "Jewish science," the Communist criticism of "bourgeois science," and Islamist efforts to simultaneously reject and transform infidel science and technology. The failures of such efforts in the past may nevertheless suggest some of the limits of nationalism as a transforming process.

Historically, nationalism was also associated with the Treaty of Westphalia (1648) that granted to nations sovereignty, that is, ultimate powers of life and death, within certain geographic borders. To some degree the positive character of these boundary conditions reflected the limits of early modern technology (especially forms of transportation and communication) and depended on them (the state did not have at its disposal mid-twentieth century means of propaganda nor a virtually unlimited ability to kill large numbers of any ethnically diverse population). Late twentieth century criticisms of nationalism in the name of internationalism in many instances reflect changes in technologies and the new forms of communication and power they place in the hands of some political elites that would statize certain pre-national identifies. The international opposition to statization by the Chinese in Tibet, the Serbs in Kosovo, or the Sunnis in Iraq all reflect a willingness to subject nationalist plasticity joined to technological power to transnationalist criticisms. In such cases science and technology themselves may likewise be seen as paradoxical promoters and delimiters of nationalism.

GAVIN KITCHING

SEE ALSO *Democracy; Science Policy.*

BIBLIOGRAPHY

Anderson, Benedict. (1983). *Imagined Communities: Reflections on the Origin and Spread of Nationalism.* London: Verso. One of the most original and imaginative treatments of the issue. Especially good on the relationship between Western and non-Western forms of nationalism.

Colley, Linda. (1992). *Britons: Forging the Nation, 1707–1837.* New Haven, CT: Yale University Press. A "modernist" treatment of British nationalism. Very good on the political construction and manipulation of ethnicity in the British context.

Gellner, Ernest. (1983). *Nations and Nationalism.* Oxford: Blackwell. One of the clearest and most accessible texts on the subject. Very orthodoxly modernist.

Hobsbawm, E. J. (1992). *Nations and Nationalism since 1780: Programme, Myth, Reality,* 2nd edition. Cambridge, UK: Cambridge University Press. An extremely skeptical treatment of nationalism by a great historian. Nationalism is here treated explicitly as an ideological phenomenon and an extremely duplicitous one.

Kitching, Gavin. (2001). *Seeking Social Justice through Globalization: Escaping a Nationalist Perspective.* University Park: Pennsylvania State University Press. Review of the various nationalist responses to globalization.

Newman, Gerald. (1997). *The Rise of English Nationalism: A Cultural History, 1740–1830.* New York: St. Martin's Press. Useful contrasting text to Colley. Much more insistent on the ethnic roots of nationalism.

Smith, Anthony D. (1986). *The Ethnic Origins of Nations.* Oxford: Blackwell. Important pioneering treatment of this very important topic.

Smith, Anthony D. (1998). *Nationalism and Modernism: A Critical Survey of Recent Theories of Nations and National-*

ism. London: Routledge. An extremely cogent and well-balanced review of this central debate.

Weber, Eugen. (1976). *Peasants into Frenchmen: The Modernization of Rural France, 1870–1914*. Stanford, CA: Stanford University Press. Fascinating text for the exploration of the differences and interrelationships of elite and mass nationalism.

NATIONAL PARKS

A national park, as distinct from a landscaped urban park, is a place set aside to preserve a natural geology or ecology deemed to possess significant inherent value. The concept of a national park thus constitutes a practical effort to place a specific ethical limit on technological development, sometimes for scientific as well as public benefit.

Historical Origin

Shortly after northwest Wyoming was annexed as part of the Louisiana Purchase in 1803, mountaineers and trappers began returning from their adventures in the American West with stories of a strange and mysterious place where steaming water bubbled from the ground and geysers shot like clockwork into the sky.

Rumors swirled for decades, until, in 1870, several expeditions were organized to explore the area around the Yellowstone River. The first expedition was so awed by the hissing, cauldron-like landscape that upon return members began a campaign for the creation of the world's first national park.

In response the federal government funded a second, scientific expedition, which was led by Dr. F. W. Hayden, then head of the U.S. Geological Survey. The group also included photographer William Henry Jackson, whose photographs (often developed *on location* in the hot springs) would prove the existence of a national treasure to skeptical Easterners and convince the country that Yellowstone needed to be set aside for the ages. Another participant, Lieutenant Gustavas C. Doane testified before Congress about what he had seen:

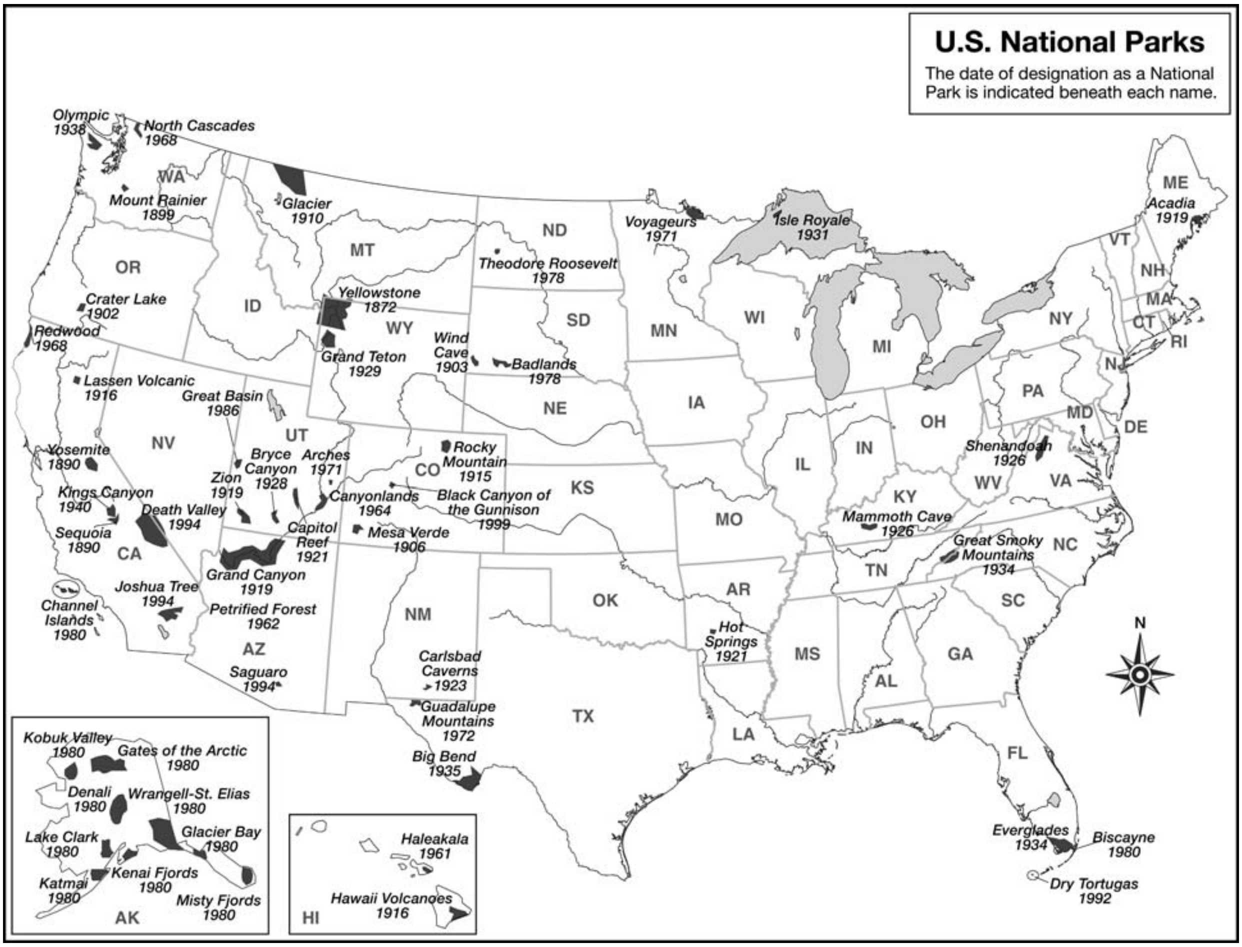
> [This land] is without parallel; as a field for scientific research, it promises great results; in the branches of geology, mineralogy, botany, zoology, and ornithology, it is probably the greatest laboratory that nature furnishes on the surface of the globe. (Everhart 1972, p. 6)

On March 1, 1872, President Ulysses S. Grant signed the Yellowstone Act. With the creation of Yellowstone National Park, 2 million acres were established "as a public park or pleasuring ground for the benefit and enjoyment of the people." The act went on to stipulate that regulations would be put in place to provide for the preservation "from injury or spoliation, of all timber, mineral deposits, natural curiosities, or wonders . . ."

Many in Congress voted for the creation of Yellowstone National Park because they did not want to see it destroyed by the type of crass commercialization and over-building that had occurred in New York's Niagara Falls. Preservation for its own sake was not a foundational idea. Indeed ideas such as Manifest Destiny and abundance were hallmarks of the frontier sensibility. Few thought the bounty of America had limits. Fewer still thought the government had any business interfering with their right to exploit the scenic wonders and natural resources at the frontier.

Though a great park was created, with visitors came despoliation. By 1886 the cavalry had to be called in to protect the park from vandalism, logging, and hunting. By the time a bill passed, creating a National Park Service within the Department of Interior to administer public lands, there were thirty-one national parks and monuments in the United States and a growing awareness that some type of protection was critical to the survival the nation's wild and scenic places. With the passage of the National Park Service Act of 1916, the debate between conservationists and preservationists over just how to protect the parks was settled: Conservationists arguing for the *wise use* of the natural resources in the national parks lost out to the preservationists who argued that wilderness areas should remain untouched and unexploited.

One of the authors of the National Park Service Act was landscape architect Frederick Law Olmstead, Jr.—of New York City's Central Park fame—who supported the notion of preserving places that would provide a contrast to and respite from the pace of the modern world. He envisioned parks where ordinary citizens could rest mind, body, and soul. From spiritual uplift to scientific research, recreation, and education, national parks were seen as a way to enhance the lives of the general public. The spread of the national park idea—that large tracts of wilderness should be protected for all time—could arguably be called one of the great contributions from the United States to world civilization.



Outside the United States

By the outbreak of World War I, Canada, Australia, New Zealand, Mexico, and Sweden had adapted the American concept of national parks to their own lands and needs. (In many of these countries, the primary motive for establishing national parks was the protection of native peoples rather than the flora, fauna, and natural wonders of the area.) In 1914 Switzerland created a national park, but dedicated it to scientific research rather than recreation.

In the inter war period, news of the massive slaughter of African wildlife led to the 1933 London Conference for the Protection of African Fauna and Flora. The conference helped inspire the creation of large national parks in eastern and central Africa to protect game populations and preserve areas for scientific study, but its ideals and goals had much wider influence and were used as a blueprint to help establish national parks worldwide.

As the national parks idea took root, an awareness developed of the need for some type of world organization that could promote nature conservation. In 1948 at a conference sponsored by the United Nations, the International Union of Conservation of Nature and Natural Resources (IUCN) was founded.

In the early twenty first century the IUCN, in coordination with the United Nations Environment Programme, is a self-described *green web* in which 140 countries, more than 750 non-governmental organizations, and 10,000 internationally renowned scientists generate environmental conventions, global standards, and scientific knowledge. It has become the voice, and often the instrument, for worldwide action to protect the biodiversity of species, ecosystems, and landscapes. The IUCN also monitors and maintains a database of National Parks and Protected Areas.

A *protected area* was defined at the Fourth World Congress on National Parks and Protected Areas (Caracas,

Bison grazing near hot springs in Yellowstone National Park. Yellowstone is the first and oldest national park in the world and covers 3,470 square miles. The park is famous for its various geysers, hot springs, and other geothermal features and is home to grizzly bears, wolves, and free-ranging herds of bison and elk. It is the core of the Greater Yellowstone Ecosystem, one of the largest intact temperate zone ecosystems remaining on the planet. *(© Michael S. Lewis/Corbis.)*

Venezuela, 1992) as "land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means" (World Conservation Monitoring Centre Internet site). Though in the early 2000s there are more than 100,000 protected areas worldwide, not all of them are national parks—defined by the IUCN as a "natural area of land and/or sea, designated to (a) protect the ecological integrity of one or more ecosystems for present and future generations, (b) exclude exploitation or occupation inimical to the purposes of designation of the area and (c) provide a foundation for spiritual, scientific, education, recreational and visitor opportunities, all of which must be environmentally and culturally compatible" (UNEP Protected Areas Programme: "Definition of a Protected Area" Internet site).

In the IUCN category of national parks, there are more than 3,300 worldwide. Other protected areas categories include Strict Nature Reserves/Wilderness Areas: protected areas managed mainly for science or wilderness protection; Natural Monuments: protected areas managed mainly for conservation of specific natural features; Habitat/Species Management Areas: protected areas managed mainly for conservation through management intervention; Protected Landscape/Seascape: protected areas managed mainly for landscape/seascape conservation and recreation; and Managed Resource Protection Areas: protected areas managed mainly for the sustainable use of natural ecosystems. Though fewer in number than the other protected areas, national parks account for 30 percent of the global network of protected areas, due to the fact that they are often much larger in size.

Ethical Defense of National Park Concept

As the global population passes 6 billion, pressure increases for human occupation of national parks as well as the exploitation of their natural resources. But the arguments for protection remain strong: It is important to preserve the genetic resources and diversity of species found in the world national parks in order to preserve the strains from which our modern and increasingly vulnerable food crops derive. These areas also serve as a repository of edible and medicinal plants and for vital watersheds that provide water to urban and agricultural regions. And they protect cultural, archeological, and natural monuments.

Visits to national parks can also revivify a sensitivity to nature and perhaps even strengthen an environmental ethic that is so essential for human survival and the continuation of all species. Finally the national parks can, as former U.S. National Park Service Director George Hartzog, Jr., so eloquently put it, help us "better understand, or perceive, our place in the universe" (Everhart 1972, foreword by George Hartzog.)

MARILYN BERLIN SNELL

SEE ALSO *Conservation and Preservation; Deforestation and Desertification; Environmental Ethics; Environmental Regulatory Agencies; Nature.*

BIBLIOGRAPHY

Everhart, William C. (1972). *The National Park Service*. New York: Praeger.

Green, Michael J. B., and James Paine. (1997). *State of the Worlds Protected Areas at the End of the Twentieth Century*. (Paper presented at IUCN World Commission on Protected Areas Symposium on "Protected Areas in the 21st Century: From Islands to Networks.") Cambridge, UK: World Conservation Monitoring Centre.

Quigg, Philip W. (1978). *Protecting Natural Areas: An Introduction to the Creation of National Parks and Reserves*. New York: National Audubon Society.

Whitman, Sylvia. (1994). *This Land is Your Land: The American Conservation Movement*. Minneapolis, MN: Lerner.

INTERNET RESOURCES

Pitcaithley, Dwight T. (2001). "Philosophical Underpinnings of the National Park Idea." National Park Service. Available from http://www.cr.nps.gov/history//hisnps/NPSThinking/underpinnings.htm.

World Conservation Monitoring Centre. Protected Areas Programme. Available from http://www.wcmc.org.uk/protected_areas/data/cnppa.html.

World Conservation Monitoring Centre. Protected Areas Programme. "Definition of a Protected Area." Available from http://www.wcmc.org.uk/protected_areas/data/sample/iucn_cat.htm.

NATIONAL SCIENCE FOUNDATION

The U.S. National Science Foundation (NSF) is a federal independent (non-cabinet) agency, established by the National Science Foundation Act of 1950, as amended, and related legislation, passed by the U.S. Congress and signed into law by the president. Its funds come through appropriations in the federal budget each year. Its budget in fiscal year 2003 was approximately $5.5 billion. These funds go mostly in the form of grants to the nation's colleges and universities for research and educational projects in all the sciences and engineering.

In the fall of 1975, NSF began a program to support research projects and related activities on ethics and science, technology, and society. The program continues in the early twenty-first century and, with continuing attentiveness, it could continue for many more years. This entry highlights some of the adventures in its survival and identifies past and continuing challenges.

Initial Stages (1972–1976)

In the early 1970s, NSF program officers began discussing ideas for research activities that would examine ethical issues associated with new developments in science and technology. Biologists in particular recognized that people would raise questions about the social implications of their research and findings, and that such questions were thus worthy of study. Because NSF supported research and educational projects, support for these activities seemed appropriate. Not all NSF staff agreed that these issues merited NSF consideration or support; some were concerned that such questions did not lend themselves to scientific study; others were concerned that such a program might be too inclined to accentuate the negative. Correspondingly, there was also disagreement about how best to organize such an effort. Should it be a separate program with its own funding authority, or should decisions about ethics projects be left to the other research programs?

In association with the National Endowment for the Humanities (NEH), the NSF organized an advisory committee to consider what should be done. After several years of deliberation and attempts to have existing programs solicit and review proposals, the advisory committee recommended that NSF establish a separate program. Using processes for review similar to other NSF programs, the new program could cooperate with the NEH in considering proposals; some could be funded individually by each agency, and some could be funded jointly.

Middle Years (1977–1985)

What was originally called the Ethical and Human Values in Science and Technology (EHVIST) program made its first awards as a program in fiscal year 1976. NSF and NEH cooperated in support of projects through 1980; in that year, NEH decided to focus on questions about science, engineering, and technology of interest in basic humanities research, and the cooperation ended. While planning for EHVIST was underway, the effort was housed in the office of the NSF director. When the grants program began, the foundation decided to place the new program in the Directorate for Science and Engineering Education, which was hospitable to the idea. An intellectual rationale was that the new program would support research to examine ethical issues in all of the sciences and engineering; thus, it would not be appropriate to house the program in one of the research directorates. At this time, NSF had three research directorates: Physical and Mathematical Sciences and Engineering; Astronomical, Atmospheric, Earth, and Ocean Sciences; and Biological, Behavioral, and Social Sciences.

Shortly after, Congress authorized and appropriated funds for another program at NSF, one to provide scientific assistance to citizens' groups (Hollander 1984). The foundation decided to house both programs in an organizational unit with the Public Understanding of Science (PUS) program (by the early 1990s known as the Informal Science Education Program) and programs involving state and local governments. As other bureaucratic reorganizations developed, the head of this unit made the case that these programs, minus PUS, which was clearly educational, would be better placed in the Directorate for Scientific, Technological and International Affairs (STIA). STIA housed international programs and statistical studies of science and technology and could also include these other special activities. Thus, EHVIST moved to STIA in 1980. It was a fortuitous move, because the administration of President Ronald Reagan zeroed out the budget for the Education Directorate for fiscal year 1981. Had ethics funds still been part of that directorate's budget, the program might have easily vanished and been very difficult to resurrect. As it was, given general budget difficulties, the administrators of the NSF might have decided not to continue the program. Although the administrators did indeed cut the program budget, they listened to numerous voices in the scientific and other scholarly communities and kept the program alive.

At the time the program began, social and intellectual movements in the United States and abroad were focusing on issues of science, technology, and society (Dickson 1984). These movements recognized the need to examine ethical and value dimensions in that interaction. The concerns are international, not just national, although they take distinctive shapes in different parts of the world. Interest among scientists and engineers in these kinds of problems might be said to have developed prominence with the nuclear bomb and the founding of the Pugwash conferences on science and world affairs in 1957. World War II also posed challenges to biologists and physicians, with the atrocities of Nazi scientists in the name of eugenics, and biologists and physicians began to recognize that new developments in genetics would pose increasing ethical questions. Environmental hazards and climate change issues, problems of scientific misconduct, new monitoring technologies—the list of concerns continues to grow. In addition science and technology create ethical opportunities that are worthy of study. They range from uses of forensics in criminal justice to uses of computer technology for disabled populations. The distinctive and increasingly powerful roles of engineering, science, and technology in modern life assure that subject matter for careful research will not be lacking anytime soon.

In these middle years, the program shortened its name slightly, from Ethical and Human Value Implications of Science and Technology (EHVIST) To Ethics and Values in Science and Technology (EVIST). It distributed more than 150 awards, ranging from a high of twenty-three in the year the program began, to a low of eight in 1983, as a result of the diminution of the program budget that year. (In the early twenty-first century, the program averages twenty-five to thirty awards per year; average award amount is $80,000 for an award of twelve to eighteen months.)

The awards covered a wide range of topics. One major area was environmental and hazards issues, which when coupled with agricultural ethics issues, formed a grouping representing about 20 percent of the total awards. These kinds of projects focus on the ethical and value dimensions of interactions of science, technology, and society, and these interactions continue to be a prominent area for program support. For awards made after 1985, this same grouping represents about 25 percent of the total. Areas that began to emerge—such as the use of animals in research, university–industry–government relations, and publication ethics—primarily examined issues in the conduct or practice of science and engineering. Awards in 1978–1979 to investigators Judith P. Swazey, Karen Seashore Lewis, and Melissa S. Anderson, for example, resulted in some of the first and most complete reports on perceptions of misconduct among science and engineering faculty and graduate students. This trend toward awards for such studies has continued and grown as societal concerns about professional accountability have increased. In the early twenty-first century, the program invests considerable resources in both research and educational projects in areas of research ethics. For example, support to the Association for Practical and Professional Ethics in 1999 through 2003 provided training in research ethics for graduate students and postdoctoral fellows in science and engineering. While the number of awards from 1989 to 2001 approximately doubled from the earlier period of 1976 to 1987, the number of awards in research and publication ethics increased eight times.

Principal investigators on ethics projects come from humanities, social science, and natural science and engineering fields. Over the period 1976 to 1987, the split among the three groups was almost even. By the early twenty-first century, a greater proportion of awards was going to social and behavioral scientists. During the period 1976 to 1987 the ratio of male to female investigators was about three to one and improving. This trend continues to be an area of program strength: From 1990 through 2002 the ratio of principal investigators was two males to one female. Support for minority and handicapped investigators in the earlier period was low. It is increasing, especially for Hispanic investigators, and there have been a few notable efforts; for instance, the award to a deaf historian of science, Harry G. Lang, resulted in the 2000 book, *A Phone of Our Own: The Deaf Insurrection against Ma Bell,* which won a number of awards. The program made a grant in 1998 to the American Philosophical Association to sponsor panels at its meetings, as well as to award small grants for investigators to research the implications for diversity of developments in science, engineering, and technology. A book containing some of the presentations and research results has been published (Figueroa and Harding 2003). Despite such examples, much room for improvement in this area remains. Finally, as with other NSF programs, investigators at universities granting postbachelor degrees received and continue to receive the majority of grants.

Years of Trial (1986–1992)

The EVIST program's support for new projects reached a low in 1983 because of the Reagan administration budget cutbacks. It was struggling back up when another blow hit. This time, the attack came from within. NSF Director Eric Bloch was looking for funds to support more large-scale projects such as engineering research centers, and he concluded that the million or so dollars per year that went to ethics should be shifted to help in this effort. Thus the NSF budget request to Congress for fiscal year 1986 contained no funds for ethics.

When news of this plan filtered out, the program's supporters, particularly grantees, members of the panel that reviewed proposals to EVIST, and officers and staff at the American Association for the Advancement of Science and other professional societies, protested to members of the Congressional committees that oversaw the NSF budget. They were able to make a persuasive enough case that the legislators insisted that NSF maintain support for ethics projects. The foundation heeded this advice, while deciding to manage its support for the activity in a new way—as a foundation-wide responsibility (Hollander 1987).

The Directorate for Biological, Behavioral, and Social Sciences agreed to assume primary responsibility for the program, but funds to support projects would have to come from all the foundation's directorates. Fortunately, directorates at NSF had been multiplying during this time. New ones included the Directorate for Engineering and the Directorate for Computer and Information Science and Engineering. They agreed to participate, effectively increasing the program's budget by 33 percent. The number of new projects being supported rose to twenty-one by 1987.

The rationale for supporting ethics across the foundation may have had both intellectual and control components. On the former, it was supposed to assure the involvement of the scientists and engineers who managed various NSF research programs. On the latter, it could provide oversight of the treatment of science and engineering in the senses of accuracy and circumspection, as these fields perceived those attributes. These goals were, to some extent, met. Any potential for good, however, was more than outweighed by the management problems. For instance, what could be done when more good proposals came in, say, in biology rather than fields in other directorates? Fortunately, the directorate housing the program provided a greater amount of funds so that adjustments could be made. And what could be done when a program officer simply did not want to be bothered, or did not think that such activities should be supported through NSF? Luckily, sympathetic division directors with a few loose dollars could often be found. But the management headaches—for the program manager—were numerous.

Other organizational changes affected the program at this time. It joined forces with NSF's History and

Philosophy of Science (HPS) program; both program directors argued that the two programs, with similar interests in science, technology, and society relations, should be housed in one unit. Management agreed. Separately, the social and behavioral sciences argued for a directorate of their own. This happened in 1992, and the two programs—with HPS now called Science and Technology Studies (STS) and EVIST now called Ethics and Values Studies (EVS)—moved to the new Directorate for Social, Behavioral, and Economic Sciences (SBE).

The increasing complexity of managing a program across all the directorates at NSF became ever more apparent and, finally, upper management agreed that funds for the effort should once again be consolidated. All the directorate heads signed a memorandum to that effect, and the NSF budget to Congress for fiscal year 1994 included funding for an independent ethics program. One unusual component remains: Because the Directorate for Education and Human Resources (EHR) has its own line in the foundation's appropriation, its support for ethics education projects remains separate. It has continued its support, and EHR, Engineering, and SBE are taking the lead in developing a foundation-wide program for 2005, on ethics education for scientists and engineers, especially science and engineering students.

In the midst and irrespective of this bureaucratic turmoil, the academic interest in the ethical and value dimensions of science and technology continued to develop. Growing numbers of journals, programs at colleges and universities, and professional associations indicated increased institutionalization of the field. New ethics centers and courses in issues of ethics for the professions continued to appear at the nation's colleges and universities. A 1990 article by Nicholas H. Steneck and Rachelle D. Hollander reviewed the EVS program. One major research areas highlighted in the report was engineering ethics. From 1999 to 2003 several of the nation's engineering colleges established chairs in engineering ethics. The Association for Practical and Professional Ethics (APPE) was founded in 1991. Besides its individual members, who represent many different disciplines and fields, APPE has more than 100 institutional members. In 1995 the journal *Science and Engineering Ethics* was established, with coeditors in the United States and the United Kingdom. An even more recent example, *Ethics and Information Technology* was founded in 1999; its editors are from the United States, the United Kingdom, and Europe. The affiliation of the two NSF programs—EVS and STS—reflects broader synergies as departments of science and technology studies are becoming more numerous at colleges and universities in the United States and elsewhere.

Years of Consolidation and Challenge (1993–)

Basically, the characterization of research topics and methods in the Hollander and Steneck article from 1990 remain appropriate for the program. Many projects fall into more than one category. Research methods remain diverse. Approaches involve individual investigations as well as collaborative research and workshops. Research includes analytical or conceptual philosophical analysis, case study or issue-oriented research, empirical research in the social and behavioral sciences, and science and technology assessment. A research approach of increasing importance is that of science and technology studies. The program supports numerous educational activities and has helped other NSF programs include ethics education in their activities.

Within NSF, EVS began a successful effort to incorporate ethics activities into the NSF Research Experiences for Undergraduates (REU) Sites projects in the early 1990s. All the research directorates support these summer programs, which bring small groups of undergraduate science and engineering majors to campuses, where they participate with faculty in research projects. The sites projects encourage promising undergraduates to continue their science or engineering education, expose them to interesting research, and promote diversity among undergraduates and in the science and engineering professions. The ethics component began with a successful pilot effort in chemistry in 1992. By the next year, the other NSF directorates had signed on and the next REU program announcement indicated that projects were eligible for small amounts of funding specifically for ethics education as part of their summer programs. Each year since the beginning of the new century, more than twenty-five projects receive ethics funds. The field with the most REU projects with an ethics component funded through EVS is biology, but all of the directorates participate, and the Engineering directorate funds many of these projects on its own.

In 1997 NSF began a foundation-wide program called Integrative Graduate Education and Research Training (IGERT). This program supports interdisciplinary graduate education projects around a research theme. These large awards, for amounts in excess of $2.5 million, extend over five years. EVS succeeded in incorporating ethics activities into IGERT. The program requires that these projects include ethics in their curricula; the announcement for IGERT states that "The graduate experience should . . . equip students to understand and integrate scientific, technical, business, social, and ethical issues to confront the challenging problems of the future" and that IGERT projects must include specifically "integrated instruction in ethics and the responsible conduct of research" (NSF, "IGERT Program" Internet site). EVS is undertaking a small-scale initial evaluation of these efforts.

In 1995 NSF management asked EVS to merge with a small NSF program called Research on Science and Technology (RST). RST supports projects that examine the role of public investments in science, engineering, and technology. After consultation with its panel and the broader communities of EVS and RST investigators, the program agreed. With neither group wishing to lose its name, both were placed under the more general rubric, Societal Dimensions of Engineering, Science, and Technology (SDEST). In the late 1990s and into the twenty-first century, the SDEST/EVS-RST budget stabilized at about $2.5 million per year, augmented by another $500,000 in assistance from other programs for ethics projects. Given NSF emphasis on foundation-wide priorities, and general constraints in the federal discretionary budget, the program is unlikely to see much direct budget expansion. One way to overcome this problem is to infuse ethics research and educational activities into other interdisciplinary research areas now getting NSF attention, such as information technology research and nanotechnology. While this is not easy, it is possible, and seems to be increasing.

Discussion was underway in Fall 2004 among the Science and Technology Studies program and the SDEST/EVS-RST program to consolidate their activities under the rubric Science and Society. The newly inclusive program would have four components:

- Ethics and Values in Science, Engineering, and Technology
- History and Philosophy of Science, Engineering, and Technology
- Social Studies of Science, Engineering, and Technology
- Studies of Policy, Science, Engineering, and Technology

The change in names is intended to assist applicants in determining where to apply. It may encourage further development of connections with the sciences and engineering programs, which are increasingly aware of the need to address social shaping of science and technology, and its implications. This increased recognition can be seen more broadly in federal funding for research on ethics and the human genome and the call for similar funding for ethics and nanotechnology.

EVS research faces problems similar to those facing other interdisciplinary or transdisciplinary areas in which NSF wants to encourage research: fostering interdisciplinary communication, defining researchable issues, and finding outlets where results will be recognized as valuable. Identifying the need for recognition captures an aspect of the difficulty. EVS research has distinctive frameworks, and investigators cite the prior literature. It is difficult, however, both to train new EVS researchers and to make the results visible for new and established researchers in the disciplines and fields that EVS researchers study.

Progress is being made. The wide variety of educational activities is making EVS results more accessible in the research communities to which they are relevant. All fields of science and engineering recognize the relevance of issues of ethics as they related to the practice of science and engineering. Most recognize the relevance of issues of ethics in connection with interactions among science, engineering, and society. This is a significant change from the situation in the early 1970s, when the thought of an ethics program at NSF was barely a gleam in one or two people's eyes.

RACHELLE D. HOLLANDER

SEE ALSO *Engineering Ethics; Nanoethics; National Academies; Science Policy.*

BIBLIOGRAPHY

Dickson, David. (1984). "Science and Society: Public Participation vs. Democratic Control." In his *The New Politics of Science*. New York: Pantheon. Provides an interesting view of the beginnings of the EHVIST program.

Figueroa, Robert, and Sandra Harding. (2003). *Science and Other Cultures: Diversity in the Philosophy of Science and Technology*. New York: Routledge. Collection of essays about the influences of science and technology on and from cultures, persons, and traditions.

Hollander, Rachelle D. (1984). "Institutionalizing Public Service Science." In *Citizen Participation in Science Policy*, ed. James C. Petersen. Amherst: University of Massachusetts Press. Includes a history of the rise and fall of the NSF program to provide scientific assistance to citizens' groups.

Hollander, Rachelle D. (1987). "In a New Mode: Ethics and Values Studies at the NSF." *Science, Technology, and Human Values* 12(2): 59–61. Describes the decision to manage EVS as a "distributed" program.

Hollander, Rachelle D., and Nicholas H. Steneck. (1990). "Science- and Engineering-Related Ethics and Values Studies: Characteristics of an Emerging Field of Research." *Science, Technology, and Human Values* 15(1): 84–104. Comprehensive review of the awards made in the programs first decade.

INTERNET RESOURCES

National Science Foundation (NSF). "Integrative Graduate Education and Research Traineeship (IGERT) Program: Program Solicitation." Available from http://www.nsf.gov/pubs/2000/nsf0078/nsf0078.htm. Information on program goals and application procedures.

National Science Foundation (NSF). "Research Experiences for Undergraduates (REU): Program Announcement." Available from http://www.nsf.gov/pubsys/ods/getpub.cfm?nsf02136. Information about program goals and application procedures.

National Science Foundation (NSF). "Societal Dimensions of Engineering, Science, and Technology (SDEST) Program." Available from http://www.nsf.gov/sbe/ses/sdest/. Includes examples of program awards via link to award abstracts.

NATIONAL SCIENCE FOUNDATION: SECOND MERIT REVIEW CRITERION

In the early twenty-first century, science finds itself caught in a dilemma that is arguably of its own making: Its very success in terms of understanding and controlling nature means that it has given birth to powers that transcend the traditional boundaries between science and society. Rather than being viewed as essentially neutral in terms of values, society increasingly views scientific knowledge as leading to various types of winners and losers. The review criteria for National Science Foundation proposals offer an instructive case study of this increasingly prominent dynamic.

Background

Established in 1950, the National Science Foundation (NSF) is the only federal agency dedicated to the support of education and basic research across all scientific and engineering disciplines, except for the biomedical sciences (which are handled by the National Institutes of Health). Although no authoritative definition exits, it is generally agreed that basic scientific research is oriented chiefly toward the discovery and creation of new knowledge, without regard for its eventual employment.

In 1993 Congress passed the Government Performance Results Act (GPRA). The purpose of GPRA was to increase the focus of federal agencies on improving and measuring "results," which would in turn provide congressional decision makers with the data they require to assess the effectiveness and efficiency of federally funded programs. In effect, GPRA sent the message that federal funding is contingent on attaining and demonstrating results. Partly in response to such demands for demonstrable results, in 1995 the NSF adopted a new strategic plan: *NSF in a Changing World* (NSF 95-24). NSF's new strategic plan included among the long-term goals of the foundation the promotion of the discovery of new "knowledge in service to society."

In 1996 the National Science Board (NSB) established the NSB-NSF Task Force on Merit Review to examine and evaluate NSF's generic merit review criteria, which had been in effect since 1981, in light of the new strategic plan. In its "Discussion Report" (NSB/MR-96-15) the task force recommended replacing previous review criteria with two simple questions: (1) What is the intellectual merit of the proposed activity? (2) What are the broader impacts of the proposed activity? The simplification was proposed to help connect NSF investments to societal value while preserving an ability to select proposals on the basis of scientific excellence. Such criteria were more clearly related to the goals and strategies of *NSF in a Changing World*. NSF published the recommendations of the task force on the web, through press releases, and through direct contact with universities and professional associations, and received around 300 responses from the scientific and engineering community.

In light of these responses, in 1997 the task force published its "Final Recommendations" (NSB/MR-97-05). The responses raised several concerns about the new criteria, including what the task force termed the issue of "weighting" the criteria: Criterion 1 was perceived by respondents as more important than 2, or criterion 2 was perceived as irrelevant, ambiguous, or poorly worded. Moreover, respondents expressed concern that for much of basic research it is impossible to make meaningful statements about the potential usefulness of the research. Ultimately, however, the task force recommended that the new criteria be adopted. Later in 1997, NSF issued Important Notice No. 121, which announced NSB approval of the new merit review criteria, effective October 1.

The NAPA Report

In 1998, and again in 1999, Congress directed NSF to contract with the National Academy of Public Administration (NAPA) to review the effects of the changes in NSF's merit review criteria. NAPA is an independent, nonpartisan organization chartered by Congress to help federal, state, and local governments improve their effectiveness, efficiency, and accountability. In 2000 NSF commissioned the NAPA study.

The NAPA study reviewed relevant legislation, reports by external review committees, interviews with NSF personnel, and interviews with members of the scientific and engineering community. In addition, the NAPA study analyzed sample projects funded under both the old and the new criteria, as well as the intentions of those reviewing proposals using the new criteria. Published in February 2001, the NAPA report provides a history of the development of NSF's new merit review criteria, compares the 1997 criteria to the 1981 criteria, and details many of the challenges faced by the merit review process during the period from 1997 to 2000. The NAPA report offers several recommendations to help NSF improve the merit review process, among which is a recommendation to address the "philosophical issues" raised by the new criteria, in particular criterion 2.

The latter recommendation was based in part on its observation of the diverse interpretations of and reactions to the new merit review criteria among members of the scientific and engineering community. Although the NAPA report fails to delineate explicitly what it considered to be the philosophical issues, it nevertheless provides an excellent source from which those issues can be gleaned. Such issues include:

- whether criterion 2 is inconsistent with criterion 1
- whether criterion 1 is more important than criterion 2
- whether criterion 2 is in need of conceptual clarification
- whether interpretations of criterion 2 are discipline-dependent
- whether reactions to criterion 2 rely on one's conception of scientific inquiry.

These issues are, of course, interrelated: A physicist committed to a strict division between basic and applied scientific research might interpret the criteria as inconsistent, whereas a geologist whose research in plate tectonics might one day lead to predictive capabilities might not; said geologist might nonetheless view criterion 1 as significantly more important than criterion 2.

Moreover, consideration of such issues also raises philosophical issues in the realm of science policy. Is NSF moving away from its emphasis on basic research? If so, is NSF offering a new conception of scientific inquiry? If so, what is this new conception? Is this new conception coherent? If not, should NSF change its merit review criteria? Should criterion 2 be abandoned? If so, must NSF's strategic plan be reconceptualized? What impact would such a reconceptualization have on NSF's compliance with GPRA? Should NSF still receive federal funding? If so, how much and for what?

In attempting to incorporate intellectual merit and broader societal impacts more fully, NSF's 1997 merit review criteria raise a host of philosophical issues. Demands for federal agencies to show results in order to receive funding show no signs of vanishing. It remains to be seen how such issues will be addressed.

J. BRITT HOLBROOK

SEE ALSO *National Science Foundation.*

BIBLIOGRAPHY

INTERNET RESOURCE

National Academy of Public Administration (NAPA). "A Study of the National Science Foundation's Criteria for Project Selection." A report by a panel of the National Academy of Public Administration for the National Science Foundation, issued February 2001. Available from http://www.napawash.org/publications.html.

NATIONAL SOCIETY FOR PROFESSIONAL ENGINEERS

SEE *Professional Engineering Organizations.*

NATURAL DISASTERS

SEE *Building Destruction and Collapse.*

NATURAL LAW

Central to natural law theories of morality is the idea that there are guiding principles for human conduct higher than those of personal self-interest, particular social custom, or positive governmental statute. Such a higher law is characteristically thought to be objectively true, accessible to reason, and universally obligatory. This law is *natural* in the sense that the goods it defines are logically related to the rational nature of human beings. Though many advocates are theists, typically from the Catholic tradition, who ground the content of natural law in divine will, the tradition includes non-theistic theorists as well.

The norms of natural law must be distinguished from *laws of nature,* which are purely descriptive propositions identifying causal relations between material entities, events, or phenomena. Yet because of its appeal to nature, the conceptualization and understanding of which has been deeply affected by modern natural science, and subject to major technological transformation, natural law has been both challenged by and sometimes taken as a challenge to science and technology.

Types of Natural Law Theories

There are two kinds of natural law theories: natural law theories of legality and natural law theories of morality. Natural law theories of legality argue there are necessary moral constraints on the content of law. Natural law theories of morality are concerned with the character, grounds, and principles of morality. Although many who subscribe to natural law ethics also subscribe to natural law jurisprudence, the two theories are logically independent. Someone who accepts the theory of law may not accept the theory of morality, and a natural law moral theorist could consistently hold that, unlike morality, law is essentially conventional in character.

Although ethicists disagree about how best to characterize natural law theories of morality, nearly every natural law ethicist accepts the following four theses: (a) moral principles are either objectively true or objectively false; (b) the truth value of a moral principle is determined, in part, by whether it accurately reflects the facts of human nature or can, in some sense, be derived from the facts of human nature; (c) at least one moral principle is objectively true; and (d) the principles of morality can be discerned by reason. Many, but not all (e.g., Moore 1996), natural law ethicists are theists who relate the content of natural law to God as the creator of human nature. All natural law theories of morality thus include meta-ethical claims (theses a, b, c), normatively ethical claims (thesis b), and epistemic claims (thesis d).

Substantive natural law theorists are generally concerned with identifying the natural goods and principles that should guide rational human behavior. At its highest level of abstraction, natural law simply requires persons to pursue what is good and avoid what is bad. But a full understanding of obligations requires identifying what is good and bad in relation to human nature. Such goods are typically argued to include the following: spirituality, life, health, inner peace, knowledge, friendship, the *marital good,* aesthetic experience, play, pleasure, intellectual creativity, and justice. Further, because human beings may respond in problematic ways to what is good, natural law ethicists also often distinguish between defective and non-defective responses; many theorists, for example, identify homosexual relations as a defective response to the marital good. Taken together, a catalogue of natural goods and a comprehensive account of what distinguishes defective from authentic responses to such goods will fully define the content of the natural law: Human beings are obligated to pursue such goods in non-defective ways. Natural law ethicists commonly believe that such pursuit will culminate in the development of virtuous character traits. As it relates to science and technology, natural law theory would evaluate science and technology according to whether they respond in an authentic way towards the basic natural goods.

Though early natural law moral theorists understood laws of nature and laws of morality as being related, modern theorists distinguish the two. Laws of nature are both descriptive and empirical in character, stating mechanistically causal regularities between various material entities or events. In contrast laws of morality are normative in character and seek to guide the behavior of persons who can freely choose to violate such laws. While natural law theorists are likely to accept that laws of nature and laws of morality ultimately both reflect the true nature of things, natural law theories are properly concerned only with explicating the norms, laws, principles, and rules that should constrain human behavior.

Some critics have argued that natural law theory cannot consistently posit a normative teleology for humans without positing a normative teleology for all other entities. On this line of reasoning, natural law theorists cannot without contradiction (a) derive both the laws of nature and the laws of morality from the natural law but (b) hold that the laws of nature are descriptive while the laws of morality are normative. If humans are subject to a normative teleology, then all entities must be.

The natural law theorist can respond in the following way. Whether or not any particular entity is subject to a normative teleology of some kind is determined by the kinds of property it instantiates. Human beings are governed by a normative teleology that posits moral standards they are obliged to satisfy because humans are moral agents in virtue of having the properties of rationality and free will. Other entities lack these properties and hence are not subject to such standards that prescribe behavior; it makes little sense to think that, in the literal normative sense, a quark ought to behave in this or that particular way.

Other living things are, of course, fairly characterized as having interests. For example, cows are sentient and hence have an interest in being free from suffering. These interests are not implausibly characterized as "goods" towards which the behavior of non-rational living beings is typically oriented. However, it is clear that goods of this kind do not define standards that *prescribe* behaviors for those other living things. Although humans, qua rational moral agents, might be obligated by a law that requires a respect of the interests of other living beings, those living beings could not be *obligated* to do anything.

By means of such reasoning, the natural law theorist attempts to reconcile the differences between rational agents, non-rational living beings, and other material beings while the claim that the movements and behaviors of all existing entities are defined and governed by the natural law. Moreover, such arguments allow natural law theory to highlight the importance of both scientific and ethical inquiry: Scientific inquiry allows humans to determine the interests of other living things, while ethical inquiry allows humans to determine the extent to which they are obligated to respect and promote those interests.

Historical Overview

Although Aristotle (384–322 B.C.E.) is frequently cited as the first natural law theorist because of his view that human behavior should be directed toward the natural function of living well or flourishing, the Stoics subscribed to a greater number of the distinguishing tenets of natural law theory. According to the Stoics, the cosmos alone is complete and hence ordered and good As rational creatures, human beings are obligated to partake of this good by deploying reason to grasp the order and goodness of the universe. Those who succeed in doing so and in living their lives in ways that cohere with these qualities of the universe cosmos will achieve happiness and fulfill their function of living well. Notable Stoics include Zeno (336–264 B.C.E.), Cleanthes (331–232 B.C.E.), Chrysippus (280–206 B.C.E.), Panetius (185–110 B.C.E.), Posidonius (135–51 B.C.E.), Epictetus (55–135 C.E.), and Marcus Aurelius (121–180 C.E.).

The most influential of Stoics was Marcus Tullius Cicero (106–43 B.C.E.), whose definition of law deeply influenced subsequent natural law thinkers. In Cicero's words, "Law is the highest reason, implanted in Nature, which commands what ought to be done and forbids the opposite" (*De Legibus*, I. 18). Implicit in this definition are most of the core tenets of natural law: Law is defined by nature, has highest authority, is accessible to reason, and directs rational beings toward what ought to be done (what is good). Like Aristotle, Cicero believed that human beings have a function, built into human nature, and that achieving this function produces true happiness and virtue. Unlike Aristotle, Cicero explicitly attributes natural law to a divine influence in human affairs.

Historically the most influential of all natural law moral theorists is undoubtedly Thomas Aquinas (1225–1274). Like many twelfth- and thirteenth-century philosophers, Thomas worked to bridge the core elements of Christian theology and Aristotelian philosophy.

Thomas saw the universe as the created material embodiment of God's perfect rationality and distinguished four types of law: eternal, natural, divine, human. Determined by divine will, the eternal law consists of the set of timeless, objective truths that govern the movement of all things in the universe, including non-human things, and includes what science calls the laws of nature. Eternal law is thus similar to what science calls the laws of nature. Natural law is a subset of eternal law that applies to the behavior of human beings. Divine law consists of the subset of eternal law pertaining to the ultimate fate of human beings following divine judgment, and is found in revelation. Human law consists of those norms that have a human source and are consistent with natural law.

Because the first precept of natural law requires "that good is to be done and pursued, and evil is to be avoided" (*Summa Theologica* I–II, Q.94, a.2), Thomas must give an account of the relevant goods. Accordingly he distinguishes three kinds of good: (a) those goods that humans share with all other entities, such as the inclination to preserve their being in accordance with their nature (b) more specific goods that humans share with other animals, such as the desire to mate; and (c) goods that are valued because of the human capacity for rationality, such as a desire to live in society and to pursue knowledge. These latter goods, on Thomas's view, include moral goods, such as honesty, integrity, and more. The natural law, then, consists in principles that direct human beings toward the pursuit of those goods that are distinctly human and hence define standards of human virtue.

The distinctly modern period in natural law history began with Hugo Grotius (1583–1645) and his famous argument that, contra Thomas, the content of natural law does not depend on God's existence. A Christian, Grotius nonetheless took the position that natural law reflects goods that are valuable independent of God's will. As Plato might express the point, it is not the case that natural law is good because God chooses it; rather, God chooses natural law because it is good. Because it is the value of these goods that explain God's choosing them (and not the other way around), God could not have changed the content of the natural law

Grotius rejected the view that the binding force of natural law depends on God's existence or on the threat of a divine sanction. Because the content of natural law is grounded in timeless principles of reason rather than divine volition and because human beings have a rational nature, natural law binds humans because its content is rational and not because it is backed by a divine sanction. Grotius subsequently developed a social contract theory of state legitimacy that was grounded in his views about natural law. Though subsequent social contract theorists were influenced by Grotius, some rejected his views about the foundations of natural law. John Locke (1632–1704), for instance, grounded his social contract theory in the idea that natural law governs life in the state of nature, but argued that its content is grounded in divine will.

Contemporary Natural Law Theory

Natural law theorizing is currently enjoying a revival due primarily to the work of various Catholic thinkers, including Germaine Grisez, John Finnis, and Robert George. Finnis develops a comprehensive theory of natural law that begins with an analysis of the concept of law. Finnis conceives of natural law as explicating the basic principles of what he calls *practical reasonableness*. He grounds an identification of these basic principles, which express fundamental human goods, partly on empirical observations of what is universally valued. For example, he notes that all human societies show a concern for the protection of human life, restrict sexual activity, display a concern for truth, know friendship, have some conception of property, and value recreation (Finnis 1980). These goods are protected by principles.

Natural law theory should not, however, be equated with Catholicism. First, many other religious traditions incorporate ideas that figure prominently in natural law theory. C.S. Lewis, for example, has pointed to various elements in the Dao that are suggestive of natural-law commitments. Some Buddhists see a natural teleology in all existing beings and sometimes describe "dharma" as being like the natural law, which is discovered by means of introspective meditation. Second, while many of the most influential contemporary natural law theorists are catholic, not all are. For example, Leo Strauss (1937–1973) is famous for his disdain for modern philosophical and political theorizing, as well as for his views that (a) life should be led in accordance with the natural order of humanity's being and (b) theorizing of all kinds should be subordinate to theology.

Much late-twentieth century work in natural law theory applies the principles of natural law to issues of sexuality, such as abortion, contraception, and homosexuality. The intrinsic value of sexuality (the marital good) consists in its capacity to create "a two-in-one-flesh communion of persons" that constitutes two persons as "becoming . . . one organism" (George 1999, p. 168). Because the unitive capacity of sexual activity is grounded in its reproductive function, sexual intercourse is legitimate only if performed by a man and a woman in a lawful marriage without contraceptives. As is readily evident, natural law theorizing on sexual morality tends to reflect the substantive Catholic doctrines to which its chief proponents subscribe.

Natural Law Assessments of Technology: General Considerations

It is sometimes thought that natural law theories imply that any technology is presumptively problematic. On this line of reasoning, natural law theories equate *good* with *natural* and *bad* with *unnatural*. Because, by definition, human technologies are artifactual and hence not natural (that is, unnatural), it follows that any human technology and its intended uses should be presumed morally problematic until an adequate moral justification for it can be given.

This reasoning misrepresents the natural law theory account of the good. While natural law theory holds that the good is defined by human nature, this does not imply—or even suggest—that artifacts are necessarily unnatural in any relevant sense. There is nothing in any plausible account of human nature that would justify believing that the development and use of artifacts is, as a matter of principle, contrary to human nature. This would imply, absurdly, that the use of food utensils is contrary to human nature.

Indeed, if anything, most mainstream natural law theories would suggest that the intended uses of technology should be presumed good until shown to be morally problematic. The moral evaluation of any particular technology will require a nuanced analysis of two issues: (a) whether the intended use of a technology promotes a fundamental moral good; and (b) whether the intended use of a technology responds in a non-defective way to some fundamental moral good. Just as natural law jurisprudence subjects positive law to assessment by a higher law, so natural law moral theory of technology would assess technology by a higher law. But just as natural law ethics evaluates positive law according to whether its content conforms to a higher law, so natural law ethics evaluates technology according to whether particular uses conform to a higher law. And just as natural law ethics begins with the rebuttable presumption that positive law is legitimate, so too it begins with the rebuttable presumption that technology is legitimate.

But most, if not all, technological advances satisfy. Serious technological research is generally focused on developing technologies designed for uses that further important human interests such as life, health, play, and other goods. In free economies, the market incentives are simply insufficient to support technological research that is not connected with basic human goods. It is true, of course, that any particular technology may respond defectively to one of the basic goods. Arguably, violent video games are a defective response to the basic human good of recreation. But in a market economy, private resources will typically be directed at producing technologies that respond in some direct (and marketable) way to the basic human goods. Accordingly in the absence of some obvious problem with a particular technology (or intended use), it may reasonably be characterized as presumptively good.

This, of course, is not to deny either that technologies can be misused or that the intended uses or functions of some technologies are themselves morally problematic. It is clear, for example, that any weapons technology can be used for wrongful purposes. Indeed one may plausibly argue that the very function of any weapons technology is morally problematic; while possession of a weapons technology may be used to deter violence, its characteristic function is to inflict injury on other living beings—a function that is presumptively problematic. Nuclear weapons and other weapons of mass destruction are especially problematic in this regard.

The point is that, as an empirical matter, most (as opposed to all) technologies are intended to be used—and are characteristically used—in ways that promote some important human interest. Thus a complete natural-law evaluation of any particular technology will usually turn on whether it satisfies (b) above (i.e., responds in a non-defective way to the relevant goods). If it responds defectively to the good, then it must be rejected as morally problematic. As the Pontifical Academy for Life explains, "[i]t is never licit to do evil intentionally in order to achieve ends that are good in themselves" (Pontifical Academy for Life, Art. 9).

In any interesting case, however, this issue will be far more difficult than the issue of whether a particular technology promotes some basic good. Consider the difficulties in giving a natural law analysis of intellectual property and digital file-sharing technologies. On the one hand, copyright protection promotes a variety of interests that are plausibly characterized as basic moral goods. Copyright protection promotes intellectual innovation and knowledge by providing a material incentive to create content. Further, by protecting inventors' material interests in their creations, copyright protection promotes physical health and well being; after all, property interests are valuable as a means to these more important ends. On the other hand, copyright protection restricts the free flow of useful information—which can be consumed by all persons at once without reducing its supply. As is readily evident, the issue of whether this feature of information warrants characterizing copyright protection as a defective response to the basic moral goods that it intends to promote is exceptionally difficult.

It is worth noting that such epistemic difficulties lead some proponents to believe that while natural law theory may guide behavior in most instances, it is indeterminate with respect to some moral issues. Natural law theory is not, on this view, intended to provide some sort of determinate decision procedure for resolving ethical issues. Rather it provides a catalogue of general considerations that point the way toward the good life.

Biotechnology

Although one would expect natural law theorists to devote considerable energy to assessing new technologies, they tend to focus on issues of sexual and reproductive morality. Because many natural law theorists belong to the Catholic Church, which has made propagation of its views on such matters a high priority, it is not surprising that so much energy is devoted to these issues. But given the importance of the various moral issues arising in connection with many new technologies, it is regrettable that natural law literature on these emerging technologies is so comparatively thin.

Most natural law research on technology has focused on biotechnology. As a general matter, natural law theorists are unanimous in affirming the need for biotechnological research to promote the vital natural goods of human health and human knowledge, but emphasize the need to focus on technologies that produce those goods in non-defective ways. Only research that responds nondefectively to the goods of knowledge and health is encouraged as morally legitimate under the natural law.

One important issue in determining whether a particular biotechnological inquiry or application responds nondefectively to some good is whether it respects the integrity of the human person. The use of human embryos in research or in a technology designed to treat a disease is condemned as failing to recognize the integrity of such lives. According to the Pontifical Academy for Life, "The attitude some adopt concerning the legitimacy of sacrificing the (physical and genetic) integrity of human beings at the embryonic stage in order to destroy them ... to benefit other human individuals is ... totally unacceptable" (Pontifical Academy for Life, Art. 9). Such research and applications are problematic because they treat intrinsically valuable human beings as mere receptacles of instrumental value, namely, as objects to be used to benefit other human beings.

Natural law theorists also converge in condemning technologies that assist a terminally ill person in committing suicide on the ground that such technologies fail to respect the moral integrity of the person. Although suicide itself should not be punished, the use of these technologies to assist a suicide should. As David Novak puts the point, "because suicide itself is prohibited, those assisting in a suicide, not being its victim, are to be punished on the grounds that *there is no agency for sin*" (Forte 1998, p. 20). Though a patient might consent to physician-assisted suicide, such consent is not morally effective because one cannot waive the integrity of one's person.

Natural law theorists criticize efforts to develop technologies that can be used to clone human beings or to select for various genetic characteristics in one's offspring for somewhat different reasons. Such technologies may be defective responses to natural goods because they fail to respect the integrity of human persons, but they are also defective for other reasons. For example, one theorist worries that "cloning and asexual reproduction may contribute to the erosion of our sense of the gift of procreation, of our role as parents, ... and of our understanding of sexual intercourse and love" (deBlois 1994, p. 213). While understanding the truth about the human genome, technologies that lend themselves to such applications are unacceptable: "Cloning with a view to the reproduction of human beings is a practice contrary to human dignity and should not be allowed" (Holy See).

Natural Law, Technology, and the Environment

Impact on the natural environment is another relevant issue in assessing a technology under natural law theory. Many technologies obviously affect the environment in deleterious ways that are potentially significant from an ethical point of view. The contribution of any particular technology to pollution, species extinction, and depletion of natural resources is important in evaluating the acceptability of that technology under natural law theories, at the very least, because all these effects may negatively impact the pursuit of basic human goods that are at least as important as the interests the technology seeks to advance.

Central to a natural-law evaluation of the environmental impacts of technology, however, is the issue of whether the theory posits a direct obligation on humanity's part to respect and promote the interests of other non-human natural beings that is grounded in the idea that such beings are deserving of respect for their own sakes. A natural law theory that posits a direct obligation to this effect assigns some measure of moral standing to non-human beings whose interests must then be taken into moral consideration. A natural law theory that does not posit such a direct obligation assigns no measure of moral standing to non-human beings. On this latter view, the only obligations to respect and promote nature are owed to other human beings and are grounded in nature's value in promoting human flourishing.

Natural law theories differ in their evaluation of a technology's effects on the environment depending on whether they assign moral standing to other beings. An anthropocentric theory that assigns moral standing to only human beings is, other things being equal, less likely to reject a technology on the strength of its environmental impacts than either an animocentric theory that assigns standing to sentient non-human animals or a biocentric theory that assigns standing to all living beings. The smaller the moral community, the fewer beings whose interests or goods count in evaluating any particular behavior. Still, it is important to note that more expansive versions of natural law theory have sufficient resources to ground a very strong ethical commitment to the environment.

KENNETH EINAR HIMMA

SEE ALSO *Aristotle and Aristotelianism; Biotech Ethics; Christian Perspectives; Human Nature; Libertarianism; Science, Technology, and Law; Thomas Aquinas.*

BIBLIOGRAPHY

deBlois, Jean; Patrick Norris; and Kevin O'Rourke. (1994). *A Primer for Health Care Ethics: Essays for a Pluralistic Society*. Washington, DC: Georgetown University Press.

Finnis, John. (1980). *Natural Law and Natural Rights*. Oxford: Oxford University Press.

Forte, David, ed. (1998). *Natural Law and Contemporary Public Policy*. Washington, DC: Georgetown University Press.

George, Robert. (1999). *In Defense of Natural Law*. Oxford: Clarendon Press.

Grisez, Germaine. (1983). *The Way of the Lord Jesus*, Vol. 1: *Christian Moral Principles*. Chicago: Franciscan Herald Press.

Grotius, Hugo. (1964). *The Rights of War and Peace*, trans. F. W. Kelley, et. al. New York: Oceana.

Haakonssen, Knud. (1996). *Natural Law and Moral Philosophy: From Grotius to the Scottish Enlightenment*. Cambridge, England: Cambridge University Press.

Moore, Michael. (1996). "Good without God." In *Natural Law, Liberalism, and Morality*, ed. Robert George. Oxford: Oxford University Press.

INTERNET RESOURCES

Pontifical Academy for Life. IX General Assembly. "Concluding Communique on *The Ethics of Biomedical Research for a Christian Vision*" Vatican official site. Available from http://www.vatican.va/roman_curia/pontifical_academies/acdlife/documents/rc_pont-acd_life_doc_20030226_ix-gen-assembly-final_en.htm.

Holy See. "Observations on the Universal Declaration on the Human Genome and Human Rights." Vatican official site. Available from http://www.vatican.va/roman_curia/pontifical_academies/acdlife/documents/rc_pa_acdlife_doc_08111998_genoma_en.html.

NATURE

Thinking about science, technology, and ethics easily raises questions about nature. Science considers whether and how nature can be understood. Technology considers whether and how humans can control nature. Ethics considers whether and how science and technology can be guided by standards of right and wrong that might be rooted in nature. One of the most common objections to science and technology is to argue that they go against nature, just as one of the strongest defenses is to present them as eminently natural.

Nature and Reason

The English word *nature* is derived from the Latin word *natura*, which is related to the verb *nasci* (to be born) and the noun *natus* (birth). The Latin *natura* corresponds to the Greek *phusis*, of which the root is *phu* (growing, becoming, being). Nature is the original birth or coming into being of something. More generally, nature is concerned with the "first things," the origins of things.

The idea of nature seems to have been discovered or invented first by ancient Greek philosophers and scientists. Aristotle (384–322 B.C.E.) identified the "first philosophers" as "humans who spoke about nature" in looking for the "principles" or "beginnings" of all things (*Metaphysics* 983b5–19). These Greek philosophers thought of *phusis* as the beginning or coming to be of something. But more often *phusis* meant the sort or kind or description of something—the essential character of a thing or a class of things. The nature of something could be what it is at birth or what it grows into at maturity, what it is at its beginning or at its end. "Nature is an end," Aristotle explained, "because whatever anything is like when its growth is completed, that we call the nature of each thing" (*Politics* 1252b33–35). These Greek philosophers began by asking about the nature of each thing, what each thing is like. And then they asked what everything was like. Thus, the Greek philosopher Parmenides (c. 515 B.C.E.) could write a book with the title *On Nature*, which considered the "nature" of everything.

When nature becomes everything, it is impossible to define. But generally nature is a term of distinction, and so its meaning may be clarified by asking what is its opposite. In ancient Greece, "nature" (*phusis*) was most commonly set in opposition to "custom" (*nomos*) or "art" (*techne*). Custom and art are human products. By contrast, nature is what arises on its own without human interference. Nature is what is not customary or artificial.

Philosophy or science arose in ancient Greece when a few thinkers noticed that customary practices and beliefs varied across human societies. This led them to doubt the authority of human customs and to look for what was universally true by nature as opposed to what was believed to be true by human custom. Whatever arises by human custom or artfulness is changeable, but what arises by nature, it was argued, is unchangeable and thus more real than the perishable products of human activity.

The ultimate justification for customary practices and beliefs is the claim that they are divine, that they originated from the commands of gods or god-like ancestors. But when Greek philosophers and scientists explained the "first things" as natural rather than customary or artificial, this suggested that even the gods might be artificial or human-made, as being products of storytelling. The natural was opposed to the divine or the supernatural. Consequently, as indicated by the Athenian trial and execution of Socrates (469–399 B.C.E.), who was charged with impiety, the philosophic discovery of nature implied a questioning of the gods.

Revelation and Nature

The religious believer could respond by denying the idea of nature as the autonomous order of the world and affirming that whatever exists is what it is only through the creative activity of the gods or God. The Hebrew scriptures contain no word that corresponds to *nature*. In the Greek scriptures, the word *phusis* does not occur except in the letters of Paul, who was influenced by Greek philosophy.

Yet the medieval scholastic tradition of Biblical theology adopted the Greek idea of nature insofar as God was understood to be the creator of nature. Indeed, this assumption allowed Thomas Aquinas (1225–1274), for instance, to interpret the order found in the cosmos (which he termed *lex aeterna* or eternal law, because absent revelation the world was seen as eternal) and in human nature (which he termed *lex naturalis* or natural law) as both rational and normative in character. The natural law of what it is to be human was manifest in three levels of natural inclination or desire: for physical life, for family and children, and for political and rational experience.

In the late medieval period, as creation itself increasingly came to be conceived in technological terms, this nevertheless led to nature being thought of as God's artifice. As a divine construction, nature could stand on its own and was governed by its own "secondary laws." Although God ultimately remained the transcendent "first cause" of all things, the divine necessarily began to be pushed to the margins of scientific investigations.

The founders of early modern science such as Galileo Galilei (1564–1642), Francis Bacon (1561–1626), Robert Boyle (1627–1691), and Isaac Newton (1642–1727) adopted this medieval teaching in defending the science of nature as the study of "secondary causes," while increasingly delimiting the higher authority of Biblical theology as the study of God as "first cause." Nature was the book of God's works, and the Bible was the book of God's words. The book of nature was written in the language of mathematics, which was more pure and more progressive than theological disputes concerning historical revelations. To understand nature, scientists were thus encouraged to discover those mathematical principles of nature that constituted the "laws of nature."

The mathematical and observational methods of modern science have succeeded in uncovering the laws of nature in a sense much more expansive and less normative than for Thomas Aquinas. Does this advance in the scientific understanding justify the control of nature? Does the possession of power convey the legitimacy of its use? Bacon, René Descartes (1596–1650), and other early modern proponents of science certainly projected that their new science would conquer nature for human benefit. Beginning in ancient Greece, philosophers and scientists had striven for a theoretical comprehension of nature. Modern scientists under the banner of Bacon and Descartes strove for power over nature. The point was not just to understand nature but to change it, so that modern science from its beginnings exhibited an inherently technological orientation.

Organism versus Machine

The contrast between traditional and modern concepts of nature may also be presented as a contrast between visions of nature as an organism and as a machine. For the Greek philosophers and medieval theologians, nature was primarily manifest as a something that is born and grows. Even for premodern materialists such as Lucretius (c. 99–c. 55 B.C.E.), nature seems to be a super organism with a consequent sacred or awe-inspiring character. Although he seeks to remove all religious superstition from the world and present nature as devoid of gods, his poem *De rerum natura* opens with praise of sky and earth as the father and mother of all living things. In the presence of such a reality—indeed, as part of such a reality—humans are called upon to accept and to live in harmony with it. And for Plotinus (204–270 C.E.), throughout "the air, the earth and sea, there are advents of terrestrial, aquatic, and aerial gods [so that] the world is throughout filled with deity; and on this account is according to the whole of itself the image of the intelligible" (Proclus, Platonic Theology, 7.2).

For modern philosophers such as Descartes, however, nature was primarily manifest by inanimate entities such as rocks that can nevertheless interact as carriers of energy to create complex structures. For Descartes, even living things are complex machines—plants, animals, and human bodies (including the human brain and nervous system) are all machines.

Such a view of nature as machine undercuts the traditional distinction between nature and artifice. The science of nature as machine yields a technology by which nature as technology can be further molded by human beings to serve human purposes. When Bacon declared that "nature to be commanded must be obeyed," he transforms the premodern basic end in itself of obedience to nature into a mere means (*Novum organum* I, 3). Although he argues that all humans can do "is to put together or put asunder natural bodies" with "the rest [being] done by nature working within" (*Novum organum* I, 4), for him nature as a mechanical process has already ceased to exhibit much in the way of intrinsic value. From the eighteenth century romantic poets to contemporary deep ecologists, humans have worried that the science and technology of nature as machine brings about first in theory and then in practice, in Bill McKibben's phrase, "the end of nature": a wholly artificial world controlled by human will with no room left for natural spontaneity or wildness.

In response to this Romantic notion of nature and technology in conflict, some people have defended technology as itself natural. All organisms alter their environments in adaptive ways, and many animals build artificial structures: Beavers construct dams, bees fabricate hives, and leaf-cutter ants cultivate fungus gardens and herd aphids. Charles Darwin (1809–1882) contended that tool-making was common in the animal world, and human technology differed in degree not in kind. Some biologists argue that human technology expresses "niche construction," which is a trait found generally in the living world, because organisms do not just adapt to fixed environments, they also change environments to construct their own niches. There is no fixed "balance of nature," because nature is constantly in flux from the ever-changing forces of both physical and organic causes. For example, the present concentration of oxygen in the atmosphere has arisen from the production of oxygen by photosynthetic organisms. As a consequence, many organisms have evolved a capacity for aerobic respiration and other traits as adaptations to this atmospheric increase in oxygen levels over the course of geological time. Without such a change in the atmosphere brought about by ancient photosynthetic organisms, human beings could never have evolved.

The Problematic Appeal to Nature

Despite the modern replacement of nature as divine with nature as machine, and outside the more extreme Romantic attempts to re-valorize nature, it is nevertheless the case that the appeal to nature exerts a popular influence. On the one side, one of the most common criticisms of genetically engineered foods or bioengineered human-machine hybrids is that they are in some sense unnatural. On the other, one of the most common general forms of praise for science and technology is that they are natural and thus improperly delimited. The so-called naturalistic fallacy is found across the spectrum of discussions about relations between science, technology, and ethics.

Among those who have criticized this appeal to nature as a ground of moral judgment, it is common to distinguish two senses of nature. When scientists speak of the laws of nature, they mean nature as the collective whole of everything that exists or could exist, including humans. When non-scientists speak of nature they more common refer to whatever is spontaneous or not the result of human contrivance.

Insofar as nature covers the entire order of things, argued John Stuart Mill (1806–1873) in a classic modern criticism of the appeal to nature, the moral injunction to "follow nature" makes no sense; humans have no choice in the matter. Everything people do must conform to nature in this abstract, all-encompassing sense. On the other hand, if nature is the spontaneous order of things free from human influence, then "following nature" would be irrational and immoral. It would be irrational, because any human action would alter the course of nature and would thus be unnatural. And it would be immoral, because natural phenomena often have evil effects. Mill declares in his essay "Nature": "Either it is right that we should kill because nature kills; torture because nature tortures; ruin and devastate because nature does the like; or we ought not to consider at all what nature does, but what it is good to do." Morality requires that we go against the impulses of nature.

So morality is not natural, Mill concludes. Rather, it is nature artificially perfected by human cultivation and artifice to satisfy the moral concerns of human beings. Those who argue for a natural moral law mistakenly assume that what *is* can be the rule and standard for what *ought* to be. Natural science can reveal the natural facts of existence, but morality must tell humans about the moral values of human life.

This distinction between is and ought, or between facts and values, supports the common distinction between nature and culture. Morality is assumed then to arise not from nature but from culture, because moral norms of right and wrong, good and bad, are products of human cultural artifice. Through science, people can understand nature. And through technology, people can control nature. But to judge the moral ends of scientific understanding and technological control, one must go beyond nature and enter the realm of culture, which is an artificial world of human social contrivance set apart from the natural world. As Remi Brague (2003) has shown, Mill's essay on nature manifests the shift from the premodern idea that nature is a model for human action to the modern idea that nature needs to be corrected, not imitated.

The proponent of natural moral law might respond by saying that although cosmic nature might be indifferent to moral distinctions, human nature is not. If one can identify some human desires and inclinations as natural and not merely conventional, one can say that the naturally good human life is one that satisfies those natural desires and inclinations. Variable moral customs of culture can then be judged as good or bad, depending on whether or not they conform to those natural desires and inclinations. So, for example, if human beings have natural desires for life, for parental care, and for social bonding, then one can judge those beliefs and practices that satisfy these desires as naturally good.

Even Mill accepts this in his utilitarian morality, when he claims that the ultimate good for human beings is the attainment of happiness, which is the satisfaction of their natural desires. For example, humans' moral duties to others arise from their natural sentiments as social animals who care for their fellow creatures (Mill 1991). Of course, as Mill insists, people's moral virtues do not spring spontaneously from their human nature, because they need to be cultivated through individual habituation and social customs. But still, as Aristotle said, the cultivation of such virtues is made possible by our natural desires and inclinations (*Nicomachean Ethics*, 1103a14–26).

And so reflections about science, technology, and ethics lead to complex questions about the meaning of nature. To ponder such questions is part of human nature.

LARRY ARNHART

SEE ALSO *Bioengineering Ethics; Christian Perspectives; Descartes, René; Earth; Environmental Ethics; Environmentalism; Nature versus Nurture; Rousseau, Jean-Jacques; Sierra Club; Thoreau, Henry David.*

BIBLIOGRAPHY

Brague, Remi. (2003). *The Wisdom of the World: The Human Experience of the Universe in Western Thought*. Chicago: University of Chicago Press.

Klein, Jacob. (1985). "On the Nature of Nature." In *Lectures and Essays*, ed. Robert B. Williamson and Elliott Zuckerman. Annapolis, MD: St. John's College Press.

Lewis, C. S. (1967). "Nature." In *Studies in Words*, 2nd edition. Cambridge, UK: Cambridge University Press.

McKibben, Bill. (1989). *The End of Nature*. New York: Random House.

Mill, John Stuart. (1969). "Nature." In *Collected Works of John Stuart Mill*, Vol. 10., ed. John M. Robson. Toronto: University of Toronto Press.

Mill, John Stuart. (1991). *On Liberty and Other Essays*, ed. John Gray. Oxford, UK: Oxford University Press.

Odling-Smee, F. John; Kevin N. Laland; and Marcus W. Feldman. (2003). *Niche Construction: The Neglected Process in Evolution*. Princeton, NJ: Princeton University Press.

Strauss, Leo. (1953). *Natural Right and History*. Chicago: University of Chicago Press.

Torrance, John, ed. (1992). *The Concept of Nature*. Cambridge, UK: Clarendon Press.

Wigner, Eugene P. (1984). "The Unreasonable Effectiveness of Mathematics in the Natural Sciences." In *Mathematics: People, Problems, Results*, ed. Douglas M. Campbell and John C. Higgins. Belmont, CA: Wadsworth.

NATURE VERSUS NURTURE

This familiar expression indicates a division between those who offer biological explanations for some human behaviors and those who insist on environmental explanations. The root of the problem is a basic uncertainty about the causes of human physical and psychological traits. Some traits are obviously inherited in a biological sense, such as having a four-chambered heart or the ability to learn to talk. Such characteristics are said to belong to humans by *nature*, from a root word meaning *birth*. Other traits are not inherited, but are a result of environmental influences. A person can inherit a parent's hair color, but not his or her tattoo; and a person must learn the French language in order to speak it. Acquired traits are said to be due to *nurture*, which in this context indicates any influence other than biological inheritance.

Distinguishing in Specific Cases

In analyzing physical characteristics, it can be difficult to tease nature and nurture apart. Why is Steve eight inches taller than Ric? Perhaps this difference is only natural because Steve's parents are taller than Ric's parents. But the difference in stature could quite literally be due to nurture: Perhaps Ric was starved as an infant. Then again, it may be the result of both: Steve picks up five inches from his Mom and Dad, and another three at the dinner table. The problem is much more difficult when analyzing behavior because the range of possibilities is greater. Natural influences on behavior might be quite strong, so that culture plays only a marginal role. At the other extreme, it may be that human beings are born with almost no instincts or innate ideas. Perhaps the only significant influence on any person's behavior is the behavior of other persons, living and dead.

This uncertainty regarding the relative weight of nature and nurture quickly becomes a controversy when discussing behaviors of greater significance. For example, suppose boys are more aggressive at play and girls more caring. One explanation is that society creates this gender difference by giving toy guns to boys and baby dolls to girls. It is possible, however, to argue the opposite: Because girls are already inclined toward motherhood, they receive the dolls they want; and because boys are more aggressive from birth, they select toys that look like weapons. This sort of question tends to divide scholars into hostile camps. Naturalist Edward O. Wilson has dubbed those who offer the second explanation *hereditarians*. Those who insist on the former, he calls *nurturists*.

Hereditarians vs. Nurturists

The opposing beliefs of hereditarians and nurturists colors almost all contemporary discussions of human behavior and its causes. A minor cause of the debate is an old turf war between the social sciences and the humanities, on one side, and the physical sciences, on the other. Some sociologists and English professors see explaining what people think, say, and do, in part by reference to genes, proteins, and neurons, as an invasion of their territory by physicists and biologists. This invasion is especially unnerving because fields such as psychology or history can never hope to match the precision, clarity, and predictive power of the hard sciences. Nurturism is an attempt to carve out a space in which the soft sciences do not have to compete with physics.

The major cause of the conflict between the soft and hard sciences arises from the political, ethical, and aesthetic implications of the hereditarian's view. Any influence that biology is allowed over human behavior seems to come at the expense of moral responsibility. Many facts about existing societies strike people as unjust: sexual inequality, crime and war, economic inequality, among others. To the extent that these social ills are due to nature, society cannot blame anyone for them. Nurturists prefer arguing that the hereditarian view always justifies the status quo. It certainly seems to undermine the indignation that might drive any fundamental change.

The hereditarian view also seems to place limits on the range of possible reforms. If male aggression and desire for status are natural, then every society will suffer from some measure of crime and inequality. If human beings have an instinct to divide themselves into mutually hostile groups, as do chimpanzees, then no society will be free from ethnic, racial, or religious conflict. If women naturally desire to care for their own children, then there is little hope of transforming childrearing into an altogether collective activity, as many utopian communities have attempted to do. The hereditarian view does not deny the possibility of reform, but it does suggest that the best societies will be only marginally better than the ones that have always existed. Nurturists tend to be offended by this idea.

Proposed Resolutions

If an intellectual impasse goes unresolved long enough, some will inevitably grow tired of it and look for a way out. The oldest peace plan is a form of dualism involving the construction of a demilitarized zone between the study of nature and the study of culture. Natural scientists would be allowed to study all natural processes, including human evolution; but should resist any temptation to explain such things as human social and political behavior, history, art or literature by reference to nature. The study of culture should be regarded as an autonomous and independent field of inquiry.

Another attempt to resolve the issue involves a holistic approach to nature and nurture. Much of the anxiety over natural explanations of behavior relies on an overly simplistic view of genetic causation. In that view causation works one way: Genes create proteins that in turn create organisms. A person's nature is fixed from the beginning, and there is very little that can be done about it. The holistic approach is based on a more complex view. Many genes spend their time switching other genes on and off, often in response to external information. A person's genetic code may be fixed, but genetic *nature* is not: It molds itself in response to the environment. Moreover many genes cannot function without information from the environment. Human beings are born with a capacity to learn language, but they must be exposed to a language during certain critical periods in development in order to learn it. Here culture is as much a part of nature as are genes.

Both dualism and holism present themselves as compromises, but are in fact attempts to win by default. Only those who believe that biology has almost no influence over individual personalities will take dualism seriously. Likewise although holism presents a very flexible version of human nature, it nevertheless makes hereditarian assumptions about the influence of biology on behavior. The argument between nurturists and hereditarians does seem likely to wind down for the simple reason that hereditarians are winning. There is little doubt remaining that genes do influence significant behaviors, and that in many cases—twin studies for example—biological inheritance is a much better predictor of an individual's life course than social environment.

Ethical and Political Significance

The moral and political significance of the difference in opinion between nurturists and hereditarians is more difficult to decipher. If the expression of genes really does change in response to the environment, culture may be as difficult to change as nature. Almost every child will easily master a first language, but few people learn a second language well enough to pass for a native. Perhaps this is because one's first language shapes the mind in more or less permanent ways. Evidence suggests that the infant mind is primed to learn language, and much the same thing may be true of morality and other aspects of political culture. Similarly acknowledging that people are naturally disposed to certain behaviors probably makes them more, rather than less, responsible. An individual who recognizes a personal propensity to alcoholism or spousal abuse, is better able to take responsibility for the condition.

The hereditarian view may be liberating in a much more profound way. For example the debate over admitting women into the military has usually turned on whether one believes that sexual differences are mostly due either to socialization or to nature. However the opposite should also be true. Males not only make up most of the soldiers in every society, they also commit almost all the violent crimes. If women serve in large numbers in the military, society must ask what effect this will have on their behavior after their military service is concluded. There is no great need to worry if psychological dimorphism is natural because no change in social environment will make women as dangerous as men. But if these behavior patterns are socially constructed, introducing women into the military might have disastrous consequences. If women learn to behave like men, not only on the battlefield but back home, the crime rate in a society could easily double. Contrary to popular belief, the hereditarian view may be friendlier to social reform than the nurturists view.

The tension between nature and nurture is at least as old as Plato's *Timaeus*. According to premodern natural philosophy, nature was largely fixed, and was superior in dignity and authority to any product of technology; only nurture was in large measure subject to human control. In this view the role of such sciences as agriculture, medicine, or politics was to tend nature as one had tended the god, in order to promote human flourishing.

The early moderns rejected this approach, and chose to view nature as a "rich storehouse" of materials, as English philosopher Francis Bacon (1561–1626) said, to be manipulated "for the relief of man's estate." The distinction between nature and nurture was relatively unimportant: Given the right technologies, either can be brought under the yoke of human will. Human beings thus acquire an unprecedented sense of responsibility for their own destiny.

Some of that early modern confidence remains in the early 2000s; however, it has been tempered by other considerations. For example the human genome project promised to provide a powerful new tool for the diagnosis and treatment of disease; however, about 5 percent of its budget was devoted to exploring the ethical and social consequences of this project. This was in part political: The public neither fully understands nor trusts innovative technologies. But it also recognizes the limits of engineering as a metaphor for technology. Much of nature as well as human behavior remains stubbornly resistant to technoscientific ambitions. This may be because human life rests on a vast array of interactions between biology and culture, an array that is too complex ever to be mastered. Perhaps an approach to nature and nurture that combines modern science and technology, with at least a dose of ancient piety, is necessary.

KENNETH C. BLANCHARD, JR.

SEE ALSO *Aggression; Ethology; Homosexuality Debate; Nature; Sociobiology.*

BIBLIOGRAPHY

Bacon, Francis. (2001). *The Advancement of Learning*. New York: Modern Library.

Fukuyama, Francis. (2002). *Our Posthuman Future: Consequences of the Biotechnology Revolution*. New York: Picador.

Lewontin, Richard. (2001). *The Triple Helix: Gene, Organism, and Environment*. Cambridge, MA: Harvard University Press.

Pinker, Steven. (2002). *The Blank Slate: The Modern Denial of Human Nature*. New York: Viking.

Ridley, Matt. (2003). *Nature Via Nurture: Genes, Experience, and What Makes Us Human*. New York: Harper Collins.

Rose, Hilary, and Steven Rose, eds. (2000). *Alas, Poor Darwin: Arguments against Evolutionary Psychology*. New York: Harmony.

Wilson, Edward. O. (1988). *On Human Nature*. Cambridge, MA: Harvard University Press.

NAZI MEDICINE

Medical research and practice under Germany's National Socialist regime (1933–1945) has come to serve as an archetype for the immoral uses to which science and technology can be applied. In many instances appeals to science were used to justify evil actions, and independent reflection failed to criticize unethical research protocols and medical interventions. Without diminishing the horrors that resulted, it is nevertheless important to place such actions in context in order not to so distance them that they offer no lessons from which others might learn.

Social Context

Genetics and related eugenic claims were at the heart of Nazi racial ideology that ultimately led to genocide in Europe during World War II. Although the study and application of eugenics did not begin with National Socialism, it was in Nazi Germany that eugenics became a central component of state policy. The same academic and research institutions that were so critical in the development of modern medicine, medical science, and medical education were also directly complicit in the most massive program of human destruction in history.

Henry Friedlander (1995) nevertheless cautions that the murderous application of eugenic and racial principles by German physicians must be understood in terms of the motivations of other professions. German physicians were professionals who, like all professionals, sought financial security, career advancement, and professional recognition. Motives certainly varied, but these physicians were all German nationalists who generally subscribed to the racist and eugenic components of National Socialism. While providing a rationalization for their actions, ideology was nevertheless probably not the primary motivation for most physicians.

Studies by Michael H. Kater (1989) reveal that German physicians tended to be more closely associated than other professionals with Nazi Party organizations such as the National Socialist Physicians' League, the SA (Sturmabteilung, the military arm of the Nazi party founded in 1921, but disarmed and neutralized by Hitler in 1934) and the SS (Schutzstaffel, initially recruited from the SA in 1923 as Hitler's personal bodyguard, and the embodiment of Nazi racial ideology that developed into a vast police, military, and economic empire). About a third of all physicians were members of the National Socialist Physicians' League, and by 1939, almost 45 percent of physicians in Germany were members of the Nazi Party, figures substantially higher than those of other professions (such as lawyers [25%], teachers [24%], and musicians [22%]). Moreover, 7 percent of all physicians in Germany were members of the SS. Their professional needs seemed to find relatively more satisfaction within the context of the growing power of the SS and its extraordinary role in matters of life and death.

Under National Socialism, German medical science soon identified individual Germans considered by the state to be inferior and expendable. Acknowledging the influence and experience of American eugenicists and compulsory sterilization laws in the United States, the Nazis on July 14, 1933, enacted the Law for the Prevention of Progeny of Sufferers from Hereditary Diseases. Hundreds of thousands of Germans and, later, Austrians were sterilized without their consent after being medically diagnosed with conditions deemed hereditary and undesirable. These conditions included "feeblemindedness," schizophrenia, and manic-depressive disorder, among others.

T4 Policies

The genocidal policies of the Nazi regime commenced shortly after the outbreak of war in September 1939, with the decision to exterminate the handicapped in Germany. Friedlander identifies the first victims as disabled children and adults who were in institutions. Under the euphemism of *euthanasia*, the killers described their task as "destruction of life unworthy of life." Hitler's Chancellery, with the support of the health division of the Ministry of the Interior, directed the killings. It established various front organizations, headquartered in Berlin at Tiergartenstrasse No. 4, and known as T4. Physicians and psychiatrists, hospital directors and bureaucrats, directed the T4 killings and served as medical experts in the selection of victims they never saw. In addition to starving some patients to death, these physicians murdered patients with overdoses of Luminal (a sedative) and Veronal (sleeping tablets), and also morphine-scopolamine.

In the spring of 1941, the T4 killings were expanded to include concentration camp prisoners. This new task was designated Special Treatment 14f13. In late 1941 and 1942, T4 methods and technology were transferred to the east where the SS established extermination centers at Chelmno, Auschwitz, Treblinka, Belzec, Sobibor, and Majdanek, modeled on the T4 centers, for the extermination of Europe's Jews and Gypsies. There, physicians supervised the registration of the arriving victims, administered the gas, pronounced the victims as dead, and participated in looting the corpses. Besides extracting gold teeth for the Reich treasury, physicians performed countless autopsies on the bodies of their victims in order to provide younger physicians with training and academic credit, as well as to recover organs, especially brains, for scientific study at medical institutes.

SS physicians tolerated unhygienic conditions, inadequate food, and inhuman working conditions in the camps. Moreover, they were complicit in inhuman corporal punishment when they certified that prisoners were healthy enough to undergo beatings. SS physicians also participated in the murder of prisoners in most camps, using lethal injections and other medications to kill their victims.

At Auschwitz-Birkenau, with its assembly line methods of killing, medical officers selected those destined for the gas chambers. In addition, most SS physicians at Auschwitz participated in cruel and unethical medical experiments on human beings. Many were young and inexperienced physicians who wanted to learn, and who did these experiments in order to obtain degrees or to secure some publications. SS physicians performed the function of both concentration camp medical officer, a position that had existed since the early 1930s, and extermination center physician, a position that materialized early on in the war as part of the T4 operation.

In the end, the T4 physicians and SS physicians at Auschwitz volunteered for their positions. They could have refused to participate but did not. There is general agreement among scholars that they became murderers because they were consumed with ambition while remaining, at the same time, more or less loyal to the racist ideology of Hitler's regime.

Historical Consequences

American military courts conducted a series of twelve trials at Nuremberg between December 1946 and April 1949, which included the trial of a group of twenty-three Nazi physicians and members of the German medical establishment for T4 ("euthanasia") killings and medical experiments. These trials generated an in-depth search for ethical rules to be observed before initiating experimental therapy with human beings. Beginning with the creation of the Nuremberg Code in 1947, which condemned medical abuses in experimentation on human beings, a body of ethical guidelines has accumulated over the years.

The Nazi medical establishment also produced some *good* science, according to Robert N. Proctor (1999), within the larger eugenic and racial context of Nazi medicine and its agenda of systematic murder of the handicapped, Jews, and Gypsies. Under National Socialism, German epidemiology was probably the most advanced in the world. Before World War II, for example, German medical science established the relationship between tobacco use and lung cancer. This reflected the regime's goal of improving the overall public health of the German people, of which its *racial hygiene* policies constituted a significant part. As Proctor concludes, the campaign against tobacco provides a compelling insight into the complex nature of the racially based public health initiatives of Nazi Germany, responsible as they were for both better nutrition and forced sterilizations, for both genocide and campaigns against smoking.

William E. Seidelman (2000) has written that the legacy of Nazi medicine included an *amnesia* that conditioned the postwar German and Austrian medical establishments until the late twentieth century particularly with regard to the continued use of the fruits of Nazi medical practice. The links between Nazi ideology, the cruel and exploitative medical experiments that German physicians conducted on the victims of that ideology, and the sterilization, euthanasia, and extermination policies conducted by physicians under Nazi authority, raise questions that have immediate relevance to contemporary controversies over the nature and course of research in human genetics and biotechnology.

FRANCIS R. NICOSIA

SEE ALSO *Eugenics; Euthanasia; Holocaust; Human Subjects Research; Race; Research Ethics.*

BIBLIOGRAPHY

Burleigh, Michael. (1994). *Death and Deliverance: "Euthanasia" in Germany, c. 1900–1945.* Cambridge, UK: Cambridge University Press. Links the Nazi mass murder of the Jews, Gypsies, and the handicapped by revealing the redeployment of "euthanasia" personnel to the mobile killing units and the extermination camps after 1941.

Friedlander, Henry. (1995). *The Origins of Nazi Genocide: From Euthanasia to the Final Solution.* Chapel Hill: University of North Carolina Press. Traces the rise of racist and eugenic ideas in Germany and elsewhere in the early twentieth century, their contribution to the Nazi "euthanasia" program beginning in 1939, and to the policy of extermination of Jews and Gypsies beginning in 1941.

Kater, Michael H. (1989). *Doctors under Hitler*. Chapel Hill: University of North Carolina Press. Focuses on the institutional framework of the medical profession in Nazi Germany and examines how German physicians participated in crimes against Jews and other victims.

Lifton, Robert Jay. (1986). *The Nazi Doctors: Medical Killing and the Psychology of Genocide*. New York: Basic. Demonstrates how many German physicians were transformed from healers to murderers, and the overall role they played in Nazi genocide.

Nicosia, Francis R., and Jonathan Huener, eds. (2002). *Medicine and Medical Ethics in Nazi Germany: Origins, Practices, Legacies*. New York: Berghahn Books. Six distinguished scholars consider the various ways in which German physicians and the German medical establishment were complicit in crimes against humanity, and the disturbing legacy they left in post-Holocaust Germany and Austria.

Proctor, Robert N. (1999). *The Nazi War on Cancer*. Princeton, NJ: Princeton University Press. Focuses on the discovery of the link between tobacco smoking and lung cancer in Nazi Germany, and demonstrates how the positive health activism of the Nazis derived from the same roots as their medical crimes against humanity.

Seidelman, William E. (2000). "The Legacy of Academic Medicine and Human Exploitation in the Third Reich." *Perspectives in Biology and Medicine* 43(3): 325–334. Examines the continued use in post-World War II Germany and Austria of some of the results of Nazi medical experiments during World War II.

NEGATIVE EUGENICS

SEE *Eugenics*.

NEOLIBERALISM

The term *neoliberalism* is used to characterize the dominant economic policies pursued in the United Kingdom, the United States, and some developing countries such as Chile since the late 1970s or early 1980s. It is noteworthy that during this same period governmental policies toward the support of science and technology were undergoing important critical assessments. On the one hand, the scientific community proclaimed its autonomy but, on the other, sought increased governmental support for its research. In the United States, however, the Federal Technology Transfer Act of 1986, requiring national laboratories to promote technology transfer and to promote partnerships, was part of the deregulation and privatization of government activities. During this same period, the disclosure of instances of misconduct in scientific research raised questions about the ability of an autonomous scientific community to govern itself.

Genesis

Neoliberal policies, first identified with the Conservative government of Prime Minister Margaret Thatcher (1979–1990) in the United Kingdom and the Republican administration of President Ronald Reagan (1981–1989) in the United States, represented a sharp break with the so-called Keynesian consensus that had dominated both domestic and international economic policy-making from the end of World War II to the late 1970s. (The consensus was called *Keynesian* because it was based on the theories of the British economist John Maynard Keynes [1883–1946] and his followers.) At the heart of that consensus had been the view that, unless continually "guided" and "pump-primed" by governments, free market or capitalist economies were unable to provide either full employment or a stable pattern of economic growth. Generated as a reaction to the Great Depression of the 1930s, and reinforced by a successful experience of strong state management of economies in the war years, Keynesian theories and policies appeared unable to cope with the so-called stagflation that marked the early 1980s—the combination of high unemployment with high inflation that hit virtually all industrial economies at the end of the postwar "long boom" in the world economy.

Keynesian policies had come under criticism from a minority of economists even before the stagflation period. Such policies were seen as having encouraged strong structural inflexibilities and rigidities in market economies, rendering them both less technologically and commercially innovative than they would otherwise have been, and making them particularly vulnerable to problems of inflation as productivity increases failed to keep pace with increases in wages and other costs. Such critiques had not been very politically effective previously, but became more so when the chronic inability of all industrial economies to absorb the 1970s oil price increases—and the double-digit inflation and sharply reduced profit rates that arose as a result in most of them—seemed to confirm the very "rigidity" and "inflexibility" of which opponents of Keynesianism had warned (Armstrong, Glyn, and Harrison 1984).

Characteristics

Neoliberalism involves a crucial reversal of the fundamental policy premise of Keynesianism. For Keynesians the fundamental problem of free market or capitalist societies was the possibility and actuality of "market failure" and the need for state intervention to prevent or correct such failures; for neoliberals the fundamental problem is that state interventions in markets fail far more frequently than they succeed, or even when they do succeed in their particular policy goals (such as full employment) have unanticipated consequences in other areas of market functioning—consequences that ultimately undermine their supposed successes. Neoliberals therefore return to the fundamental premise of Adam Smith's *Wealth of Nations* (1776): that economic policy should, in general, err on the side of *laissez-faire,* of "letting alone," of allowing "market forces" to function unimpeded by state action—unless there is some very strong reason *not* to do so. Their fundamental policy premise therefore is that in capitalist or market economies "state failure" is a much greater problem and danger than "market failure." According to John Williamson (2002), the only "strong reasons" that neoliberal economists will usually countenance as justifications for state action are the enforcement of legal contracts (requiring a judicial system and a police force) and the requirements of state external defense (requiring a state-funded military apparatus).

Because of its reversal of Keynesian policy premises and of the "burden of proof" for state intervention, neoliberalism undoubtedly received an enormous political impulsion from both the collapse of communism in the USSR and Eastern Europe in the early 1990s and the failure—or perceived failure—of the state-led economic development (often referred to as import substitution industrialization) that dominated many parts of the Third World from the 1960s through the 1980s. Both phenomena could be seen as classic examples of "state failure"—of the failure of state-dominated economic policies to generate economic innovation and development and to raise mass living standards—relative to the performance of more "free market" economies (Stiglitz 2002). Neoliberal economists and policymakers are particularly given to seeing the success of economic development efforts in certain parts of the former Third World—in China and East Asia most notably—as examples of "free market" success. This neoliberal view of the so-called Asian Tiger economies, or newly industrializing economies, however, has been strongly contested by opponents of neoliberalism, as described further below.

Originality

Questions arise about the originality of neoliberalism—and in particular about its relationship to classical nineteenth-century economic liberalism. Some analysts have denied that neoliberalism, as an economic doctrine, is in any way original, and have seen it simply as a return to the fundamental *laissez-faire* policy premises of both the classical and neoclassical economists of the nineteenth century. Others have denied this and sought to justify the prefix *neo* in a variety of ways: neoliberals are much more concerned with market exchanges, and in particular with legally guaranteed ("contractual") monetary exchanges of goods and services, than were their nineteenth-century predecessors who (so the argument goes) were much more concerned with "real," "material" production processes and with monetary exchanges only as a part or aspect of these real processes (Treanor Internet article). Neoliberals are "neo" precisely because they are in general more politically conservative, especially on social issues, than their nineteenth-century predecessors, who were politically as well as economically liberal (Shah Internet article). They are *neo*liberals because they are generally more nationalistic than classical nineteenth-century liberals. It has even been argued, that, in practice, neoliberals actually support disguised modern forms of "mercantilist" economic policy (the kind of nationalistic economic policy expressly attacked by Adam Smith). They do so because, so it is alleged, they use "free market" and (especially) "free trade" ideas to justify and reinforce the economic power and domination of the rich nations of the world—especially the United States (Shah Internet article).

None of these justifications of the *neo* prefix seem especially convincing for two reasons. First, all these characterizations come from neoliberalism's opponents. In fact, with very rare exceptions (DeLong Internet article), economists and politicians who are referred to by their opponents as neoliberals do not use this term themselves. Generally speaking, people who are tagged as neoliberals refer to themselves simply as "conventional economists" or "believers in free markets" or even "economic pragmatists." Second, all the above justifications are empirically doubtful, in the following ways:

1. If modern neoliberals can be attacked as disguised economic nationalists or even as apologists for economic imperialism, then so can classical nineteenth-century liberals (and especially British liberals) (Kitching 2001).

2. Although some neoliberals are undoubtedly very nationalistic (Thatcher comes immediately to mind), others seem just as "globalist" or "internationalist" in their outlook as any nineteenth-century liberal, and have indeed not infrequently been attacked for justifying or defending "free trade" policies that lead to job losses in the United States, Europe, or elsewhere.
3. While it probably is true that modern economic theory in general is even more "abstract/mathematical" and "monetary-exchange" oriented than its nineteenth-century predecessors, this is probably much more a reflection of the changing structure of capitalist markets in the contemporary period than a mark of any major theoretical or ideological shift.
4. While some neoliberals may be politically or socially conservative (Thatcher again comes to mind, along with her economic "guru" Friedrich Hayek and the American economist Milton Friedman), a number of others are almost anarchistic in their support for "free individual choice" in social issues. Others, still tagged "neoliberal" by their opponents, are in fact advocates of a rather wider range of state interventions (often on social or equity grounds) than the majority of market-oriented economists. Joseph Stiglitz (2002, 2003), former chief economist of the World Bank, frequently espouses such "modified Keynesian" views now, as does the neoliberal (or former neoliberal?) trade economist Paul Krugman.

On balance then it seems most accurate to ignore the *neo* prefix or to see it as simply a synonym for *new* or, perhaps better yet, for *revived*. Neoliberalism is in fact simply a revived form of nineteenth-century "free market" economic liberalism adapted in specific ways to the changed economic context of the late twentieth and early twenty-first centuries, but not theoretically or ideologically new in its fundamentals. Insofar as part of the changed economic context involves the increased importance of science and technology, the proper relation between science, technology, and economic liberalism is one *neo*liberalism issue.

Merits and Demerits

Neoliberalism's merits include:

1. Its acute, and to a large degree empirically accurate, analysis of the severe shortcomings of state economic policymaking both in the former communist countries and in many parts of the Third World. In particular, neoliberals have revealed the very peculiar cultural assumptions about the values and actions of state power holders that were built into Keynesian economics and into the Keynesian-influenced "development economics" of the 1950s to 1970s. Working in a European context Keynes and his followers felt able to ignore classically Smithian questions about the corruptibility of state power holders. But there are many parts of the world where such questions *cannot* be ignored, or are ignored only at the peril of total policy failure. Neoliberalism seems most justified when arguing, in line with Adam Smith, that free markets should be preferred to state economic policymaking in many contexts *not* because the former are perfect, or even near perfect in their results, but because they are *less* radically *imperfect* (in social and political, as well as economic, terms) than the only alternative can offer (DeLong Internet article).
2. Its insistence that mass standards of living can rise substantially *only* in countries and societies that have a dynamic involvement in world trade. Neither attempted economic autarchy nor attempts at minimization of involvement in the world trade system can or will lead to anything other than economic stagnation and impoverishment. Moreover, this is true even when the pattern of world trade is "biased" or "distorted" in various ways in the interests of strong or dominant nations and economic interest groups (Mandle 2003).

Neoliberalism's principle weaknesses are:

1. A chronic inability to grasp that human activities and interactivities that in one intellectual framework may be termed "economic" can equally well (and equally accurately) in another intellectual framework be conceived as "social" and/or "political." This is a weakness built not into neoliberalism specifically but into economics as such, as an intellectual discipline. The most common confusion in which it results is the supposition that because there are processes in the real world that are "simply" or "purely" economic (and not "social" or "political"), governments and states can then also make and implement policies that are "purely" economic (and not "social" or "political"). But this is a delusion. *All* economic processes are simultaneously social and/or political, and *all* economic policies have social or political dimensions or aspects. Significantly it is those economists who, for one reason or another, transcend their training enough to grasp this, and grasp it firmly, who usually move to become "modified" or "critical" neoliberals (Stiglitz, Krugman, and J. Bradford DeLong, for example, all fall into this category).

2. A tendency for neoliberal economists in particular to *ignore* the less than optimal political context in which current capitalist markets operate in the *developed* as well as the underdeveloped world. These include: protection or subsidization of special-interest groups for domestic electoral reasons (Stiglitz 2003); global economic regulatory bodies whose functioning is hamstrung by the insistence of powerful states that such interests be protected (Stiglitz 2002); the political "muscle" of large international firms and the way this effects their competitive behavior; and above all the socially polarizing and politically destabilizing effects of market-produced inequalities. Neoliberals most frequently justify their ignoring of such issues by claiming that these are "social" or "political" issues (and not "economic" ones) and therefore beyond their compass. Such weaknesses lead to allegations that neoliberalism is simply a justifying ideology of "capitalist imperialism" and in particular of the rich capitalistic elites of the Western world (Martínez and García Internet article). Though such allegations are an oversimplification, they are perfectly understandable given the obtuse or "head-in-the-sand" behavior described above. In addition,
3. If one accepts the "anti-neoliberal" account of the success of the Asian Tigers, viz. that these economies developed through carefully and cleverly *state-guided* forms of industrialization and trade policy (Wade 1990, Amsden 1989), then it follows that the powerful "minimalist" argument for the market over the state, though it may hold in many cases, does not hold in all. This opens up the possibility that the difference between countries that successfully develop economically and those that do not is *not* a simple difference between those that are market oriented and those that are state oriented in their economic philosophies and policies. Rather it is simply a difference between those that make appropriate and effective state economic policies and those that do not.

Finally, the degree to which successful economic development can be explained solely as a free market phenomenon, questions arise about the productive importance of science and technology. It would be interesting to known whether different levels of public and private investments in science and technology among countries with similar liberal economic policies can be associated with different rates of economic growth.

GAVIN KITCHING

SEE ALSO *Communitarianism; Liberalism.*

BIBLIOGRAPHY

Amsden, Alice H. (1989). *Asia's Next Giant: South Korea and Late Industrialization*. New York: Oxford University Press. Excellent empirical and theoretical account of South Korea's industrial "miracle," emphasizing both the domestic and international political background to this success.

Armstrong, Philip; Andrew Glyn; and John Harrison. (1984). *Capitalism since World War II*. London: Fontana. Compendious account of post-war capitalism utilizing a mass of statistical material and an extremely original theoretical framework.

Kitching, Gavin. (2001). *Seeking Social Justice through Globalization: Escaping a Nationalist Perspective*. University Park: Pennsylvania State University Press. An account of globalization sympathetic to the economics of the neoliberal view but highly critical of its social and political perspectives.

Krugman, P. (1997). *Pop Internationalism*. Cambridge, MA: MIT Press. A very good defense of neo-liberal free trade doctrines written to be readily comprehensible to the non-economist.

Mandle, Jay R. (2003). *Globalization and the Poor*. New York, Cambridge, UK: Cambridge University Press. Takes a rather similar theoretical view of globalization to Kitching but focuses much more tightly and empirically on the issue of poverty.

Stiglitz, Joseph E. (2002). *Globalization and Its Discontents*. New York: Norton. Excellent critical account of the workings of the World Bank and the International Monetary Fund in the current global economy, by a former "insider."

Stiglitz, Joseph E. (2003). *The Roaring Nineties: A New History of the World's Most Prosperous Decade*. New York: Norton. Stiglitz's most forthright condemnation of the application of neoliberalism to U.S. domestic policy-making.

Wade, Robert. (1990). *Governing the Market: Economic Theory and the Role of Government in East Asian Industrialization*. Princeton, NJ: Princeton University Press. Probably the most well-known text arguing that the success of the Asian tigers is not a vindication of free market economic doctrines.

INTERNET RESOURCES

DeLong, J. Bradford. "'Globalization' and 'Neoliberalism.'" Available from http://www.j-bradford-delong.net/Econ_Articles/Reviews/alexkafka.html.

Martínez, Elizabeth, and Arnoldo García. "What Is Neoliberalism?" CorpWatch. Available from http://corpwatch.radicaldesigns.org/article.php?id=376.

Shah, Anup. "A Primer on Neoliberalism." Available from http://globalissues.org/TradeRelated/FreeTrade/Neoliberalism.asp.

Treanor, Paul. "Neoliberalism: Origins, Theory, Definition." Available from http://web.inter.nl.net/users/Paul.Treanor/neoliberalism.html.

Williamson, John. "The Washington Consensus as Policy Prescription for Development." World Bank, 2002.

Available from http://www.worldbank.org/etools/bspan/PresentationView.asp?PID=1003&EID=328. All the above are relatively brief, readily accessible but moderately sophisticated Internet discussions of neoliberalism. Only DeLong's piece, however, is totally free from any kind of axe grinding.

NETWORKS

Networks are particular types of human relations or technological creations, sometimes compared to systems and webs, that establish unique exchanges between human beings and spaces. Since the 1700s, and especially since the invention of the Internet, networks have been subject to scientific analysis. Insofar as they define or influence human behavior they may be subject to ethical assessment.

Network Types and Influences

In mathematics a network is commonly defined as a directed graph with vertices (or nodes) and weighted edges (also called arcs or links). As such networks come in different structural types: bus, ring, star (hub and spoke), mesh (web), and more (see Figure 1). Networks can be further distinguished in terms of numbers of vertices and edges. Each structure has its own intrinsic properties, which can be enhanced or modified by giving different weights or strengths to the various links, as when (for instance) one link in a star network is weighted more heavily than another.

Throughout history networks have provided the foundation and infrastructure for humans to conduct wide-ranging economic and social activities. Well-known physical networks in which nodes correspond to locations in space and links to appropriate connections with associated flows include transportation and communication networks. Transportation networks have evolved over the centuries through advances in science and technology and come in a myriad of forms: road, rail, air, or waterway, with a variety of associated modes of travel. They traverse physical distances to facilitate business transactions, military conquest, and visits among colleagues, clients, friends, and family, as well as enabling people to explore new areas and to expand horizons. Communication networks, in turn, allow exchanges of information not only within communities but also across regions and national boundaries by means of postal services, telephones, radio, television, computers, satellites, and microwaves that carry written messages, video, and/or electronic data. Energy networks, as another example, provide the necessary fuel to support many transportation and communication network transactions.

In addition, more abstract networks such as financial networks, a variety of logistical networks (e.g., supply chains), as well as knowledge and social networks (based on transportation and communication networks) play new and not yet completely understood roles in societies and economies. The reliability, efficiency, and accessibility of such networks enhance production and distribution, facilitate the exchange of information and knowledge, and add to the diversity and richness of goods and services. At the same time, the structure of such networks and the connectivity provided by them may yield insights and advantages for particular individuals and organizations.

Organizations today, be they local, regional, national, or global in scope and as diverse as businesses, educational institutions, or governments, are highly dependent on networks, which are becoming increasingly interrelated. Indeed, individuals may now be able to conduct financial transactions electronically and to shop globally from their places of employment and have the products delivered to the desired destinations. They may also, in certain circumstances, be able to work from home or other chosen locations depending on the management of the underlying networks, their utilization and availability, and the auxiliary ethical character of network designs, accessibility, and usage.

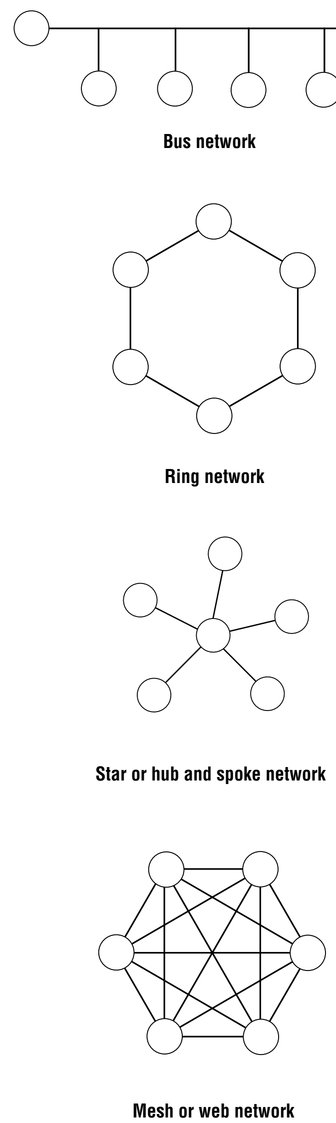
Fascinatingly, the structure of social relationships may also be represented as a graph/network, and the study of social relationships has given rise to the multidisciplinary topic of social network analysis. In such a context, important measures include the number of connections for an individual (represented by nodes in the network), the strength of these connections, the centrality of various individuals, and the existence of cliques and subgroups. Moreover, one can calculate the degrees of separation. Clearly, the existence and structure of social networks also affects the usage of physical networks, notably transportation and various communication networks. The latter networks, in turn, play pivotal roles in the evolution of social networks.

The Science of Networks

The topic of networks and network management dates to ancient times with classical examples including the publicly provided Roman road network and the time-of-day

FIGURE 1

Network Typologies



SOURCE: Courtesy of Carl Mitcham.

chariot policy, whereby chariots were banned from the ancient city of Rome during particular times of the day (Nagurney 2000). The topic of networks as a subject of scientific inquiry originates in a 1736 paper by the Swiss mathematician Leonhard Euler (1707–1783), which is considered the earliest paper on graph theory, where a graph in this context is meant as an abstract or mathematical representation of a system by its depiction in terms of vertices (nodes) and edges (or arcs) connecting various pairs of vertices.

Interestingly, not long thereafter, François Quesnay (1694–1774), in his *Tableau économique* (1758), conceptualized the circular flow of an economy as a network. Gaspard Monge (1746–1818), who had worked under Napoleon Bonaparte in providing the infrastructure support for his army, published what is probably the first paper on the transportation network model in 1781. Much later, and following the first book on graph theory by Dénes König in 1936, works by the economists Leonid V. Kantorovich (1939), Frank L. Hitchcock (1941), and Tjalling C. Koopmans (1947) considered the network flow problem associated with the classical transportation problem. Thus the study of network flows, primarily in a transportation context, preceded the development of even optimization theory and such elegant algorithmic techniques as the simplex method (see Dantzig 1948).

Indeed, the emergence and evolution of a plethora of physical networks over space and time, coupled with realizations of the importance of abstract networks, and the effects of human decision-making on networks through their utilization and management, has given rise to the development of rich and powerful theories that are rigorous, scientific, and network-based. The novelty of networks lies in that they are pervasive and fundamental and provide the fabric for the connectivity of societies and economies. At the same time, methodologically, network theory has developed into a powerful and dynamic medium for abstracting complex network-based problems. Many contemporary networks (including the Internet) are characterized by a large-scale structure, complexity of interconnections and interrelationships, congestion, and distinct behavior of the users. One illustrative phenomena is the Braess paradox (1968), in which the addition of a new road in a transportation network—or a link in a communications network such as the Internet (see Korilis, Lazar, and Orda 1999)—makes all users of the network worse off. Methodologies for the formulation and analysis of network systems are thus of wide practical significance (see Ahuja, Magnanti, and Orlin 1993; Nagurney 1999; Nagurney and Dong 2002).

Today it is possible, through advances in scientific models, theories, and computational tools, to predict optimal routes on networks from different origins to destinations both from a system-optimized perspective, in which there is a central controller of the network flows, and from a user-optimized one, in which users of the network select their optimal routes in what may be viewed as a selfish manner (see Beckmann, McGuire, and Winsten 1956; Dafermos and Sparrow 1969; Nagurney 1999; Nagurney and Dong 2002). In addition, it is possible to optimize financial portfolios from a network perspective (Nagurney and Siokos 1997; Nagurney 2003), to predict the profit-maximizing production and shipment patterns between tiers of network decision-makers (Nagurney and Dong 2002), and to even determine information flows in an organization (Wu et al.).

More recently, social networks have been integrated with economic networks, in the form of supply chains, through the theory of supernetworks (see Walkobinger and Nagurney 2004) in order to capture relationship levels as flows in addition to product shipments. Such complex networks not only synthesize and integrate the structure of the underlying social and economic relationships but also capture human behavior and decision-making and the associated impacts. Moreover, the dynamics of the interactions between the various decision makers as well as how their relationships evolve over time (and how they compete and/or cooperate) can be modeled, along with the optimal product flows and prices.

There are nevertheless many questions of ethical significance concerning networks, their operation and management, and their accessibility and usage.

Accessibility and Ethics

In regard to accessibility, consider transportation and communication networks. Accessibility concerns the design of the network itself. The number of nodes and the number of links connecting the nodes determine the network topology, whereas the quality of the links affects the ultimate accessibility and usage. For example, well-built roads will support travel and trade, whereas an impoverished transportation network infrastructure can seriously impede development and growth. At the same time, the availability of alternative modes of transportation may enhance employment because workers can reach their (possible) places of work. Similarly, those who cannot drive or cannot afford car ownership may be able to use cost-appropriate transportation modes (if such are available).

The interrelationships between networks in this context also have ethical implications. For example, it is now well-established that transportation and especially vehicular transportation on congested urban networks not only results in a loss of productivity but has serious consequences for the environment because of pollution emissions (Nagurney 2000). Moreover, these emissions are not necessarily local but are often *transported* over political boundaries. Hence, the choices made by an individual in terms of route/mode selection can negatively affect distant populations. Although there may be economic approaches to ameliorating some of these negative effects through, for example, tolls or pollution charges, there may also be incentives put in place that appeal to humans' individual sense of ethics.

In terms of communication networks, notably the Internet, the accessibility issue has received a great deal of attention especially from a variety of government organizations. Indeed, terms such as the *digital divide* have become part of the popular lexicon. In certain fields, particularly science, the essentialness of accessibility to the Internet for research, information, and knowledge dissemination is well known (Alberts; Newman 2001). Less emphasized and as important is to increase the connectivity in less-developed and developing nations, which not only may have poor communication infrastructures but may suffer from substandard energy networks, as well.

Not only do scientists benefit from accessibility to communication networks such as the Internet, but educational systems throughout the globe can only be enriched through reliable and efficient Internet connections.

Usage and Ethics

Increased access to interconnected networks also raises ethical issues. For example, given that information on individuals can be retrieved in seconds by anyone with appropriate computer connections, there are serious questions concerning privacy of the information and the right of individuals to check the correctness of the data and information concerning themselves. Moreover, the regulation of the content of what is circulating on the Internet, given its huge and immediate reach, is a subject of both ethical and legal importance. In addition, such computer-based crimes as hacking and computer piracy are examples of illegal and unethical usage of communication networks. Such activities can have serious financial as well as personal consequences (see, e.g., UNESCO).

The Internet, by helping to span the globe and enhancing people's right to communicate, has given freedom to many voices. It has played a major role in social and economic transformations and has helped in the internationalization of trade, especially through electronic commerce and the globalization of nations' economies. In addition, the Internet has allowed new social networks to evolve, oftentimes between individuals and among groups who have never even met face-to-face. Freedom, however, must come with responsibility, a sense of ethics, and solid judgment of the consequences of one's actions on others. Never has the subject of networks and ethics been more timely and relevant.

ANNA NAGURNEY

SEE ALSO *Communication Ethics; Computer Ethics; Digital Divide; Information Society; Internet; Radio; Roads and Highways; Telephone.*

BIBLIOGRAPHY

Ahuja, Ravindra K.; Thomas L. Magnanti; and James B. Orlin. (1993). *Network Flows: Theory, Algorithms, and Applications.* Englewood Cliffs, NJ: Prentice Hall.

Barabási, Albert-Laszló. (2002). *Linked: The New Science of Networks.* Cambridge, MA: Perseus.

Beckmann, Martin J.; C. B. McGuire; and Christopher B. Winsten. (1956). *Studies in the Economics of Transportation.* New Haven, CT: Yale University Press.

Braess, Dietrich. (1968). "Über ein Paradoxon der Verkehrsplanung" [On a paradox of traffic planning]. *Unternehmenforschung* 12: 258–268.

Dafermos, Stella C., and Frederick T. Sparrow. (1969). "The Traffic Assignment Problem for a General Network." *Journal of Research of the National Bureau of Standards* 73B(2): 91–118.

Dantzig, George B. (1948). "Programming in a Linear Structure." Washington, DC: Comptroller, U.S. Air Force.

Euler, Leonhard. (1736). "Solutio problematis ad geometriam situs pertinentis" [The solution of a problem relating to the geometry of position]. *Commetarii Academiae Scientarum Imperialis Petropolitanae* 8: 128–140.

Hitchcock, Frank L. (1941). "The Distribution of a Product from Several Sources to Numerous Localities." *Journal of Mathematics and Physics* 20: 224–230.

Kantorovich, Leonid V. (1939). *Mathematischeskiye metody organizatsiyi i planirovanya proizvodstva.* Leningrad: Publication House of the Leningrad State University. Translated in 1960 as "Mathematical Methods in the Organization and Planning of Production." *Management Science* 6: 366–422.

König, Dénes. (1936). *Theorie der Endlichen und Unendlichen Graphen* [Theory of limited and unlimited graphs]. Leipzig, Germany: Teubner.

Koopmans, Tjalling C. (1947). "Optimum Utilization of the Transportation System." In *Proceedings of the International Statistical Conferences.* vol. 5: 136–145. Reprinted in *Econometrica* 17 (supplement) (1949): 136–145.

Korilis, Yannis A.; Aurel A. Lazar; and Ariel Orda. (1999). "Avoiding the Braess Paradox in Non-cooperative Networks." *Journal of Applied Probability* 36(1): 211–222.

Monge, Gaspard. (1781). "Mémoire sur la théorie des déblais et des remblais" [Memorandum on the theory of excavation and embankment construction]. In *Histoire de l'Académie Royale des Sciences,* avec les Memoires de Mathematique et de Physique, pour la Meme Annee. Paris: Tires des Registres de Cette Academie.

Nagurney, Anna. (1999). *Network Economics: A Variational Inequality Approach,* 2nd edition. Boston: Kluwer Academic.

Nagurney, Anna. (2000). *Sustainable Transportation Networks.* Cheltenham, UK: Edward Elgar.

Nagurney, Anna, ed. (2003). *Innovations in Financial and Economic Networks.* Cheltenham, UK: Edward Elgar.

Nagurney, Anna, and June Dong. (2002). *Supernetworks: Decision-Making for the Information Age.* Cheltenham, UK: Edward Elgar.

Nagurney, Anna, and Stavros Siokos. (1997). *Financial Networks: Statics and Dynamics.* Heidelberg, Germany: Springer-Verlag.

Newman, M. E. J. (2001). "The Structure of Scientific Network Collaborations." *Proceedings of the National Academy of Sciences of the United States of America* 98: 404–409.

Quesnay, François. (1895 [1758]). *Tableau économique.* British Economic Society. Reprint, with an introduction by H. Higgs.

Van Alstyne, M., and E. Brynjolfsson. (1996). "Could the Internet Balkanize Science?" *Science* 274(5292): 1479–1480.

Walkobinger, Tina, and Anna Nagurney. (2004). "Dynamic Supernetworks for the Integration of Social Networks and Supply Chains with Electronic Commerce: Modeling and Analysis of Buyer-Seller Relationships with Computations." *Netnomics* Amherst: Virtual Center for Supernetworks, Isenberg School of Management, University of Massachusetts at Amherst.

INTERNET RESOURCES

Alberts, Bruce. "Science and Human Needs." President's address, 137th annual meeting of the National Academy of Sciences, Washington DC, May 1, 2000. Available from http://www.nationalacademies.org/president/alberts.html.

United Nations Educational, Scientific and Cultural Organization (UNESCO). "UNESCO and an Information Society for All." Available from http://www.unesco.org/webworld/telematics/gis.htm. Published in 1996.

Wu, Fang; Bernardo A. Huberman; Lada A. Adamic; and Joshua R. Tyler. "Information Flow in Social Groups." Information Dynamics Laboratory, Hewlett-Packard Labs, Palo Alto, CA. Available from http://www.hpl.hp.com/shl/papers/flow/. Published in 2003.

NEUMANN, JOHN VON

SEE *von Neumann, John.*

NEUROETHICS

• • •

Neuroethics is the area of bioethics that focuses on issues unique or especially relevant to neuroscience. It is a relatively new term that has been used in a variety of more restricted ways referring to: (1) ethical issues associated with neurology (the subfield of medicine focused on disease and injury of the nervous system) (Pontius 1993); (2) ethical issues associated with the technological advances of neuroscience (Farah and Wolpe 2004); and (3) the neurological basis of ethical thought and behavior (Caplan 1983, Roskies 2002). While attention has primarily focused on the potential applications of technological development, all of these topics appropriately fall under the purview of neuroethics.

Neuroscience is that field of the biological sciences that examines the structure and function of the nervous system. It includes all stages of development from initial differentiation of cells that will become part of the nervous system in the developing organism, through senility and brain death. Topics of investigation range from the submicroscopic level, that is, ions and molecules that are involved in nerve cell function and the genes that are uniquely expressed in the brain, to mental activity and behavior. It includes, but is not limited to, the fields of neurochemistry, neurophysiology, neuropharmacology, neuroanatomy, neuroendocrinology, psychoneuroimmunology, neurology, psychiatry, psychology, and cognitive science.

Neuroscience, directly or indirectly, examines the underpinnings of thought, feeling, and behavior. Neuroethics is concerned with ethical, legal, social and or public policy implications of neuroscience research findings, as well as with the character of the research itself. The neurosciences are rapidly evolving and advances in science and technology have made possible ever more detailed examination of the nervous system and its activity, and of behavior and mental processes. As a result, what were once merely hypothetical situations and potential ethical issues and concerns are increasingly more real and immediate.

History

The term neuroethics seems to have first been coined in 1993 (Pontius 1993), though widespread usage of the term followed a seminal conference in 2002 (Marcus 2002). However the concept has a long history: The tension between notions of free will and determinism and the seeming duality of the mind and body have been of substantial interest to ancient as well as modern philosophers and increasingly among neuroscientists themselves. In the 1950s and before, concerns associated with prefrontal lobotomy and brainwashing as techniques for altering or influencing brain function received increasing attention (Valenstein 1986). In the 1960s some proposed psychosurgery as a method of social control, which created considerable controversy (Chorover 1979, Valenstein 1980). Beginning in 1983 the Society for Neuroscience, the primary professional society of neuroscientists in the United States, initiated annual social issues roundtables aimed at examining the ethical, legal, and social implications of neuroscience research. These symposia examine a wide array of topics including research into possible sex differences in the brain and the application of that research, therapeutic and nontherapeutic use of cognitive enhancers, neurotoxicity of food additives, brain death, the use of fetal tissue to treat neurological diseases, and the role of neuroscience research into drug addiction in the development of health and public policy. In 1983, the Office of Technology Assessment (OTA, a former congressional agency whose mission was to provide legislators with information about scientific findings relevant to the development of public policy) commissioned a report on the societal impacts of neuroscience (OTA 1984). Thus while the term neuroethics is relatively new, the field that it names is not. Rather it is a long-standing area of interest given new life with a new name and new tools.

Features of the Nervous System

Four characteristics of the nervous system with important implications for neuroethics are (1) its complexity, (2) its plasticity, (3) the dynamic, interactive quality of its elements, and (4) the remarkable variation in structure and function from one individual to the next. Although the brain is widely thought of as an organ of the body analogous to the heart, kidney, or liver, the brain and associated elements of the nervous system are more complex than the rest of the body. More genes are uniquely expressed in the brain (Hahn, Van Ness, and Chaudhari 1982) and more different types of cells are found in the brain than in the rest of the body. In addition, cells are interconnected, sending and receiving electrical and biochemical communications from nearby cells as well as cells in distant parts of the brain and the body. As a result, cell circuits extend the complexity of the brain.

The nervous system is remarkably adaptive. The interconnectivity of the cells of all components of the nervous system including the brain and sense organs, (and indeed connections with the endocrine, immune, and other physiological systems) lead to dynamic, interactive communication that makes it possible for brain cells to be sensitive to, and responsive to, changes both internally within the organism, and in its external environment. The interactive communication between cells also results in short-term and sometimes long-term changes in the cells themselves that, for example, may make the individual organism more, or less, responsive to a particular external stimulus.

Technological advances reveal increasingly detailed information about molecular and cellular mechanisms of perception, emotion, cognitive function and behavior. At the same time, the complexity and adaptive nature of the nervous system result in a certain fluidity of information about the brain. Theories of brain structure and function continue to evolve and however much is known, much remains to be discovered.

Ethical Issues

The concerns that are encompassed in the domain of neuroethics are associated uniquely or especially with the practice or conduct of neuroscience research or with the application of neuroscience findings.

CONDUCTING NEUROSCIENCE RESEARCH. All areas of research share some ethical issues associated with the nature of research itself. Integrity of the research process affecting reliability of results, appropriate allocation of credit, and management of potentially conflicting interests are among the many issues that are common to all areas of research to one degree or another, and do not fall exclusively into the purview of neuroethics. However even topics that are common to many fields, such as the humane treatment of research subjects and controlling for bias in research design, have special relevance to research in the neurosciences.

As an example, one of the ethical principles fundamental to research involving humans is respect for persons and its corollaries of autonomy and informed consent or decision making. Among the implications of these principles are that individuals must voluntarily choose to participate in research (i.e., they cannot be coerced, deceived, or manipulated into participating), and that they can discontinue their involvement at any time during the research. One broad area of neuroscience research explores the causes and mechanisms that underlie dementia, including Alzheimer's disease, with a primary long-term goal of developing treatments and a cure. Participation or involvement of individuals with early symptoms can be invaluable to various lines of research into any disease. However the capacity of ill individuals, even those who are healthcare professionals, to make a fully informed decision to participate in research is debatable. Moreover unlike most ill individuals, for example those with heart disease, patients with dementia may have a diminished capacity to fully comprehend the ramifications of consent to research participation depending upon the extent of their disease. As an example, agreement to provide a monthly blood sample may seem less onerous when an individual can comprehend an altruistic goal of developing a cure for Alzheimer's disease. As the disease progresses the individuals understanding of the research may become little more than the awareness of a painful needle. While the clinical research community has developed proxy or surrogate consent as a strategy that allows family members or other legal guardians to give consent for the patient, the notion of research participation as a fully informed choice becomes questionable and problematic.

Neuroscience research with laboratory animals also poses special concerns. Required for both the ethical and scientific justification of the use of laboratory animals in research is that the work has the potential to provide valuable insights into biological structure and/or function that lay the foundation for the understanding, and ultimately treatment, prevention, and/or cure of disease. The companion expectation is that research with animals can be carried out with minimal or no pain, suffering, or distress to the animals. Some areas of neuroscience research challenge these two concepts. For example, when research focuses on mental conditions like schizophrenia or elements of cognition like intentionality, investigators must make assumptions about the similarity between the brain activity of laboratory animals and humans. The reliability of those assumptions and their implications for the understanding of human brain function and disease can be questioned. Moreover when the focus of research is pain or stress, then pain and/or stress are unavoidable elements of the research itself. Indeed, paradoxically, the more like humans a research animal is, the more informative is the research yet, one could argue, the less reasonable the justification for conducting the research in animals because it is unethical to investigate the phenomenon in humans. Institutional Animal Care and Use Committees (IACUCs), in particular, and, to a lesser degree, the peer review process consider the ethical issues associated with the use of animals in research. However the special problems posed by neuroscience research may not always be explicitly or fully considered.

Controlling for bias in research design, while always an important aspect of research ethics, is of particular relevance and concern in neuroscience research because of the extent, nature, and implications of findings in this field. Assumptions that underlie research questions may not be adequately investigated themselves. Yet they are likely to reflect conscious or unconscious bias that arises from long-standing socially determined beliefs. For example, it is widely assumed that some differences in male and female behavior reflect anatomical and physiological differences in the brains of males and females. While this may be true, it is not clear whether biological differences relevant to behavior result from the presence of different sex-related genes or molecules, or from differences in the myriad external factors that shape interactions with others from birth, or a combination of both. Whatever the basis of sex differences in behavior, the extent to which they are linked to biology and perceived as predetermined and immutable can have far-reaching ramifications for education, employment, healthcare, and other areas of social and public policy.

APPLICATION OF RESEARCH FINDINGS. The ethical issues associated with the use of research findings are linked to the particular application: Who uses the information, how is used (e.g., to monitor brain activity, to manipulate behavior, etc.), and for what purpose (e.g., therapy, enhancement, etc.). In addition, whether the information is about the general population or about a particular individual, the accuracy and reliability of the information is always an important consideration, as is accurate presentation of its limits because it directly affects the capacity of individuals to make informed decisions.

Individuals may seek information for self-knowledge, therapy, or self-enhancement. If the information is general and benign, with noninvasive applications (e.g., mnemonic techniques for remembering names) the accuracy and reliability of the research findings are less critical than if the information may expose an individual to risk (e.g., research that suggests a particular dietary supplement is an effective sleep aid although it has the potential for inducing heart arrhythmias). When research findings provide information specific to a particular individual, the accuracy and reliability of the information is critically important depending on the nature of the information and the purpose for which it is being gathered. Thus the reliability of predictions of a test for a debilitating hereditary neurological or mental illness is key. If test findings are perceived to be consistent indicators (markers) for the disease (i.e., individuals with a positive test result inevitably get the disease), then the actual reliability and limits of the test (and the research upon which the test is based) are critically important so that individuals being tested can make adequately informed medical and personal decisions. At the other end of the continuum, if the test is an indication of a predisposition for a mental illness (a much more common occurrence), then additional ethical concerns arise.

In particular, given the dynamic and interactive nature of the human mind, knowledge of the identification of a biological element that is neither necessary nor sufficient for a mental illness but rather indicates a predisposition for that condition can become a contributing factor in its own right, and a self-fulfilling prophecy. Thus ethical concerns regarding information about predispositions to disease are related not only to the accuracy and reliability of the test, but also to the nature of the nervous system and the independent power of the information itself. In addition, given the continuing social stigma associated with mental illness, provision of test results to third parties, whether health insurance providers, employers, family members, or others, may also contribute to stress and the development, expression, and manifestation of disease. As a result, information about mental function poses risks as well as benefits because it is provided in a personal and social context with which it interacts. Technological advances can improve the accuracy of the information but may not have much impact on the contexts in which it is provided.

When neuroscience research yields scientific information and technological developments that make possible access to the brain activity of others, additional ethical concerns arise. Fundamental to this is the actual and perceived correlation between brain activity and mental activity. The possibility of monitoring the mental activity of others raises concerns about privacy and notions of individual integrity. In general, respect for the individual includes the right to privacy and exceptions are only allowed when the health, safety, and welfare of that individual, or others, is threatened. The extent of the invasion of privacy (and attendant harm to the principle of respect for persons and potential harm to that individual) is balanced against the seriousness and certainty of the harm or threat to be averted. An obvious setting in which such privacy might be invaded is in the criminal justice system. It is well-established that eyewitness testimony is unreliable. The potential for conflicting interests among experts as well as the concerns of a hostile or threatened witness can also call into question the reliability of courtroom testimony. Thus, if and when it is possible and in the putative interest of justice, authorities might seek to access directly the memories of a witness or an accused to determine what actually happened. Similarly they might seek access to the mental activity of a perpetrator in order to determine the individual's intentions.

Increasingly, advances in technology also make possible direct intervention in brain function in an even more nuanced and refined way. In the mid- to late-twentieth century, brainwashing, electroconvulsive shock therapy (ECT), and psychosurgery were used to alter brain function and behavior. These procedures are relatively crude and invasive. Current psychosurgery methods, referred to as stereotaxic surgeries, use heat or radiation to destroy very specific tissue identified using brain imaging techniques. Compared to earlier forms of psychosurgery (also known as functional neurosurgery for psychiatric disorders), such as prefrontal lobotomy, stereotaxic surgeries are relatively less invasive, success rates are high, and complications are minimal. Nevertheless the procedures are irreversible, and surgeries (and electroconvulsive shock therapy) are employed in therapy only as a last resort for treating serious mental illness that has not responded to other forms of treatment.

With increased understanding of brain chemistry, physiology, and pharmacology has come the development of pharmacological agents targeted to particular biochemical pathways because research indicates that the neurotransmitter systems associated with these pathways are associated with particular mental activity. These pharmacological agents are primarily designed to be prescribed to treat an individual's self-report of dysfunction. Issues of benefit versus risk, patient expectations and informed decision making, and allocation of resources are ethical issues that arise with any therapy. However because brain dysfunction and mental illness are often at the extreme ends of normal brain function, some therapeutic agents may be able to enhance normal function. For example, some treatments for Alzheimer's disease or other forms of dementia may be able to enhance normal cognitive function. The use of pharmaceuticals for nontherapeutic enhancement rather than therapy not only changes the benefit versus risk analysis, and alters discussions of the fair allocation of scarce resources, but also raises questions regarding who is being enhanced, by whom, and for what purpose.

Computer Brain Interfaces. In the early twenty-first century research is exploring the possibility of electrochemical implants that can serve as a brain computer interface (BCI). These, too, are initially designed to be therapeutic (e.g., to overcome physical limitations or visual deficits). However there is a distinct and important difference between the BCI that makes the brain of a quadriplegic a *transmitter* that can manipulate the external environment (e.g., move a cursor on a computer screen) and an implant that makes the brain a *receiver* either for information about the outside world or for altering brain function (e.g., to treat obsessive-compulsive disorder).

While manipulation and control of others are always ethically problematic because they violate the basic bioethical principle of respect for individuals and their autonomy, two primary considerations are (a) the degree of invasiveness and (b) the extent to which the individual being controlled is aware of, and consents to, the control (Dworkin 1976). The degree of invasiveness is a fluid notion since education and subliminal suggestion while not physically invasive like pharmaceuticals and BCIs can permeate one's thinking with long-term, widespread effect (e.g., educational programs that include evolutionary theory and/or creationism or that exclude reference to or acknowledgment of the Jewish holocaust and/or Chinese *comfort women*). Moreover the conscious intent of manipulation or control may well be in the eye of the beholder. Thus education while not physically invasive is potentially manipulative, subliminal suggestion is not physically invasive but is designed to be manipulative, and psychoactive agents and BCIs are invasive but can be perceived as manipulative or not. Scientific and technological advances that reflect new or refined understanding of brain structure and function have the potential for making possible more specifically targeted monitoring and manipulation of individual or group perceptions and function, but the ethical concerns are akin to those raised regarding con artists, rabble rousers, propaganda, and deceptive advertising.

Issues of Self-Knowledge. More complicated are the ethical issues associated with the scientific and technological advances in neuroscience that make possible increased nontherapeutic self-knowledge, modification, and enhancement. While insights into one's own motivation, self-understanding, personal growth, and development are generally lauded, artificial means for obtaining such insights, for example, through psychoactive *recreational* drugs, is often frowned on primarily because of the potential risks associated with psychoactive drugs and their uncertain benefits. Yet it is possible that techniques in brain imaging may reveal individual traits or thought patterns similar to (or different from) those revealed by less scientifically or technologically dependent approaches (e.g., psychotherapy, meditation, or prayer). Psychotherapeutic agents that modify brain chemistry to treat mental conditions (e.g., anxiety, depression, or schizophrenia) are prescribed, and taken, to modify brain function, mental activity, and behavior. Individuals taking these agents may feel *more like themselves* or conversely *not themselves*. This not only prompts the philosophically interesting question of how one defines and recognizes *the self*, but also raises ethical concerns regarding the extent to which peer and/or societal pressures may lead an individual to modify his or her mental processes, behavior, or other elements of the self in order to conform to the expectations of others or to internalized social norms. In addition, artificial enhancement of performance, whether mental or physical, is highly controversial, and the potential development of cognitive and/or emotional enhancers to gain personal advantage raises issues of respect for persons (i.e., the self and others) and informed-decision making, risk versus benefit, the fair allocation of resources, and fairness in competition.

Neurobiology of Ethics

The other side of the conceptual coin of neuroethics is the neurobiological underpinnings of ethical thought and practice (Caplan 1983, Roskies 2002). The cognitive and emotional elements that contribute to ethical reasoning and behavior are relatively unexamined. Nevertheless ongoing and future neuroscience research is likely to contribute to an intellectual understanding of moral development, the processes of moral reasoning and decision making, and the mechanisms by which ethical decisions are expressed in behavior. How society understands notions of free will and moral agency will be influenced by the findings of neuroscience research. Of necessity this understanding will reflect recognition of the limits of human capabilities: "it simply makes no sense to talk about ethical ideals that are beyond the reach of human conduct, motivation and behavior" (Caplan 1983, p. 106).

However a potential pitfall, as with research in neuroscience in general, is the way that conscious and unconscious assumptions may introduce an inappropriate bias into research design, analysis, or reporting. For example, it is widely assumed that moral reasoning is a rational rather than emotional process. This assumes a potentially false dichotomy in brain processing. Thus the ethical issues that are likely to be raised by future investigations of the neurobiological basis of ethics will be complex and dynamic like the nervous system itself.

Controversies

As suggested, a critical element in identifying and examining some ethical issues associated with neuroscience hinges on the relationship between brain activity and mental activity. While the consensus of the neuroscience community is that, at least in humans, brain and mind are two sides of the same coin, there is considerable controversy and disagreement regarding the degree to which mental activity can be correlated with, identified as, and reduced to brain activity. An early notion was that each individual memory was embodied in a single cell so that, for example, every individual has a specific cell dedicated to his or her grandmother (hence the name *grandmother cell theory*). That particular concept of memory has been discredited. Moreover, the view that patterns of brain activity detectable with imaging technologies or by monitoring electrical changes can be identified with specific cognitive functions is not universally accepted. The reliability of this correlation is central to the ethical concerns associated with the scientific and technical developments in neuroscience.

There is much more to be learned about the structure and function of the nervous system. It is clear that the ethical issues inherent in the practice, applications, and implications of this area of research will continue to become apparent.

STEPHANIE J. BIRD

SEE ALSO *Bioethics; Consciousness; Emotion; Medical Ethics; Research Ethics.*

BIBLIOGRAPHY

Caplan, Arthur L. (1983). "Out with the 'Old' and In with the 'New'.—The Evolution and Refinement of Sociobiological Theory." In *Ethical Questions in Brain and Behavior: Problems and Opportunities*, ed. Donald W. Pfaff. New York: Springer-Verlag.

Chorover, Stephan L. (1979). *From Genesis To Genocide*. Cambridge, MA: MIT Press.

Dworkin, Gerald. (1976). "Autonomy and Behavior Control." Hastings Center Report 6, no. 2: 23–28.

Farah, Martha J., and Paul Root Wolpe. (2004). "Monitoring and Manipulating Brain Function: New Neuroscience Technologies and Their Ethical Implications." Hastings Center Report 34, no. 3: 35–45.

Hahn, William E.; Jeffrey Van Ness; and Nirupa Chaudhari. (1982). "Overview of the Molecular Genetics of Mouse Brain." In *Molecular Genetic Neuroscience*, eds. Francis O. Schmitt, Stephanie J. Bird, and Floyd E. Bloom. New York: Raven Press.

Marcus, Stephen J., ed. (2002). *Neuroethics: Mapping the Field: Conference Proceedings, May 13–14, 2002, San Francisco, California*. New York: Dana Press.

Office of Technology Assessment. (1984). *Impacts of Neuroscience*. Washington, DC: Congress of the United States.

Pontius, Anneliese A. (1993). "Neuroethics vs. Neurophysiologically and Neuropsychologically Uninformed

Influences in Child Rearing and Education." *Psychological Reports* vol. 72, pp. 451–458.

Roskies, Adina. (2002). "Neuroethics for the New Millenium." *Neuron* 35 (July 3): 21–23.

Valenstein, Elliot S. (1986). *Great and Desperate Cures: The Rise and Decline of Psychosurgery and Other Radical Treatments for Mental Illness.* New York: Basic Books.

Valenstein, Elliot S., ed. (1980). *The Psychosurgery Debate.* San Francisco: Wh Freeman.

NEUROSCIENCE ETHICS

SEE *Neuroethics.*

NEUTRALITY IN SCIENCE AND TECHNOLOGY

The fundamental relationship among science, technology, and ethics is often claimed to be one of neutrality. After all, science and technology can be put to good or bad uses by good or bad people; they are thus value-neutral. It is sometimes implied paradoxically that this neutrality constitutes the special value of science and technology. In contrast, critics have argued that assertions of neutrality are attempts to escape responsibilities for the specific consequences of various scientific and technological projects. How can weaponized anthrax spores designed to kill people be described as value-neutral? This entry attempts to reference some of these claims and counterclaims and provide an analysis for their assessment.

Preliminary Distinctions

It is important to note that neutrality may be modified not just by moral or ethical but also by political, aesthetic, religious, epistemological, ontological, or any number of other qualifiers. Most discussions deal with issues of what are called axiological neutrality, that is, some form of value. The following discussion of value neutrality thus aims to cover questions of not just of moral or ethical but also political, aesthetic, religious, and related senses of neutrality, though not epistemological, ontological, and other forms of neutrality.

With regard to value neutrality a distinction should be made between the antecedent values that motivate the realization of science and technology, and the value that science and technology have once they are realized. Claims about neutrality and antecedent values focus on the value judgments that motivate scientific and technological activity: Science or technology is neutral with respect to a set of values if its processes and products are not informed by those values. Claims about the value of science and technology once realized focus on the consequences of scientific and technological activity and the value of those consequences. In this context those who make claims about neutralism assert that scientific and technological activities merely create possibilities but do not cause any specific possibilities to be realized. To actualize any of those possibilities, other events beyond science (the investigation of phenomena) and technology (the creation of specific objects, or "artifacts") are needed, and those other events are not conditioned, required, or determined by science or technology. On this view, the value neutrality of science and technology is a product of their causal neutrality, of their not being sufficient in themselves to bring about either good or bad consequences.

Neutrality of Science and Technology With Respect to Antecedent Values

A simple interpretation of the claim that science is neutral is that science is value-free. Science is the impartial search for truth without regard for the interests of those affected. If scientists are allowed to work without external hindrance, they will provide objective answers to questions such as whether tanning booths cause cancer and whether humans have evolved from nonhumans.

This position is informed by a fundamental presupposition: The world is independent of how humans might want it to be. The natural order is not determined by human interests. If people want to get as close as possible to understanding how things really are, they must leave their values—expressions of what they want—out of that effort.

This view overlooks the fact that although the natural order may not be influenced by human interests, science is. What people are interested in is an expression of their values, and one of the things they want is to understand how things are. Science, like every other human activity, is driven and influenced by human values. The idea of neutrality with respect to values must be modified to account for this argument.

The standard modification is to divide the antecedent values motivating science into two categories. On the one hand there are the external or contextual values that direct scientific work. These values include the political, economic, and cultural interests that scientists bring to their practice. On the other hand there are the internal or constitutive values that direct science. These are the scientific values of scientists. Patrick Grim (1982) identifies the most fundamental internal values as *truth* and *demonstration*. Scientists want to find out which claims are true and which are false, and they insist on some kind of demonstration as the means of sorting true from false claims.

The idea of the neutrality of science with respect to values can be reformulated as follows: Although some set of external values is always present and may play a role in determining which problems a scientist will work on, once scientists begin their work, those external values should play no role in guiding procedure or determining findings. Instead, internal values should take over and guide the application of methods, the determination of results, and the reporting of both.

Critics have challenged this view, arguing that contextual values are present even in the application of method and the determination of findings (Longino 1990). However, the idea of scientific neutrality cannot be eliminated as an ideal, for it is *what people want from science:* People do not want contextual values to determine scientific results. Suppose the question is whether exposure to ultraviolet rays in tanning booths increases the risk of contracting skin cancer. For many people the reports of findings generated by tanning booth manufacturers would not be sufficient to answer the question even if the internal norms of truth and demonstration were values strongly held by the manufacturers' scientists. The context of that research raises suspicions. People would want independent verification by scientists with different contextual values, preferably values that are neutral with regard to the investigation at hand. Thus, people recognize the distorting power of contextual values and try to minimize that distortion; that is, people seek to get science as close to the ideal as possible.

In regard to the idea that technology is neutral with respect to values, it again becomes clear that this notion cannot be maintained in the form of a strict absence of values. Technology, like science, is a human endeavor that necessarily is guided by values: conceptions of what is good or desirable for humans to be or do.

One approach to maintaining a form of freedom from values in technology parallels the case of science. An external-internal distinction can be made, with all the political, ethical, social, and other values on the external side and the values of *effectiveness* and *efficiency* seen as the internal, constitutive values of technology.

Just as truth, the fundamental constitutive value of science, is independent of human aim, so too is effectiveness. Effectiveness is the degree to which an action achieves its end. Given an end, a technological means to that end is either effective or not effective, and that effectiveness is independent of people's values (what people want). To this extent the independence of technology from external values parallels that of science.

Efficiency, however, is problematic. As Alex Michelos (1972) points out, efficiency is not an unanalyzable basic value but a relationship between other values, specifically a ratio between what people value as benefits and what they value (negatively) as costs. Judgments of the efficiency of an action depend on what is counted as its benefits and costs, and the decision about what to count as benefits and costs is external to technology. Consider, for example, the different assessments of efficiency that can be obtained for a technology such as a poultry-eviscerating line if in one assessment the physical and psychological costs borne by those working on the line are excluded whereas in another assessment those costs are included. Efficiency is a value derived from external, non-technological values. As one description would have it, efficiency is a socially constructed value.

Neutrality of Science and Technology with Respect to Consequences

The second form of value neutrality is founded on two claims: (1) there is always more than one possible use for the products of science or technology, and (2) the activities or products of science and technology do not determine if or how those products (knowledge or artifacts) will be used.

The claim that there are multiple uses for every piece of knowledge or artifact seems correct in the case of basic science: Because the knowledge that the basic sciences provide is general knowledge of the most fundamental composition, structure, and events of the natural world, it seems that there are always several possible applications. For example, knowledge of elements and their atomic structure can be applied in metalworking, firefighting, criminology, cooking, and so on. A more specific piece of knowledge, such as knowledge of geologic fault lines, can be used to predict earthquakes and set insurance rates for homeowners.

The applied sciences, however, seek to focus basic science on materials of and processes for possible use; thus, applications are already "in mind." In some cases the range of applications is wide, such as with knowledge about the electrical properties of ceramics. In other cases the range of uses is more narrow: Knowledge about the microstructure of oil-bearing shale seems to have only one application.

However, a neutralist might contend that there could be other applications of a piece of specific knowledge that have not yet occurred to anyone. Rather than known applications in the sense of current, technologically feasible applications, a neutralist might contend that the range of applications is the set of logically and materially possible applications, including those not yet conceived. On this view the range of applications for any piece of knowledge is unknown, although in principle there would still be a finite range of uses for every piece of scientific knowledge.

With regard to technology, the claim that artifacts can serve ranges of uses needs clarification. If one focuses on an artifact's use in the sense of what that artifact does—its *function*—it is clear that many artifacts have more or less specific functions built into them. A canoe transports people and goods over water; that is what it does, and it does nothing else. Although a canoe may be turned upside down on land to provide shelter, that is not the purpose for which it was designed, and a canoe is ill suited to that purpose. Similarly, the function of a wool topcoat is to shield one's body from the cold; it is not well suited to serve as a blanket or a painting dropcloth. To this extent the neutralist case regarding multiplicity of purposes is overstated.

A second sense of use is the *purpose* served by artifacts in performing their functions. This sense of the word points to *why* humans make artifacts do what they do. Purposes generally come in hierarchies: People do A in order to get B, want B in order to get C, and so on. If this is the meaning of the neutralist claim that artifacts can serve multiple purposes, that claim is true but trivial. However, the neutralist claim here is that artifacts are flexible with respect to their *immediate* purpose: A carpenter's hammer can perform its functions of driving and pulling nails in serving the purpose of hanging a picture or constructing gallows; a bicycle can perform its function of moving people over land, for the purpose of making deliveries or getting exercise. The history and sociology of technology tend to highlight this phenomenon. Alexander Graham Bell thought that the telephone would be used for business communication only, never imagining its use for personal communication. The sociologist Michel de Certeau (1984) has noted numerous creatively adept technologies.

Assessing this version of neutralism, it must be granted that people use canoes and hammers and bicycles to serve multiple purposes. The same thing is true of machine tools and electrical power grids. Yet there are many artifacts that can serve only one purpose in performing their functions. A bomber flies off and drops bombs in order to damage people and things. That is the only immediate purpose a bomber serves. A bulletproof vest shields one's body from a bullet (its function) so that one may survive a shooting (its purpose). Washing machines and raincoats are other examples of single-purpose artifacts. If this argument is correct, the claim that artifacts can serve multiple purposes is false as a universal proposition: The question of the neutrality of artifacts with respect to the range of purposes they serve must be decided on a case-by-case basis.

The second neutralist claim regarding consequences—that science and technology do not determine *that* their products be used or to *what* use those products will be put—is most plausible in the case of pure science. The activity of pure science is removed from the context of practical use in terms of both the content of the activity and the intent of the practitioners. Indeed, there may not be currently possible uses.

Technology has a different relationship to practical context. Although it is correct to say that humans can decide not to use an artifact they have created, the whole point of technological activity is use. Human needs are insufficiently met by the unmediated interaction of people with nature: People *must* make and use artifacts in order to live. Although people are free to choose not to use a particular artifact, they are never free to choose to use no artifacts.

A focus on artifact use reveals one way in which technology is not always value-neutral. Artifacts determine *how* they are used: All artifacts, from saws to computers, impose methods of operation on would-be users, and people who effectively use artifacts for *any* purpose—good, evil, or neutral— use them in accordance with their operational functions. One cannot cut a board effectively by holding on to the blade of a saw. Artifacts determine what behaviors must be brought to bear by humans in order to operate them.

At least in some cases the exercise of those behaviors is directly beneficial or detrimental to the agent independently of the purposes served, objects made, or payment gained. Using a computer for any purpose causes eyestrain. In such cases the artifact used is a causal condition of positive or negative value regardless of human intentions regarding its use or its instrumental consequences.

This argument may apply to scientific activity as well. To the extent that such activity produces satisfying or dissatisfying experiences, science may have value independently of the values that constitute it or its instrumental value.

An argument raised against neutralism is that in choosing to use a certain technological object or system one is simultaneously, if unconsciously, making a commitment to a certain form of social organization. Lewis Mumford (1964) and Langdon Winner (1986) have argued, for instance, that nuclear power plants typically require a hierarchical social organization with authoritarian relationships of command and control. Such forms of organization are certainly not politically neutral. Empirical research on the deployment of specific artifacts in specific organizations (Liker, Haddad, and Karlin 1999) raises serious questions about the generalizability of this argument. The evidence suggests that although artifacts determine task characteristics such as skill variety, the nature of organizational governance and control over technological activity is a matter of human choice.

RUSSELL J. WOODRUFF

SEE ALSO *Biological Weapons; Critical Social Theory; Efficiency; Existentialism; Values and Valuing.*

BIBLIOGRAPHY

Certeau, Michel de. (1984). *The Practice of Everyday Life*, trans. Steven Rendall. Berkeley: University of California Press.

Grim, Patrick. (1982). "Scientific and Other Values." In *Philosophy of Science and the Occult*, ed. Patrick Grim. Albany: State University of New York Press. Argues that all science is shaped by values, and distinguishes its inessential, background values from its essential values of truth and demonstration.

Liker, Jeffrey K.; Carol Haddad; and Jennifer Karlin. (1999). "Perspectives on Technology and Work Organization." *Annual Review of Sociology* 25: 575–596. Reviews the literature on the relation between technology and the nature of work, and concludes that technology's impact is contingent on a large number of non-technical factors such as the reason for introducing the technology, management philosophy, labor-management contracts, and the degree of agreement about technology and work organization.

Longino, Helen. (1990). *Science as Social Knowledge: Values and Objectivity in Scientific Inquiry*. Princeton, NJ: Princeton University Press. Challenges the claim that the scientific practice is shaped by constitutive or cognitive values while being routinely insulated from contextual values.

Michalos, Alex. (1972). "Efficiency and Morality." *Journal of Value Inquiry* 6: 137–143. Argues that efficiency is not an unanalyzable technical value, but is rather a ratio of benefits to costs that is always constructed by reference to norms outside technology.

Mumford, Lewis. (1964). "Authoritarian and Democratic Technics." *Technology and Culture* 5(1): 1–8. Makes the case that two types of technologies have existed side by side since the late Neolithic era: democratic technologies—small-scale, employing concrete, tacit knowledge, controlled by the individuals directly engaged, and powered by individual humans or animals; and authoritarian technologies—large-scale, employing abstract symbolic knowledge, controlled by disengaged authorities, and powered by mass armies or machines.

Rosenbrock, Howard. (1999). "Engineers and the Work That People Do." In *The Experience of Work*, ed. Craig Littler. New York: Palgrave Macmillan. Describes how assumptions guiding the construction of technical apparatus tend to implicitly devalue humans and result in inefficient use of the humans interacting with the apparatus.

Rudner, Richard. (1953). "The Scientist Qua Scientist Makes Value Judgments." *Philosophy of Science* 20(1): 1–6. Argues that ethical judgments are indispensable elements of scientific practice: Because no scientific hypothesis is ever completely verified, the decision to accept a scientific hypothesis as sufficiently warranted always depends on a judgment about how ethically significant a possible mistake would be.

Winner, Langdon. (1986). "Do Artifacts Have Politics?" In *The Whale and the Reactor*. Chicago: University of Chicago Press. Argues that technological objects can be political in two ways: some are designed to control or channel the decisions and actions of people; others are elements of socio-technical systems that either require or are strongly compatible with specific forms of social organization, typically authoritarian, hierarchical social organization.

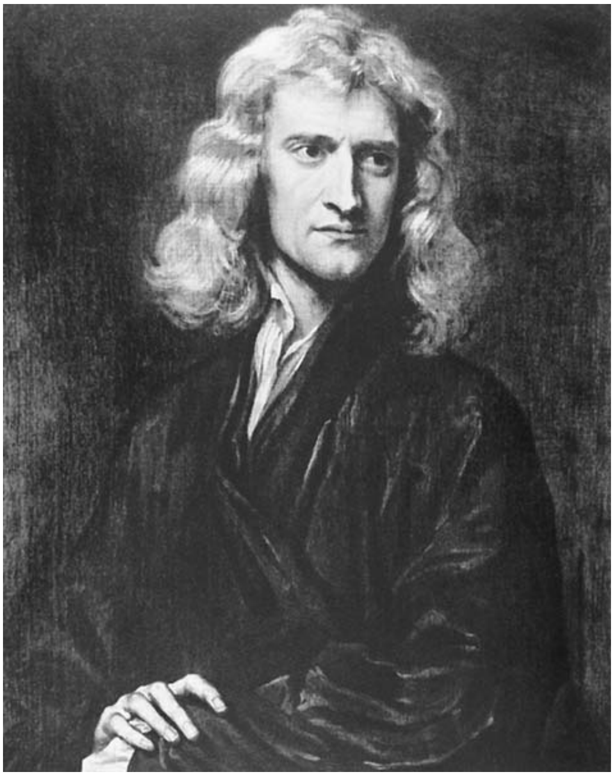
Woodruff, Russell. (1997). "Artifacts, Neutrality, and the Ambiguity of 'Use.'" *Research in Philosophy and Technology* 16: 119–127. Distinguishes "use" as function, purpose and method, and uses these distinctions to discuss the neutrality of technological objects.

NEW ATLANTIS

SEE *Atlantis, Old and New.*

NEWTON, ISAAC

A central figure in the foundation of modern physics, mathematics, optics, and the scientific method, Sir Isaac Newton (1642–1727) was born in the Lincolnshire hamlet of Woolsthorpe on December 25. Newton matriculated at Trinity College, Cambridge in 1661, receiving there his B.A. (1665) and M.A. degrees (1668). He became a Fellow of the College in 1667, and in 1669, at the age of twenty-six, was appointed Lucasian Professor of Mathematics. Election to the Royal Society followed in 1672. In 1696 Newton relocated to London, where he became Warden and then Master of the Royal Mint.



Sir Isaac Newton, 1642–1727. An English scientist and mathematician, Newton made major contributions in mathematics and theoretical and experimental physics and achieved a remarkable synthesis of the work of his predecessors on the laws of motion, especially the law of universal gravitation. (*© Bettmann/Corbis.*)

He was elected President of the Royal Society in 1703 and knighted in 1705. He died on March 20 in London.

Newton's greatest discoveries and innovations came during his Cambridge years. In the mid-1660s he developed the calculus. His 1672 paper on colors confirmed the heterogeneous nature of light. In the early 1670s Newton constructed the first practical reflecting telescope. In the following decade, the mathematical physics of the *Principia mathematica* (1687) yielded spectacular results: the laws of motion, the inverse-square law of universal gravitation, elegant mathematics to underpin astronomy and physics, and the unification of terrestrial and celestial mechanics. In the three editions of this work, he also developed principles of an inductive method that still serve science in the early twenty-first century. The *Principia* is the grandest achievement of seventeenth-century mechanical philosophy and one of the most revolutionary books in the history of science. Newton's *Opticks* (1704) codified earlier research and placed optics on a firm footing; later editions helped establish an experimental agenda for the subsequent decades. As President of the Royal Society, Newton reinvigorated the organization's experimental program. His first curator of experiments, Francis Hauksbee, Sr., developed an electro-static machine that helped foster the study of electricity in the eighteenth-century. His second curator, John Theophilus Desaguliers, exemplified the Baconian ideal of producing useful knowledge through liaising with proto-industrialists, developing mine ventilation machines, and during his employment as a waterworks engineer on the Thames.

Enlightenment Image and Correction

Despite his popular association with a deterministic and purely mechanical cosmos, Newton's image as a rationalist proponent of a clockwork universe is a wishful construction of Enlightenment apologists who re-crafted him in their own mold. Newton's natural philosophical ethos conforms more closely to Renaissance ideals. He was committed to the goal of recovering the *prisca sapientia* (ancient wisdom), believing that the ancients possessed superior forms of knowledge that could and should be recovered. Newton's public and private writings show that he rejected the idea of a mechanized universe, holding instead to a providentialist view in which God periodically intervenes to keep Nature on course. Newton's supporter Samuel Clarke (1675–1729) eloquently defended these ideas in his famous correspondence of 1715 to 1716 with the German philosopher Gottfried Leibniz (1646–1716). Newton also worked to reintroduce spirit into natural philosophy. Further his surviving papers reveal that he was not only a practicing alchemist, but that he devoted more time and energy to the study of theology and prophecy than to natural philosophy.

These commitments did not remain in a separate intellectual sphere, but played a role in shaping Newton's metaphysics and his natural philosophical style. An example of this is his adherence to a form of epistemological dualism in which knowledge is divided into two categories. Lower, relative forms of knowledge are accessible to the vulgar, while higher, absolute forms of knowledge can only be penetrated by the adept—a distinction seen in the thought of the Pythagoreans, Plato, Maimonides, in the alchemical tradition, and Newton believed, in the Bible. Accordingly Newton emulated the coded literary style he believed was used by the Hebrew prophets and the Pythagoreans in order that only the *wise* would understand his meaning (Daniel 12:10). This helps explain why so many had so much difficulty understanding his *Principia*. Newton once explained that "to avoid being baited by little Smatterers in Mathematicks . . . he designedly made his Principia abstruse; but yet so as to be understood by able Mathematicians" (Newton in Snobelen 2001, p. 205).

The distinction between the relative and the absolute plays a role in Newtonian physics as well. In the "Scholium to the Definitions" at the beginning of the *Principia,* Newton distinguishes relative space and time from absolute space and time. Absolute space is rigid and immovable, while "absolute, true and mathematical time" flows evenly and uniformly; both exist "without reference to anything external" (*Principia,* p. 408). In contrast, the space and time of sensation and measurement are relative or relational. Thus he writes in the "Scholium": "Accordingly, those who there interpret these words [time, space, place, motion] as referring to the quantities being measured do violence to the Scriptures. And they no less corrupt mathematics and philosophy who confuse true quantities with their relations and common measures" (*Principia,* p. 414). By alluding to biblical hermeneutics, Newton hints at a link between theology and science. For Newton, absolute space and time are predicates of God's omnipresence and eternal duration, an idea he developed from biblical theology, Stoicism, Philo, and Rabbinical thought. As a reflection of this, Newton suggested in private that God's omnipresence might be the cause of gravity, something that would help explain the universal nature of the phenomenon.

Newtonian Method

In the "Rules of Reasoning" laid out in the *Principia,* Newton advocates an inductive approach to the study of Nature. This approach is also commended in the "General Scholium," in which he expresses a disdain for discussions about substance and states that his natural philosophy does not extend beyond a description of the phenomena. Newton was satisfied with his ability to describe the phenomenon of universal gravitation mathematically; as for the ultimate cause of gravity, he famously declares: "I feign no hypotheses" (*hypotheses non fingo*). Both the inductive method and the derogation of frivolous hypotheses are outlined in Query 31 of the *Opticks*: "As in Mathematicks, so in Natural Philosophy, the Investigation of difficult Things by the Method of Analysis, ought ever to precede the Method of Composition. This Analysis consists in making Experiments and Observations, and in drawing general Conclusions from them by Induction, and admitting of no Objections against the Conclusions, but such as are taken from Experiments, or other certain Truths. For Hypotheses are not to be regarded in experimental Philosophy" (*Opticks,* p. 404). Natural philosophical reasoning should be a posteriori rather than a priori.

But Newton does not reject the use of hypotheses outright; instead, he eschews dreaming up vain and unwarranted hypotheses, especially those that lead to system building. This approach is a pointed attack against the French philosopher René Descartes (1596–1650). For Newton, as for his most passionate disciples, there are also moral corollaries to scientific method. When Roger Cotes, Cambridge's Plumian Professor of Astronomy, wrote the preface to the second edition of the *Principia,* he contrasted the Newtonian inductive method with the speculative-hypothetical approach: "Those who take the foundation of their speculations from hypotheses, even if they then proceed most rigorously according to mechanical laws, are merely putting together a romance, elegant perhaps and charming, but nevertheless a romance."

Similarly, Colin Maclaurin, the Scottish Newtonian and professor of mathematics at Edinburgh, compares Newton's inductivism with "that pride and ambition, which has led philosophers to think it beneath them, to offer anything less to the world than a complete and finished system of nature; and, in order to obtain this at once, to take the liberty of inventing certain principles and hypotheses, from which they pretend to explain all her mysteries" (Maclaurin, *Account of Newton's Discoveries,* p. 7). Maclaurin likens this method to beginning "at the summit of the scale, and then, by clear ideas, pretend[ing] to descend though all its steps with great pomp and facility, so as in one view to explain all things" (p. 18). Instead Newton's experimental method, which begins with analysis before progressing to mathematical synthesis, is the better approach to truth in natural philosophy, even though "the beginnings are less lofty" because "the scheme improves as we arise from particular observations, to more general and most just views" (p. 18).

Right science must be preceded by and coupled with right method. Natural philosophical arrogance and presumption leads to error, corruption, and systems constructed out of thin air. Newton's followers championed the inductive method that prioritized gathering empirical evidence as a humble technique in contradistinction to what they saw as the intellectual hubris.

Newton was convinced that similar methods would also lead to a recovery of true, biblical doctrine and the teachings of the primitive Christians. Rather than shape Scripture to fit a priori theories, Newton believed God's truth should be drawn directly from a close reading of the Bible. This project led him to reject several central orthodox teachings as doctrinal corruptions, including the Trinity and the immortality of the soul. Newton distained the fourth-century hypothetical and ontological discussions of the substance of God that distorted the unipersonal God of the Bible into the Trinity—a doctrine that he saw as little better than polytheism. By the standards of his day, such conclusions made him a heretic and brought the need for caution and circumspection. Nevertheless, Newton covertly attacked the Trinity in his "General Scholium." That this attack appeared with an overt challenge to Cartesian planetary vortex theory shows that Newton believed that corruption in natural philosophy was linked to corruption in religion. The inductive approach extended to his prophetic interpretation, and there are striking parallels between his "Rules of Reasoning" and a series of prophetic rules he developed earlier in the 1670s.

Newton applied an inductive approach to his natural theology as well, writing in one manuscript "God is known from his works" (Newton in McGuire 1996, p. 119) Newton was convinced that an inductive program in natural philosophy would lead to God. Near the end of Query 28 in the *Opticks* Newton argues that "the main Business of natural Philosophy is to argue from Phænomena without feigning Hypotheses, and to deduce Causes from Effects, till we come to the very first Cause, which is certainly not mechanical" (*Opticks*, p. 369). Likewise, at the end of his discussion of God in the General Scholium, Newton asserts that "to treat of God from phenomena is certainly a part of natural philosophy" (*Principia*, p. 943).

Assessment

The recovery of this pre-enlightenment understanding of Newton disrupts common contemporary notions of Newton as an advocate of completely mechanical and deterministic universe. Newton may not have anticipated the degree to which the ethical and religious corollaries would be separated from his natural philosophy after his death by Enlightenment thinkers and later by positivists. Yet it is clear that he attempted to found a science that is thoroughly infused with a religious understanding of nature and that emphasizes the need for moral virtue on the part of its practitioners. While most in science in the early twenty-first century accept the Enlightenment reading of Newton's legacy, Newton himself would have seen the development of the study of nature after his death as another corruption to be deplored.

Although Newton recognized disciplinary distinctions, ultimately for him there were no impermeable barriers between philosophy, physics, and faith. Because Newton was committed to the topos of the Two Books, namely, that God had *written* both the Book of Nature and the Book of Scripture, he believed that truth ultimately comes from the same divine source and thus is one. Consequently Newton highlights moral and religious corollaries to the study of Nature in the conclusion of his *Opticks*: "And if natural Philosophy in all its Parts, by pursuing this Method, shall at length be perfected, the Bounds of Moral Philosophy will be also enlarged. For so far as we can know by natural Philosophy what is the first Cause, what Power he has over us, and what Benefits we receive from him, so far our Duty towards him, as well as that towards one another, will appear to us by the Light of Nature" (*Optics*, p. 405). For Newton, advances in natural philosophy were completely bound up with moral and religious concerns. These, in turn, related to right method: a humble empiricism. Whether in science or religion, Newton believed that the inductive method led to purity and truth.

The recovery of this pre-Enlightenment understanding of Newton poses at least two challenges. The first is whether Newton himself appreciated the extent to which his science could in succeeding generations be cut free from religious and ethical perspectives. The failure to recognize the degree to which his work could so easily be reinterpreted by his Enlightenment followers may raise some doubts about the sagacity of Newton's own self-understanding. The second is whether the severing of the ties that Newton experienced is justified, that is, whether it in truth represents a purification or a corruption of modern natural science. Although the general consensus is, of course, that it represents a purification, and that Newton was in fact mistaken about the connections he experienced between science and religion, a full appreciation of Newton himself might be a stimulus to question such a position.

STEPHEN D. SNOBELEN

SEE ALSO *Descartes, René Royal Society.*

BIBLIOGRAPHY

Alexander, H. G. (1956). *The Leibniz-Clarke Correspondence*. Manchester, UK: Manchester University Press.

Cohen, I. Bernard, and George E. Smith, eds. (2002). *The Cambridge Companion to Newton*. Cambridge, UK: Cambridge University Press. A valuable collection of essays on Newton's mathematics, physics, philosophy and religion.

Cohen, I. Bernard, and Richard S. Westfall, eds. (1995). *Newton: Texts, Backgrounds, Commentaries*. New York: Norton.

Dobbs, Betty Jo Tetter. (1991). *The Janus Faces of Genius: The Role of Alchemy in Newton's Thought*. Cambridge, UK: Cambridge University Press.

Fauvel, John; Raymond Flood; Michael Shortland; and Robin Wilson, eds. (1988). *Let Newton Be! A New Perspective on His Life and Works*. Oxford: Oxford University Press.

Force, James E., and Richard H. Popkin, eds. (1999). *Newton and Religion: Context, Nature, and Influence*. Dordrecht, The Netherlands: Kluwer Academic.

Leshem, Ayval. (2003). *Newton on Mathematics and Spiritual Purity*. Dordrecht, The Netherlands: Kluwer Academic.

McGuire, J. E. (1978). "Newton on Place, Time, and God: An Unpublished Source." *The British Journal for the History of Science* 11: 114–129.

McGuire, J. E. (1996). *Tradition and Innovation: Newton's Metaphysics of Nature*. Dordrecht, The Netherlands: Kluwer.

Maclaurin, Colin. (1968). *An Account of Sir Isaac Newton's Philosophical Discoveries*. New York and London: Johnson Reprint Corporation. Originally published in 1748.

Newton, Isaac. (1999). *The Principia: Mathematical Principles of Natural Philosophy*, trans. I. Bernard Cohen, and Anne Whitman, with the assistance of Julia Budenz. Berkeley: University of California Press. The standard English translation of the *Principia*.

Newton, Isaac. (1952). *Opticks: or a Treatise of the Reflections, Refractions, Inflections & Colours of Light*. New York: Dover Publications. The standard English edition of the *Opticks*.

Snobelen, Stephen D. (2001). "'God of Gods, and Lord of Lords': The Theology of Isaac Newton's General Scholium to the *Principia*." *Osiris* 16: 169–208.

Stewart, Larry. (1992). *The Rise of Public Science: Rhetoric, Technology, and Natural Philosophy in Newtonian Britain, 1660–1750*. Cambridge, UK: Cambridge University Press.

Westfall, Richard H. (1980). *Never at Rest: A Biography of Isaac Newton*. Cambridge, UK: Cambridge University Press. The leading and most comprehensive biography of Newton

NEW ZEALAND PERSPECTIVES

SEE *Australian and New Zealand Perspectives*.

NIETZSCHE, FRIEDRICH W.

Friedrich W. Nietzsche (1844–1900) was born in Röcken, Prussia, on October 15. He attended the prestigious boarding school at Pforta, where he was educated in the classics, literature, poetry, and the arts. He went on to study classical philology, first at the University of Bonn, and later at the University of Leipzig. His scholarly promise was so great that he was appointed in 1869 as professor extraordinarius of classical philology at the University of Basel (Switzerland). Following a brief and debilitating tour of duty in the Franco-Prussian War, he returned to Basel and produced his first major work, *The Birth of Tragedy out of the Spirit of Music* (1872). The book was so poorly received that its publication effectively signaled the end of his academic career. He finally resigned from the university in 1879 and lived on a small pension awarded him by the Swiss government.

Nietzsche's most influential work was *Thus Spake Zarathustra*, published in four parts between 1883 and 1891. In this ambitious work, he depicted the fictitious Zarathustra as a charismatic teacher whose appearance heralds the redemption of the modern world. Zarathustra is best known for his controversial teaching of the *Übermensch* (or "overman"), whom he proposes as "the meaning of the earth." Were his auditors to embrace this untimely teaching, Zarathustra insists, they would be prepared finally to emerge from the shadow of the dead God and take their rightful place as the legislators of the future. In doing so, they would shed the burden imposed on them by the resentful, ascetic morality that they have inherited from its twin sources, Christianity and Platonism. Zarathustra's teaching of the *Übermensch* thus conveys the promise of a life predicated on a love of the body and an aspiration to noble values.

Nietzsche intensifies his attack on conventional morality in his next two books, *Beyond Good and Evil* (1886) and *On the Genealogy of Morals* (1887). In both works he rehearses his influential distinction between *master* (or *noble*) *morality* and *slave morality*. Whereas the master morality takes its shape and direction from an originating act of self-affirmation, by means of which the master deems "good" everything about and pertaining to him, the slave morality originates in the slave's designation of his tormentors as "evil." Only as an afterthought, and in contrast to his "evil" oppressors, does the slave deem himself "good." According to Nietzsche, the master morality celebrates passion, commitment, struggle, and immediacy, whereas the slave morality honors the virtues of suffering, deprivation, passivity, and psychological cunning.

In both books, Nietzsche advances the controversial thesis that contemporary European (or Christian) morality is in fact descended from a slave morality. Although freed from the material conditions of slavery, modern people have become habituated to serve as their own slave masters. Burdened by guilt and wearied by relentless self-surveillance, moderns impose upon themselves the defining values of slavery. Nietzsche further conjectures that protracted adherence to a descendant version of the slave morality may have crippled moderns beyond repair, such that a renaissance of nobility may no longer be possible.

In *On the Genealogy of Morals*, Nietzsche extends his critique of conventional morality to include the scholarly practice of science (*Wissenschaft*). Here he investigates the role of science in the reign of the ascetic ideal, hoping to expose contemporary practitioners of science as unwittingly honoring the values of declining life—even as they increasingly turn their research to matters related to health, evolution, leisure, and longevity. The problem with the contemporary practice of science, he explains, lies in its failure thus far to determine the actual *value* of truth; the scientific enterprise thus remains stubbornly unscientific with respect to itself. He consequently asserts that the otherwise unimpeachable "will to truth" masks a more basic expression of *faith* in truth. It is in this sense that science serves the ascetic ideal, for it proceeds under the uninterrogated assumption that possession of the truth will redeem humankind, which implies that humankind stands in *need* of redemption. Although science continues to sponsor exciting discoveries, its dependence on the ascetic ideal implicates all such discoveries in the ongoing assault on our beleaguered affects. This assault in turn hastens the advent of the "will to nothingness," which Nietzsche identifies as the will never to will again.

Nietzsche said little about emerging technologies, despite availing himself of railways, typewriters, experimental drugs, postal systems, and other innovations of the late nineteenth century. He was deeply suspicious, however, of the rise of technology in general, which he regarded as symptomatic of advancing cultural decay. He was particularly critical of the technologies marshaled in support of European imperial expansion. He regarded the aspiration to empire as an organized distraction from the crisis of European culture. In his view, the pursuit of imperial possessions would not solve the problem of European decadence but simply export it across the globe.

Nietzsche's productive philosophical career ended in 1888. At the beginning of the next year he suffered a nervous breakdown. After a brief stay in a Jena sanitarium, he was placed in the care of his mother, who relocated him to her home in Naumburg. He lived there in a state of catatonic silence, which was broken only by occasional piano improvisations and infrequent bursts of babble. Following the death of his mother in 1897, he was relocated to Weimar by his younger sister, Elisabeth Förster-Nietzsche, the widow of a prominent anti-Semite and Aryan supremacist. Elisabeth succeeded not only in fashioning her now-famous brother into a kind of cult figure, but also in forging a connection between his philosophy and the rising tide of reactionary politics in Germany. Following his death in Weimar on August 25, his sister continued her appropriation of his philosophical teachings, eventually steering them into convergence with the ideology that soon would inform National Socialism. That Nietzsche would have repudiated any such alliance did not deter Elisabeth from presenting her brother's ideas as providing the philosophical inspiration for Hitler's *Reich*.

DANIEL CONWAY

SEE ALSO *Alienation; Existentialism.*

BIBLIOGRAPHY

Aschheim, Steven E. (2001). *In Times of Crisis: Essays on European Culture, Germans, and Jews*. Madison: University of Wisconsin Press.

Kaufmann, Walter. (1968). *Nietzsche: Philosopher, Psychologist, Antichrist*. New York: Vintage Books.

Moore, Gregory. (2002). *Nietzsche, Biology, and Metaphor*. Cambridge, UK: Cambridge University Press.

Nietzsche, Frederich. (1966). *Beyond Good and Evil: Prelude to a Philosophy of the Future*, trans. Walter Kaufmann. New York: Vintage Books.

Nietzsche, Friedrich. (1999). *Thus Spake Zarathustra*, trans. Thomas Common. Mineola, NY: Dover.

Nietzsche, Friedrich. (2000). *Basic Writings of Nietzsche*, trans. and ed. Walter Kaufmann. New York: Modern Library Classics.

NIGHTINGALE, FLORENCE

The founder of modern secular nursing, a social activist, and a pioneer in the use of social statistics, Florence Nightingale (1820–1910) was born on April 12 in Florence, Italy, the child of a wealthy, prominent English family. Given a classical education by her father, the serious, devout young woman was drawn to caring for the sick, but nursing was then a form of menial labor that was considered inappropriate for members of her social class. Nightingale persisted; for years she visited and gathered information on hospitals in England and abroad, sought training in Germany, and in 1853 became superintendent of a nursing home in London, where she undertook reforms to improve patient care.

After the start of the Crimean War (1854–1856) the public reacted with outrage to newspaper reports of the horrid conditions endured by British soldiers wounded in battle, and Nightingale was appointed to bring nursing care to the military. Arriving at the hospital in Scutari, Turkey, with a team of thirty-eight nurses, including fourteen Anglican and ten Roman Catholic sisters, she found overcrowding, filth, infestation, and disease. Far more soldiers were dying of cholera and typhus than were dying of their wounds. Against the objections of the hospital staff, Nightingale took firm administrative measures, set up sanitary kitchen and laundry facilities, and procured supplies with private funds. The death rate fell from 42.7 percent to 2.2 percent in six months. An international heroine at age thirty-six, Nightingale was immortalized by Henry Wadsworth Longfellow, as "a lady with a lamp" making her nightly rounds on the hospital wards, in his 1857 poem "Santa Filomena."

Nightingale used her Crimean experience to lobby for the reform of medical care in the army, publishing an 800-page book, *Notes on Matters Affecting the Health, Efficiency, and Hospital Administration of the British Army* (1857). She included documentation that the death rate of army recruits in peacetime was nearly twice that of the comparable civilian population. Queen Victoria, to whom Nightingale had been presented as a debutante, supported her aims, as did friends in influential positions. Despite resistance within the bureaucracy, reforms followed. A Royal Commission for the Health of the Army was set up in 1857, and a similar commission was established for the army in India in 1859. Nightingale wrote *Notes on Nursing* (1859) and *Notes on Hospitals* (1859) and founded the Nightingale School of Nursing at St. Thomas's Hospital in London (1860). Nurse training programs based on her system were established during her lifetime in twenty countries, including a thousand in the United States alone.

Florence Nightingale was called the "Passionate Statistician" because her spirited campaigns for reform were anchored in carefully compiled data to convince those in power of the validity of her cause. Fascinated by mathematics since childhood, she found guidance in the social physics of Adolphe Quetelet (1796–1874), a Belgian astronomer and pioneer of sociology who developed the notion of the *average man* to show that observed regularities in the traits and behavior of groups could be characterized by the laws of probability. She devised graphic techniques to convey her politically explosive findings and was aided in her analyses by William Farr (1807–1883), a physician and the founder of British vital statistics. She urged the introduction of statistics into higher education and with the help of the scientist Francis Galton (1822–1911) sought to establish a university chair in statistics.

Florence Nightingale, 1820–1910. The English nurse was the founder of modern nursing and made outstanding contributions to knowledge of public health.

After 1857 Nightingale lived as an invalid and rarely left her home. According to a comprehensive biography (Dossey 1999), her disability was consistent with chronic brucellosis, an infection contracted in the Crimea, but equally significant was the central role of religion in her life. Much is revealed in Nightingale's journals and the thousands of letters she wrote. Since the age of seventeen Nightingale felt that she had been called by God for a special mission. Well versed in the tradition of Western mysticism, she was inspired by strong women such as Saint Catherine of Siena (1347–1380), Saint Catherine of Genoa (1447–1510) and Saint Teresa of Avila (1515–1582), whose intense spiritual lives found expression in service to humanity. In her daily life, coping with illness and engaged in widespread reform activities through her writing and personal contacts, she accommodated the contemplative's need for solitude, guided to the end by her inner vision. She died in London on August 13, 1910.

It was Florence Nightingale's mission to lessen human suffering through better healthcare and the prevention of disease. Her novel approach was the use of statistical evidence to show the way: quality data on which to base policies to serve the common good, with a call for the education of administrators as well as the public to help them understand. The study of statistics was for her a moral duty.

VALERIE MIKÉ

SEE ALSO *Bioethics; Medical Ethics.*

BIBLIOGRAPHY

Cohen, I. Bernard. (1984). "Florence Nightingale." *Scientific American* 250 (3): 128–137. Article assessing Nightingale's contributions contains samples of her statistical graphics methodology

Dossey, Barbara Montgomery. (1999). *Florence Nightingale: Mystic, Visionary, Healer.* Springhouse, PA: Springhouse Corporation. A large-size, richly illustrated volume, a thoroughly researched biography that includes analysis of the spiritual motivation of Nightingale's life and work.

Kopf, E. W. (1916). "Florence Nightingale as Statistician." *Journal of the American Statistical Association* 15: 388–404. Reprinted in *Studies in the History of Statistics and Probability,* vol. 2, ed. M. G. Kendall and R. L. Plackett (1977). New York: Macmillan.

Nightingale, Florence. (1969). *Notes on Nursing: What It Is and What It Is Not.* New York: Dover. A manual of nursing care, revolutionary in its day.

Nightingale, Florence. (2002–2005). *Collected Works of Florence Nightingale,* 8 vols., ed. Lynn McDonald. Toronto: Wilfrid Laurier University Press. The first 8 in a projected series of 16 volumes.

Walker, Helen M. (1929). *Studies in the History of Statistical Method, with Special Reference to Certain Educational Problems.* Baltimore: Williams & Wilkins. Includes discussion of Nightingale's efforts to promote statistics education.

NONGOVERNMENTAL ORGANIZATIONS

Nongovernmental organizations (NGOs), as independent of both governments and corporations, are the major components of an international or global civil society. The term first came into official use in the Charter of the United Nations (1945), Chapter 10, Article 71, in order to acknowledge a consultative role for non-state actors in the Economic and Social Council. Since then the term has broadened to include, in the World Bank definition, "private organizations that pursue activities to relieve suffering, promote the interests of the poor, protect the environment, provide basic social services, to undertake community development" (Operational Directive 14.70). In common usage, NGOs are simply non-profit organizations that, even as they have become increasingly professionalized, remain dependent on donations, voluntarism, and appeals to ethical ideals.

Although it is difficult to provide exact numbers, in 2000 there were certainly more than 25,000 NGOs operating worldwide. The rapid development of NGOs since the 1970s has been stimulated in part by scientific and technological developments, especially in communication, while NGOs also play increasingly significant roles in promoting the ethical uses of science and technology.

Classifications of NGOs

NGOs can be divided into different overlapping categories according to both form and content. Formally it is useful to distinguish between operational NGOs that seek to realize various projects, and advocacy NGOs that seek to raise consciousness about some particular cause. The International Red Cross/Red Crescent is an example of an operational NGO; Amnesty International an example of an advocacy NGO. Of course, many NGOs include both operational and advocacy activities, for example the American Association for the Advancement of Science (AAAS), which promotes both professional development within the technical community and seeks to educate the general public about the importance of science.

NGOs may also be classified in terms of their interests. From the perspective of interests, NGOs may focus on humanitarian relief such as the Médicins Sans Frontières (Doctors without Borders) or humanitarian development such as Habitat for Humanity; emphasize human rights or environmental issues; exhibit religious or secular bases; and promote professional, trade, or social developments. NGOs are also sometimes distinguished as primarily community-based, national, or international organizations.

Environmental NGOs

One type of NGO that is especially relevant to science, technology, and ethics issues is environmental NGOs, which will be considered here in more detail in order to illustrate relevance, strengths, and weaknesses. Environmental NGOs have formed in direct response to the impact of an increasingly technological world and the increased exploitation of the world's natural resources. Again, although many groups fall under this broad category, environmental NGOS are not uniform in mission, priorities, strategies, or activities. NGOs range from small, grassroots organizations to large nonprofit corporations with boards of directors and professional staffs. Many specialize in particular areas of advocacy or activity and tend to focus their work either geographically or topically. Some are located primarily in North America and work mainly on local or national issues. Others are headquartered in the North, but focus their attention on issues primarily involving developing countries. Still other NGOs have a global focus with affiliated groups active in many different countries.

Local environmental groups are concerned with specific issues such as protection of a local water supply or a site-specific contamination problem. Some of the larger organizations tend to focus on broad areas of national or global concern, such as the Wilderness Society, the National Audubon Society, and The Nature Conservancy, which are concerned with wildlife and habitat protection. Other national groups emphasize the public health threats associated with pollution. Many organizations focus more comprehensively on environmental quality, linking concern for public land and wildlife with pollution and public health issues.

Environmental NGOs attempt to bring about change in a variety of ways. Some engage in public protest marches and demonstrations, civil disobedience, and other participatory public actions and media events to draw attention to specific concerns. Some groups prepare and distribute educational materials and sponsor public educational events. Some environmental NGOs are actively involved in lobbying efforts to ensure appropriate policy solutions to environmental problems. These groups may also act as watchdogs, to ensure that those subject to environmental regulations comply with requirements. Some NGOs pursue environmental remedies through legal action. Other groups work directly on issues such as protecting biodiversity by purchasing land to protect endangered habitats for plants and wildlife. Most NGOs employ a variety of strategies to accomplish their objectives.

Brief History of Environmental NGOs

The conservation movement, in the mid- to late-1800s, gave rise to the first notable environmental NGOs in the United States, many of which remain active in the twenty-first century. This era is often referred to as the "first wave of environmentalism." Influenced by the growth of scientific knowledge that revealed the consequences of more than two centuries of unchecked human exploitation of the environment, Americans began to understand the costs of losing vast expanses of land and resources. Conservationists challenged the notion that America's resources were inexhaustible.

Several influential writers and activists during this period inspired the forming of the first environmental NGOs in the United States. For example, in 1886 George Bird Grinnell (1849–1938) proposed a society for the protection of the nation's birds; this idea gave rise to the Audubon Societies. The Boone and Crockett Club, founded in 1887 by Theodore Roosevelt (1858–1919) and other well-heeled sportsmen, brought attention to the wasteful slaughter of big game animals.

Early conservationists tended to take an anthropocentric or human-centered view of the environment. The underlying philosophy was the efficient use and conservation of resources for human benefit. By the late 1880s, a second strand of thinking emerged. In 1892 John Muir (1838–1914), a Scottish-born immigrant and advocate for the preservation of nature, founded the Sierra Club. While Muir did not dispute the conservationist notions of resource management, he believed that certain natural areas should be treated as sacred realms and protected from all resource exploitation. Muir advocated the preservation of nature for its own sake, and for the preservation of vast areas of land through public ownership.

During the first half of the twentieth century, hunting and fishing organizations, primarily elite organizations of affluent white men, were the most active and influential NGOs. In 1922, a group of Midwestern sportsmen formed the Izaak Walton League of America to advocate for the protection of wildlife habitat. The National Wildlife Federation was formed in 1936 as a clearinghouse for conservation issues.

In 1935, naturalist Aldo Leopold (1886–1948) founded the Wilderness Society based upon a "land ethic" in which humans are viewed as part of nature rather than conquerors of nature. Like Muir, Leopold believed that nature has value in its own right.

The second wave of environmentalism did not emerge in the United States until in the 1960s. For almost 100 years, environmental NGOs were concerned primarily with preserving wilderness or conserving natural resources. The second-wave environmental movement grew out of many concerns. The industrial growth of the United States following World War II produced prosperity, population growth, and pollution. Increased public attention on the problems of pollution, population, consumption, and waste enlarged the environmental agenda

TABLE 1

A Representative List of Environmental NGOs and Founding Dates

Environmental Organization	Date Founded
Audubon Society —became the *New York Audubon Society,* the precursor organization to the *National Audubon Society.*	1886
Boone and Crockett Club—"promotes the management of big game and associated wildlife in North America and maintain all aspects of sportsmanship in big game hunting."	1887
Sierra Club—"encourages the exploration, enjoyment and protection of the wild places of the earth and practices and promotes the responsible use of the earth's ecosystems and resources; seeks to educate and enlist humanity to protect and restore the quality of the natural and human environment, uses all lawful means to carry these objectives."	1892
American Scenic and Historic Preservation Society—no longer in existence.	1895
National Audubon Society—"to conserve and restore natural ecosystems, focusing on birds, other wildlife, and their habitats for the benefit of humanity and the earth's biological diversity."	1905
National Parks and Conservation Association—"to protect and enhance national parks for present and future generations."	1919
Izaak Walton League—"to conserve, maintain, protect and restore the soil, forest, water and other natural resources of the United States and other lands; to promote means and opportunities for the education of the public with respect to such resources and their enjoyment and wholesome utilization."	1922
The Wilderness Society—"deliver to future generations an unspoiled legacy of wild places, with all the precious values they hold."	1935
National Wildlife Federation—"educating and empowering people from all walks of life to protect wildlife and habitat for future generations."	1936
Ducks Unlimited—"conserves, restores, and manages wetlands and associated habitats for North America's waterfowl."	1937
Defenders of Wildlife—"the protection of all native wild animals and plants in their natural communities; programs focus on the accelerating rate of extinction of species and the associated loss of biological diversity, and habitat alteration and destruction."	1947
The Nature Conservancy—"preserve the plants, animals and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive."	1951
World Wildlife Fund (now known as *WWF*) "to stop the degradation of the planet, natural environment and to build a future in which humans live in harmony with nature, by conserving the world's biological diversity and ensuring that the use of renewable natural resources is sustainable."	1961
Environmental Defense Fund—"links science, economics and law to create innovative, equitable and cost-effective solutions to society's most urgent environmental problems."	1967
Friends of the Earth—"international network of grassroots groups in 70 countries. Defends the environment and champions a healthy and just world."	1969
National Resources Defense Council—"safeguard the Earth, its people, its plants and animals and the natural systems on which all life depends; to restore the integrity of the elements that sustain life — air, land and water — and to defend endangered natural places; to establish sustain ability and good stewardship of the Earth as central ethical imperatives of human society."	1970
Clean Water Action—"national citizens' organization working for clean, safe and affordable water, prevention of health-threatening pollution, creation of environmentally-safe jobs and businesses, and empowerment of people to make democracy work."	1971
Greenpeace—"an independent, campaigning organization that uses non-violent, creative confrontation to expose global environmental problems, and force solutions for a green and peaceful future. Greenpeace's goal is to ensure the ability of the Earth to nurture life in all its diversity."	1971
Zero Population Growth (now known as *Population Connection*)—"educates young people and advocates progressive action to stabilize world population at a level that can be sustained by Earth's resources."	1972
Cousteau Society—"to educate people to understand, to love and to protect the water systems of the planet, marine and fresh water, for the well-being of future generations."	1973
Worldwatch Institute—"through accessible, and fact-based analysis of critical global issues, informs people around the world about the complex interactions between people, nature, and economies; focuses on the underlying causes of and practical solutions to the world's problems, in order to inspire people to demand new policies, investment patterns and lifestyle choices."	1975
Earth First!—loosely affiliated with the tenets of deep ecology, "seeks to encourage a more harmonious relationship between nature and humans."	1980
People for the Ethical Treatment of Animals—"dedicated to establishing and protecting the rights of all animals; operates under the simple principle that animals are not ours to eat, wear, experiment on, or use for entertainment."	1980
Citizens Clearinghouse for Hazardous Waste (now known as the *Center for Health, Environmental and justice*)—"provides technical information and training for local citizens to hold industry and government accountable and to work towards a healthy, environmentally sustainable future."	1981
Earth Island Institute—"develops and supports projects that counteract threats to the biological and cultural diversity that sustain the environment. Through education and activism, these projects promote the conservation, preservation, and restoration of the Earth."	1982
Conservation Fund—"forges partnerships to protect America's legacy of land and water resources. Through land acquisition, sustainable programs, and leadership training, the Fund and its partners demonstrate effective conservation solutions emphasizing the integration of economic and environmental goals."	1985
Rainforest Action Network—"campaigns for the forests, their inhabitants and the natural systems that sustain life by the global marketplace through grassroots organizing, education and non-violent direct action."	1985
Rainforest Alliance—"to protect ecosystems and the people and wildlife that depend on them by transforming land-use practices, business practices and consumer behavior.	1986
Conservation International—"to conserve the earth's natural living heritage, global biodiversity, and to demonstrate that human societies can live harmoniously with nature."	1987

SOURCE: Courtesy of M. Ann Howard.

and gave new impetus to the work of environmental NGOs. During this second wave, national organizations such as the Sierra Club and the Wilderness Society used the new public concern for environmental issues to educate the public and expand membership. In addition, an average of eighteen new NGOs were forming each year during the period 1960 to 1980.

National NGOs were effective lobbying organizations, compelling political action in a variety of areas such as wilderness protection, pollution control, and management of hazardous chemicals. The United States Congress responded to the new public concern through a complex array of statutes. New environmental laws such as the National Environmental Policy Act (1970), the Clean Air Act (1970), and the Clean Water Act (1972) widened public access to the courts, allowing legal challenges to federal agency actions. A new category of environmental NGOs appeared during this period. Although some of these groups were offshoots of the older, more traditional organizations, these new organizations, such as the Environmental Defense Fund (1967) and the Natural Resources Defense Council (1970), used the courts to bring attention to serious environmental problems. Many of the new federal environmental laws gave environmental NGOs and their issues standing in the courts, leading to a whole new field of law and environmental advocacy.

Third wave environmentalism emerged in the 1980s and was characterized by the "mainstreaming" of environment issues. The largest national NGOs grew significantly in the early 1980s, in large measure due to growing public pessimism about the state of environment, in spite of the legislative initiatives of the 1960s and 1970s. For example, the Wilderness Society grew by more than 140 percent between 1980 and 1983, and the Sierra Club increased its membership by 90 percent during the same period. Toward the end of the 1980s, most of the larger NGOs experienced additional growth in membership as the public grew more concerned about global environmental problems such as ozone depletion and global climate change.

By the mid 1980s, the national environmental NGOs were shifting their strategies from legal challenges and anti-business lobbying to a more collaborative problem-solving stance working directly with corporate interests. During this time, many of the larger national NGOs began working with government and industry to fashion "market-based" solutions to environmental problems.

Not all NGOs embraced cooperative strategies. More radical environmental activists encouraged "direct action" and more controversial activities. For example, Greenpeace, founded in 1971, was one of the most visible environmental groups in the early 1990s because of its highly publicized protests against polluting companies. Critics often described the actions of some of these groups as "ecoterrorism." Earth First!, a splinter group of the Wilderness Society, practiced tree-spiking, driving nails into trees with the intent of damaging chain saws in opposition to cutting down trees in major forest areas.

Grassroots environmentalism was a significant force during the 1980s and 1990s, and remains so in the twenty-first century. In contrast to the larger national NGOs that tend to be very centralized and led by mostly white, well-educated, middle-class professionals, grassroots organizations are comprised of people who cut across racial, class, and educational lines. Inspired by the efforts of Lois Gibbs at Love Canal in the 1970s, the grassroots movement began as a populist movement against toxic waste. Although most of the grassroots organizations operate independently of the mainstream organizations, a number of national networks, such as the Citizens' Clearinghouse for Hazardous Wastes, provide organizational skills and technical assistance to local groups.

Part of the growth of grassroots environmentalism included the emergence of environmental justice groups. These groups have coupled environmental issues with other social issues associated with poverty, racism, and classism. These organizations are concerned with distributive justice and remedying past injustices (based on race and class) and focus on a variety of issues including waste disposal, worker health and safety, housing, pesticides, and facility siting. Some of the larger NGOs have taken up environmental justice causes; however, most local groups, wary of the larger NGOs, tend to work outside the mainstream organizations.

The International Environmental Movement

The international environmental NGOs emerged in the 1990s, almost a century following the appearance of the first wave of American environmentalism. During the 1970s and 1980s, the global implications of environmental issues became more evident. A growing body of scientific knowledge brought to life the damage caused by worldwide exploitation of natural resources by the relatively few industrialized nations. Most of the serious problems of global air and water pollution were directly attributable to the activities of the developed countries. The watershed was the 1992 United Nations Conference on Environment and Development—called the

"Earth Summit"—held in Rio de Janeiro. While official country representatives met under the auspices of the UN conference, more than 30,000 individuals representing several thousand environmental groups, many from the developing world, held a global forum to draw attention to issues impacting people and the environment around the world. The Earth Summit had a catalytic effect on NGO growth and network building throughout the world. NGOs in developing nations perform somewhat different roles than the NGOs of developed countries. They may fill a void due to ineffective or nonexistent government programs or they may supplement the work of government agencies.

Analysis

As the history of NGOs suggests, these organizations can be instrumental in organizing public pressure on environmental issues at the local, national, and international levels. NGOs have played an important role in bringing new issues to the public agenda and have sponsored innovative solutions to key environmental issues. The NGO presence heightens public scrutiny of government decision making on critical environmental issues. Historically, NGOs had a different stake in power politics and were able effectively to serve as a counterpoint to other political or economic interests. However, as NGOs have become more mainstream and engaged in working relationships with government and industry, many have observed the changing nature of the NGOs.

Decision-making structures within environmental NGOs vary widely. At the heart of grassroots organizations is a strong commitment to citizen participation. The process within these organizations is often very participatory and direct stakeholders decide upon agendas and strategies. In contrast, mainstream environmental NGOs are often criticized for their undemocratic practices. In many, central staff or the board of trustees has the final say on issues and strategies, often without the advice or consent of members or regional chapters. Some have grown so large that more democratic decision making is not feasible.

The national NGOs must deal with the tensions caused by the conflicts associated with preserving the organization and preserving the environment. Many of the nationals have been criticized for excessive deference to industry in effort to reach collaborative solutions. They also are criticized for abandoning grassroots interests in favor of organizational protectionism.

Most national NGOs rely on member contributions to fund their activities. Some groups hire consultants to determine what issues would elicit the highest donations. Fundraising activities and newsletters often are primarily designed to maximize contributions rather than to inform membership. Some groups have been criticized for exaggerating or overexploiting potentially harmful problems such as asbestos or pesticides, in order to enlarge memberships or increase member contributions.

Most of the larger NGOs must also raise funds from outside sources. Most do not have memberships large enough to be financially autonomous, especially to support professional administrators, lawyers, and scientific experts. NGOs raise funds from foundations, governments, other NGOs, and private corporations. Often funding interests are represented on governing boards. This may lead to questions of cooptation. Critics argue that organizational priorities may be more influenced by the interest of the funders rather than environmental quality. Even large foundations have directed the priorities of mainstream NGOs, favoring cautious reform and noncontroversial strategies such as public education. Some large foundations tend to shut out organizations that take more radical positions such as zero-cut policies in public forests or zero discharge of contaminants.

Some critics note that the largest industrial polluters have become the largest donors to the bigger environmental NGOs. Because of this, some suggest that while national NGOs may be better positioned to influence national policy, grassroots organizations will have a greater impact on industry practices and corporate interests in the future because they are willing to openly confront industry's management of pollution and hazardous waste, the siting of hazardous waste facilities, and private sector exploitation of resources.

M. ANN HOWARD

SEE ALSO *American Association for the Advancement of Science; Bioethics Centers; Professional Engineering Organizations; Sierra Club.*

BIBLIOGRAPHY

Dowie, Mark. (1995). *Losing Ground: American Environmentalism at the Close of the Twentieth Century*. Cambridge, MA: MIT Press.

Lafferty, William M., and James Meadowcraft, eds. (1996). *Democracy and the Environment: Problems and Prospects*. Cheltenham, UK: Edward Elgar.

Redclift, Michael, and Graham Woodgate, eds. (1997). *The International Handbook of Environmental Sociology*. Cheltenham, UK: Edward Elgar.

Shabecoff, Philip. (1993). *A Fierce Green Fire: The American Environmental Movement*. New York: Hill and Wang.

Taylor, Dorceta E. (2000). "The Rise of the Environmental Justice Paradigm." *American Behavioral Scientist* 43(4): 508–580.

Thiele, Leslie Paul. (1999). *Environmentalism for a New Millennium: The Challenge of Coevolution*. New York: Oxford University Press.

NORMAL ACCIDENTS

The concept of *normal accidents* was formulated by sociologist Charles Perrow in *Normal Accidents: Living with High Risk Technologies* (1984), but is related to a number of other analyses of accidents in complex, technological societies. Perrow used the concept to describe a type of accident that inevitably results from the design of complex mechanical, electronic, or social systems. The theory has had extended influence on subsequent analyses of accidents and errors related especially to advanced technologies.

Perrow's Normal Accidents

The unexpected and interactive failure of two or more components is not sufficient to cause a normal accident when there is enough time to solve the problem before it becomes critical. Instead normal accidents in Perrow's sense occur only in systems that, in addition to being *complexly interactive*, are also *tightly coupled*. One example would be two components whose failures start a fire while silencing the fire alarm. Intervention by system operators in the early minutes or hours of such an incident often makes things worse, as when manual fire alarm activation might open doors that allow the fire to spread.

Perrow believes that normal accidents are an inevitable consequence of human reliance on complex and tightly coupled systems. By confronting the causes of normal accidents, the designers, users, and potential victims—in fact, society as a whole—can make appropriate practical and ethical decisions about the systems involved. Once one understands why normal accidents occur, and also the fact that they are almost inevitable in complex systems, Perrow suggests that "we are in a better position to argue that certain technologies should be abandoned, and others, which we cannot abandon because we have built much of our society around them, should be modified" (Perrow 1984, p. 4).

In *Normal Accidents*, Perrow provides several examples to flesh out his argument. One case involves the loss of the two square mile Lake Peigneur in Louisiana. The lake was in simultaneous use by shipping companies (via a canal connected to the Gulf of Mexico), fishermen, tourists (the Rip van Winkle Live Oak Gardens was on its banks), and oil companies (Texaco was drilling for oil in a part of the lake only three to six feet deep). Under the lake was a salt mine operated by the Diamond Crystal Company. Texaco's oil rig penetrated the mine and vanished from sight, after which all of Lake Peigneur drained into the mine, creating a whirlpool that pulled in several barges, a tug, and sixty-five acres of the Rip van Winkle Gardens. The canal to the Gulf reversed course, creating a 150-foot waterfall as the lake drained away. An underground natural gas well ruptured and bubbles floated to the surface, caught fire and burned. In just seven hours, Lake Peigneur was gone—without, however, taking a single life.

The accident was caused by the fact that the lake, oil rig, and mine were complexly interactive and tightly coupled. Subsystem operators understood none of the relationships and did not communicate adequately with one another. The Peigneur Lake incident illustrates another of Perrow's points, about the social allocation of responsibility. Instead of analyzing the system as a whole with an eye to reducing complexity or ameliorating the tight coupling, each of the players held the others responsible, Texaco accusing Diamond Crystal and vice versa. In analyzing the near-meltdown at the Three Mile Island nuclear plant in 1979, Perrow noted that the equipment vendor and the system operators blamed each other. Systems of adversarial litigation can in such cases militate against the solving of system problems.

Another phenomenon analyzed by Perrow is that of *non-collision course collisions*, in which ships on parallel, opposite courses suddenly turn and hit one another at the last moment. Perrow tells the story of the Coast Guard cutter *Cuyahoga*, operating at night. Although lookouts correctly interpreted the three lights visible on the *Santa Cruz II* to mean the ship was headed toward them on a parallel course, they did not inform their captain, because they knew he was aware of the other ship. What they did not realize was that the myopic captain had noted only two lights on the *Santa Cruz II*, interpreting these to mean that it was a smaller fishing vessel, sailing ahead of the *Cuyahoga* and in the same direction. As the *Cuyahoga* came closer to the freighter, the captain turned to port, to pass outside the other ship. In reality, since the *Santa Cruz II* was headed toward him, he turned out of a parallel course, which would have passed the *Santa Cruz II* without incident, right into its track, causing a collision with the loss of eleven lives.

Ruins on Lake Peigneur. The generally accepted cause of the disaster is that a miscalculated oil probe punctured the roof of a salt shaft, creating a drain for the lake. The lake then proceeded to drain into the hole, as the mine was evacuated. The giant whirlpool created sucked in the drilling platform, eleven barges, many trees, buildings, and some of the surrounding terrain. *(© Philip Gould/Corbis)*

Perrow argued that in the relatively brief moments available, operators who must function rapidly in real time construct a simplified view of the environment based on available, often incomplete, information. Once this has been accomplished, all contradictory information is excluded. A related problem is the extremely authoritarian command structure used at sea; in which first mates are much less comfortable questioning their captains than copilots are in the air. Such non-collision course collisions are common and, according to Perrow, constituted a majority of the cases he studied in which ships hit other ships.

Perrow noted the differences in social factors between air and sea travel and transport that promote the much larger percentage of accidents at sea. The differing factors include levels of government regulation, pressure to meet schedules, communication between captains and crew, and social status of air versus sea travelers. He concluded that much of the technology developed to make aviation safer, such as traffic control systems, is not used at sea, though it could be.

Perrow also analyzed cases in which safety devices encourage people to engage in more risky behaviors. For example, the installation of new braking systems in trucks, decreasing the possibility of failure on mountain roads, has not resulted in a decline in the number of accidents. Truck drivers who believe they have safer brakes will drive faster because it can save time and money. Similarly in some industries such as marine transport, insurance may make owners complacent, as the real cost of upgrading ships to prevent loss may exceed that of replacing them. Studies of these and related phenomena of automobile accidents (and even business and financial management) have resulted in development of the concept of risk homeostasis, in which increases in safety tend to be complemented by changes in behavior that once again increase risk to a certain acceptable level (Wilde 2001, Degeorge, Moselle, and Zeckhauser 2004).

Perrow's analysis is largely confirmed by high profile systems accidents that have occurred since the book was published. The loss of the *Challenger* (complex interaction, tight coupling between the fragile o-rings and the explosion potential of the fuel tanks) and the *Columbia* (complexity plus coupling between the disposable tanks, off which ice or insulation might fall, and the fragile tiles on the wings which could be damaged by them) space shuttles are two cases in point. In both instances the communications failures highlighted by Perrow are visible (the engineers on the *Challenger* knew that o-rings fail at freezing temperatures, but could not get their managers to postpone the launch; those on the *Columbia* launch wanted to get military spy satellite photos of the wing tiles but could not get their supervisors to agree). A blackout in the eastern and central United States and part of Canada in August 2003 is another example: The highly interdependent utilities failed to function as part of one system, the malfunctioning problem-detection software failed to warn of the overload in one provider, resulting in cascading failures of turbines, and the providers and utilities failed to warn others of known problems.

Competing Analyses

Since Perrow's work a number of studies have both criticized and extended his arguments. Among the most influential are Scott Sagan's *The Limits of Safety* (1993) and Dietrich Dörner's *The Logic of Failure* (1996). Sagan examines two competing theories on safety, normal accident and high reliability, for their ability to explain historical experiences in the control of nuclear weapons. In opposition to normal accident theory, high reliability theory posits that systems can be made safe by employing redundancy measures, decentralizing authority so that those nearest a problem can make quick decisions, and rigorously disciplining operators. It is an optimistic belief that well-managed and designed organizations can be perfectly safe.

Sagan shows that nations such as the United States and Russia use high reliability theory to manage their nuclear weapons. He then provides several examples of accidents and near-accidents that challenge the central assumption of this theory, namely, that nuclear systems can be made safe. Sagan argues that the normal accident theory better explains nuclear weapons systems, which are so complex and tightly coupled that accidents, although rare, are inevitable. He points to such limitations on high reliability theory as conflicting goals and priorities, constraints on learning, limitations on leaders' ability to control the human and technical components of the system, and pressure to turn memories of failures into successes. Sagan concludes that more outside reviews and information sharing, changes in organizational cultures (including less faith in redundancy), complete nuclear disarmament, and decoupling interactions are all alternatives to increase the safety of nuclear weapons systems. None of these alternatives, however, is very likely to occur.

Dörner claims that our main shortcomings when faced with complex problems are a tendency to oversimplify and a failure to conceive of a problem within its system of interacting factors. Failure does not necessarily result from incompetence. For example, the operators of the Chernobyl nuclear reactor were experts, and in fact ignored safety standards precisely because they felt that they *knew what they were doing*.

Dörner identifies four habits of mind that account for the difficulty in solving complex problems: (a) slowness of thinking; (b) a desire to feel confident and competent; (c) an inability to absorb and retain large amounts of information; and (d) a tendency to focus on immediately pressing problems and to ignore the problems that solutions are likely to create. Dörner's work highlights the area of normal accident theory dealing with cognitive and psychological factors (i.e., human error) in accidents.

In line with Dörner's analysis, Keith Hendy's Systematic Error and Risk Analysis (SERA) software tool investigates, classifies, and tracks human error in accidents. It employs a five-step process that guides investigators through a series of questions and decision ladders in order to determine where errors occurred (Defence Research and Development Canada 2004).

Perrow's initial work has thus sparked continuing analyses of complex technological systems and the causes of their failures, so that debates about the risks and benefits of technology are regularly influenced by normal accident theory. The results of such debates are nevertheless mixed. In fact, Perrow maintained that some systems, like nuclear power, should be abandoned, while others, like marine transport, require significant modification, but can be made reasonably safe.

Perrow's book, though presented as a narrow study of the functioning of technological systems, is also a study of the psychology of human error, which could be fatal even in low-tech systems, and is much more dangerous today given the speed, size, and clout of modern technology. Perrow's work deserves continuing recognition because he was arguably the first to introduce the concept that accidents, rather than being a lightning bolt from the blue, are inherent in the nature of complex systems, and that human provisions to avoid the consequences may actually engender more danger.

JONATHAN WALLACE
ADAM BRIGGLE

SEE ALSO *Unintended Consequences.*

BIBLIOGRAPHY

Degeorge, François; Boaz Moselle; and Richard J. Zeckhauser. (2004). "The Ecology of Risk Taking." *Journal of Risk and Uncertainty* 28(3): 195–215.

Dörner, Dietrich. (1996). *The Logic of Failure: Recognizing and Avoiding Error in Complex Situations.* New York: Perseus Books Group.

Perrow, Charles. (1984). *Normal Accidents: Living with High Risk Technologies.* New York: Basic Books. Reprinted, Princeton, NJ: Princeton University Press, 1999. The leading analysis of the primary role of human error in high technology accidents.

Sagan, Scott. (1993). *The Limits of Safety: Organizations, Accidents, and Nuclear Weapons.* Princeton, NJ: Princeton University Press.

Wilde, Gerald J. S. (2001). *Target Risk 2: A New Psychology of Safety and Health.* Toronto: PDE Publications. Revised and expanded edition of a book first published in 1994.

INTERNET RESOURCE

Defence Research and Development Canada. "Using Human Logic and Technical Power to Explain Accidents." Available from http://www.drdc-rddc.dnd.ca/newsevents/spotlight/0402_e.asp.

NUCLEAR ETHICS

Industrial Perspectives
Weapons Perspectives

INDUSTRIAL PERSPECTIVES

There are powerful undercurrents in motion that seek to change the way people work with and think about the nuclear industry. The nuclear energy industry is capable of transforming terrestrial life for better or worse. Never has an industry possessed such awesome forces, and never has there been a greater need for an ethics to guide the way an industry develops. To this end it is useful to review the history of the industry and the highly diverse influences that have produced it. In particular there are two main influences. One is associated with military policy and focuses on geostrategic decisions related to nuclear war, whether offensive or defensive. The second is located within the civilian area, includes both nuclear medicine and nuclear power generation, and touches on issues of safety, environmental pollution, and economics. The focus here will be on the civilian aspects of the industry.

The Discovery of Radioactivity

At the end of the nineteenth century scientists were examining the properties of cathode ray tubes. These consisted of an enclosed glass vessel that had two electrodes set into the glass at opposite ends of the chamber. When almost all the air in the chamber had been removed and one of the electrodes was heated while the other electrode was given a positive charge (the anode), it was noticed that rays were emitted from the hot (cathode) electrode. In 1895 in Würzburg, Germany, Wilhelm Conrad Röntgen (1845–1923) noted that a plate coated with barium platinocyanide held in front of a functioning cathode-ray tube fluoresced and emitted light. What was more, when he placed a light-opaque material between the plate and the tube, the fluorescence did not cease. Clearly the rays derived from the tube, which he called "X rays," by passing through an opaque material, had done something that visible light rays did not do.

The next year in Paris, Antoine-Henri Becquerel (1852–1908) noted that certain minerals fluoresced when they were exposed to ultraviolet light and that they were capable of fogging an adjacent photographic plate, even when that plate was covered by a double layer of light-opaque paper. One such mineral was uranyl potassium sulfate crystal. He later showed that the effect was largely due to the metal component, uranium. While most of the interest at the time focused on the X rays, Marie Curie (1867–1934) and Pierre Curie (1859–1906) showed that other elements were capable of making penetrating radiations and in the process discovered the elements radium and polonium.

Becquerel, however, made one further vital discovery. After putting a sample vial containing the Curies' radium into his vest pocket, he noted some time later that his skin in the region covered by the pocket became burned. He thus discovered the biological effects of radiation, a phenomenon that was soon put to medical use for a wide variety of ailments, although most such treatments led to a worsening of the condition being treated. (Both the Curies and Becquerel received Nobel Prizes for their discoveries; Marie Curie became the first person to receive two such prizes for her discoveries in the chemistry of radioactive elements.)

Types of Radiation

From these beginnings it became clear that the radiation could be divided into several clear types. X rays and later c-rays (gamma rays) were shown to behave like light rays, being part of the electromagnetic spectrum, whereas β-rays (beta rays) were shown to be streams of negatively charged electrons and α-rays (alpha rays) were helium atoms without the electrons (that is, helium atomic nuclei consisting of two protons and two neutrons). Each of these radiations can be made to generate point sources of light for each energetic emission. From this it has been observed that each gram of radium emits some 3.7×10^{10} emissions per second—or 1 curie of radioactivity, a baseline parameter. By comparison, all humans are exposed to both cosmic rays from the sun and to radioactivity from rocks and gases of the earth to a level that varies between 20 detectable emissions per second to about 200 in special areas of such countries as India, Iran, and Brazil. In term of other units of measure, such radiations give normal background levels of 3–600 millisieverts (mSv or mGray) per year.

To acquire a concept of the properties of such radiations it is useful to note that

- In terms of emissions, exposure to X rays, β-rays, or c-rays is less damaging than the equivalent amount of α-rays by a factor of about 20.
- Exposure to 10 sieverts (Sv) in one day is normally lethal to one human.
- Exposure to 10 Sv over one year would have a chronic effect on one human, such as cancer.
- Workers or sailors involved in the nuclear industry or the nuclear-powered navy are allowed to be exposed to 2.2 mSv/day.
- The 541 atmospheric tests of nuclear weapons set off between 1945 and 1980, which exploded the equivalent of 440 megatons of TNT, have increased the normal background radiation by 0.04 mSv/year.
- The additional radiation from all the world's nuclear power stations amounts to 0.002 mSv/year.
- A medical or dental X ray delivers, in seconds, 0.4 to 10 mSv.
- A modern CAT scan exposes a person to some 10 mSv.
- To achieve a biological effect the amount of radiation that has to be delivered has to exceed a certain "threshold" level.

Radioactivity in the Laboratory and Medicine

The civilian nuclear industry has, as a by-product, made available many radioactive materials that find uses in the laboratory or medical diagnostic facilities. Elements such as tritium (H^3 or hydrogen with one proton and two neutrons), carbon-14, sulfur-35, and phosphorous-32 are all β-ray or -particle emitters, while iodine-131 is a c-ray emitter. People who work with chemical compounds containing such isotopes need not be unduly worried about the effects of radioactivity on their persons, because β-rays travel only a few millimeters and do not penetrate the walls of glass tubes or containers. By contrast, 3 million c-rays and 250,000 β-particles emanating from natural sources pass though an individual human every minute.

These radioactive isotopes have enabled scientists to map out the route taken during the chemical transformation of food materials to cellular components and wastes and have unlocked the mysteries that surrounded the process of photosynthesis on which advanced life depends. In the medical area, the use of X rays for diagnosis is widespread, and the use of radioactive iodine in immunoassays for the detection of micrograms of materials per milliliter of sample is a powerful tool in measuring hormone and other metabolites of interest in medical and veterinary applications. A more recent use of radioactive isotopes has been in assay systems that enable determining the sequence of the bases in molecules of nucleic acids. Such assays have been used to acquire knowledge of the full sequence of the human genome and identify particular genes that cause inherited defects.

Most ethical debate on the use of genetic engineering techniques for the correction of defects in single gene disorders (typically, cystic fibrosis or immune disorders caused by a faulty enzyme, amino deaminase) has taken the view that such efforts are worthy and should be encouraged. It is also held, however, that only the phenotype should be affected and efforts to correct the defect in gametes should not be allowed. When it comes to the use of genetic engineering to effect enhancements of individuals (eye, hair and skin color, intelligence, musical and athletic abilities, etc.), ethical arguments are adduced to prevent such efforts, although the use of the growth hormone gene may be applied to correct a pathological condition, dwarfism, but not to produce basketball players.

Cancer treatments based on radiation (X rays, c-rays, and β-rays) are many and varied. Whole-body radiation of 10 Sv (10,000 times the annual background exposure) will cause the cessation of the development of bone marrow. Cancer treatment is based on the need to kill cells whose replication control mechanism has become ineffective. There is, however, the risk of killing other (collateral) cells and also of causing a cancer as a result of damaging nucleic acid molecules (genes) in neighboring tissues. Therefore the basis of successful therapies is to engineer treatments to maximize the therapeutic effects while minimizing the chances of coincident damage.

From Nuclear Energy to Electrical Power via the Atomic Bomb

The route from radiation to the atomic bomb came via the demonstration of the fission of atomic nuclei in 1938 by the German chemists Otto Hahn and Fritz Strassmann, which was followed by the separate investigations of Niels Bohr and Enrico Fermi on the fission of uranium atom nuclei. Experiments of all four led to the understandings of the crucial position of the uranium-235 isotope as opposed to the more abundant version of that element, uranium-238. The separation of these isotopes occupied the scientific and engineering acumen of many in both the United Kingdom and the United States.

In 1941 the work done in the United Kingdom influenced Vannevar Bush in the United States to authorize the construction of a subcritical experimental nuclear reactor or "pile." President Franklin D. Roosevelt backed the program in October of that year. In April of the next year, Fermi relocated to the University of Chicago, where he built a larger and more active reactor in the Stagg Field squash courts; calculations regarding the amount of material that would be needed to make a bomb were set in motion. Using the mental and physical understandings and skills of tens of thousands of scientists and engineers who were given an unlimited budget the outlines of the nature of an atomic bomb emerged. In January 1945 after much empirical experimentation and theoretical calculation, the scientists concluded that some 10 kilograms of plutonium or 40 kilograms of uranium-235 would be the minimal amounts of material necessary to set off an atomic explosion. The first such explosion took place on July 16, 1945, at the Alamogordo bombing range in New Mexico, while the second was over the city of Hiroshima, Japan, twenty-one days later. In 1952 the first deuterium-(H^2-) based fusion bomb (in which protons fused together to make the nucleus of an atom of higher atomic weight [lithium] than the original atoms [hydrogen]) was exploded at Enewetok Atoll in the Pacific Ocean, releasing power 100 times greater than that of the fission bombs—the equivalent of some 10 million tons of TNT.

Now that the genie had left the bottle, the way was open for both the peaceful and military use of nuclear energy by any country that could afford the time, expertise, and money. The first use of a nuclear reactor for the production of electrical energy occurred onboard a submarine, namely the USS *Nautilus,* completed in January 1954. As of 2005 there were over 150 ships (mainly submarines, aircraft carriers, and icebreakers) powered by more than 220 small nuclear reactors.

Land-based nuclear reactors that were designed to generate usable power in the form of electricity had the dual function of also making plutonium as a result of the nuclear reactions that occur when the fissile uranium generates heat. The uranium provided the electricity for national power grids, while the plutonium was added to the material that could be used for the production of bombs. The first such station to have this dual function was built in the United Kingdom at Calder Hall; it went commercial in October 1956. Since then, some 440 commercial nuclear power reactors and 284 research reactors have been built. They operate in 56 countries and supply some 16 percent of the world's total electricity base load. In Lithuania and France over 70 percent of the electricity supply is derived from nuclear reactors.

Assessment

Despite the large number of facilities that contain a nuclear reactor, the number of casualties that have resulted are relatively few. From the late 1950s to the early 2000s casualties directly associated with nuclear reactors numbered less than fifty. This is many fewer than the fatalities caused by other methods of generating electrical energy during the same period. There have been six serious events in which radioactivity has spilled over into the environment, the most damaging being that of the Chernobyl explosion in 1986 near the city of Kiev in Ukraine (then part of the USSR). Thirty-one people died and 1,800 children had to be provided with antidotes to thyroid cancer. Almost a million people were evacuated, and 10,000 square kilometers of land were designated as unfit for use. There was no evidence of other radiation-induced illnesses in the local population, which began moving back into the vacated area in the late 1990s.

There have been many studies examining the relationship between the incidence of leukemia and cancer and the locality of a power-generating nuclear reactor. Thorough examination of such data leads to the conclusion that although from time to time some radioactive material may have leaked from such establishments there has not been a noticeable and definitive increase in cases of cancer in the vicinity of such power stations.

Nevertheless, because nuclear reactors are associated with bombs, the fear of this technology has been disproportionate to its actual lethality. Paul Slovic's book on the perception of risk (2000) provides data that shows that while nuclear energy is *perceived* as generating the greatest risk, the *actual* risk is less than one chance in a million that a person who lives within five miles of a nuclear reactor for fifty years will die by an accident related to the reactor (a risk equivalent to that provided by smoking 1.4 cigarettes). Additionally, much has been made of the costs and dangers of decommissioning nuclear power reactors and of handling radioactive materials from this operation as well as the waste materials from the processing of spent fuel rods. The technology of radioactive waste storage has progressed, yet it is necessary to annually remove from circulation relatively small quantities (several tons) of highly radioactive material that retains its radioactivity for tens of thousands of years or longer. Were such material buried, as is suggested, there remains a danger that the containers may rupture, allowing seepage of radioactive material into the local groundwater. Nevertheless, sites for the indefinite storage of such materials held in a glass matrix within metal containers may be found in deep abandoned mines located in geologically stable areas.

The real terrors of the nuclear industry are in the area of bombs, a complex issue in and of itself. On the one hand, the end of the cold war (1945–1989) led to an overall decrease in the total number of nuclear weapons and agreements concerning the disposition of the remainder. On the other hand, China, India, Pakistan, and other countries have developed their own nuclear weapon capabilities. The expansion of trade will at least in some instances promote nonbelligerent conditions. And regardless of the connection between the nuclear power industry and nuclear weapons, one day oil and gas supplies will run out, and energy will still be needed.

At that time both worldwide population and its average rate of energy consumption are likely to have increased considerably. Although the energy of winds, rivers, tides, waves, and solar photons are likely to be increasingly captured and converted to distributed electrical power, it is unlikely that such supplies will satisfy human needs. The nuclear power option will increase in importance as conventional sources of energy are used up. It could be prudent to create the conditions for such an eventuality while the opportunity still exists to experiment without the pressures of urgent needs.

If in fact humanity turns to the nuclear power option, the issue of safety will need to be addressed. Modern societies have developed extensive systems of rules and regulations to protect the health and safety of those working with dangerous procedures, chemicals, or physical conditions. It may be expected that a parallel suite of regulations already in use in the nuclear industry will be extended and refined for a future, enlarged nuclear industry.

A related issue herein is that of global warming (or climate change). It is widely believed that the anthropogenic (human) production of carbon dioxide is, at the least, partly responsible for the increase in temperatures that has been observed around the planet. Many believe that this has been caused by human combustion of fossil fuels (coal, methane gas, and oil) for generating electricity and powering vehicles. An approach to militate against further increases in carbon dioxide proposed by James Lovelock, the initiator of the Gaia hypothesis, and others, is to use more nuclear reactors for the production of electricity. This electricity in turn could be used to generate hydrogen from the electrolysis of water to provide fuel for vehicles fitted with hydrogen-based fuel cells that generate electricity for onboard motors. This approach does not add to the carbon dioxide in the atmosphere and is safe, clean, and cost effective; it is possible to obtain 2.5 million times more energy from a gram of uranium than from the same amount of coal. A nuclear power program could be used in conjunction with other environmentally friendly approaches to energy generation, including wind, wave, biomass, and solar power.

Conclusion

The history of the development of the nuclear industry provides a paradigm of the emergence of a powerful technology from the observation of natural phenomena at the level of the individual scientist. At each stage the emerging new knowledge coupled with the development of techniques and equipment brought humanity to a more reliable understanding of the way nature worked and how humans operated. When the survival of the nation state was threatened as never before (after the devastating attack on Pearl Harbor, Hawaii, on December 7, 1941) America poured unlimited resources into the building of the atomic bomb. Could the scientists and engineers have decided not to develop atomic weapons at that time on the basis that the expression of the capability to develop such weapons could jeopardize the future survival of humanity? The question remains how humanity would respond to a similar challenge if it occurred again. In the end, humans have acquired awesome capabilities. It is perhaps thanks to the ethical strictures that humans have also built up over the ages that, for the most part, the use of the new and powerful technology has been restrained to beneficial ends. Such ethics are predicated on the bending of all human efforts to achieve the enhancement of the survival of humans on this planet, and they are perhaps encompassed in the following ethical statement by Hans Jonas: "Act so that the effects of your action are compatible with the permanence of genuine human life" (Jonas 1984, p. 11).

It might also be noted that there have been prominent scientists (Albert Einstein and Robert Oppenheimer in particular) who, having surveyed the results of their decisions in the heat of wartime, later recanted their enthusiasm for the project on which they worked so hard. Such retroactive evaluations may serve as a teaching device, but they do not help solve the problems that humans face in the early twenty-first century.

Energy released from nuclear reactions has the potential of providing almost unlimited amounts of virtually clean power into the indefinite future. It may also power spaceships, enable humans to colonize other planets of the solar system, and resolve medical pathologies. If it ever becomes feasible to progress to the harnessing of fusion power as demonstrated in the hydrogen bomb, then issues of power generation would no longer distract humanity from efforts to enhance the personal and social lives of all human beings. Yet, as with all the tools developed by humankind over the last 2.5 million years, it must be recognized that nuclear energy may be used to cause harm as well as provide benefits. Humanity's efforts, therefore, have to be directed at developing and practicing those ethics and morals that prevent harmful uses while enabling and encouraging beneficial deployments. The future of the human species depends upon the success of this endeavor.

RAYMOND E. SPIER

SEE ALSO *Chernobyl; Nuclear Waste; Three-Mile Island.*

BIBLIOGRAPHY

Jonas, Hans. (1984). *The Imperative of Responsibility: In Search of an Ethics for the Technological Age*, trans. Hans Jonas and David Herr. Chicago: University of Chicago Press.

Slovic, Paul. (2000). *The Perception of Risk*. London: Earthscan Publications.

Spier, Raymond E. (2001). *Ethics, Tools, and the Engineer*. Boca Raton, FL: CRC Press.

Spier, Raymond E. (2002). "Ethical Issues Engendered by Engineering with Atomic Nuclei." In *Science and Technology Ethics*, ed. Raymond E. Spier. London: Routledge.

INTERNET RESOURCES

Lovelock, James. "Nuclear Power Is the Only Green Solution." Available from http://www.perfect.co.uk/2004/05/james-lovelock-nuclear-power-is-the-only-green-solution. Lovelock's comment on the need for the activation of the nuclear power option.

Uranium Information Centre. "Nuclear Power in the World Today." Available from http://www.uic.com.au/nip07.htm. Provides information on commercial nuclear reactors that provide electricity to national grids.

Washington and Lee University. "Alsos Digital Library for Nuclear Issues." Available from http://alsos.wlu.edu. Provides a wide range of annotated references for the study of nuclear issues.

WEAPONS PERSPECTIVES

Ethical and political reflection on nuclear power was initially stimulated by the dangers of nuclear weapons. Even as the possibility of the atomic bomb began to be imagined in the 1930s, physicists became worried about its social, political, and ethical implications. By the time the first bomb was exploded in 1945, and even more as the nuclear arms race took hold in the 1950s, scientists, engineers, military professionals, politicians, and the attentive public became increasingly concerned about nuclear research and development, testing, and deterrence policy. As much as any other science and technology during the twentieth century, nuclear weapons have challenged ethical reflection. Although such weapons present major benefits—otherwise they would not have been invented, produced, and used—they also have built-in disadvantages that are not always easy to assess. As Albert Einstein remarked in 1946, the problem created by nuclear weapons is "not one of physics but of ethics."

Communities of Reflection

Nuclear weapons and ethics have been discussed in three overlapping communities of reflection. As the community of discovery and inventive origins for both nuclear science and weapons technology, scientists and engineers have played a major role in promoting ethical criticism. As the community that pioneered the use of nuclear weapons, the military has analyzed from its own perspective many ethical and political aspects of nuclear weapons. Finally, as the primary source of funding and ultimate beneficiary (and victim) of nuclear weapons, citizens and their democratic leaders have sought to place nuclear weapons in the broadest ethical context. Nuclear ethics and weapons issues may thus conveniently be considered in relation to the interacting discourses opened up by these three communities.

THE SCIENTIFIC-ENGINEERING COMMUNITY. In the 1930s scientists in Great Britain and the United States promoted nuclear weapons research because of the threat that Nazi Germany might develop such weapons. In 1945, when it became clear that Germany had not come close to developing the atomic bomb, some scientists at Los Alamos National Laboratory, where the bomb was being designed and fabricated, argued that such work was no longer justified. The majority view, however, was that work should go forward in order to demonstrate to the world the possibilities of such weapons, to complete a challenging technoscientific project, and perhaps in order to contribute to the continuing war effort against Japan.

After the bombing of Hiroshima and Nagasaki a group of scientists and engineers involved with atomic bomb development took the initiative to promote public education about the awesome power of nuclear weapons and lobbied for their international control. This ethical work led to three institutional initiatives—the Federation of Atomic (later American) Scientists (founded 1945), the *Bulletin of the Atomic Scientists* (first published in 1945), and the International Pugwash movement (founded 1957)—each of which became critical of the subsequent nuclear arms race, especially in the form of atmospheric testing and later proliferation.

Generally speaking, scientists and engineers felt a strong moral responsibility to educate politicians and the public about both the benefits and dangers of nuclear weapons. Yet a divide developed within the technical community between those who maintained the benefits outweighed the dangers and those who argued the dangers outweighed benefits. In the early 1950s this came to a head in a dispute between J. Robert Oppenheimer, who opposed hydrogen bomb development, and Edward Teller, who supported it. For Oppenheimer, the atomic bomb was sufficiently powerful for any conceivable military purpose, whereas for Teller the threat that the Soviet Union might develop a hydrogen bomb was sufficient to justify its pursuit. Among scientists one of the basic disagreements was and has continued to be over when enough is enough, and what precisely scientific responsibility entails.

THE MILITARY COMMUNITY. Among those involved with the military both as professional soldiers and policy analysts, questions arose primarily in relation to strategic policies. In the military there was never any sense that German defeat should undermine the justification of nuclear weapons work. From an early date the military saw nuclear weapons as a means of exercising military power and set about formulating appropriate strategies to take advantage of its unique features. The major result was development of the concept of nuclear deterrence—a strategy that nevertheless gave rise to a number of important and well-explored ethical quandaries.

One quandary concerned whether nuclear weapons should be directed toward military or civilian targets. Although traditional just war theory argued against "countervalue" targeting of civilians, to limit nuclear weapons targeting to "counterforce" assets might, especially during a crisis, actually encourage an enemy toward a preemptive nuclear strike in order to try to avoid the loss of its nuclear capabilities. Counterforce targeting also tends to encourage a nuclear arms race for increasingly accurate weapons. The policy question then becomes: What is the most ethical way to target nuclear weapons?

Another quandary considers in what sense it is ethically permissible to threaten what it would not be ethically permissible to do. There is little disagreement that it would be ethically wrong to use nuclear weapons against a large civilian population in an enemy country, especially because the results would affect large numbers of people in other, neutral countries, and be likely to rebound even on the attacking country. But what if the best way to avoid the actual use of nuclear weapons is to threaten their use on civilian populations? What, then, is the most ethically defensible policy, especially in relation to a totalitarian country or a regime ruled by someone whose behavior may not be rational?

Finally, insofar as there are prima facie justifications for defending oneself against attack from nuclear weapons, to threaten a country with nuclear retaliation seems legitimate. But insofar as there are prima facie prohibitions against threatening innocent people, and given that nuclear weapons cannot but harm innocent people, to threaten the use of nuclear weapons seems equally illegitimate. Prima facie or deontological arguments thus both support and oppose the development and use of nuclear weapons.

THE POLITICAL COMMUNITY. The political community is divided into two groups: the established political community and the oppositional political community. Each form of the political community has sought to overcome the quandaries elaborated within the military community.

From the beginning the established political community, in alliance with the military community, sought ways to use nuclear weapons to pursue political ends (especially in relation to the nuclear standoff with the

Soviet Union). For the United States especially, nuclear weapons allowed the country to counter a Soviet superiority in ground troops in Europe in a way that was politically tolerable (that is, without maintaining a large standing military and at a relatively low annual financial burden). The solution to the ethical quandaries was to promote technological fixes in the form of civil defense and/or the development of some kind of defensive missile system.

By contrast, the oppositional or alternative political community, in alliance with a vocal segment of the scientific community, argued for a political fix to the quandaries of nuclear deterrence. One such political fix comprised proposals for the internationalization of nuclear weapons control. An even more radical proposal argued for unilateral nuclear disarmament. In the middle, the alternative political community actually succeeded in 1963 in getting the major nuclear powers to sign the Limited Nuclear Test Ban Treaty halting nuclear weapons testing in the atmosphere. Later voluntary and reciprocal moratoriums were developed among some powers with regard to underground nuclear testing. But such U.S.–USSR agreements have had only marginal influences on many other countries. And oppositional efforts to limit nuclear proliferation have been problematic at best.

Further Issues

Disagreements among the three communities of reflection have carried over into a number of closely related issues. Among such issues are questions of the moral probity of civilian defense and defensive missile systems, the effectiveness of such systems (especially missile defense systems that rely on complex, automated responses to information that can itself be quite problematic), the problem of how to respond to worries in civilian populations affected by nuclear weapons industry sites, and the difficulties of nuclear waste disposal.

Three ethical issues that have received only marginal discussion may also deserve notice. First, there is a somewhat suppressed debate regarding whether many of the fears about nuclear weapons have been well founded. After all, since 1945 nuclear weapons have not been used except as features of deterrence strategies. Are worries about the dangers of nuclear weapons misplaced? Or have the expressions of fear had the salutary effect of helping to keep mistakes from being made? Second, some have suggested that the shift in nuclear testing to an increasing reliance on computer simulations may deprive nuclear scientists and engineers, not to mention soldiers and politicians, of a direct experience of the destructive powers of nuclear weapons that itself has also had a salutary effect on their handling and use. Third, with the advent of the possible use of nuclear devices by nonstate actors and terrorists, new questions arise about the responsibilities of those who have developed and are continuing to develop nuclear weapons.

Finally, it might be suggested that despite initial appearances, many of the issues with regard to nuclear weapons only present in especially dramatic form questions that relate to modern science and technology in general. Science and technology in general place in human hands enormous power for transforming the world, many of which entail quandaries similar to those associated with nuclear weapons. The pollution of the natural environment and the burning of fossil fuels, which seem necessary to pursue benefits for present generations, may have negative impacts on future generations in ways that mirror the deterrence targeting of enemy populations (which benefit the targeting populations at the potential expense of the targeted populations). Thus it can be argued that ethical reflection on nuclear weapons should not be isolated from ethical reflection on other technologies, or that the results of ethical reflection in regard to both nuclear and nonnuclear technologies should be compared and contrasted for the benefit of science, technology, and ethics as a whole.

CARL MITCHAM

SEE ALSO *Baruch Plan; Just War; Limited Nuclear Test Ban Treaty; Military Ethics; Nuclear Nonproliferation Treaty; Nuclear Waste.*

BIBLIOGRAPHY

Cohen, Avner, and Steven P. Lee, eds. (1986). *Nuclear Weapons and the Future of Humanity: The Fundamental Questions*. Totowa, NJ: Rowman and Allanheld. The single best collection of articles on this topic.

Einstein, Albert. (1946). "The Real Problem Is in the Hearts of Men." *New York Times Magazine*, 23 June, 7 and 42–44. An interview with Michael Amrine.

Hashmi, Sohail H., and Steven P. Lee, eds. (2004). *Ethics and Weapons of Mass Destruction: Religious and Secular Perspectives*. Cambridge, UK: Cambridge University Press.

Hollenbach, David. (1983). *Nuclear Ethics: A Christian Moral Argument*. New York: Paulist Press.

Jaspers, Karl. (1961 [1958]). *The Future of Mankind*, trans. E. B. Ashton. Chicago: University of Chicago Press. One of the first philosophical reflections on the need for "an essentially new way of thinking" if human beings are to survive the invention of nuclear weapons.

Kavka, Gregory S. (1987). *Moral Paradoxes of Nuclear Deterrence*. Cambridge, UK: Cambridge University Press. A tightly argued exploration of the major quandaries.

Lee, Steven P. (1993). *Morality, Prudence, and Nuclear Weapons*. Cambridge, UK: Cambridge University Press.

Nye, Joseph S., Jr. (1986). *Nuclear Ethics*. New York: Free Press. An important analysis of deterrence policy by a U.S. policy analyst.

Shrader-Frechette, Kristin S. (1983). *Nuclear Power and Public Policy: The Social and Ethical Problems of Fission Technology*, 2nd edition. Dordrecht, Netherlands: Reidel Publishing. The first and still influential philosophical assessment of nuclear power, which also makes some relations to the nuclear weapons–nuclear power connection.

Shrader-Frechette, Kristin S. (1993). *Burying Uncertainty: Risk and the Case against Geological Disposal of Nuclear Waste*. Berkeley and Los Angeles: University of California Press. Although this book focuses on Yucca Mountain, Nevada, the arguments developed here are of quite general significance.

NUCLEAR NON-PROLIFERATION TREATY

The nuclear Non-Proliferation Treaty (NPT) is the only legally binding multilateral agreement that commits signatory states to an active pursuit of disarmament. It is a major example of an attempt to govern the development and use of technology, in this case, one of the most powerful technologies ever developed.

Historical Development

Early post-World War II efforts to contain the proliferation of nuclear weapons were unsuccessful. The United States (1945) was followed rapidly by the Union of Soviet Socialist Republics ([Soviet Union] now Russia, 1949), United Kingdom (1952), France (1960), and the People's Republic of China (1964) as nuclear weapons states (NWS), quickly dissipating assumptions that nuclear technology was difficult to both acquire and master. In fact the increasing construction of nuclear reactors introduced a sense of urgency for a multilateral treaty that would halt and eventually reverse the proliferation of nuclear energy and weapons technology. The NPT was therefore designed to strike a balance between the NWS, the five states who manufactured and or exploded a nuclear weapon prior to January 1, 1967, and non-nuclear weapon states (NNWS), in ways that would diminish and eventually eradicate the use of nuclear weapons.

Throughout the 1950s, there were a series of initiatives by both NWS and NNWS to check the proliferation of nuclear technology. Although there were fundamental disagreements between the United States and the Soviet Union on the specifics of these initiatives, these efforts nevertheless set the precedent for a multilateral treaty that would include non-dissemination and non-acquisition principles as its fundamentals.

These NPT negotiations took place in three distinct phases. Phase one consisted of bilateral talks in the late 1950s and early 1960s between the United States and the Soviet Union. Although both countries favored nonproliferation, there were serious divergences on how to implement it. The United States, along with Canada, France, and the United Kingdom, submitted a package to the United Nations in August 1957 that included a nontransfer commitment. The Soviets objected on the grounds that it still allowed for the deployment by a nuclear power of its weapons under the justification of self-defense, and wanted to add a clause prohibiting the stationing of nuclear weapons in foreign countries.

The main sticking point continued to be the U.S. proposal for a North Atlantic Treaty Organization-based (NATO) Multilateral Nuclear Force (MNF), which the Soviets argued constituted proliferation. Although the U.S. draft treaty sought to clarify collective defense arrangements by maintaining that the United States would hold a veto on deployment of U.S. weapons, the Soviets would not agree to such a provision. However both countries ultimately agreed on the premise that nuclear nonproliferation was of the utmost importance. The United States conceded on the collective defense MNF and in the end of 1966 the Soviet and U.S. chairmen of the Eighteen-Nation Disarmament Committee (ENDC) reached a tenable agreement on the basic premises of the proposed NPT.

Phase two of deliberations occurred between the United States and its NATO allies. The NNWS members of NATO expressed significant concern over the planning of nuclear defense within the confines of their region without their full consent. The United States sought to clarify how a non-proliferation treaty would support collective defense obligations. The U.S. interpretation of the draft treaty stated that while nuclear weapons and the framework of the treaty covered explosive devices, delivery systems were not included. Therefore the treaty did not prohibit planning of nuclear defense between the NATO allies, nor deployment of U.S. controlled and operated nuclear weapons on territory of non-nuclear NATO members. The Soviets did not object to this interpretation, as the United States would maintain full control over their nuclear weapons throughout Europe, specifically where nuclear weapons were deployed.

Phase three of the negotiation took place throughout the 1960s in the United Nations and occurred simultaneously with the bilateral U.S.–U.S.S.R. talks as well as the NATO negotiations. It began when the United Nations General Assembly adopted the Irish resolution in 1961 calling for all states to enter into a nonproliferation treaty that would outlaw the transfer and acquisition of nuclear weapons. Following the Irish resolution was UN resolution 2028 in 1965, which codified five principles necessary for a non-proliferation treaty: Both NWS and NNWS states would be prohibited from proliferation of any kind; NWS and NNWS would share the responsibilities of the treaty; the goal of the treaty would be nuclear disarmament but also general and complete disarmament; there would be practical policies in place to ensure the effectiveness of said treaty; and the establishment of nuclear weapon free zones should not be hindered by the treaty. Resolution 2028 provided the fundamental framework for the final version of the NPT and it was from this document that the United States and Soviet Union began to develop an actual codified multilateral treaty to end proliferation of nuclear weapons.

Finally on August 24, 1967, the United States and the Soviet Union submitted identical but separate drafts of the treaty to the ENDC. After many revisions, the treaty was approved by the UN General Assembly and opened for signature on June 12, 1968, to the depositary governments of the United States, the United Kingdom, and the Soviet Union. The treaty went into effect on March 5, 1970. France and China eventually signed on as did 183 NNWS.

NPT Commitments: Successes and Failures

The NPT commits signatory NWS to not transfer their nuclear weapons to NNWS, or assist them in acquiring nuclear weapons. NNWS signatories agree to renounce nuclear weapons, and to remain open to inspections of their nuclear materials and activities by the International Atomic Energy Agency (IAEA). The NPT further commits states to hold conferences every five years in Geneva, Switzerland, to review the implementation and effectiveness of the treaty. In 1995, twenty-five years after the formal commencement of the treaty, the review conference voted to extend the agreement indefinitely, as opposed to holding five year reviews.

The NPT is important in that it is the legal basis for the nonproliferation and disarmament regime and the only universal arms control treaty. Countries throughout the world have been able to develop nuclear power for peaceful purposes without threatening neighbors or enemies. The NPT has had such an impact that, more than thirty-five years later, there are only eight countries that possess nuclear weapons (United States, Russia, France, England, China, India, Pakistan, and North Korea), a far cry from the hundred that was once predicted. Several countries, including South Africa, Argentina, and Brazil, have even been convinced to give up nuclear capabilities based on the strength of the regime.

While all the successes of the NPT may never be known, there are also some negatives to the regime. Critics contend that the larger share of the responsibility falls on NNWS, and that they face a military disadvantage because they are required to submit their programs to IAEA inspections while NWS are not. Non-aligned NNWS—that is, countries who are not part of a military alliance with the NWS states—sought security assurances that the NWS would not use weapons against them, but this was never explicitly confirmed in the final draft of the NPT.

Others claim that IAEA safeguards are oftentimes ineffectual, as was the case with Libya, which denied, and North Korea, which continues to deny access for IAEA inspection. India, which first tested a peaceful nuclear device in May 1974; Pakistan which tested a nuclear weapon in May 1998 following a test by India; and Israel are not party to the NPT, but all have nuclear weapons. For them to join, they would have to dismantle their nuclear weapons, as South Africa did in 1991. The world continues to encourage these countries to renounce their nuclear program and join the NPT. However each of the three nations is known to have nuclear weapons, as is North Korea, proving that despite the strides made by the NPT, proliferation is still possible and a valid threat to international security. Nevertheless those states party to the NPT continue to endeavor to strengthen the effectiveness of the NPT, and remain committed to securing nuclear free zones, and checking the proliferation of nuclear weapons.

The NPT, in both its successes and failures, exemplifies efforts to develop mechanisms of international governance for technologies of international significance. In this respect it may be compared to the Montreal Protocol for the reduction of the emissions of chlorofluorocarbons (CFCs) or the Kyoto Protocol for the reduction of green house gas emissions. Comparisons might also be made with the Law of the Sea Treaty for international sharing in the exploitation of seabed mineral resources and treaties to demilitarize space. The need for multinational governance of science and technology is clearly an important issue about which greater sophistication will only be developed by trial and error learning.

JESSICA L. COX
MARGARET COSENTINO

SEE ALSO *Baruch Plan; Just War; Limited Nuclear Test Ban Treaty; Military Ethics; Nuclear Ethics.*

BIBLIOGRAPHY

Bailey, Emily; Richard Guthrie; Daryl Howlett; and John Simpson. (2000). *Programme for Promoting Nuclear Non-Proliferation Briefing Book Volume I: The Evolution of the Nuclear Non-Proliferation Regime*, 6th edition. Southampton, UK: Mountbatten Centre for International Studies.

Sokolski, Henry. (2001). *Best of Intentions: America's Campaign against Strategic Weapons Proliferation*. Westport, CT: Praeger Publications.

INTERNET RESOURCES

Monterey Institute of International Studies. "Center for Nonproliferation Studies Non-Proliferation of Nuclear Weapons Treaty Tutorial." Available from http://cnsdl.miis.edu/npt.

United Nations. "Treaty on the Non-Proliferation of Nuclear Weapons." Available from http://www.un.org/Depts/dda/WMD/treaty/.

United States Department of State. "Treaty on the Non-Proliferation of Nuclear Weapons." Available from http://www.state.gov/www/global/arms/treaties/npt1.html.

NUCLEAR REGULATORY COMMISSION

The U.S. Nuclear Regulatory Commission (NRC) is an independent agency of the federal government with a mission to protect public health and safety from the hazards of the civilian use of nuclear energy technology. The NRC oversees nuclear power reactors, radioactive waste disposal, and medical, industrial, and academic uses of nuclear materials. The NRC was created through the Energy Reorganization Act of 1974, which divided the Atomic Energy Commission (AEC, created in 1947) into the NRC and the Energy Research and Development Administration (ERDA). The ERDA was subsequently subsumed into the Department of Energy (DOE).

Prior to the reorganization, the AEC both regulated and promoted nuclear energy technology as well as managed the nuclear weapons complex. Having both regulatory and promotional functions for nuclear technology within the AEC led many in Congress and in the general public to charge the AEC with a conflict of interest. Recognizing that low public confidence in the AEC to regulate objectively would slow and perhaps paralyze the growth of nuclear technology, Congress created the NRC solely to regulate the nation's civilian nuclear energy activities. The DOE meanwhile had assumed the former AEC nuclear technology promotional functions and its management of the U.S. nuclear weapons complex.

Five commissioners, with one as chair, lead the NRC. All are presidential appointees who require Senate confirmation to staggered five-year terms. In addition to the staff officers who perform the daily work of the NRC, there is the Atomic Safety and Licensing Board Panel (ASLBP), which is the adjudicatory arm that conducts public hearings primarily on licensing and enforcement actions.

Regulatory Practice

When a reactor license holder decides to decommission a reactor and terminate the license, any member of the potentially impacted public may request an adjudicatory hearing. Depending on the regulatory action, a formal or informal hearing may be held. Formal hearings are trial-like proceedings with discovery of evidence, sworn testimony, and cross-examination. The determination of whether a hearing will be informal or formal is codified in NRC rules, Title 10 of the Code of Federal Regulations, Part 2, but there is allowance for some discretion. Although ASLBP members are employees of the NRC, there are rules under the Administrative Procedures Act that enable panel members' judicial independence. There are some stakeholders, however, who believe that the ASLBP cannot truly preside over an unbiased hearing because it is part of the NRC. ASLBP decisions ultimately may be appealed to the U.S. Supreme Court. There also exist three external advisory committees to the NRC, one on reactor safeguards, one on nuclear waste, and one on the medical uses of isotopes. These committees are made up of nuclear professionals from industry, academia, and government.

The NRC also regulates the production and use of source, special, and by-product nuclear materials. Source materials are the elements of thorium and uranium not enriched in the isotope uranium-235. Source material may be converted into special nuclear material, which is capable of undergoing the fission reaction (splitting of the atom). Special nuclear materials are uranium isotopes 233 and 235 and plutonium. By-product materials are made in the process of producing or using special nuclear material. By-product materials are used in medical, industrial, or research applications, such as carbon-14 for radioactive dating. By-product materials are also wastes from reactor operations, such as spent nuclear fuel, and from mining operations, which are called mill tailings. Collectively, source, special, and by-product materials are referred to as AEA (Atomic Energy Act) materials.

To produce or use AEA materials requires an NRC license. In general licenses may be considered either reactor or material licenses. For instance, a nuclear power plant owner holds at least two licenses, a reactor license for the operation of the power plant and a material license for possession of the fuel. The NRC regulates all aspects of a license, from initial licensing through termination. It is primarily license fees that fund the NRC. The NRC also has a fee-based certification and quality assurance program. In lieu of issuing a license, the NRC will certify some products, such as spent-fuel shipping casks. NRC certification then enables the potential user of these products to begin using them as long as the product meets the certification standards. Certification enables the NRC to expedite the regulatory process because standardization of design assures regulatory compliance without the burden of determining whether an individual case meets its regulatory criteria.

NRC regulations are promulgated through a formal rule-making process. Petitions for rule-makings may come from any of the NRC stakeholders, such as industry, nongovernmental environmental organizations, or individual citizens. The proposed rule is published in the *Federal Register*, and the public is invited to comment. In promulgating its final rule, also published in the *Federal Register*, the NRC explains how it had considered the public's comments. In general, the NRC does not hold hearings about proposed rules. Additionally, the NRC has an electronic rule-making forum, RuleForum, where the public may assess information and documents related to a rule, such as the comments of other stakeholders. An electronic reading room that contains all the NRC's public documents is also available. All NRC public documents are physically located in the reading room at headquarters in Rockville, Maryland. The NRC also performs research to support its regulations. Other activities include international cooperation regarding safety and security.

Regulatory Philosophy

Beginning in the mid-1990s, the NRC started to adopt a general regulatory philosophy across all its activities that is more risk-informed as well as performance-based. To implement this philosophy requires the NRC to ask three questions of its regulatory activities, the so-called risk triplet: What may go wrong? What are the consequences? How likely are these consequences to occur? Since its inception, the NRC had focused primarily on the consequences of what may go wrong and had prescribed "defense-in-depth" measures to effectively manage consequences; such measures include redundancy in emergency systems and engineering margins of safety. Asking how likely or probable a technology failure is requires carefully examining the relationships among the constituent elements and considering how each element contributes to the performance of the whole. This process enables the NRC to identify critical areas that may need more attention to safety. It may also find that a marginal decrease in resources in some areas is warranted because the decrease has no measurable effect on safety. This is one way risk information contributes to regulatory decision-making.

Enabling the public to better understand the reasons why the NRC believes a particular course of action poses no undue risk to the public health and safety is a major, continuing challenge. Indeed recognizing that the public's confidence in its regulatory integrity is critically dependent on the transparency of the decision-making process, the NRC continues to explore opportunities for open communication.

DARRYL L. FARBER

SEE ALSO *Nuclear Ethics; Three-Mile Island.*

BIBLIOGRAPHY

Balogh, Brian. (1991). *Chain Reaction: Expert Debate and Public Participation in American Commercial Nuclear Power, 1945–1975*. Cambridge, UK: Cambridge University Press.

Mazuzan, George T., and J. Samuel Walker. (1985). *Controlling the Atom: The Beginnings of Nuclear Regulation, 1946–1962*. Berkeley and Los Angeles: University of California Press.

Walker, J. Samuel. (1992). *Containing the Atom: Nuclear Regulation in a Changing Environment, 1963–1971*. Berkeley and Los Angeles: University of California Press.

Walker, J. Samuel. (2000). *Permissible Dose: A History of Radiation Protection in the Twentieth Century*. Berkeley and Los Angeles: University of California Press.

INTERNET RESOURCE

"U.S. Nuclear Regulatory Commission." Available from http://www.nrc.gov.

NUCLEAR WASTE

Disposal of nuclear waste has been a contentious issue both in the United States and elsewhere in the world. Difficult questions are involved, including: (1) where should one put the waste? (2) How long must such waste be stored before it does not pose a hazard to society? (3) What confidence can be placed in estimates of long-term confinement, and how great are the uncertainties? Because of the differing views on these topics and their complexity, their treatment here will necessarily be limited.

The focus here will be high-level radioactive waste produced at nuclear power plants. Excluded is any discussion of defense-related radioactive waste, or low-level radioactive waste generated from nuclear power, medical applications, industrial applications, and research. The basic issues for these other types of waste are related to and can be informed by the present analysis. There are, as well, books and lengthy articles providing more comprehensive treatments, which are included in the references.

Nuclear Waste Itself

In the United States there are two types of radioactive waste produced at nuclear reactors: low-level waste (LLW) and high-level waste (HLW). While low-level nuclear waste represents most of the waste volume, high-level waste represents most of the radioactivity. For this reason HLW presents the major problem.

High-level waste in the United States (and also Sweden and Finland) comprises the used nuclear fuel elements, called spent fuel. In France, Great Britain, and Japan, where fuel is reprocessed to remove unused uranium fuel and plutonium (which represents 95 percent of the material in spent fuel), HLW primarily includes fission products and long-lived radioactive materials called actinides. (Russia and China are developing reprocessing capability, and Germany, the Netherlands, Switzerland, and Belgium reprocess their spent fuel elsewhere.) These are incorporated into radiation-resistant glass to produce blocks that can be placed into a temporary storage facility or a permanent underground facility. In the United States there is no reprocessing, so the HLW is in the form of solid fuel elements that contain all the products mentioned above.

High-Level Waste Disposal Facilities

In the early twenty-first century, all spent fuel in the United States was stored on the sites of the nuclear power reactors because no long-term storage facilities were available. This included sixty-four reactor sites in thirty-one states. When spent fuel is initially removed from the reactor it generates considerable heat from radioactive decay so that initial storage is in pools of water. After the spent fuel has been stored for a minimum of five years it can be moved to specially designed steel and concrete aboveground casks, approved by the Nuclear Regulatory Commission (NRC), that rely on air cooling to remove the heat. No accidents with spent fuel elements have occurred in which radiation has been released to the public. The HLW generated at a reactor in forty or more years of operation can be stored on-site, indicating that the volume of HLW generated at each reactor is quite low. Indeed, as Kristin S. Shrader-Frechette (1993) has argued at length, aboveground monitored retrieval storage may be a defensible option.

Political Processes for High-Level Radioactive Waste Disposal

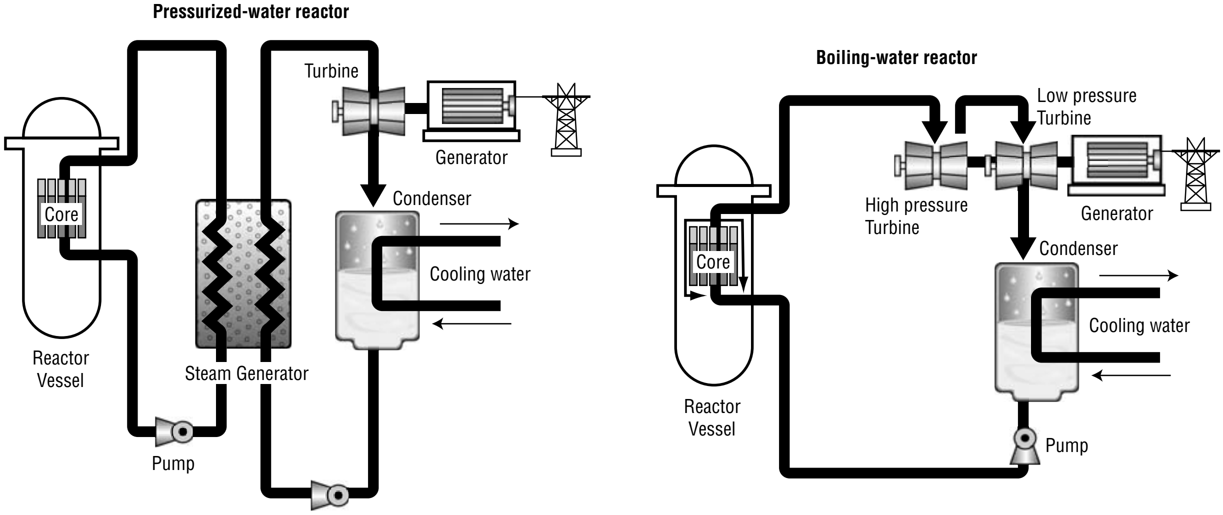
The U.S. Department of Energy (DoE) has the ultimate responsibility for permanent disposal of high-level waste in the United States. Based on a strong consensus of international expert opinion, the best place for permanent storage of HLW is in a geologic repository deep underground in an environment that is both geologically stable and exceptionally dry. The Nuclear Waste Policy Act (NWPA) of 1982 chartered the DoE with the responsibility to develop a permanent geological repository for HLW. The NWPA also charged the Environmental Protection Agency (EPA) with the responsibility for developing environmental standards and the NRC with responsibility for evaluating whether the repository design submitted by the DoE meets these standards.

Initially three potential sites were identified for detailed study as possible repositories. The law was amended in 1987, however, to focus on a single site at Yucca Mountain in Nevada. Through these amendments, Congress also established an independent advisory group of experts, the U.S. Nuclear Waste Technical Review Board (NWTRB), to evaluate the technical and scientific validity of the DoE's efforts to develop a repository. The NWTRB issues annual reports to Congress and the secretary of energy with their evaluations.

Under the DoE plan, solid nuclear waste would be placed in extremely durable containers—called waste packages—that would be put into deep underground tunnels in dry, stable, volcanic rock. The safety concern is that, over time, enough water would come in contact with

FIGURE 1

Pressurized-Water Reactor and Boiling Water Reactor



SOURCE: U.S. Energy Research and Development Administration. "Advanced Nuclear Reactors," ERDA-76-107, May 1976.

the waste to cause the release of radioactive elements and the transport of these materials to the water table. The proposed Yucca Mountain repository is about 1,000 feet below the land surface and 1,000 feet above the water table.

In 2002, after fifteen years of study, the DoE issued reports concluding that the Yucca Mountain site was suitable for a geologic repository for HLW. The DoE that year submitted to the president a recommendation for approval to proceed with the development of the Yucca Mountain repository. The NWTRB did not make a judgment regarding this recommendation because acceptability involves public policy issues that are beyond the board's mandate. The board did note that no scientific or technical factor had been identified that would eliminate Yucca Mountain as a permanent repository site, but also that there were gaps in data and basic understanding that result in important uncertainties in performance estimates. In essence, although sophisticated models have been used to predict whether the waste can be safely stored to meet EPA and NRC criteria, there remain uncertainties in the accuracy of the models and in the predictions. How much certainty is required to make a decision? And are the criteria for leak rates or confinement times the appropriate ones to use? These critical issues are difficult for experts to evaluate and for the public to understand. In the end, a political decision on acceptability is required.

Notwithstanding the concerns indicated above, President George W. Bush approved the recommendation and sent it to Congress, which then voted to approve it as well. The DoE's goal is to begin storing spent fuel beginning in 2010. A minimum of fifty years has been specified for studies of the repository performance before it can be closed. The DoE then has to apply to the NRC for a license to close the repository. During this time the repository will be monitored to enhance the understanding of the processes taking place in the repository, to determine if the behavior is in agreement with predictions of the models, and to correct any problems that are identified.

Yucca Mountain

The approvals to proceed with the repository at Yucca Mountain were highly controversial. The citizens and government of Nevada have strongly opposed the repository, regardless of whether the site is suitable. They contend that the benefits of nuclear power are primarily obtained elsewhere in the nation, but Nevada is expected to accept the risks for any kind of problem or accident related to handling or disposing of spent fuel at the repository. Because this is a national issue it is probably inevitable that there would be a conflict between federal and state interests. In December 2001 Nevada filed suit in federal court against the decision to proceed based on several technical and legal issues. In July 2004

Drums of radioactive waste lying in a trench at Hanford Nuclear Reservation. *(© Roger Ressmeyer/Corbis.)*

the U.S. Court of Appeals ruled that the U.S. Environmental Protection Agency (EPA) illegally set its radiation release standards for groundwater for the proposed high-level radioactive waste dump. Two months later, the Nevada attorney general initiated a new lawsuit, claiming the DOE lacked the authority to make many of the decisions required to continue the project.

Some opponents of Yucca Mountain repository argued that outstanding scientific questions remained that should be answered before one could be reasonably confident that the safety criteria can be met. They called for further research and a resolution of some of the technical uncertainties. Antinuclear groups, such as Greenpeace, expressed opposition to any solution to the waste problem, including Yucca Mountain. This strikes at the core issue of acceptable risk and how the United States, as a society, is to deal with wastes. Not doing anything is simply a different kind of solution and may not be the best one for society. Furthermore, the waste is a by-product of a technology that was introduced for the benefit of society, in this case to produce electricity without the environmental problems of fossil fuels. Ultimately to gain the benefit it is necessary to address and solve the waste problem. But can one find a solution in which all the stakeholders are satisfied? Certainly Nevada and its citizens were not satisfied. Whether the Yucca Mountain decision achieves fairness and acceptability will continue to be debated by groups with differing opinions.

Another issue that affects public acceptability is whether spent fuel can be shipped safely to the site or whether such shipments pose an unacceptable hazard. What about accidents or terrorist attacks? The transport of spent fuel would occur on railway cars or in trucks in specially designed casks. These casks, designed to meet requirements of both the NRC and the U.S. Department of Transportation, are tested to demonstrate they can withstand crashes, fire, water immersion, and puncture. A truck carrying such a cask was crashed at 80 miles per hour into a concrete barrier. Although the cask was damaged it did not leak. Moreover, shipments of spent fuel are not new. From the early 1960s to the early 2000s, about 3,000 such

Entrance to a tunnel into Yucca Mountain in Nevada. The mountain is the site of the proposed Yucca Mountain Repository, a U.S. Department of Energy terminal storage facility for spent nuclear fuel and other radioactive waste. *(© Dan Lamont/Corbis.)*

shipments covered more than 2.7 million kilometers (1.7 million miles) of U.S. roads and railways without any radioactive material being released as a result of an accident. Regarding terrorist acts, there are factors that make such shipments undesirable targets. The casks are massive and weigh many tons; and the trucks and trains that carry them are guarded and tracked via satellite communication. Even a shoulder-mounted rocket would be unlikely to crack the cask, and if it did little radioactivity would be released to the environment because the fuel is solid. The implication by anti–Yucca Mountain groups that the transported fuel represents a serious hazard is not supported by experience or analyses.

The plutonium that is in the spent fuel presents a different type of issue. Reprocessing reduces the volume of waste by about 75 percent and slashes the amount of time that the waste needs to be stored; reprocessed HLW will return to the radioactivity levels of mined ore within a couple thousand years, whereas spent fuel requires considerably longer because of the plutonium. Furthermore, the plutonium that is recovered through reprocessing is incorporated into fuel, thus reducing the total inventory of plutonium. But reprocessing also carries risks of proliferation, because reprocessed plutonium might be diverted or stolen to produce nuclear weapons. Initially the United States was committed to reprocessing, but in the late 1970s President Jimmy Carter decided not to proceed with reprocessing in the hope that other nations would follow the U.S. example. This would have limited the opportunity to clandestinely obtain plutonium that was produced in nuclear power reactors. Carter's effort proved unsuccessful because neither the Europeans nor the Japanese showed any interest in following suit. Independent of the security argument over reprocessing there is no economic incentive in the United States to revive reprocessing unless the price of uranium fuel rises significantly.

High-Level Waste in Other Countries

High-level waste disposal is required for every country that has nuclear power. Active research programs for deep geologic storage are under way in many countries, including Sweden, Finland, Germany, France, Switzerland, Great Britain, Russia, and China. Only Finland has committed politically to a specific disposal site. Other nations are carrying out research at one or more sites and have yet to complete the selection process. In December 2003 the European Union decided to evaluate the possibility of regional repositories, primarily to assist smaller countries. Based on the experience in the United States and in many of the above nations, it may be a difficult and contentious process before a final decision is reached.

Assessment

While critical issues have been decided in creating the Yucca Mountain repository there are many outstanding issues still to be resolved. Scientific studies that support critical engineering design decisions are still needed. The issuance of an NRC license, which will include extensive public hearings and most likely legal challenges, is also ahead. Furthermore, numerous construction activities must be completed. With expected appeals, it will be a daunting task for the Yucca Mountain repository to be ready to receive spent fuel by 2010.

Finally, creating a permanent repository will be a very expensive undertaking. As of September 2002, the fund to pay for design, development, and ultimate storage of spent fuel has accumulated $23 billion and grows by $1 billion per year because of the Congressionally mandated 0.1 cent per kilowatt-hour charge on nuclear-generated power.

Nevertheless, the full cost to society of safely disposing of nuclear waste must factor in the damages avoided or benefits because of the noncarbon emissions from nuclear power. In other words, depending upon how the damages to the environment from fossil fuel plants are valued, the cost of disposing of nuclear waste may be a real bargain.

Future generations will judge whether the nation acted responsibly and appropriately in its decision regarding the disposal of spent fuel at an HLW repository at Yucca Mountain. If the decision is reversed, long-term monitoring would be needed to assure that this repository has solved a problem and not created a new one.

EDWARD H. KLEVANS
DARRYL L. FARBER

SEE ALSO *Nuclear Ethics; Nuclear Regulatory Commission; Waste.*

BIBLIOGRAPHY

Carter, Luther J. (1987). *Nuclear Imperatives and Public Trust: Dealing with Radioactive Waste.* Washington, DC: Resources for the Future.

Murray, Raymond L. (2003). *Understanding Radioactive Waste,* 5th edition, ed. Kristin L. Manke. Columbus, OH: Battelle Press.

Organisation for Economic Co-operation and Development. Nuclear Energy Agency. (1995). *The Environmental and Ethical Basis of Geological Disposal of Long-Lived Radioactive Wastes.* Paris: Author. Also available from http://www.nea.fr/html/rwm/reports/1995/geodisp.html.

Shrader-Frechette, Kristin S. (1993). *Burying Uncertainty: Risk and the Case against Geological Disposal of Nuclear Waste.* Berkeley and Los Angeles: University of California Press.

INTERNET RESOURCES

"Nuclear Science and Technology." American Nuclear Society. Available from http://www.aboutnuclear.org/. Contains information on waste types and disposal methods.

"Office of Civilian Radioactive Waste Management." U.S. Department of Energy. Available from http://www.ocrwm.doe.gov/. Includes information on the Yucca Mountain Project, including reports relating to the recommendation submitted to President George W. Bush.

"Radioactive Waste." U.S. Nuclear Regulatory Commission. Available from http://www.nrc.gov/waste.html. Contains explanations of waste, its regulation and transportation.

"Radioactive Wastes." World Nuclear Association. Available from http://www.world-nuclear.org/info/inf60.htm.

"RadWaste.org." Herne Data Systems. Available from http://radwaste.org/. General website with a great deal of information on radioactive waste.

U.S. Nuclear Waste Technical Review Board. "Report to the Secretary of Energy and the Congress." Available from http://www.nwtrb.gov/reports/reports.html. Report from March 2003 summarizing the board's activities during 2002.

NUTRITION AND SCIENCE

Although awareness of the relationship between food and health has a long history, the science of nutrition developed out of discoveries in modern chemistry and medicine. The professionalization of nutrition science resulted in its directly influencing food production, preparation, and consumption. Increased influence also meant increased responsibility to the public and the food industry as well as to governmental and international agencies. Such issues as the safety of food and its just distribution led to both controversies and codes of ethics. Nutrition scientists have not always recognized and analyzed the relationship between their work and moral values, but with the growth of the world's population and the increase in knowledge of what constitutes a healthful diet, the ethical debates surrounding nutrition science are likely to multiply and deepen.

Historical Developments

As with their animal ancestors, members of *Homo sapiens,* in order to survive, learned about edible fruits, vegetables, and animals from experience, and to increase the quality of their lives in difficult conditions, humans domesticated crops and animals for food. Though the process was slow, they also learned how to improve plants and animals by selection and hybridization. Before the science of nutrition developed, humans had discovered how to exploit such microorganisms as yeast and bacteria to manufacture such new foods and beverages as cheese and beer. By the use of salt and desiccation, they could also preserve foods to sustain life during times of shortages.

In the nineteenth century, as chemistry became a sophisticated discipline, knowledge of complex organic compounds allowed researchers to pinpoint foodstuffs essential for good health and to reveal insalubrious or fraudulent foods. Technological changes associated with food production during this period were much more dramatic than in the previous millions of years of *Homo sapiens*' evolution. During the nineteenth century problems associated with rapid industrialization, such as polluted water, adulterated food, and inadequate sanitation in overcrowded slums, led to the public health movement in England, Germany, France, and the United States. Stimulated by ethical concerns, public health officials alerted citizens to the dangers of foods that were nutritionally inadequate, sometimes even dangerous. For example, milk, traditionally viewed as a nutritious food for most children, could be the carrier of disease, until Louis Pasteur introduced a procedure, pasteurization, whereby heating milk killed infectious microorganisms. Advocates of pasteurization, however, were often opposed by members of the food industry who wished to avoid additional costs. In the 1880s in the United States, the agricultural chemist Stephen M. Babcock attacked milk adulteration by discovering an efficient test to determine milk's fat content, which did more, according to a Wisconsin governor, to promote ethical behavior among dairymen than reading the Bible.

The most dramatic developments in the science and technology of nutrition occurred in the twentieth century when new knowledge, techniques, laws, governmental agencies, and public policies contributed to extending life expectancies in many industrialized nations in Europe and America by over twenty-five years. But at the beginning of the century nutrition science remained in its infancy as, for example, many physiologists believed that what kind of food people ate mattered little, as long as diets supplied enough energy (calories) and sufficient materials (proteins) for the body's growth and maintenance. Only slowly did scientists discover the importance of trace nutrients for ideal health.

During the first third of the twentieth century researchers found that such diseases as rickets, beriberi, and scurvy had a specific dietary origin. Lack of small amounts of vitamins (water-soluble or fat-soluble organic substances essential for good health) caused these diseases. Concurrently American and German scientists, studying the roles of amino acids in nutrition, found several of these compounds essential to good health. Furthermore, work done largely in the United States indicated that, besides vitamins and amino acids, the healthy survival of experimental animals and humans required in their diets such inorganic elements as sodium, potassium, calcium, magnesium, iron, zinc, and phosphorus. This accumulated knowledge was so important that, by the time of World War II, the National Research Council published a set of Recommended Dietary Allowances (RDAs) for foods, vitamins, and minerals. Though concerns growing out of wartime food rationing prompted this list, RDAs proved so helpful that they continued to be periodically issued, with modifications based on up-to-date nutritional research.

Nutritional Professionals and Ethics

The communication and multiplication of discoveries by nutrition scientists was facilitated by the formation of professional organizations and journals. For example, the American Institute of Nutrition began publishing its *Journal of Nutrition* in 1928, and in 1939 several important nutrition scientists in the United Kingdom formed the Nutrition Society, whose official publication was the *British Journal of Nutrition*. In the decades after World War II, agricultural chemists discovered high-yield crops that enabled farmers to produce enough food to nourish every person on Earth (the "green revolution"). Nevertheless, hundreds of millions of people remained malnourished, presenting concerned authorities with profound ethical problems, because the United Nations (UN) as well as various religious organizations maintained that every human had an inalienable right to be free from hunger and deficiency diseases.

At the UN, the Standing Committee on Nutrition established an Intergovernmental Working Group to develop guidelines for the implementation of the right to adequate food, as recommended by the 2002 World Food Summit. As international and national agencies and various professional societies became sensitive to the ethical implications of food and nutrition, so did trade associations involved with the production of foods and dietary supplements. For example, the Council for Responsible Nutrition, a trade organization, developed a code of ethics "dedicated to enhancing the health of the American public through improved nutrition, including the appropriate use of dietary supplements." This organization, founded in 1973, played an important role in several laws passed by the U.S. Congress in the last quarter of the twentieth century regulating nutritional substances.

Despite these ethical codes, laws, and world conferences, the numbers of the malnourished, according to reports issued by the UN's Food and Agriculture Organization, continued to increase in the decades after World War II. Some believed that the problem could be solved only in terms of development, that is, providing poor countries with the scientific and technical know-how to grow the food they needed. Others criticized this approach, because technology, while it could help to increase crop yields and improve food distribution, could prevent neither natural disasters nor political turmoil. Still others believed that malnutrition, which occurred not only in developing but also in developed countries, is a complex problem involving science and technology as well as economics, politics, and culture. These people held that what was needed was a multifaceted program that, while introducing new foods and technologies, also paid attention to economic growth, health education, and regional ecologies and cultures.

Safety and Equity

Unlike early nutrition scientists, who were able to link various diseases to specific dietary causes, modern researchers have discovered that such diseases as cancer and arteriosclerosis have multiple causes. According to some researchers, foods high in saturated fats will increase blood cholesterol levels, and many nutrition scientists agree that elevated levels of low-density lipoproteins (LDLs), which carry most of the cholesterol, increase the risk of coronary artery disease. Based on this evidence some criticized McDonald's and other fast-food restaurants for selling unsafe foods. Indeed, some critics went so far as to attack the majority of American food-production companies for reducing the consumption of fresh fruits and vegetables and increasing high-fat, high-sugar artificial foods, thus being partially to blame for such health problems as obesity, diabetes, and heart disease.

Cultural groups and their associated ideologies often influence dietary practices. Some traditional foods, such as green tea in Asian countries, have proven to be beneficial, but other practices, such as Latin American mothers' withholding milk and eggs from sick children, are harmful. Several cultural groups have practiced vegetarianism for a variety of social, religious, economic, or nutritional reasons. Some prominent nutritionists have attacked vegetarianism, insisting that meat is needed to avoid deficiencies of such essential substances as vitamin B_{12}. Others have pointed out, however, that there are hundreds of millions of Hindus, most of whom do not consume any animal products throughout their lives, and few of them exhibit B_{12} deficiencies and they generally have reduced incidences of heart disease, colon cancer, and diabetes.

A principal aim of the ethics of nutrition is to improve the food habits of people, and an important component of this good work is to understand a country's culture. Equity requires that every human being in every culture has the right to be properly nourished. Consequently developed countries, with their surpluses of food, have a duty to the undernourished in developing countries. Even in developed countries citizens have the right to be provided with good food, but in the United States, for example, many consumers have either wasted their money or harmed their health by various food and diet fads. Many nutrition scientists consider it unethical for "medical quacks" to be making large amounts of money in this way from gullible Americans.

Nutrition Controversies

While many believe that science and technology should be an important part of the solution of such problems as malnutrition, others see science and technology as part of the problem. For example, scientists invented various herbicides to aid farmers in food production, but some of these herbicides were used in the Vietnam War to deprive people of food. This was certainly not the first war in which participants used starvation as a weapon, as the siege of Paris during the Franco-Prussian War (1870–1871) and the siege of Leningrad by the Germans during World War II make clear.

Controversies also exist about what constitutes a balanced diet and whether or not dietary supplements should be used. For example, medical researchers and nutrition scientists seem to have reached agreement that Americans should reduce fats in their diets, an assertion repeatedly confirmed by the U.S. Department of Agriculture's dietary guidelines and in its widely disseminated Food Guide Pyramid, in which fats and sweets occupy a tiny area at the pyramid's top, indicating that fats, oils, and sweets should be consumed only "sparingly." But recent critics of the "dogma of the deadliness of dietary fats" have pointed out that the data are ambiguous on the benefits of low-fat diets. Despite the proliferation of reduced-fat food products, obesity and diabetes have actually increased. Furthermore, epidemiological studies of countries such as France, where animal fat consumption has risen, have shown that heart-disease death rates have declined.

Mainly in Western countries, recent controversies have centered on anorexia nervosa, a self-imposed starvation disorder, and bulimia, a binge–purge eating disorder. Scientists are divided over the roles played by society and the media as well as by a person's genetic makeup, psychological state, and physiology in fostering such conditions. Other controversies over vitamins, herbs, and fiber in the diet have revealed the complex interrelationships existing among professional nutritionists, members of the natural-foods movement, food producers, and various scientists outside the nutritional field. Ethical issues are inextricably bound into these controversies because of various conflicts of interest. For example, the work of some nutrition scientists has been supported by food producers, but advocates of megavitamin therapy for health problems ranging from the common cold to cancer have accepted contributions from companies manufacturing these vitamins. Some who express concern over the unregulated sale of herbs and nutritional supplements want the government to control their use the way they do prescription drugs, but those who consider these substances as foods see such actions as infringing their freedom of choice.

Advances in medical technologies have also raised concerns about the nutrition of the elderly and dying. Many religious ethicists distinguish between ordinary and extraordinary means of treatment, claiming that a moral obligation exists to use ordinary means (food and water) to maintain life but no strict obligation exists to use extraordinary means (respirators). Others hold that no obligation exists to continue feeding a patient when only biological, not mental, life remains; still others argue that this assessment exhibits an impoverished view of human personhood. Ethical issues raised by feeding the world's poor, sick, and dying are certainly controversial and complex. Scientific knowledge and new technologies can help solve some of these problems, but they may exacerbate others. Further complexities will confront humankind in the future, because nutrition is an evolving science. As research generates new knowledge and technologies, ethicists, as they have in the past, will have to take into account this expanded understanding in making their moral judgments.

ROBERT J. PARADOWSKI

SEE ALSO *Agricultural Ethics; Food Science and Technology.*

BIBLIOGRAPHY

Brogdon, Jennie, and Wallace C. Olsen, eds. (1995). *The Contemporary and Historical Literature of Food Science and Human Nutrition.* Ithaca, NY: Cornell University Press. A bibliographical survey of primary journals, core monographs, and historical literature in nutrition science with chapters covering 1850 to 1950, 1950 through the early 1990s, and important recent developments in food science.

Brown, Lester Russell, and Erik P. Eckholm. (1974). *By Bread Alone.* New York: Praeger. Brown, who began his presidency of the Worldwatch Institute in the year this book was published, is concerned with the ethics of global food production and distribution and their relationship to population growth and resource depletion.

Lacey, Richard W. (1994). *Hard to Swallow: A Brief History of Food.* Cambridge, UK: Cambridge University Press. Lacey wrote this popular account of the production, processing, and healthfulness of foods to stimulate readers to think about the nature of what they eat.

Mather, Robin. (1995). *A Garden of Unearthly Delights: Bioengineering and the Future of Food.* New York: Penguin. A science journalist analyzes the controversial new field of food bioengineering and the movements against it.

Maurer, Donna, and Jeffrey Sobal, eds. (1995). *Eating Agendas: Food and Nutrition as Social Problems.* New York: Aldine de Gruyter. A sociological analysis of food safety, biotechnology, vegetarianism, and other issues by experts from around the world.

Mayer, Jean. (1972). *Human Nutrition: Its Physiological, Medical, and Social Aspects.* Springfield, IL: Charles C. Thomas. Surveys the field of human nutrition in its scientific as well as social and political contexts.

McCollum, Elmer Verner. (1957). *A History of Nutrition: The Sequence of Ideas in Nutrition Investigations.* Boston: Houghton Mifflin. McCollum, who has been called "America's most eminent nutrition scientist," presents a knowledgeable survey of the principal advances.

Sanjur, Diva. (1982). *Social and Cultural Perspectives in Nutrition.* Englewood Cliffs, NJ: Prentice-Hall. A sociocultural analysis of food, with an emphasis on conceptual frameworks and methodological options.

Shue, Henry. (1996). *Basic Rights: Subsistence, Affluence, and U.S. Foreign Policy,* 2nd edition. Princeton, NJ: Princeton University Press. This new edition of a well-received book updates the author's thesis that justice requires developed nations to share their knowledge and wealth with the chronically malnourished nations.

O

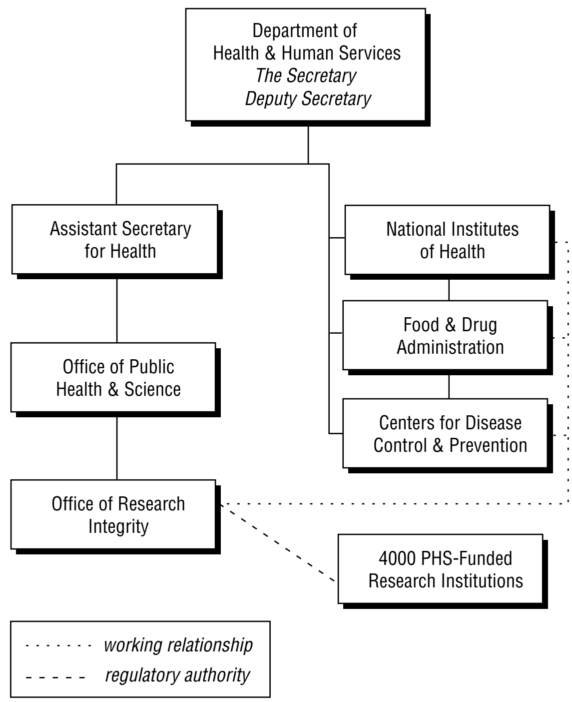
OFFICE OF RESEARCH INTEGRITY

• • •

The United States Office of Research Integrity (ORI) has broad responsibilities for monitoring investigations of misconduct and promoting integrity in research supported by the Public Health Service (PHS). It is administratively located in the Office of Public Health and Science (OPHS) within the Office of the Secretary of Health and Human Services (OS, HHS) and reports to the Secretary of HHS through the Assistant Secretary for Health (ASH). The scope of its responsibilities extends to about four thousand research institutions worldwide. Although separate from the major PHS research funding agencies, such as the National Institutes of Health (NIH), the Centers for Disease Control (CDC), and the Food and Drug Administration (FDA), ORI works with these agencies as well as other government agencies to promote responsible conduct in federally supported research.

FIGURE 1

Placement of the Office of Research Integrity Within DHHS



SOURCE: Courtesy of Nicholas H. Steneck.

Origin and Development

The origins of ORI extend back to the early 1980s when Congress began formal investigations into a number of widely reported cases of misconduct in research. The federal agencies that supported the research and the research community initially assured Congress that misconduct in research was rare and appropriately handled through professional self-regulation. However, after more cases emerged, some involving high profile researchers, Congress intervened and passed the Health Research Extension Act of 1985 requiring PHS to establish a formal definition of and provisions for investigating misconduct in PHS-funded research.

In response to the Congressional call for action, PHS published an Interim Policy on Research Misconduct in 1986, followed in March 1989 by the announcement that two offices would be established to investigate and adjudicate research misconduct cases: the

Office of Scientific Integrity (OSI) in the Office of the Director of NIH and the Office of Scientific Integrity Review (OSIR) in the Office of ASH (OASH). Five months later in August 1989, in a so-called Final Rule for research misconduct, PHS outlined the responsibilities of the new offices as well as those of research institutions accepting PHS funds for research. The two offices were combined in May 1992 to form the ORI, located in OASH.

During its early years, ORI focused the majority of its efforts on research misconduct, including the investigation of individual cases, the development of an assurance program for institutional misconduct policies, and the organization of programs designed to help research institutions develop expertise for handling their own misconduct cases. In the early twenty-first century, spurred in part by a reorganization plan published in May 2000, more attention has been given to understanding the factors that influence research integrity and ways to foster responsible conduct in research. These efforts are promoted through both funding and professional support for conferences, educational programs, and research projects.

Relations to Science, Technology, and Ethics

The ORI role in the discussion of the relationships between science, technology, and ethics is concerned with actual researcher practices and whether these practices conform to the standards and/or ideals for responsible conduct in research. Accordingly its efforts generally *do not* encompass the consideration of broader ethical questions, such as the appropriateness of particular research topics or the ethical dilemmas posed by human- or animal-subject research. ORI is also concerned principally with biomedical and behavioral research. Its work, however, relies on methods and advice from the social sciences, natural sciences, humanities, and relevant professions.

ORI has played a prominent, if at times controversial, role in stimulating the national debate about the importance of integrity in research and the adoption of policies to promote responsible conduct in research. During the 1990s, ORI and its counterpart agency in the National Science Foundation (NSF), the NSF Office of the Inspector General, assumed the lead in defining research misconduct and establishing procedures for its investigation. The three inappropriate behaviors that were identified by PHS and NSF as antithetical to responsible conduct in research—fabrication, falsification, and plagiarism (FFP)—quickly became community standards and were adopted by many research institutions as the basis of their misconduct policies. The common federal definition of research misconduct, formulated in December 2000, begins with FFP. During the prolonged discussion of the definition of research misconduct in the 1990s other options were suggested, but none received wide acceptance by the research community.

ORI has also played an important role in encouraging the research community to think of integrity in research as more than simply avoiding misconduct. Others have contributed to this effort. In 1992 a National Academy of Sciences (NAS) Report, *Responsible Science,* argued that along with misconduct researchers must be concerned with other *questionable research practices,* such as the failure to maintain adequate records, improper or undeserved authorship, or the inappropriate use of statistics. Through its conference programs and research on research integrity grants, ORI continues to encourage serious discussion of and research on the many factors that foster and detract from integrity in research.

Finally ORI is deeply involved in efforts to foster education on the responsible conduct of research (RCR). National recognition of the importance of RCR can be traced to the 1989 Institute of Medicine Report, *The Responsible Conduct of Research in the Health Sciences.* Within a year, NIH made RCR education a requirement for all Training Grant (T-32) applications and in 2000 ORI proposed, but later suspended, a requirement that would have made RCR education mandatory for key personnel on all PHS-funded research. Whether or not ORI ever issues a final RCR policy/requirement, it is committed to and is providing resources for developing and assessing ways to improve integrity in research through education.

The pressures and public concerns that led to the formation of ORI are unlikely to disappear in the near future. While the number of cases remains small in comparison to the size of the research community, research misconduct remains a problem that continues to undermine public confidence. Moreover, as the financial, political, and social stakes of research outcomes grow in importance, the significance of questionable research practices takes on new meaning. Improper or undisclosed conflicts of interests have been discovered in the deaths of subjects enrolled in clinical trials and the biased reporting of research results. Research data are sometime improperly hoarded, taken, or used. Authorship standards vary widely and are frequently abused. As long as the *human side* of research remains an important factor in shaping both practice and outcomes, ORI, its companion agencies elsewhere in government, and institutional research offices should continue to play an important role in protecting the public's investment in research.

NICHOLAS H. STENECK

SEE ALSO *Misconduct in Science; Research Integrity.*

BIBLIOGRAPHY

Bivens, Lyle W. (1994). "ORI and Misconduct Investigations." *Science* 263: 593.

Commission on Research Integrity, U.S. Department of Health and Human Services. (1995). *Integrity and Misconduct in Research: Report of the Commission on Research Integrity*. Washington, DC: Author. This *Report* began the internal review process that led to the reorganization plan published in May 2000.

Hallum, Jules V., and Suzanne W. Hadley. (1990). "OSI: Why, What, and How." *ASM News* 56(12): 647–651.

Institute of Medicine, and Committee on the Responsible Conduct of Research. (1989). *The Responsible Conduct of Research in the Health Sciences*. Washington, DC: National Academy of Sciences. The first major report to urge research institutions to institute training in the responsible conduct of research.

National Academies of Science. (1992). *Responsible Science: Ensuring the Integrity of the Research Process*. Report of the Committee on Science Engineering and Public Policy, Panel on Scientific Responsibility and the Conduct of Research. Washington, DC: National Academy Press. A careful study of the issues raised by misconduct in research that influenced later discussions even though its proposed definition of research misconduct was not adopted.

Pascal, Chris B. (1999). "The History and Future of the Office of Research Integrity: Scientific Misconduct and Beyond." *Science and Engineering Ethics* 5(2): 183–198.

Pascal, Chris B. (2000). "Scientific Misconduct and Research Integrity for the Bench Scientist." *Proceedings of the Society for Experimental Biology in Medicine*. 224(4): 220–230.

Price, Alan R. (1994a). "The 1993 ORI/AAAS Conference on Plagiarism and Theft of Ideas." *Journal of Information Ethics* 3(2): 54–63.

Price, Alan R. (1994b). "Definitions and Boundaries of Research Misconduct—Perspectives from a Federal-Government Viewpoint." *Journal of Higher Education* 65: 286–297.

Steneck, Nicholas H. (1994). "Research Universities and Scientific Misconduct—History, Policies, and the Future." *Journal of Higher Education* 65: 310–330.

Steneck, Nicholas H. (1999). "Confronting Misconduct in Science in the 1980s and 1990s: What Has and Has Not Been Accomplished?" *Science and Engineering Ethics* 5(2): 1–16.

Steneck, Nicholas H., and Mary D. Scheetz. (2002). *Investigating Research Integrity: Proceedings of the First ORI Research Conference on Research Integrity*. Washington, DC: Office of Research Integrity.

OFFICE OF TECHNOLOGY ASSESSMENT

The U.S. Congress established the Office of Technology Assessment (OTA) in 1972, late in the administration of President Richard Nixon (1969–1974). The brainchild of Representative Emilio Q. Daddario, a Connecticut Democrat (1959–1971), the OTA would become, along with the Library of Congress (established 1800) and the Congressional Budget Office (established 1974 one of three federal agencies providing advice directly to Congress rather than to the executive branch of government. Envisioned as an "early warning" mechanism that would alert lawmakers to the unwanted side effects of developing technologies, it also aimed to provide Congress with expertise somewhat analogous to that provided by presidential science advisors since the administration of Franklin Delano Roosevelt (1933–1945).

Historical Context

The OTA emerged in an era when science and technology were, on the one-hand, undergoing rapid expansion thanks in large measure to government sponsorship of research and development. On the other hand, science and technology during the 1960s and early 1970s had also come under increasing scrutiny and criticism in such works as Rachel Carson's *Silent Spring* (1962), Jacques Ellul's *The Technological Society* (1964), Ralph Nader's *Unsafe at Any Speed* (1965), Theodore Roczak's *The Making of a Counter Culture* (1967), and Charles Reich's *The Greening of America* (1970). Issues ranging from the unwanted side effects of pesticides to unsafe automobiles and the escalating arms race between the United States and the Soviet Union all contributed to an increasing awareness of, and concern about, the direction of modern technological society.

Against this backdrop, Representative Daddario, as chair of the Science, Research, and Development Subcommittee of the U.S. House Committee on Science and Astronautics, began exploring possibilities for equipping lawmakers with a mechanism through which the unwanted side effects of the burgeoning technological revolution could be foreseen and, thereby, forestalled. In essence, he envisioned arming the federal government with "a method of analysis that systematically appraises the nature, significance, status, and merit of a technological program" (Daddario 1967, p. 8). To perform this task, he recommended establishment of a technology assessment board, which, with its apt acronym, "TAB," would remain alert to the potential dangers and benefits of new technologies.

Concern over unwanted side effects of technological development, however, composed only one-half of the OTA mandate. In the face of an expanding federal budget for science and technology, members of Congress increasingly expressed concern that the legislative branch of government was being outstripped by the executive branch, thus making it difficult for Congress to fulfill its duties in the appropriations process and in the oversight of executive agencies. Specifically, members of Congress began demanding that the legislature have its own source of technical advice, independent from the executive branch.

These two distinct functions—namely, an early warning mechanism and independent scientific and technical advice—came together as Daddario's subcommittee completed the OTA legislation. The marriage, however, was an uneasy one. At the outset, Congress ensured that its membership would retain tight control over both the overall direction of the office and its specific tasks. A bipartisan Technology Assessment Board (TAB) governed the OTA. In addition to the nonvoting director, it consisted of six senators and six representatives, with an equal number of Democrats and Republicans. Assisting the TAB was the Technology Assessment Advisory Committee (TAAC). Comprising scientific and technical experts appointed by the TAB, the TAAC was charged with making recommendations to the TAB on the operations of the office and on specific assessments—but only on TAB request.

Success and Failure

Under Daddario, who served as the first director from 1973 to 1977, the OTA managed to navigate the tensions of its dual mission of providing independent advice and assessing the negative impacts of technology. Under Daddario, the office earned a reputation for providing timely and high-quality, if rather low-profile, studies in response to committee requests. But in contrast to the initial vision of the OTA as a bold early-warning apparatus, the office, in those early years, failed to fulfill its role as an assertive policy-influencing mechanism. As such, in the eyes of some critics, the office proved a stark disappointment.

The second director, Russell Peterson (a former Republican governor of Delaware), had grander visions. Rather than dodging controversy and serving as mere adjunct of congressional committees, Peterson sought more autonomy for the OTA. In concert with the original early-warning idea, he envisioned the office as a leading force in defining federal technology policy. To that end, he had the OTA promulgate its own list of priority areas in need of attention. These ranged from "Applications of Technology in Space" to "Impacts of Technology on Productivity, Inflation, and Employment" to various environmental issues. Peterson's initiatives, while truer to the original technology-*assessment* idea, failed to reckon with the other *raison d'être*: the desire for experts beholden to the legislature, independent of the executive branch. Not surprisingly, members of the TAB bristled at his attempt at autonomy, and Peterson's tenure lasted barely a year.

In contrast to Peterson and his idea of defining a broad agenda to influence national policy, the third director, John Gibbons, a former research director at oak ridge national labs, moved the office back into a more reserved role as obedient respondent to congressional committee requests and reliable information source for Congress. Under Gibbons, the office consciously avoided making policy recommendations in its reports. Small by federal government standards, the office had about 200 employees and an annual budget of approximately $20 million. The OTA stabilized and survived for the next fifteen years under Gibbons and its final director, Roger Herdman, who took over when Gibbons left in 1993 to become science adviser to President Clinton. But, in forsaking a role as a policy advocate "assessing" alternatives, its leaders sowed the seeds of its eventual demise.

In early 1995, fresh off victory in the 1994 elections, fiscally conservative members of Congress sought to reduce the federal budget. Precisely because the OTA had defined itself as an objective information agency rather than a more autonomous and assertive policy advocate, it became hard to defend the office against charges that its functions could be subsumed into the legislature's much larger source for independent information, the Congressional Research Service (CRS) of the Library of Congress. Not persuaded that the OTA offered something that set it apart from the more traditional research capabilities of the CRS, Congress eliminated funding for the OTA in 1995.

In its twenty-three year history, the OTA produced some very solid and reputable studies in response to congressional committee requests. These included approximately 750 reports on topics ranging from energy to transportation to health. In the broader scheme of things, however, the OTA is perhaps more noteworthy insofar as it sheds light on an interesting attempt by U.S. lawmakers to equip government with an ability to foresee technological development and how, because of the executive–legislative tensions existing in the U.S. federal government, that initiative became configured and constrained by broader political and institutional dynamics.

GREGORY CLIFFORD KUNKLE

SEE ALSO *Constructive Technology Assessment; Discourse Ethics; Technology Assessment in Germany and Other European Countries.*

BIBLIOGRAPHY

Bimber, Bruce. (1996). *The Politics of Expertise in Congress: The Rise and Fall of the Office of Technology Assessment*. Albany: State University of New York Press. Professor Bimber uses the OTA as a case study to explore the politicization of expert advice in congressional agencies, concluding that the pluralistic nature of Congress results in more objective advice than that which prevails in executive agencies.

Daddario, Emilio Q. (1967). *Technology Assessment*. Statement prepared for the Subcommittee on Science, Research, and Development of the House Committee on Science and Astronautics. 90th Cong., 1st sess. Committee Print.

Kunkle, Gregory C. (1995). "New Challenge or the Past Revisited: The Office of Technology Assessment in Historical Context." *Technology in Society* 17(2): 175–196. The author examines the early history of the OTA to shed light on the then-current debate about abolishing the OTA, arguing that proponents of the OTA had to redefine the mission of the agency as something more than mere independent information in order for the OTA to survive.

U.S. Office of Technology Assessment. "The Ota Legacy, 1972–1995." CD-ROM, Sn 052-003-01457-2. Pittsburgh, PA: U.S. Government Printing Office. This CD contains a collection of all of the official OTA reports prepared for Congress. The reports are also available at http://www.wws.princeton.edu/%7eota/ns20/pubs_f.html.

OIL

The word *oil* is derived from the Greek *elaia* by way of the Latin *oleum*, both of which mean olive. Olive oil and other clear oils derived from plants have been closely associated with civilization and health for thousands of years. In *Genesis* a dove brought an olive leaf to Noah as a sign that the biblical flood was over and humans could reinhabit the earth. The Greeks considered the olive tree to be a symbol of victory and purification. Oils have been part of diverse traditions of medical practice in many parts of the world. They have been used to treat wounds and for general care of the body. In addition, oils have been integral to the preparation of foods and fine cuisine. Three types of oil are recognized in the early twenty-first century: vegetable oil, animal oil, and rock oil. Olive oil is a vegetable oil, whale oil is an animal oil, and petroleum is rock oil.

From Oil for Health to Oil for Energy

From the perspective of modern science and technology, oil is liquid petroleum. Petroleum is composed primarily of hydrocarbon molecules with some inorganic impurities. It can exist in the solid, liquid, or gas phase. The phase depends on composition, temperature, and pressure. The average molecular weight of hydrocarbons in oil is usually greater than the average molecular weight of hydrocarbons in gas at the same temperature and pressure. Natural gas is predominantly methane.

People have used petroleum for thousands of years. As early as 3000 to 2000 B.C.E., Middle Eastern civilizations such as those in Egypt and Mesopotamia used oil to construct buildings, waterproof boats and other structures, and mummify bodies. During that period, small amounts of oil were collected from surface seepages. Arabs used oil to create incendiary weapons as early as 600 C.E. By the 1700s, oil produced from shale oil was being used in Europe to light streets in Modena, Italy, and to make paraffin wax candles in Scotland (Shepherd and Shepherd 2003).

American George Bissell has been called the person most responsible for creating the modern oil industry (Yergin 1992). Bissell realized in 1854 that rock oil—as oil was called in the nineteenth century to differentiate it from vegetable oil and animal fat—could be used in lighting and cooking. Bissel formed the Pennsylvania Rock Oil Company of Connecticut in the mid-1850s and named James M. Townsend president.

Bissell and Townsend believed that rock oil could be produced from below the surface of the Earth in the same way that water was produced using water wells. Townsend commissioned Edwin L. Drake to drill a well in Oil Creek, near Titusville, Pennsylvania, where many oil seepages had been observed. The project began in 1857 and struck oil on August 27, 1859.

The value of oil increased dramatically as a result of the success of Drake's well. The abundant supply of rock oil served as a substitute for whale oil, which was growing scarce and expensive, and reduced the need to hunt whales for fuel. Within fifteen months of Drake's strike, Pennsylvania was producing 450,000 barrels per year from seventy-five wells. By 1862, 3 million barrels of oil were being produced and the price of oil dropped to ten cents per barrel (Kraushaar and Ristinen 1993).

The invention of the electric light bulb caused a drop in the demand for kerosene in 1882 and a corresponding drop in the demand for rock oil. The drop did not last long, however, because the rapidly expanding automobile industry needed oil for fuel and lubrication.

By 1900 Standard Oil, a company founded by John D. Rockefeller in 1870, held a virtual monopoly over oil production in the United States. Congress passed the Sherman Antitrust Act to reintroduce competition in the oil industry. By 1909 the United States was producing 500,000 barrels of oil per day, which was more oil than the combined production of all other countries. The United States produced more than half of the world oil supply in the first half of the twentieth century.

The Politics and Ethics of Oil

Discoveries of large deposits of oil in Central America, South America, and the Middle East in the early 1900s eventually led to increased production outside of the United States. Production in the continental United States peaked in 1970 and has since been declining. Oil demand has continued to grow, however, in both the United States and the rest of the world. Since 1948 the United States has imported more oil than it exports. In the early-twenty-first century, the United States imports about half of its oil (Deffeyes 2001).

Petroleum has been an internationally traded commodity since the end of the nineteenth century. International and multinational petroleum companies have appeared as a result of the global distribution of oil and its importance to societies around the world. These companies are based in a home country, but must operate within the regulatory framework of each host country. Relationships between oil producing companies and host countries vary widely. Most host countries issue licenses or leases to production companies.

Until 1973 oil prices were influenced by market demand and the supply of oil that was provided in large part by a group of oil companies called the *Seven Sisters*. In 1960 Saudi Arabia led the formation of the Organization of Petroleum Exporting Countries (OPEC). OPEC became a major player in the oil business in 1973 when it raised the price of oil exported by its members. This rise in price became known as the first oil crisis as prices for consumers in many countries increased significantly.

In the early-twenty-first century, nations around the world are concerned about the global dependence on finite resources and the environmental impact of fossil fuel combustion. For example, how should the supply of oil be distributed? Should developed nations encourage less developed nations to seek self-sufficiency? Or should all nations seek an equitable distribution of energy to prevent social turmoil? As another example, measurements of ambient air temperature have shown a rise in the average temperature of the Earth's atmosphere. The rising temperature is called global warming and is attributed in large part to the emission of fossil fuel combustion byproducts into the atmosphere. The need to address these concerns is motivating an international effort to implement a sustainable development policy as the world undergoes a transition from an energy mix dominated by fossil fuels to a broader energy mix that depends on a range of energy sources.

JOHN R. FANCHI

SEE ALSO *Energy; Environmental Ethics; Global Climate Change.*

BIBLIOGRAPHY

Deffeyes, Kenneth S. (2001). *Hubbert's Peak: The Impending World Oil Shortage.* Princeton, NJ: Princeton University Press. Describes a particular methodology for forecasting the supply of oil and predicts an impending oil shortage. Designed for a general readership.

Fanchi, John R. (2004). *Energy: Technology and Directions for the Future.* Boston: Elsevier. Reviews the science and technology of energy sources, the environmental impact of energy sources, and energy forecasts. Assumes the reader has a technical background.

Kraushaar, Jack J., and Robert A. Ristinen. (1993). *Energy and Problems of a Technical Society,* 2nd edition. New York: Wiley. Explains the technological problems of society to a non-technical audience.

Shepherd, William, and D. W. Shepherd. (2003). *Energy Studies,* 2nd edition. London: Imperial College Press; River Edge, NJ: World Scientific. Reviews several energy sources primarily for a general readership.

Yergin, Daniel. (1992). *The Prize.* New York: Simon and Schuster. Provides a historical introduction to the modern oil industry.

OPEN SOCIETY

The term *open* has a special salience in such phrases as "open markets," "open records," "open government," and "open-ended" discussion or project. In such contexts it denotes both freedom and transparency, two fundamental values of a democratic society. Indeed, the term *open society* has itself become almost synomous with democracy, and is sometimes used to name the ideal of both the scientific and the non-scientific social orders.

Although Henri Bergson (1859–1941) first employed the term *open society* in *The Two Sources of Morality and Religion* (1935) and Eric Voegelin (1901–1985) made Bergson's interpretation a key concept in his philosophy of history, it was *The Open Society and Its Enemies* (1945) by Karl R. Popper (1902–1994) that gave the phrase wide currency. The concept of the open society has since sparked numerous scholarly debates as well as practical applications. Although based on core values such as equality in social relations, freedom of inquiry and speech, and transparancy in decision making and knowledge production, the precise meaning of an open society has never been settled. Furthermore, globalization and the increasing threat of terrorism are reshaping conventional understandings of closed and open societies.

Bergson and Popper

From the earliest articulations of the concept by Bergson and Popper, there have been important differences in the ways in which the open society has been interpreted and used. Bergson's concept was more a vertical openness to the ground of being or the transcendent. Popper's openness was primarily within the framework of secular liberalism; it was a horizontal openness to the experimental trial and error method. As one commentator remarks, Bergson's openess was centered on his "theocentric humanism," whereas Popper's was based on his "anthropocentric humanism" (Germino 1974, p. 14).

For Bergson, the primitive closed society attached strict obligations to custom and operated under the rules of "Authority, Hierarchy, and Immobility." It was warlike, dominated by a religious dogma, and controlled by an elite. Bergson envisioned the open society as an ideal yet to be wholly realized. Although the spread of Western values in the process of globalization may approximate his vision, it is important to note that Bergson's open society went beyond material and political conditions. Central to his conception was a spiritual openness to the rhythm of the cosmos and the interrelatedness of life. One way to sum up Bergson's account of closed and open societies is to see the former as emphasizing impersonal *orders* as the source of morality, whereas the latter emphasizes the source of morality found in "*appeals* made to the conscience of each of us by *persons* who represent the best there is in humanity" (1935, p. 84). The closed society is bound by static laws and conventions, whereas the open society is best represented by heroes and mystic saints who break with the strictures of their group in a dynamic fashion. Thus, the two sources of morality are *dogma* (which can include science and its static, mechanistic ideal) and *inspired intuition* (and its ideal of dynamic, free creativity).

Unlike Bergson's work, Popper's critique of closed societies came with the benefit of hindsight by which to characterize and judge the brutal totalitarianism of the Nazi regime. Although initially lenient and even approving with regard to the Soviet Union, Popper eventually categorized Stalinism as a closed society. For Popper, a closed society is marked by the rigidity of its customs and their irrational acceptance by the masses. An open society, by contrast, is one in which citizens face personal choices and moral responsibilities (both absent in closed societies). Open societies are marked by personal interaction, wherease closed societies present only abstract, impersonal, and anonymous human relations. Open societies replace saturating social conventions with personal freedom, rationality, and critical thought.

Finally, it should be noted that for Popper, the concept of the open society flowed naturally from his philosophy of science. Both rely on fallibalism: Scientific progress is made by subjecting theories to critical scrutiny, and progress in an open society can be sustained only if individuals are free to critically evaluate governmental decisions and engage in "piecemeal social engineering." Disputes in scientific communities and open societies should be resolved by critical discussion rather than force.

Despite their differences, both Bergson and Popper agreed that there was a general historical trend toward democracy and openness. However, both explicitly denied any inherent momentum or logic to history, insisting rather on its open-endedness based on the historical engine of human choice. Both also warned that a relapse to the condition of closed societies is always possible, because the natural will to power can never be completely erased by the virtuous conventions of open societies. In fact, their very openness and tolerance ensure that these societies will remain vulnerable to such a relapse. A rational (Popper) or enlightened (Bergson) citizenry can always be duped by a strong-willed leader or clan.

Open Society Debated

Popper did not associate his concept of open society with any particular political or economic philosophy.

His refusal to define the concept in this manner has fueled critical and theoretical debates. Dante Germino and Klaus von Beyme collected a wide-ranging series of essays on *The Open Society in Theory and Practice* (1974) that touches on its implications for work, education, politics, religion, and other fields of human experience. The book exposes the plurality of viewpoints and contested meanings of the open society. Many papers raise doubts about the ability of modern industrial or post-industrial society, with its emphasis on technological rationality, to foster openness. Some in this camp call for radical departures from prevailing assumptions about humans and nature. Others argue that it is precisely and only within the modern, secular world of western liberalism that values of openness can prevail. This debate signals the durability of the original fissure underlying the Bergsonian and the Popperian uses of the term. The former critics call for a new consciousness focused on deep experiences, which have been marginalized by the scientific and secular world-view. The latter insist that reason and (properly demarcated) science are essential for the flourishing of open societies.

In *Popper's Open Society After Fifty Years: The Continuing Relevance of Karl Popper* (1999), Ian Jarvie and Sandra Pralong collect fifteen essays that introduce Popper (including an interview with Popper on his ninety-second birthday), critique the central ideas of *The Open Society*, and apply those ideas to later social, political, and philosopohical concerns. Some contributors argue that Popper's arguments have lasting value but need restating away from the particular instances of Plato (427–347 B.C.E.), Georg Wilhelm Friedrich Hegel (1770–1831), and Karl Marx (1818–1883) toward more general critiques of authority, community, and bureaucracy. Others criticize Popper for practicing the very historicism he attacked. Still other essays take up the relation between Popper's philosophy of science and his thoughts on the open society. The work concludes with several reflections on the implications of Popper's work, especially for Eastern European countries.

In *The Governance of Science: Ideology and the Future of the Open Society* (2000), Steve Fuller argues that the increasing scale of the scientific enterprise has eroded the ideal of science as an open society. He connects this claim with three political theories of science, and argues that "[t]he open society is possible only in a republican regime, where, unlike liberal or communitarian regimes, a clear distinction is drawn between staking an idea and staking a life. This distinction underwrites the fundamental principle of the open society: the right to be wrong" (p. 5). Fuller also traces the opposing pulls of liberalism (capitalism) and communitarianism (multiculturalism) in the governance of science by the university. He concludes with a look toward the future of the social contract with science, which he argues is best reformed by continuing the process of decoupling state power from the authorization of knowledge claims. In this, Fuller echoes one of Popper's central concerns, namely, that scientific claims and the direction of scientific research always remain open to public debate.

Related Concepts

Popper's open society was based on a critique of two practices in the philosophy of history. First, he criticized historicism, or the belief that history develops according to certain intrinsic principles toward a determinate end. Second, he challenged holism, or the belief that societies are greater than the sum of their members. Popper argued instead that history is open-ended and driven by individual choices.

Popper's analysis was anticipated by previous examinations of the social order within science (see the work of Robert Merton) and echoed by other post-World War II concerns for scientific freedom (see the work of Michael Polanyi). More generally, while never explicitly referencing the open society, holism, or historicism, Hannah Arendt develops a critique of totalitarianism and an analysis of the human condition (1958) that can be interpreted as supportive of Popper's basic argument against the "making" of history, although she would question any sanguine interpretation of individual autonomy.

A much more radical promotion of open society principles is found in the work of Popper's student, Paul Feyerabend, and his arguments for "epistemological anarchism." For Feyerabend, Popper is too limited in the application of his openness ideal, and in *Science in a Free Society* (1978) argues that the movement that once led to the separation of church and state should now bring about a separating of science and state. Science should be disestablished as the rational norm in advanced technological societies; society should not just be free for science but freed from science, that is, open to more than science.

In *The Closing of the American Mind* (1987), Allan David Bloom distinguishes between two types of openness in modern Western societies. First, there is the openness of reason that refuses to equate the good with one's own way of life, but takes the further step of using reason to inquire into nature in order to discover truth, beauty, and goodness: "Nature should be the standard by which we judge or own lives and the lives of peoples" (p. 38). Second, however, is the openness of indifference.

This openness denies reason's ability to find a standard for right living in nature or models of right conduct in history. Instead, it slips into moral nihilism and cultural relativism.

Bloom thus suggests that the open society at once presents the chance to discover an a-cultural, transhistorical, natural truth and the possibility that such a search will compel its members into another type of closed society, closed within the culture of relativism. People must escape their contingent cultural conventions to be fully human, but such an escape leads to a closed indifference if they cannot use reason to discover stable and more universal standards of conduct. His argument also hints at Stanley Rosen's (1989) distinction between the ancients and the moderns. In a sense, the ancients represent closed societies that offer security and order at the risk of tyranny. The moderns represent open societies that offer freedom and choice at the price of nihilism and licentiousness. Building off of this latter possibility, Bloom maintains that "Openness used to be the virtue that permitted us to seek the good by using reason. It now means accepting everything and denying reason's power. The unrestrained and thoughtless pursuit of openness [equals] closedness" (pp. 38–39).

The notion that openness reveals mere contingency and meaninglessness is challenged by Richard Rorty (1989). Rorty would accuse Bloom of the metaphysical assumption that reason must provide "an order beyond time and change which both determines the point of human existence and establishes a heirarchy of responsibilities" (Rorty 1989, p. xv). Rorty's utopia is one of "liberal ironists"—liberal in that they aspire to personal excellence and social justice, ironical because they recognize such goods are not guaranteed by a stable ontological order. For Rorty openness is retained by means of nominalist cultural narratives that construct compassion rather than by the seeking of moral formulas for action based on theory.

Open Society Applied

In the construction of such narratives, perhaps the Open Society Institute (OSI) is the largest concrete application of Popper's notion. The philanthropic activist George Soros founded OSI in 1993 as a way to synthesize initiatives that began in Central and Eastern Europe as early as 1984 to encourage the transition to democracy. Since then, the Soros network has expanded to include initiatives throughout the world, including the United States, to promote open societies through legal, governmental, and economic reform. It also supports education, media, public health, and human rights initiatives. The OSI seeks to diminish and prevent the negative consequences of globalization. In this sense, it recognizes the threats posed to open socieities by global capitalism in addition to those posed by more traditional forms of authoritarian rule.

Other concrete (if perhaps unconscious) manifestions of Popper's notion are found in the open source and free software movements, and in the promotion of open access in scientific publishing. The claim that the source code for programs should be open to all users, thus enabling them to identify weaknesses in the code and correct them—as is the case with the software that makes possible the World Wide Web on the Internet (a program that Tim Berners-Lee, its designer, explicitly declined to patent)—exemplifies Popperian principles. The argument that basic software utilities should be freely available rather than controlled by a quasi-monoply such as Microsoft is a natural extension of these principles. Finally, the promotion of open access scientific publication—that is, publication that allows all users a free, worldwide right of access to read, copy, and distribute the results of scientific research—constitutes a further effort to institutionalizes practices in harmony with open society ideals.

Globalization and Terrorism

The globalizing reach of modern science, technology, and production forces as well as Western values and political associations can be interpreted as the intrusion of the open society on "traditional" or more "closed" cultures. Ethics is not as easily globalized as science and technology. Although a simplification, something similar is true with regard to the economic globalization of markets versus the political globalization of democracy. Modernizing forces do not produce any uniform transition from closed to open societies, which is a mixed blessing for all involved. Diverse movements from wars of independence to environmental and human rights activism have tried to respond to the dislocations that can result from this selective globalization. But perhaps the most serious backlash against modernization and globalization, and the one that best illustrates the contemporary relationship between closed and open societies, is terrorism.

Although an ancient tactic, terrorism (especially those attacks carried out by extremists who justify their actions by appeal to Islamic ideologies) has taken on heightened global importance since the attacks against the United States on September 11, 2001. The potential to utilize the machines and weaponry of modern technoscience has increased the threat posed by terrorists to the citizens of open societies. Just as important, however, is the vulnerability to terrorist attacks created by the very ideals of an open society. Personal and civil liberties, tolerance, and multiculturalism all inhibit the leadership of open societies in their efforts to thwart terrorist plots. Terrorists are also able to capitalize on the freedom of information presented by the Internet. Thus, relatively loose networks of people bounded by a set of beliefs can organize and commit complex, integrated attacks due in large measure to modern telecommunication technologies. This form of "closed society" retains the dogmatic, hierarchical, and ideological characteristics criticized by Bergson and Popper, even though it now lacks the geographical and political organizing structures and avails itself of "open" streams of information.

The controversy over the Patriot Act signed by President George W. Bush in 2001 "to deter and punish terrorist acts in the United States and around the world" demonstrates the tension that terrorism presents between closed and open societies. It is an open question whether an effective war against terrorism requires the curtailment of certain civil liberties in order to more effectively control and monitor suspects. If so, however, at a certain point, such tactics may jeopardize the very ideals of the open society that they aim to defend.

Shortly after the September 11 attacks, Atef Ebeid, the Egyptian Prime Minister, criticized human rights groups for defending the human rights of potential terrorists. "You can give them all the human rights they deserve until they kill you," he said. "After these horrible crimes committed in New York and Virginia, maybe Western countries should begin to think of Egypt's own fight against terror as their new model" (Remnick 2004, pp. 75–76). In the war against terror, the leadership of Egypt maintains that all pretenses to an open society must be discarded, thus suggesting that democratic states run the danger of winning one war by losing another.

ADAM BRIGGLE
CARL MITCHAM

SEE ALSO *Governance of Science; Political Economy; Science Policy.*

BIBLIOGRAPHY

Arendt, Hannah. (1958). *The Human Condition.* Chicago: University of Chicago Press.

Bergson, Henri. (1935). *The Two Sources of Morality and Religion.* Garden City, NY: Doubleday. The original French edition appeared in 1932.

Bloom, Allan. (1987). *The Closing of the American Mind.* New York: Simon and Schuster.

Feyerabend, Paul. (1978). *Science in a Free Society.* London: NLB.

Fuller, Steve. (2000). *The Governance of Science: Ideology and the Future of the Open Society.* Philadelphia: Open University Press.

Germino, Dante, and Klaus von Beyme, eds. (1974). *The Open Society in Theory and Practice.* The Hague: Martinus Nijhoff.

Jarvie, Ian, and Sandra Pralong, eds. (1999). *Popper's Open Society after Fifty Years: The Continuing Relevance of Karl Popper.* London: Routledge.

Merton, Robert. (1938). "Science and the Social Order." *Philosophy of Science* 5: 321–337.

Polanyi, Michael. (1946). *Science, Faith, and Society.* London: Oxford University Press.

Popper, Karl. (1945). *The Open Society and Its Enemies.* 2 vols. London: Routledge.

Popper, Karl. (1961). *The Poverty of Historicism,* 2nd edition. London: Routledge. Revised book version of original articles of 1944.

Remnick, David. (2004). "Letter from Cairo: Going Nowhere." *New Yorker* July 12 and 19: 74–83.

Rorty, Richard. (1989). *Contingency, Irony, and Solidarity.* Cambridge, UK: Cambridge University Press.

Rosen, Stanley. (1989). *The Ancients and the Moderns.* New Haven, CT: Yale University Press.

OPERATIONS RESEARCH

Operations Research (OR) is defined, according to the International Federation of Operational Research Societies, as a scientific approach to the solution of problems in the management of complex systems. Unlike the natural sciences, OR is a science of the artificial in that its object is not natural reality but rather human-made reality, the reality of complex human-machine systems. OR involves not just theoretical study but also practical application. Its purpose is not only to understand the world as it is, but also to develop guidelines about how to change it in order to achieve aims or to solve certain problems. Ethical considerations are thus crucial to almost all aspects of OR research and practice.

Origins

OR as a specific scientific discipline dates back to the years immediately preceding World War II. First in the United Kingdom and later in the United States, interdisciplinary groups were constituted with the objective of improving military operations through a scientific approach. A typical example is the British Anti-Aircraft Command Research Group, better known as Blackett's Circus, which consisted of three physiologists, four physicists, two mathematicians, one army officer, and one surveyor.

Experience with OR in the military context during the war was the basis for new applications in industry afterward. The development of complex, large, and decentralized industrial organizations together with the introduction of computers and the mechanization of many functions required novel scientific approaches to decision making and management. This need led to the establishment, not only in industry but also in academia, of what formally became known as *operational research* in the United Kingdom, and *operations research* or *management science* in the United States (these last two terms are often used synonymously).

The first national OR scientific society was founded in 1948 in the United Kingdom. The U.S. societies, Operations Research Society of America (ORSA) and the Institute of Management Science (TIMS), which later merged as the Institute for Operational Research and the Management Sciences (INFORMS), followed a few years later. In 1959 the International Federations of Operational Research Societies was established.

Optimization plays a major role in OR methodologies: Problems are formulated by means of a set of constraints (equalities or inequalities) and an objective function. The maximization or minimization of the objective function subject to the constraints provides the problem's solution.

Codes versus Principles

Ethics in any applied science develop along two complementary lines. First scientific or professional codes of ethics can be created. These are typically sets of rules, sometimes well-defined, sometimes generic. Useful as they are, ethics codes are external directives not evolved from any individual's ethical beliefs and may lead to double standards. Some evidence suggests that people apply ethical standards at work that are often different and significantly lower than those they follow in their private lives. Although no major national OR society has a formal ethics code, the codes of related scientific disciplines may be applied to OR.

A second way to develop a particular ethics is through an individual approach based upon principles and values instead of rules that govern behavior. According to philosopher Hans Jonas (1903–1993), the following principle can be the basis of an ethical discourse: People have a responsibility toward others, be it humankind (past, present, and future generations) or nature. Another principle of responsibility complements this general rule: Knowledge in all forms must be shared and made available to everyone; cooperation rather than competition should be at the basis of research activity. The latter is called the sharing and cooperation principle (Gallo 2003). These principles are basic to confronting two issues that are crucial to the survival of society: increasing societal inequalities and sustainability.

Models and Methods

If the above are accepted as appropriate principles of responsibility, they can be applied to OR, and, in particular, to model building, which is the fundamental OR activity. The first issue in this regard is determining whether ethics has anything to say about model construction. In his excellent book on ethics and models, William A. Wallace (1994) reports a consensus in the OR research community to the effect that "one of the ethical responsibilities [of modelers] is that the goal of any model building process is objectivity with clear assumptions, reproducible results, and no advocacy" (Wallace 1994, p. 6), and on the "need for model builders to be honest, to represent reality as faithfully as possible in their models, to use accurate data, to represent the results of the models as clearly as possible, and to make clear to the model user what the model can do and what its limitations are" (Wallace 1994, p. 8).

But might responsibility also arise at an earlier stage, when choosing the methodology to create the model? In other words, are methodologies (and hence models) *value neutral*? This is a controversial issue. It can be argued that behind the role of optimization in OR and the parallel development of optimality as a fundamental principle in the analysis of economic activities and in decision making related to such activities, there are assumptions with ethical implications. Among these is whether self-interest is the only motivation for individual economic choices; whether maximization of the utility function is the best formal way to model individual behavior; and whether, by applying the proper rate of substitution, anything can be traded for anything else, with the consequence that everything can be assigned a monetary value.

These considerations have led some, including J. Pierre Brans (2002), to advocate the use of multicriteria approaches in order to balance objective, subjective, and ethical concerns in model building and problem solving. Such approaches do not reduce, by weighting, different, often noncommensurable, criteria (including those derived from ethical considerations) to one single criterion. Instead each criterion maintains its individuality, leading to a solution that is acceptable to or appropriate for the parties, rather than one that is objectively optimal.

Another issue in the application of principles of responsibility is that optimization-based models are often solution oriented: The final goal of the model is the solution, for instance, the recommendation of action to be made to the client. Some argue that the process is more important than the solution: creating a learning process in which all parties involved acquire a better understanding of the problem and of the system in which the problem arises, with its structure and its dynamics, and have a say in the final decision. These concerns, which call for a broader sense of responsibility not only with respect to the client but to all stakeholders, have led to divisions in the OR community. The development of alternative approaches such as systems thinking and soft operational research are some results.

Clients and Society

Another important question concerns the kind of clients served. As pointed out by Jonathan Rosenhead (1994), OR practitioners "have worked almost exclusively for one type of client: the management of large, hierarchically structured work organizations in which employees are constrained to pursue interests external to their own" (Rosenhead 1994, p. 195). Yet these are not the only possible clients. Other types of organizations exist, operating by consensus rather than chain of command, and representing various interests in society (health, education, housing, employment, environment). Such organizations usually have limited resources though the problems they face are no less challenging for the OR profession.

This fact has ethical relevance. Because the use of models constitutes a source of power, the OR profession runs the risk of aiding the powerful and neglecting the weak, thus contributing to the imbalance of power in society. A positive but rather isolated example of OR assistance outside the sphere of big business is community operational research in the United Kingdom. This initiative has allowed many OR researchers and practitioners to work with community groups, such as associations, cooperatives and trades unions.

Another way OR may contribute to power imbalances at the international level is in the strict enforcement of patents and intellectual property rights. Wide dissemination of methodologies and software, in accordance with the sharing and cooperation principle mentioned above, might reduce the technology divide between rich and poor countries.

GIORGIO GALLO

SEE ALSO *Management; Models and Modelling.*

BIBLIOGRAPHY

Brans, J. Pierre. (2002). "Ethics and Decisions." *European Journal of Operational Research* 136: 340–352.

Gallo, Giorgio. (2003). "Operations Research and Ethics: Responsibility, Sharing and Cooperation." *European Journal of Operational Research* 153: 468–476.

Rosenhead, Jonathan. (1994). "One-Sided Practice—Can We Do Better?" In *Ethics in Modeling,* ed. William A. Wallace. Tarrytown, NY: Pergamon.

Wallace, William A., ed. (1994). *Ethics in Modeling.* Tarrytown, NY: Pergamon.

OPPENHEIMER, FRANK

Frank Oppenheimer (1912–1985) was born in New York on August 14, the younger brother of J. Robert Oppenheimer. Like his brother he became a physicist, but with a focus on experimental work rather than theory. As a physicist he contributed to the development of the atomic bomb, and then in 1969 became a leader in science education by founding the interactive San Francisco Exploratorium. He died of lung cancer in Sausalito, California, on February 3.

After earning a B.S. in physics from Johns Hopkins University in 1933 he studied for a time in Europe before going to the California Institute of Technology where he earned his PhD in 1939. In 1941 he began work at Oak Ridge, Tennessee, on separating Uranium–235, the fissile isotope, from the more common Uranium–238, then subsequently became special assistant to his older brother at the Los Alamos National Laboratory where the atomic bomb was being designed and constructed. Like many other scientists he was upset by the use made of the atomic bomb at the end of World War II, and became involved in efforts to educate the public about the new dangers of nuclear weapons.

Immediately after the war he held teaching appointments first at the University of California, Berkeley, then at the University of Minnesota. When the U.S. Congress House on Un–American Activities Committee exposed the fact that he and his wife had for a time during the 1930s been members of the Communist Party, he was forced to leave university teaching. For the next decade he became a cattle rancher in southern Colorado. Then in 1957 he took a job teaching high school science in Pagosa Springs, Colorado, where he became an enthusiastic and creative educator, moving shortly thereafter to the University of Colorado in Boulder. There he created the "Library of Experiments" to pioneer the kinds of interactive techniques that eventually became the hallmark of the Exploratorium.

The idea for the Exploratorium gestated during a 1965 Guggenheim fellowship in which Oppenheimer studied science museums in Europe, and became convinced of their need as a form of public science education. Although invited to work at the Smithsonian Institution in Washington, DC, he chose to start from scratch in San Francisco, where he proposed to create a new kind of science museum in the abandoned Palace of Fine Arts near the San Francisco marina. He served as its director until his death.

CARL MITCHAM

SEE ALSO *Atomic Bomb; Education; Museums of Science and Technology; Oppenheimer, J. Robert.*

BIBLIOGRAPHY

Oppenheimer, Frank. (1972). "The Exploratorium: A Playful Museum Combines Perception and Art in Science Education," *American Journal of Physics*, vol. 40, no. 7 (July), pp. 978–984.

INTERNET RESOURCES

Oppenheimer, Frank. (1984). "Interview with Frank Oppenheimer," Oral History Project, California Institute of Technology Archives, Pasadena, California. Available from http://oralhistories.library.caltech.edu/69/.

Frank Oppenheimer web site at the San Francisco Exploratorium. Available from http://www.exploratorium.edu/frank/index.html.

OPPENHEIMER, J. ROBERT

J(ulius) Robert Oppenheimer (1904–1967) was born in New York City on April 22 of a privileged, assimilated German-Jewish family. Known widely as the "father of the atomic bomb," Oppenheimer also thought that physicists had special responsibilities as a result of their contributions to this development. He argued for international control of nuclear weapons and against the U.S. development of the hydrogen bomb. He died of throat cancer in Princeton, New Jersey, on February 18.

J. Robert Oppenheimer, 1904–1967. The American physicist made fundamental contributions to theoretical physics and was director of the atomic energy research project at Los Alamos, New Mexico. *(National Archives and Records Administration.)*

Education and Career

Oppenheimer received a liberal and wide-ranging education in New York City, at Harvard University, and at several leading scientific centers in Europe, receiving his Ph.D. under Max Born in 1927. His most creative scientific work was performed in the period 1927–1942, first at Göttingen, Germany, with Born, and then at the California Institute of Technology and, primarily, at the University of California Berkeley. His first major contribution was the *Born-Oppenheimer approximation,* a seminal recipe for dealing with molecular interactions. He subsequently published important papers on nuclear and particle physics. He also studied astrophysical phenomena, involving general relativity, neutron stars, and gravitational collapse.

At Berkeley Oppenheimer became arguably the most important and certainly the most charismatic American-born physics theorist. His close association with Ernest O. Lawrence helped spread his fame as a theoretical physicist capable of understanding and working with the most advanced high energy experiments. In 1942 he became scientific director of the Los Alamos center of the Manhattan Project, where the atomic weapons of World War II were designed, built, and finally delivered for use over Japan in August 1945. Resigning from Los Alamos after the war, he became director of the Institute for Advanced Studies at Princeton, where he once again demonstrated his talents as an organizer and scientific leader.

Politics and Ethics

As a result of his spectacular accomplishment with the atomic bomb, Oppenheimer was elevated to a position of extraordinary prestige and power in both the scientific and the political worlds. He became an international celebrity and governmental adviser, raising questions of conscience for the scientific community and arguing for United Nations (UN) control of nuclear weapons. In 1947, at the Massachusetts Institute of Technology, he gave a talk in which he made the comment that as a result of their development of the atomic bomb physicists had *known sin* and thus had a responsibility to help educate other scientists, politicians, and the public about the devastating power of these new weapons.

Early in his Berkeley years Oppenheimer became involved in political activities. He supported many organizations and interest groups that could be identified as leftist. Such activities and associations later caused Oppenheimer difficulty during the period of intense anti-communist sentiments that gripped the United States in the early days of the Cold War, and an Atomic Energy Commission (AEC) hearing resulted in the removal of his secret security clearance in 1954.

The denial of Oppenheimer's clearance was based on several factors. One was his unswerving opposition to the efforts of the U.S. government to develop a hydrogen bomb. Another was his past associations with left wing and pro-Soviet groups, and also the fact that at one time in 1943 he did not reveal a discussion with Haakon Chevalier, a friend and French professor at Berkeley, about the possibility of personal contacts between American and Soviet scientists outside official channels. The reason for not reporting this incident may have been his unwillingness to betray a friend, whom he felt was innocent of venal motive. As for his opposition to the hydrogen bomb, in retrospect Oppenheimer appears to have been punished for a dissenting view on a controversial topic, a state of affairs that is part of the normal democratic decision making process. In any case President John F Kennedy ordered what amounted to his rehabilitation in 1963 by awarding him the Enrico Fermi prize, the highest honor granted by the AEC.

Oppenheimer was an aesthete; a consummate scholar of languages, ancient cultures, and literature; as well as an accomplished physicist. He had refined tastes, supported by his inherited wealth. He was a self-proclaimed lover of the *common man,* exemplified in his espousal of liberal and leftist causes. Yet he worked on military weapons and projects. He did not oppose *research* on the hydrogen bomb, only on its development as a deliverable weapon. In telling testimony before the U.S. Congress, he once commented that such development was so *sweet technically* that it could not but be tried. Although known for acerbic remarks at scientific presentations, he was admired, even loved, by students and junior colleagues. Although loyal to friends, in the Chevalier case he caused irreparable damage to a career when he did belatedly describe their conversation. While his scientific productivity was outstanding, he missed producing any single contribution that would have placed him in the first ranks. In sum he was a scientist, teacher, scientific administrator, and public figure, whose flaws prevented him from achieving the highest level in the intellectual pantheon, and yet who raised important ethical issues for the scientific community and public.

BENJAMIN BEDERSON

SEE ALSO *Atomic Bomb; Oppenheimer, Frank; Science Policy.*

BIBLIOGRAPHY

Herken, Gregg. (2002). *Brotherhood of the Bomb.* New York: Henry Holt and Company.

Schweber, Silvan S. (2000). *In the Shadow of the Bomb: Bethe, Oppenheimer, and the Moral Responsibility of the Scientist.* Princeton, NJ: Princeton University Press.

INTERNET RESOURCE

Bethe, Hans A. "Biographical Memoirs: J. Robert Oppenheimer." National Academy of Sciences. Available from http://nap.edu/html/biomems/joppenheimer.html.

ORGANIC FOODS

At the most basic level, organic food is grown or raised without the use of synthetic chemicals. In the production of vegetables and fruits, no synthetic pesticides or fertilizers may be used, and no hormones or antibiotics

Fresh tomatoes with a "No Pesticides" sign. Organic vegetables are grown without the chemical herbicides and pesticides used in conventional agriculture. *(Nancy R. Cohen/Getty Images.)*

may be used in the rearing of livestock or poultry. The concept of organic food, however, remains fuzzy. Beyond restricting the use of synthetic chemicals, other issues sometimes incorporated into the idea of organic food include: no sewage-sludge fertilizers, no food irradiation, no genetically modified organisms, humane conditions for livestock and poultry, sustainable land use practices, and just treatment of workers in the food production process.

Until the twentieth century, all human food was organic. At the dawn of World War II, the few pesticides in use were derived from plants (for example, nicotine, rotenone, pyrethrum) or minerals (for example, arsenic and sulfur compounds). Paul Müller's 1939 discovery of the insecticidal properties of DDT, in conjunction with military needs to control infectious disease, propelled the chemical industry to full-scale production, which continued after the war as DDT and other pesticides were put to agricultural use. Pesticides and chemical fertilizers, along with new crop hybrids, farm machinery and irrigation techniques, enabled industrial agriculture, which aims to increase agricultural yield while decreasing the costs of production in order to maximize both food production and profits. Following World War II, the United States exported industrial agriculture across the globe for humanitarian and economic purposes. The green revolution began in the 1940s according to Norman Norlaug, Nobel laureate and widely recognized father of the green revolution. New hybrid crops were only one part of the green revolution, new agricultural techniques, including the heavy use of synthetic fertilizers, pesticides, irrigation techniques, and new farm equipment played a significant role in both the green revolution and the viability of the new plant hybrids.

Meanwhile, Lady Eve Balfour of England investigated, practiced, and promoted organic farming starting in 1938. She published *The Living Soil* in 1943, which led to the 1946 formation of the Soil Association, still the United Kingdom's leading organic foods organization. In the United States J. I. Rodale popularized organic gardening through the soil and health foundation, founded in 1947. He created several publications including *Organic Farming and Gardening* (est. 1942) and *Prevention Magazine* (est. 1950). His son, Robert, expanded this work by establishing the Rodale Institute and Rodale Press to promote the healthy land/healthy human connection. It was not until the environmental movement began in the 1960s, however, that organic foods flourished. In 1962, Rachel Carson's *Silent Spring* called attention to the public health and environmental consequences of industrial agriculture and unchecked pesticide use. The resulting concern over public health and the environment created a demand for organic food throughout the industrialized world.

In 1990 the United States Congress passed the U.S. Organic Foods Production Act, mandating the U.S. department of agriculture "(1) to establish national standards governing the marketing of ... organically produced products; (2) to assure consumers that organically produced products meet a consistent standard; and (3) to facilitate interstate commerce in fresh and processed food that is organically produced." But the debate over the development of organic standards between the initial 1994 recommendations and the final rules implemented in October 2002, and the global debate more generally, exposed significant ethical and scientific disagreements.

Organizations such as the Soil Association (est. 1946), Organic Trade Association (est. 1985), and the Organic Consumers Association (est. 1998) claim that organic foods promote a healthy, safe, and sustainable system of food production. But critics such as the Hudson Institute Center for Global Food issues and the American Council on Science and Health point out that no scientific evidence exists that organic foods are significantly more nutritious, safer, or tastier than conventionally grown foods. These critics have suggested that government promotion of organic foods undermines confidence in conventionally grown foods to the detriment of the poorest members of society and perpetuates a kind of fraud whereby organic food producers charge extra for products with no significant benefit.

Arguments for industrial agriculture rest on efficiency and the elimination of hunger, while arguments for organic food emphasize environmental and sometimes social sustainability. Some people accuse advocates of organic agriculture of elitism in prioritizing the environment over the needs of the poor. At the same time, organic advocates accuse industrial agriculture of prioritizing profits over environmentally and socially sustainable agriculture. Issues over how to define organic standards, how to enforce standards in an international food market, the appropriate burden of proof for the organic foods industry, and the relative importance of feeding the poor versus creating a sustainable system of food production pervade the organic debate.

Underlying this debate is the critical issue of global population growth. The Green Revolution succeeded in the sense that it prevented the starvation catastrophe predicted by Thomas Robert Malthus (1766–1834) and Paul R. Ehrlich (b. 1932). But with rapid increases in agricultural yield diminishing, one must explicitly consider the roles of organic and conventional food production in a world with a still burgeoning population.

JASON M. VOGEL

SEE ALSO *Agricultural Ethics; Food Science and Technology; Genetically Modified Foods; Nutrition and Science; Vegetarianism.*

BIBLIOGRAPHY

Balfour, Eva B. (1943). *The Living Soil and the Haughley Experiment*. London: Faber & Faber.

Lipson, Elaine Marie. (2001). *The Organic Foods Sourcebook*. New York: McGraw-Hill.

Trewavas, Anthony. (2001). "Urban Myths of Organic Farming." *Nature* 410: 409–410.

U.S. Congress. *Organic Foods Production Act of 1990*. Public law 101–624.

INTERNET RESOURCE

Organic Consumers Association. Available at http://www.organicconsumers.org/

ORGANIZATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

The Organization for Economic Co-operation and Development (OECD) was born in 1961 as the successor to the Organization for European Economic Co-operation (OEEC), which itself was created after World War II to administer the United States' Marshall Plan funding of European recovery. OECD is related in its structure, antecedents, and goals to other post–World War II international agencies such as the International Monetary Fund and the World Bank.

Brief History

In December 1959 the presidents of the United States and France, the West German chancellor, and the British prime minister, meeting in Paris, issued a communiqué calling for the industrialized countries to cooperate to help the less-developed world and to "pursu[e] trade policies directed to the sound use of economic resources and the maintenance of harmonious international relations, thus contributing to growth and stability in the world economy and to a general improvement in the standard of living" (OECD 1961, p. 11).

The OEEC member countries agreed on several principles. First, Europe's economic recovery was complete, and the OEEC was no longer needed. Second, it had become more evident in the postwar years that "the policies of any individual country had a direct and unavoidable influence for good or bad on economic conditions in every other country" (OECD 1961, p. 9). Third, the member nations, acting together, could use the new organization as a forum for giving "a higher priority than in the past to the problems of helping the less-developed countries of the world." The convention establishing the OECD was signed on December 14, 1960, and it went into effect on September 30, 1961.

Late in 1961, the twenty member nations met for the first time in Paris. They set a joint target of 50 percent growth in gross national product for the period 1960 to 1970, in support of the thesis that the industrialized countries could support the developing world only by sustaining their own growth at the same time. And they reaffirmed their commitment to interdependence: "[I]ndependent pursuit by each country of its legitimate objectives could not only aggravate existing disequilibria in the world economy but might also prevent the attainment of its objectives" (OECD 1961, p. 21).

The U.S. Senate, which under the Constitution was called upon to "advise and consent" to the convention creating the OECD, reacted with some anxiety. To some isolationist senators and their constituents, the OECD seemed like a Trojan horse containing the elements of a new, international executive organization that would usurp Congress's legislative powers. In the February 1961 hearings of the Senate Foreign Relations Committee, chaired by Senator William Fulbright, a Democrat from Arkansas, the senators were gradually lulled by witnesses from the executive branch reassuring them that the OECD would neither supplant the United Nations nor infringe upon the powers of Congress. "[T]he impression might be left," Senator Fulbright said, "that the OECD does not do anything." No, countered the State Department witness, OECD is an "important instrumentality . . . providing for the first time for an opportunity for full and free discussion . . . [in an] atmosphere of complete candor."

Structure

The OECD Council, the organization's supreme governing body, includes representatives of all the members. The Council meets occasionally at a higher "ministerial" level, and more regularly holds gatherings of the permanent representatives. The Council acts through the issuing of decisions, agreements, recommendations, and resolutions. Because there must be complete unanimity for the issuance of any of these, the negative vote of any member is sufficient to veto any OECD action.

The Executive Committee, consisting of representatives of ten members, meets every week. Other entities appointed by OECD are committees on economic policy, technical cooperation, and trade. OECD's broad-ranging interests include nuclear power, immigration, capital flows, science, technology, tourism, fisheries, and education.

In January 1960 the OEEC created the Development Assistance Group. Under the newly formed OECD, this entity was renamed the Development Assistance Committee (DAC) in October 1961, and it was given a key role in OECD's efforts to aid the Third World. The original DAC members were Belgium, Canada, France, Germany, Italy, the Netherlands, Norway, Portugal, the United Kingdom, the United States, the European Economic Community organization, and Japan. DAC has never disbursed funds of its own, but acts "as a centre for the exchange of information and experience in this field" (OECD 1961, p. 22). Its members are the source of 90 percent of the total flow of private and public capital to developing nations. The DAC nations recognized that aid would be wasted unless the recipient countries were able to increase their own exports as a result. DAC and OECD therefore took on the subsidiary mission of providing "expanding markets for the products of the less developed countries and to remedy the instability of their export earnings" (OECD 1961, p. 23).

Assessment

The DAC has been highly criticized for its failures. DAC and OECD treat aid as an absolute good, without ever confronting the variety of existing definitions and implementations, let alone the political underpinnings. Most aid relationships are based on "historical circumstances or some particular interest. . . . [T]he work of DAC must to a large extent be an exploration of the margins within which a joint or common policy exists or can be created" (*International Organizations*, p. 235).

OECD and DAC both were explicitly created lacking any legislative or executive power; their effectiveness is limited to "mutual exhortation" of the member countries. "One might well get the impression," says *International Organizations* dryly, "that much of its work must have been in vain" (p. 236). The overall volume of capital flow from the industrial nations to the developing ones has almost stagnated since DAC's creation.

DAC's main strength has been in the gathering and reporting of information. Its Annual Aid Review is a comprehensive collection of data and also serves as an "exercise in shame tactics, exposing behavior of those countries which give least or do so with the most demands and conditions." However, all the data is provided by the states surveyed; there is little independent collection or assessment of the data. According to critics, it is "difficult to identify individual improvements of aid policies clearly attributable to" the Annual Review (*International Organizations*, p. 237).

Very occasionally, specific solutions to problems are proposed at DAC meetings, but most such proposals have come to nothing, and "for the most part hopes of actual coordination have been dashed, and even the best-prepared meetings have remained exchanges of uncertain usefulness" (*International Organizations*, p. 238).

DAC's official view is that aid is the bounty of rich countries to Third World nations, and the self-interestedness of most aid is "never alluded to in its publications" (*International Organizations*, p. 239). DAC members, used to working behind the scenes without more comment or criticism than the organization's lack of authority warranted, were undoubtedly surprised to be the target of developing nations' anger at the 1964 conference of the United Nations Conference on Trade and Development (UNCTAD). Third World resentment of DAC's high-handedness led the organization to set new, possibly retaliatory, standards under which aid would be tied to the performance of the recipient.

DAC's contributions are difficult to evaluate. Its members never wanted it to be an executive agency—it is a forum only. DAC's already minimal clout has diminished as world aid policies, effected through treaties and other forums, have stabilized. "As a 'rich man's club,' it attracts suspicions of a power which it does not possess. . . . Theories of the conspiratorial neo-colonialist character of Western aid are certainly not confirmed in [OECD] deliberations" (*International Organizations*, p. 245).

The Cold War (1945–1989), and the West's desire to counteract Soviet influence, was a major motivation for aid to developing countries from the 1950s on. The dissolution of the Soviet Union in 1989 may have made OECD's work even less significant. During the cold war, there was a struggle between "realism" and "liberalism" within DAC: Is the purpose of aid to counter the spread of Communism, or is it the developed world's humane obligation to help? DAC has never officially decided to concentrate on either the neediest countries or those that do the best job promoting democracy.

After 1989, OECD was active as a consultant to former Soviet satellites liberalizing their economic systems. An OECD delegation sent to advise Poland announced that "radical changes in attitude" among Polish workers and enterprises would be necessary for Poland's ambitious program to succeed (Greenhouse 1990).

In more recent years, OECD has again found itself on the receiving end of public anger, this time as a "fellow traveler" of globalizing forces. In October 1997 the staid and reclusive organization was astonished to be confronted by a coalition of antiglobalization activists and nongovernmental organizations, which asked it to suspend negotiations on a proposed Multilateral Agreement on Investment. OECD complied, placing a hold on talks, and France then withdrew, ending the effort entirely because of OECD's unanimity requirement.

OECD's Directorate for Science, Technology and Industry (STI) has studied and reported on ethical issues in the use of technology. In a 2001 policy brief titled "Sustainable Development: Critical Issues," the organization asked, "How can we meet today's needs without diminishing the capacity of future generations to meet their own?" It concluded that government must protect the environment and the resources available to future generations by "internaliz[ing] the costs" of bad behavior. For example, taxes on polluters, or a pollution permit trading system, align the market with the goals of sustainable development by causing the polluters to pay the actual costs of their activities, rather than making the public do so. The directorate regards this approach as more effective than a regulation-based one. STI has also done substantial work on biotechnology, including patent issues with a strong ethical component.

Another OECD crusade has been against the bribery of public officials, particularly by companies wishing to obtain international trade contracts. The organization proposed an Anti-Bribery Convention, which by December 2003 had been ratified by thirty-five nations (OECD, "Steps Taken").

OECD has also focused on the issue of decreasing the military expenditures of developing countries, in order to free resources for redeployment to sustainable development and other areas of concern. In 1997 DAC commissioned a series of case studies of military expenditures, noting that the majority of the funds borrowed by certain developing countries were for military purposes (OECD, "Final Report").

Another of DAC's significant concerns has been high population growth, which DAC links to the "vicious circle of underdevelopment [which causes] poverty, malnutrition, illiteracy and environmental degradation" (OECD, "DAC").

Conclusion

In its more than forty years of existence, OECD has kept a low profile consistent with its lack of executive power. Most references to it in research databases concern the organization's own publications or lead to the phrase "OECD countries," which is commonly used as shorthand for industrialized, aid-giving nations. OECD is entirely uncritical when it comes to the motives and modalities of international aid, avoiding the ethical questions raised in worldwide debates on modernization and globalization. The general impression given in the literature is of a publicly funded think tank busily producing valuable statistics and research reports, but with minimal impact on real-world policymaking.

JONATHAN WALLACE

BIBLIOGRAPHY

Greenhouse, Steven. (1990). "World Economic Aide Sees Trouble for Warsaw Policy." *New York Times* January 19.

Ohlin, Goran. (1968). "The Organization for Economic Cooperation and Development," in *International Organization* 22, no. 1 (Winter 1968) Cambrige: MIT Press.

Organisation for Economic Co-operation and Development (OECD). (1961). *Organization for Economic Cooperation and Development*. Paris: OECD Publications.

INTERNET RESOURCES

Organisation for Economic Co-operation and Development (OECD). "DAC: Development Co-operation in the 1990s." Available from http://www.oecd.org/LongAbstract/0,2546,en_2649_201185_1896179_1_1_1_1,00.html.

Organisation for Economic Co-operation and Development (OECD). "Final Report and Follow-Up to the 1997 Ottawa Symposium." Available from http://www.oecd.org/dataoecd/16/48/1886718.pdf.

Organisation for Economic Co-operation and Development (OECD). "Steps Taken and Planned Future Actions by Participating Countries to Ratify and Implement the Convention on Combating Bribery of Foreign Public Officials in International Business Transactions." Available from http://www.oecd.org/dataoecd/50/33/1827022.pdf.

Organisation for Economic Co-operation and Development (OECD). "Sustainable Development: Critical Issues." Available from http://www.oecd.org/document/55/0,2340,en_2649_34499_1890487_119696_1_1_1,00.html.

ORGAN TRANSPLANTS

From the first successful kidney transplant in 1954, organ transplantation has advanced radically to become one of the greatest technological achievements in medicine. As of the early twenty-first century, doctors have successfully transplanted six different organs: the liver, kidney, pancreas, heart, lung, and intestine, as well as several different types of tissue. Simultaneous transplantation of multiple organs is possible as well. The possibility of organ transplant offers hope to thousands of patients suffering from organ failure who may have no other option. However, as the technique improves, the number of people waiting for an organ increases rapidly. More people die on the waiting list each year as the organ shortage escalates. Based on OPTN data as of November 26, 2004, there are 86,876 people on the United Network of Organ Sharing (UNOS) waiting list in need of a transplant and approximately 7,983 individuals died in 2003 while waiting for an organ.

Process and Costs

Cadaveric organ transplant is currently the most popular form of transplantation. However, living donation from both related and non-related donors is widely accepted for kidneys and increasingly more common for liver patients. In the United States, UNOS functions as a centralized system for the allocation of available organs. When an organ becomes available, UNOS is contacted by a local Transplant Coordinator and determines which candidate is the most suitable for the organ, based on clinical factors such as tissue matching, blood type, length of time on the waiting list, immune status, and geographical location. For heart, liver, and intestine transplants, the medical necessity of the potential recipient is also considered (United Network of Organ Sharing Internet site).

As organ transplant becomes a more routine procedure for those suffering from organ failure, it is important to recognize that there continues to be risks involved in this type of surgery. Transplant success has historically hinged on whether or not the recipient's immune system would attack the foreign organ, jeopardizing the effectiveness of the transplant. To limit this, antigen matching between the donor and recipient is a primary concern of UNOS. In the early 1980s, cyclosporine became the first of many drugs to effectively suppress the human immune system to prevent organ rejection. Although not perfect, immunosuppression has become critical to further advancements in transplantation. The intensity

A kidney transplant. The high cost of immunosuppressant therapy for kidney recipients has become a subject of Congressional debate. *(© UPI/Corbis-Bettmann.)*

of the immunosuppressant treatment can leave recipients susceptible to potentially life-threatening infections.

Immunosuppressant drugs are a lifetime commitment for organ recipients; unfortunately, they are expensive. Kidney recipients spend an average of $10,000 to $14,000 on such medications each year. Congress has struggled with how to pay for this expensive therapy since its conception. Numerous policies have been passed since 1972 to aid in the cost of kidney transplantation as well as immunosuppressant medications for recipients of kidney, liver, and heart transplantations who qualify for Medicare at the time of transplantation and extends for limited time post-transplant. Despite much effort, many transplant recipients still struggle with the increased cost of post-transplant medication critical for their survival. Noncompliance rates due to inadequate finance for organ recipients has been difficult to determine, but may be a common cause of graft failure (Kasiske, Cohen, Lucey, and Neylan 2000). Ethical debates have arisen on this issue. Some believe giving an organ to a patient for whom it is financially impossible to continue treatment is wasting an organ that could save another life. Others argue it is unethical to deny the life-saving procedure to those of lower socioeconomic class.

Allocation Issues

The allocation of organs has been the source of extensive ethical and political concern. Organs are considered a precious and limited resource because few are available for transplantation, and because of the altruistic nature of the gift of an organ. Many question whether there ought to be standard psychosocial criteria added to the evaluation process to prevent various types of discrimination. Providing prisoners with a transplantable organ has prompted a significant public debate. This was highlighted by the controversy surrounding a prisoner in California who received a heart transplant in January 2001. The debate is centered on the question of who should be given the power to determine whether one individual is more worthy of an organ transplant; beginning this type of preferential treatment is what many ethicists consider a "slippery-slope."

Xenotransplantation

Xenotransplantation is one potential method of attacking the organ shortage. The prefix *xeno-* means "foreign"; a xenotransplant refers to the process of transplanting a cell or organ from a foreign species. After consideration of factors such as availability, anatomy, and familiarity with the animal, pigs have emerged as the most promising donor option. Genetic engineering offered opportunity to modify the donor animal to more closely resemble the human recipient; coupled with improvements of immunosuppressant therapy, the chance of organ rejection could potentially be significantly decreased (Sachs, Sykes, Robson, and Cooper 2001). At the beginning of the twenty-first century, there had been little success in xenotransplantation, and much debate on the ethics and policy involved with the field. One primary concern with the development of xenotransplantation is the potential for an epidemic caused by previously unknown animal diseases being transferred to humans. Some believe this risk is too dangerous and that xenotransplantation should not be tested.

Another concern that arises with xenotransplantation, a discussion also relevant for certain allotransplant policy, is the commodification of the human body. Organ donation in the United States is considered an altruistic gift. However, policy proposals for financial incentives and some international policies for the buying and selling of organs puts a monetary value on organs. Organs for xenotransplant will be controlled by commercial companies; a recipient will have to purchase an organ. Because these organs will be genetically modified to resemble human organs, commercialization of the organs may have implications for socioeconomic equality. It would also create a rhetoric of human body parts as a purchasable commodity, a concept with which many ethicists have been skeptical (Bach, Ivinson, and Weeramantry 2001).

The benefit of organ transplantation for those suffering from organ failure is virtually undisputed. Unfortunately due to the complexity of the procedure, availability of organs, and the many other variables that factor into an organ transplant, there is still enormous debate surrounding transplantation.

SHELDON ZINK

SEE ALSO *Bioethics; Medical Ethics.*

BIBLIOGRAPHY

Bach, Fritz A.; Adrian J. Ivinson; and Christopher Weeramantry. (2001). "Ethical and legal issues in technology: Xenotransplantation." *American Journal of Law & Medicine* 27(2–3): 282–300. Discusses the risks and benefits of technology in general with a focus on xenotransplantation. The authors examine some of the legal, ethical and human rights considerations that this innovation raises.

Fishman, Jay A., and Robert H. Rubin. (1998). "Medical Progress: Infection in Organ-Transplant Recipients." *The New England Journal of Medicine* 338(24): 1741– 1751. Examines the risk of infection for transplant recipients. Provides detailed information regarding the most common infections faced by patients and the points at which various infections arise. Also addresses ways to potentially reduce the risk of infection, through pre-transplant screening of both the donor and the recipients, and treatment of infection with antimicrobial therapy post-transplant.

Kasiske, Bertman L.; David Cohen; Michael R. Lucey; and John F. Neylan. (2000). "Payment for Immunosuppression After Organ Transplant." *Journal of the American Medical Association* 283(18): 2445– 2450. Deals with the problem of payment for immunosuppressant therapy for organ recipients. The government has struggled with this issue and does cover some immunosuppressant medication for eligible donors; the authors discuss the need for expanding this coverage.

Sachs, David H.; Megan Sykes; Simon C. Robson; and David K. C. Cooper. (2001). "Xenotransplantation." *Advancements in Technology* 79: 129– 205. Provides a detailed overview of the field of xenotransplanation. Includes a history and explanation of the science and mechanism of transplanting an organ from an animal into a human, and discusses the possibilities and implications of using xenotransplantation in the future.

INTERNET RESOURCE

United Network of Organ Sharing. "Who We Are." Available from www.unos.org. A section of the UNOS Internet site that provides a detailed description of the history and membership of the organization.

ORTEGA Y GASSET, JOSÉ

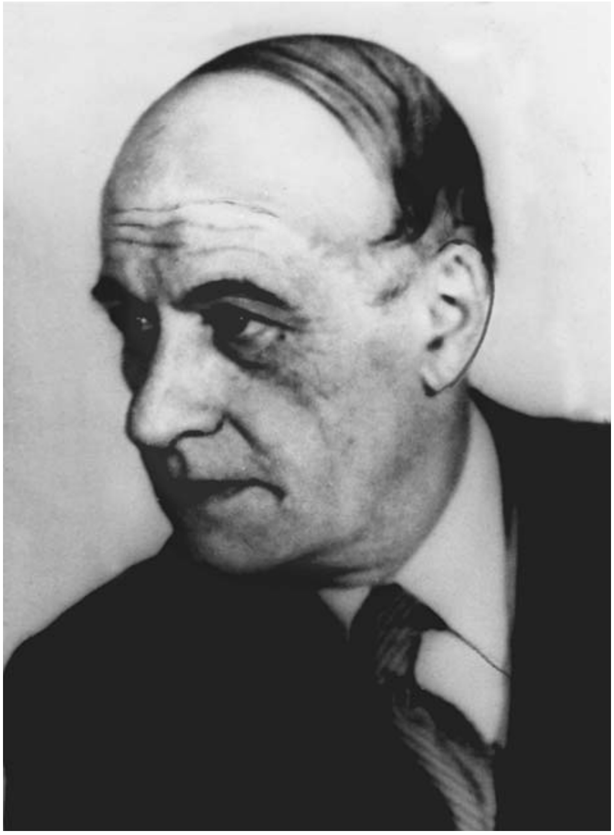
José Ortega y Gasset (1883–1955) was born in Madrid on May 8 and became the most influential Spanish philosopher of the twentieth century, with a reputation and influence that extended from Spain to Latin America and beyond. Ortega was the first professional philosopher to make technology an explicit theme for critical reflection. He died in Madrid on October 18.

Ortega in His Circumstances

Ortega earned a doctorate at the University of Madrid in 1904, after which he did postdoctoral work in Germany. His course of study included not only philosophy but also comparative literature, law, biology, and psychology. Having been influenced by the Generation of 98 (1898, the year in which Spain lost the last of its colonies to the United States and a period in which Miguel de Unamuno [1864–1936], Pío Baroja [1872–1956], and other writers responded with new visions of the nation), Ortega became a leading figure of the Generation of 27 (1927, the year of the emergence of a literary and artistic avant garde that included Federico García Lorca [1898–1936] and Pablo Picasso [1881–1973]).

Outside the academic world Ortega worked as a journalist, publisher, and politician and served as a member of parliament between 1931 and 1933, during the Second Spanish Republic. After the Spanish Civil War (1936–1939) he went into exile, initially in Argentina, but in 1945 he settled in Portugal and then returned to Spain in 1948 to found the Institute de Humanidades, where he lectured until his death.

The basic theme of Ortega's philosophy was announced in *Medicaciones del Quijote* [Meditations on Quixote] (1914), in which he argued for understanding human beings in relation to their circumstances. "Yo soy yo y mi circunstancias" [I am myself and my circumstances] was the formative statement with which he placed *razón vital* (living reason), a kind of existentialist vitalism, at the center of philosophical reflection. It was in an attempt to understand living reason at work in his own circumstances that Ortega, over the course of his



José Ortega y Gasset, 1883–1955. The Spanish philosopher and essayist is best known for his analyses of history and modern culture, especially his penetrating examination of the uniquely modern phenomenon "mass man." *(NYWTS/The Library of Congress.)*

philosophical career, analyzed the historical condition of Spain (*España invertebrada* [1921]), the character of modern art (*La deshumanización del arte* [1925]), the transformation of politics (*La rebelión de las masas* [1930]), the dynamics of history (*Historia como sistema* [1936]), and the post–World War II destiny of Europe (*Meditación de Europa* [1949]).

Ethics and Technology

Ortega's philosophy is a critique of the rationalism that has been dominant since the eighteenth century. As an affirmation of life that nevertheless acknowledges the essential character of reason in human beings, his philosophy is fundamentally ethical in its orientation. The primordial reality is life, in which individuals find themselves as castaways struggling not to drown. This is the basic human activity: not contemplation or science but rather "staying alive," with one of the instruments in the struggle being technology.

It is this perspective that Ortega brought to bear on technology in a number of works but especially in a 1933 university course that appeared in book form under the title *Meditación de la técnica* [Meditation on technics] (1939). More partial contributions to this analysis can be found in works as diverse as *The Revolt of the Masses; En torno a Galileo* [Around Galileo] (1933), translated as *Man and Crisis*; *La idea principio en Leibniz* [The idea of principle in Leibniz] (published posthumously in 1958); *Una interpretación de la historia universal* [An interpretation of universal history] (published posthumously in 1959); and lectures such as "Goethe sin Weimar" [Goethe minus Weimar] (1949) and "El mito del hombre allende la técnica" [The myth of humans outside technics] (1951).

Meditación de la técnica begins with a prophetic pronouncement about the future of philosophy and technology: "One of the themes that in the coming years is going to be debated with the most determination is the sense, advantages, dangers, and limits of technics" (*Obras completas* 1946–1983, Vol. V, p. 319). According to Ortega, technology does not so much help humans adapt to and be able to live in the natural world that surrounds them as it is an instrument that permits them to adapt nature to the satisfaction of their needs. Those needs include not only those of the primary type (food, shelter, etc.) but also those, which produce well-being, not just life but a vision of the good life. For example, the bow is an invention created both to hunt and to play music.

Whereas an animal can live only in a manner that is dependent on nature, humans are capable of distancing themselves from nature, becoming introspective, and, from the point of this self-absorbtion, performing the act of inventing. Technological innovation creates a "supernature" that becomes a mediator between humans and nature. In the historical development of this technology Ortega distinguishes three stages: accidental technology, crafted technology, and the technology of the technician.

In the first stage technology appears in limited and rudimentary forms; human beings view technological innovation as the result of chance, not of their capacity for invention. In the second stage craft techniques have a greater presence and complexity, although invention and production are not clearly distinguished. More important, humans do not realize their capacity for invention because the technical advances they produce are considered not innovations but variations within a craft tradition.

In the third stage humans finally recognize that technology is the fruit of their ability to invent. They dissociate the moment of invention, which belongs to the inventor or engineer, from the act of application, which belongs to the worker. In this stage humans begin to create not only instruments or tools but also machines that replace human work: the set of "invention factories" (as the inventor Thomas Edison [1847–1931] called his laboratory) and systems for research and development leading to new and imaginative technologies.

It is in this third stage, Ortega argues, that humans now find themselves and in which they discover a horizon of unlimited possibilities. Before the modern period most people were limited by the circumstances in which they both inherited a vision of how to live and adopted the apparently unchanging technical means to realize it. In the contemporary world, however, with the emergent ease of external technical invention, human attention is distracted by ever more superficial activity. In Ortega's words, in the modern world "before having some particular technics one has technics itself" (*Obras Completas* 1946–1983, p. 369).

However, at this point human beings must face two temptations. On the one hand, they tend to lose interest in the science on which technology depends because it seems so readily available that producing it does not seem to be required any longer. On the other hand, they specialize, thus abandoning any comprehensive view of reality that might provide a basis for orienting or focusing technological developments. Able to become anything they want, they cease to want to become anything at all.

Ortega presents a defense of technology as an element that makes human life human. However, he points out that the capacity, in principle unlimited, that technology now offers to humans may tempt them to believe that they live from technology and not with it, that they are merely forms of technological life, not creatures that use technology to live. Insofar as human beings allow themselves to give in to that temptation, human life eventually will become meaningless and living reason will wither and die.

Implications

More than other seminal philosophers of technology in the European tradition, such as Martin Heidegger (1889–1976), Herbert Marcuse (1898–1979), and Jacques Ellul (1912–1994), Ortega appreciated the positive aspect of technology, its intimate engagement with what it means to be human. At the same time, more than some people today who enthusiastically celebrate the achievements of technology, he recognized the dangers of what might be called "technology only technology." Whether and to what extent Ortega's thought can be brought to bear in specific discussions about science, technology, and ethics remains to be seen.

VINCENTE BELLVER CAPELLA
TRANSLATED BY JAMES A. LYNCH

SEE ALSO *Conservatism; Existentialism; Spanish-Language Perspectives.*

BIBLIOGRAPHY

Gray, Rockwell. (1989). *The Imperative of Modernity: An Intellectual Biography of José Ortega y Gasset.* Berkeley: University of California Press.

Ortega y Gasset, José. (1946–1983). *Obras completas,* 12 volumes. Madrid: Alianza. Volume V contains *Meditación de la técnica* in *Ensimismamiento y alteración* (1939). An incomplete translation is available as "Thoughts on Technology" in *Philosophy and Technology: Readings in the Philosophical Problems of Technology,* ed. Carl Mitcham and Robert Mackey. New York: Free Press, 1972, pp. 290–313. Though Ortega's reflections on technology can be found in many of his writings, *Meditación de la técnica* gives a comprehensive vision of his thoughts on the matter.

OZONE

SEE *Montreal Protocol.*

P

PARETO, VILFREDO

The unique contributions of Vilfredo Pareto (1848–1923) to mathematical economics as well as sociopolitical theory were predicated on a remarkable background and education. The son of Raffaele Pareto (a minor Italian noble, civil engineer, political refugee, repatriated professor, and then government minister) and a Frenchwoman, Marie Méteníer, Fritz Wilfried Pareto (renamed in 1882 Vilfredo Frederico Damaso Pareto, ultimately the Marchese of Parigi), was born in Paris on July 15. The household was bilingual, but after his father's political safety was assured, the family removed to his native Genoa (1855–1859); spent several years in Casale Monferrato, Piedmont, so his father could improve his professional position as a government administrator of mines and industry; then went to Turin; and finally settled in Florence. In 1889 Pareto married Alessandrina "Dina" Bakounine (Bakunin; not from the anarchist's family), who left him in 1901. He lived with Jeanne Régis from 1906 and married her in 1923 (after relocating in order to divorce Bakounine), and adopted her daughter, Marguerita Antoinette Régis. He died on August 23 in Céligny, Switzerland, where he had lived since 1900, spurning honors bestowed on him *in absentia* by the new Italian fascist government.

Vilfredo Pareto, 1848–1923. The Italian sociologist, political theorist, and economist is chiefly known for his influential theory of ruling elites and for his equally influential theory that political behavior is essentially irrational. *(The Library of Congress.)*

Pareto was rigorously educated in mathematics and the natural sciences, as well as the classics, partly in the school where his father taught—he imitated his father by pursuing mathematics, physics, and engineering. He precociously finished his doctorate in 1870 with a thesis on the then-new applications of differential equations to the question of elasticity and equilibrium in solid bodies, a work he always valued.

His subsequent management positions (with the Rome Railway and then the Italian iron industry, 1870–1889) compelled him to travel throughout Europe to learn practical business matters, and eventually to loathe the seedy deal making that accompanied the job. His anti-government lectures to laborers were shut down, and repelled by the plutocratic government; he ran for a Florentine seat in the legislature. He wrote 167 political articles for newspapers and magazines between 1889 and 1893, arguing that the Italian aristocracy had ruined the national economy through protectionism, cronyism, and graft.

Barred from a professorship in Italy, he accepted Léon Walras's (1834–1910) vacated chair in political-economics at Lausanne, Switzerland in 1893. He retired at fifty with a substantial inheritance from his uncle and perfected his quest for a quantifiable social science inspired by his reading of Auguste Comte (1798–1857) (another prodigy who had studied mathematics and engineering and coined the term *sociology*). It was his extraordinary proficiency in applied mathematics that facilitated Pareto's cardinal contributions to early econometrics, to equilibrium and systems theory in sociology, and, by redefining cyclical patterns to rulership, to political science.

Pareto is a neglected genius of the modern period. Living coterminously with Max Weber (1864–1920), Émile Durkheim (1858–1917), Georg Simmel (1858–1918), and Sigmund Freud (1856–1939), he shared none of their posthumous fame—except for a brief period in the 1930s when he was lionized, especially among Harvard intellectuals. This is probably more a quirk of history than a sound judgment about the quality of his ideas and research. In his autobiography, Mussolini claimed to have attended Pareto's lectures on political economy at Lausanne (with many other students), and a link was forged in the popular mind between fascism and Pareto's theory of *the circulation of elites*. The connection is artificial because Pareto detested any form of authoritarian rule, including fascism. Yet his ideas have suffered as a consequence of this unsavory historical connection.

The arguments of Pareto's *Course of Political Economy* (1896), which features *the Pareto optimality or ophelimity principle* are nevertheless referenced in every economics textbook. Moreover his *Socialist Systems* (1902), the *Manual of Political Economy* (1904), and his million-word *Mind and Society* (1916) evidence a level of speedy productivity and creativity that has few rivals. These works have not been seriously reconsidered, except in Italy and France, during the entire post-World War II period.

Like other gifted scientists and technicians who since the Enlightenment have turned their analytic tools toward social analysis, Pareto realized that economics alone, even if elegantly quantitative in design, could not explain the great bulk of human behavior because people do not generally behave to *maximize their utilities*. Even though he claimed to rely on the *logico-experimental method* in all his socioeconomic analyses, he thoroughly understood its limitations. Pareto's complex typological analysis of the role of nonrational, nonlogical, or irrational behaviors (*resides, derivations,* and *sentiments,* as he called them) in individuals and social groups has not been equaled in scope and depth. Yet the pessimistic conclusions he drew from his dogged historical and cultural research repels most readers today who are understandably, given recent history, more interested in ameliorative than in denunciative social theory.

What makes Pareto so difficult to embrace is his clear-eyed insistence on examining history and contemporary events through the scientist's lens, free of any idealized notions of what *ought to be* or *might have been*. Intensely idealistic when young, he soured on the *illusions of the epoch* (e.g., nationalism, Marxism, socialism, anarchism, imperialism, among others), viewing all of them as delusionary systems enabling social actors to feign rational behavior while hiding their real motives behind baroque structures of excuses and ideological justifications (derivations). Pareto never read Freud, but his work could be viewed as adding a macroanalytic dimension to the microanalysis common to psychoanalysis. Similarly when economists now speak about the *irrational exuberance* of stock markets, they are unknowingly speaking in Pareto's terms, and could well put to use his analysis of the socioeconomic environment. The same goes with regard to many discussions of science and technology policy that propose benefits from cancer research or space exploration that lack sound justifications.

ALAN SICA

SEE ALSO *Comte, Auguste; Efficiency; Engineering Ethics; Italian Perspectives; Management.*

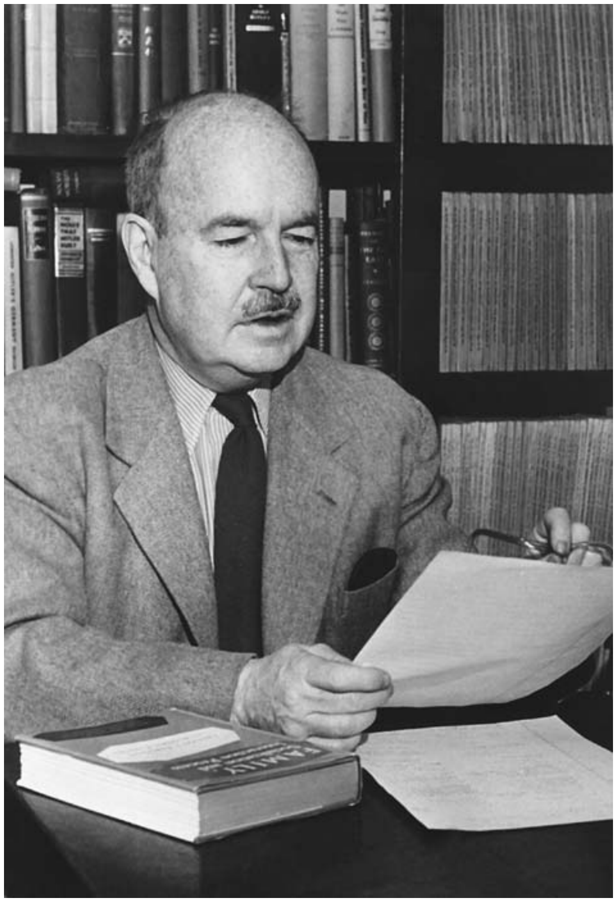
BIBLIOGRAPHY

Pareto, Vilfredo. (1935). *Trattato di sociologia generale* [Mind and Society]. 4 volumes, trans. Andrew Bongiorno and Arthur Livingston, with the advice and active cooperation of James Harvey Rogers. New York: Harcourt, Brace, and Co.

PARSONS, TALCOTT

The leading anglophone social theorist between about 1940 and 1965, Talcott Parsons (1902–1979), who was born in Colorado Springs, Colorado, on December 13, was a tireless synthesizer of ideas from classical social and economic theory, functionalist anthropology, psychoanalysis (in which he was trained), and psychology. Though he did not create pathbreaking scientific concepts or procedures, nor contribute formally to ethical reasoning, he did succeed in grafting a robust affection for scientific method (as his generation understood and venerated it) onto the massive edifice of classical social theory in a way that no one else had managed.

Parsons was the youngest child of an early feminist mother (who could trace her ancestry to Jonathan Edwards [1703–1758], the American "divine") and a Congregational minister who became president of Marietta College. Parsons first studied biology at Amherst College, then shifted to political economy of the German-historical type. After a year at the London School of Economics (1924–1925), he moved to the University of Heidelberg, receiving his doctorate there with a dissertation on "'Capitalism' in Recent German Literature: Sombart and Weber." After teaching one year at Amherst he became an economics instructor at Harvard University, where he became a full professor in 1944 and where he remained until his retirement in 1974. He married Helen Bancroft Walker on April 30, 1927, and with her produced three children, Anne (an anthropologist of Italian culture), Charles (an economist), and Susan. Diabetic since the age of fifty-six, he died at seventy-six while on a trip to Heidelberg, on May 8, 1979, while celebrating his formative academic experience in that town fifty-three years earlier.



Talcott Parsons, 1902–1979. The American sociologist analyzed the socialization process to show the relationship between personality and social structure. His work led to the development of a pioneering social theory. *(AP/Wide World Photos.)*

In 1946 Parsons helped form a new department, Social Relations, which brought together anthropology, political science, social psychology, and sociology. His keen attention to the claims of progressive, liberalizing science, coupled with an ever-present desire to understand the ethical meaning of social action (individually and collectively) were provoked by his parentage and upbringing, plus the special context of Harvard between 1927 and 1974, where he worked closely with a galaxy of gifted students and colleagues. His fascination with the proper role for "the professions," and how groupings of professionals could serve as a bulwark against the deadening routine of bureaucracy, on the one hand, and the self-serving market scramble of the capitalist on the other, was a theme adopted straight from Émile Durkheim's 1892 book, *Division of Social Labor*. It dovetailed perfectly with the strict Protestant morality, left-leaning in its politics, that he had absorbed while a boy. Parsons was also president of the American Sociological Association in 1949.

At Harvard, Parsons educated four self-aware generations of enterprising sociologists who carried his structural-functionalist scheme around the country and the world, particularly during the 1950s and 1960s (with a small renaissance in the early 1980s). His leadership of the theory wing of American sociology began to wane with C. Wright Mills's (1916–1962) famous attack on "grand theory" in *The Sociological Imagination* (1959) and was ended by Alvin Gouldner's (1920–1980) rhetorical masterpiece, *The Coming Crisis of Western Sociology* (1970).

Of Parsons' fourteen books, his first one, *The Structure of Social Action* (1937), remains of paramount interest. In this large study of Max Weber (1864–1920), Durkheim, Vilfredo Pareto (1848–1923), and the English economist Alfred Marshall (1842–1924), Parsons claimed to have discovered a "convergence" of ideas among four geniuses that culminated in Parsons's own ideas about the nature of normatively ordered social action. He was especially interested in how societies deal with the "Hobbesian problem of order," which is understandable given the history of the twentieth century to that point. But he was equally dedicated to updating the perennial question first systematically presented by Durkheim in 1892: What is the proper balance between the rights of individuals to express their uniqueness and the needs of the larger society to constrain these egocentric rights through normative controls? Fascinated with normative "consensus" and the avoidance of costly societal conflict, Parsons created his own sociological glossary, including such terms and concepts as voluntarism, pattern variables, the AGIL scheme of action (1963), and universalistic versus particularistic norms, as well as a large assortment of two-by-two tables that illustrated the personality/social structure dialectic in terms that seemed to validate his way of seeing the world.

Parsons's statements about science and technology now seem banal because he uncritically echoed the great enthusiasm for Big Science that so much infected the post–World War II period. A comment from his 1971 book, *The System of Modern Societies*, is typical:

> Applied science did not begin to have a serious impact upon technology until the late nineteenth century. But technology has now become highly dependent upon research "payoffs," involving ever-wider ranges of the natural sciences, from nuclear physics to genetics, and also the social or "behavioral" sciences, perhaps most obviously economics and some branches of psychology. The social sciences share with the natural sciences the benefits of some striking innovations in the technology of research. (p. 96)

His most important work in this regard is a little-known empirical study he conducted with many collaborators between 1946 and 1948, "Social Science: A Basic National Resource." Here he argued that the new National Science Foundation ought to support the social sciences (contrary to the desires of President Franklin Roosevelt), because of its "scientifically based" contribution to the war effort. He wrote op-ed pieces for the *New York Times* making the same point, and led the fight for equal funding for social science because of its basic importance to national security, as well as its pivotal role in the general acquisition of knowledge.

Parsons was rediscovered briefly in the 1980s by a new generation of theorists, both in the United States and in Europe, but the "neofunctionalism" that briefly carried his banner has since become moribund. His future importance will probably turn around his first book, and he will be remembered as a great systematizer in an era that no longer cared for the presentation of knowledge in such "grand" synthetic gestures.

ALAN SICA

SEE ALSO *Durkheim, Émile.*

BIBLIOGRAPHY

Gouldner, Alvin W. (1970). *The Coming Crisis of Western Sociology*. New York: Basic Books.

Mills, C. Wright. (1959). *The Sociological Imagination*. New York: Oxford University Press.

Parsons, Talcott. (1937). *The Structure of Social Action: A Study in Social Theory with Special Reference to a Group of Recent European Writers*. New York: McGraw-Hill.

Parsons, Talcott. (1986 [1948]). "Social Science: A Basic National Resource." In *The Nationalization of the Social Sciences*, ed. Samuel Z. Klausner and Victor M. Lidz. Philadelphia: University of Pennsylvania Press.

Parsons, Talcott. (1971). *The System of Modern Societies*. Englewood Cliffs, NJ: Prentice-Hall.

PARTICIPATION

Participation can mean different things depending on context. In the context of science, technology, and ethics, the concept of participation points toward questions of how technologies might be developed to promote political interaction among democratic citizens, and issues of how technoscientific expertise may itself be related to democratic decision making. The present analysis focuses on the second issue by examining three philosophical perspectives on participation in preface to making a sociological argument—an argument that will (a) refine how the problem of participation ought to be conceptualized and (b) consider all the normative aspirations of philosophy to work in conjunction with empirical studies for the purpose of offering citizens and scientists alike greater reflexive purchase on their collective decision making.

Preliminaries

Before turning to the three perspectives on participation, it is useful to note a few things in general about the problem of participation. *Expertise* is a term that is not only associated with knowledge, skill, and authority, but also with hierarchy—elitism, paternalism, and power. On the one hand, hierarchy is an essential component of representative democracy. If a government encouraged people to vote about everything without regard to expert knowledge, it would promote self-destructive mob rule rather than democracy. On the other hand, the existence of hierarchy can threaten the possibility of democracy. Democracy is practically synonymous with *equality:* Democratic citizens are equal in the legal, rights-based context of public involvement and participation in their own governing.

Because an essential condition of a democratic society is arguably the right of its citizens to participate in the public processes that directly affect them, and because justice demands that vulnerable groups who might be adversely impacted by such decisions be represented in the decision-making process, it is difficult to determine the proper relation between expertise and democracy. Stakeholders who represent different values find it difficult to agree on exactly who should participate in establishing the policies influencing what scientific and technological research is pursued, how it should be conducted, and the methods for disseminating results. Even when consensus exists over who has the right to participate, debate continues over the extent of the participation that different groups are justified in expecting. Sometimes a demand that marginalized voices be heard is associated with expectations that lay perspectives be given preferential treatment. The problem of participation is therefore one that ultimately concerns the politics of inclusion and exclusion. It is not only about how science and technology are mobilized, but also about how they are practiced and who benefits.

Three Circumspect Views

The gateway to a deeper appreciation of the problematics of democratic participation in science and technology is through three existing perspectives on relations between scientists and non-scientists: (a) Some believe that if enough patience is exerted, experts and laypeople can simply resolve any disagreements through dialogue and further experimentation, (b) others argue that laypeople simply cannot provide better answers for technical questions than experts can, and (c) still others maintain that technoscientific research ought to be self-governing because only experts are competent enough to decide how technoscientific inquiry ought to proceed. Each of these positions will be considered in turn, and objections noted. (Given the almost religious authority granted to science in the early-twenty-first century, it is common to refer to nonscientists as the laity. The terminology is adopted here simply for convenience and with no intent to accept its subordinating implications.)

POLANYI'S REGULATIVE IDEAL. Michael Polanyi (1891–1976) best articulates the first view: If enough patience is exerted, experts and laypeople can solve their disagreements through dialogue and further experimentation. Polanyi calls attention to the fact that the popular authority of science is challenged in many circles, and he thus raises the question: How can conscientious citizens in a free society competently decide rival interpretations of nature? Recognizing that participants who espouse fundamentally different views cannot resolve their differences if they frame their discussion as if it were taking place within one organized branch of knowledge, Polanyi appeals to the democratic process of free discussion and respect for civil liberties, thus placing particular emphasis on *fairness*. He defines fairness as trying to state one's case objectively, and *tolerance* as the capacity to discover whatever sound points an interlocutor espouses. Polanyi insists that striving for fairness and tolerance can further the end of resolving controversies only if people who make strong epistemic commitments endorse these virtues.

In order for a community to effectively promote free discussion, its members must not only be committed to believing that there is such a thing as objective truth but must feel obligated to pursue it, and indeed they must believe themselves capable of acquiring it. Polanyi's solution to the problem of participation thus rests upon a regulative ideal, one that a community must autonomously choose to pursue. His solution also rests on the conviction that participation in the common enterprise of science by scientists, which is to say, the devotion of all scientists qua scientists to scientific ideals, is itself a model for political democracy because the basic ideals that guide the cognitive ambitions of science are democratic ideals. For example, the ideal of the equality of all observers—genuine scientific research must be replicable by anyone who has the appropriate scientific training and the appropriate technical apparatuses—and the ideal of publication and open dissemination—the results of scientific investigation belong to humanity—are ideals that accord with a democratic vision of the politics of science.

MESTHENE'S NEW DEMOCRATIC ETHOS. Emmanuel Mesthene, who at one time directed the Harvard University Program on Technology and Society (1964–1972), puts forth the second view: Laypeople simply cannot provide better technical answers to technical questions than experts. Mesthene points out that experts are becoming integrated into all phases of the process of government. The information that needs to be gathered and analyzed in order to make so many of our modern choices depends on the successful coordination of the experts who have mastered technological devices and scientific knowledge. Mesthene claims that as a result of the pervasive practice of deferring issues that were once the subject of public debate to experts in particular fields—experts who function almost independently of the democratic political process—traditional democratic aspirations are eroding. Under the assumption that the expert-lay divide will only continue to grow as the gap enlarges between the technoscientific experts who actually guide policy and the citizens who are in principle charged with establishing it, Mesthene contends that people need to revise their understanding of what democracy is and accept a new democratic ethos adequate to the demands and structure of the modern technoscientific society.

What might this new democratic ethos look like? On the one hand, Mesthene insists that the experts who gather the information that society needs to shape its policies should be ultimately accountable to the electorate; the freedom of the general populus to express its opinions and preferences must somehow be preserved. Presumably what Mesthene has in mind is a process that would allow elected representatives to act as proxies for public opinion by helping to establish federal research funding priorities. On the other hand, he famously declares that "no amount of *participation*—in the popular sense of the term—can substitute for the expertise and decision-making technologies that modern government must use" (Mesthene, p. 81).

POLANYI'S AUTONOMOUS RESEARCH. Polanyi articulates the third view: Technoscientific research ought to be self-governed because only experts are competent enough to decide how such inquiry ought to proceed. He succinctly expresses this point when he writes, "The choice of subjects and the actual conduct of research is entirely the responsibility of the individual scientist, [and] the recognition of claims to discoveries is under the jurisdiction of scientific opinion expressed by scientists as a body" (Polanyi 1951, p. 53). This view found its way into the public sphere when presidential science advisor Vannevar Bush challenged Senator Harley Kilgore's populist position by arguing for a *social contract* with science, one that protects the right of scientists to autonomously pursue basic research.

Objections

Pragmatist philosopher John McDermott (1969) objects to Mesthene's view that laypeople cannot do better than experts in providing technical answers to technical questions. Although Mesthene's view of the expert-lay divide may appear to rest on a realistic understanding of just how deep the differences between them in knowledge, skill, and ability are, McDermott contends that Mesthene's view also reinforces the technocratic position that the greatest resource of a society is its experts and not the general populus. In McDermott's classic critique of Mesthene, he points out that what Mesthene must presuppose idealistically, in order to have as much confidence in the technical elites as he does, is that the people who pursue technoscientific careers are *altruistic bureaucrats*: that they lack a generalized drive for power; that they gain advantage and reward only to the extent that they bring technical knowledge to bear on technical problems; and that they remain shielded from the bias of ideology because their commitment to solving technical problems rules out subjective forces of influence.

While Polanyi characterizes scientists in a free society as tolerant, and Mesthene envisions them to have no general interests antagonistic to those of their problem-beset clients, Paul Feyerabend (1975, 1978), by contrast, resolutely declares that modern scientific experts have become *ideologues:* The more time and energy they devote to advancing a position, the more difficult it becomes for them to be open-minded to points of view that challenge their core beliefs. Noting how students in the natural sciences are instructed in the technical dimensions of a scientific field but only minimally exposed to the historical arguments against the theories that make the contemporary conventional wisdom seem true or useful, Feyerabend insists that scientists have become overconfident about how to conduct research properly and how to set the boundaries for generating accurate conclusions; as a result, they are prone to uncritically dismissing alternative research methods and conclusions. In order to break the hold of expert ideology, Feyerabend argues that nonexperts ought to be institutionally empowered to judge expert viewpoints and agendas. The view of participation that Feyerabend puts forth is that duly elected committees of laypeople should regulate all scientific research that can affect the public sphere. Because the exalted authority of science is incompatible with any legitimate democracy, experts ought to be regarded first and foremost as public servants. Were this result achieved, Feyerabend argues, laypeople would realize that they have more to contribute to the pursuit of knowledge than experts who distort the value of their own achievements.

Although Feyerabend's reputation in philosophical circles remains mixed, his principal message concerning the need to better investigate the inflated authority of expertise, notably the ways in which technical decision making can be value-laden, has been enormously influential. But Feyerabend's commitment to a certain vision of democracy drives him to dichotomize the world into experts (elites) and laypeople (commoners). He is thus criticized for being insensitive to the possibility that laypeople are a disparate lot, with a variety of background skills, who do not share a common aptitude for regulating—and, as he sometimes suggests, for criticizing—expert advice. Ultimately, by classifying laypeople reductively, Feyerabend unwittingly licenses the possibility for the opposite trend to occur, for scientific elites to reduce laypeople to a mass of ignorance. Hence it was possible for Paul Gross and Norman Levitt to respond: "Scientific decisions cannot be submitted to a plebiscite; the idea is absurd. Applied to science education, for example, letting people vote on what should be taught would give us countless schools in which *creation science* would replace evolutionary biology" (Leavitt and Gross, p. B2). Even Philip Kitcher (2001) felt justified in referring to the possibility of laypeople making direct decisions on matters of science policy as *vulgar democracy* leading to the *tyranny of the ignorant*.

The consequence of using extreme positive or negative terms to caricature all laypeople and all scientific elites, and all the options by which they might participate politically, cannot escape the astute observer. The insistence that laypeople should have absolute and sole regulatory authority over technoscientific practice, or that they should have no right whatever to intervene in important technoscientific decisions, obscures the plausible ways of legitimately increasing citizen involvement in technoscience.

Interdisciplinary Research

Moving beyond the reductive expert-lay dichotomy requires that theorists focus on more subtle categories, as for example Don Ihde (1996) does in his discussion of *well-informed amateurs*. Ihde suggests that such an amateur would have the critical advantage of being neither a complete insider nor complete outsider to the domain of technoscience under dispute. Ihde's analysis further suggests that in order for philosophers to better address the problem of participation they need to become more empirically oriented. They need to have a more concrete understanding of how different constituencies interact with scientists, engineers, and policy makers. What Ihde can be interpreted as advocating, then, is that in order to better pursue normative projects, it is necessary for philosophers to do empirical fieldwork or to have more felicitous interdisciplinary exchanges with anthropologists, historians, and sociologists.

If philosophers were more empirically focused, what would they study? Perhaps what philosophers should do is carefully study different instances of technoscientific negotiation, noting, for example, what has *enabled* or *prevented* successful encounters. Robert Crease, a philosopher of science and technology who is also the official historian for Brookhaven National Laboratory, provides an exemplary instance of this type of empirically oriented philosophical research. In "Fallout: Issues in the Study, Treatment, and Reparations of Exposed Marshall Islanders," he examines a failed account of expert-lay negotiation. Crease's essay concerns the actions of U.S. doctors, politicians, and activists, all of whom sought to aid Marshallese inhabitants accidentally exposed to fallout in the wake of a nuclear weapons test in 1954. He thus investigates a classic case of Western intervention in non-Western culture during a period in which a politically volatile climate was conducive to traditional technoscientific experts losing their authority. Crease argues that it would be a mistake to pigeonhole this kind of story into traditional social movement narratives involving victimization or oppression, the civil rights struggle, the struggle against cultural imperialism, or the Tuskegee syphilis experiments, among others. He demonstrates that the only way to explain the distrust that the Western scientists experienced is to concretely examine the context in which specific forms of participation were prohibited.

An example of successful expert-lay interaction suggests the kinds of cases that deserve further study. Theorists such as Steven Epstein, who have written on the AIDS pandemic, noted how people with HIV and AIDS were capable of developing credibility with scientists researching the issue despite being initially marginalized. This expert-lay alliance was hard to forge. It required that activists: (a) learn about the culture of medical science, including not only its dominant assumptions, but also how to speak its language; (b) successfully present themselves as representing a potential clinical-trial subject population (that is, people with HIV or AIDS); (c) provide compelling epistemological, moral, and political arguments; and finally, (d) form strategic alliances with scientists by taking advantage of preexisting personal, political, and epistemological tensions. Ultimately this alliance depended on the creation and maintenance of an interdependent and overlapping discourse. It depended on what Crease calls *impedance matching* between networks of science groups and networks of stakeholders.

As philosophers working in conjunction with the interested and affected constituencies come to inquire empirically into which provisions and circumstances have successfully promoted both better participation and more socially successful technoscience, they will be better placed to address the normative question: Which provisions should be instituted, and under what circumstances, to allow laypeople to have greater legitimate participation in technoscientific affairs? Extrapolating from existing research, it seems likely that successful solutions to the problem of participation will be ones in which theorists refrain from positing an ideal intermediary to serve as an arbitrator between experts and the putatively lay public. Participation therefore remains an important philosophical topic because it is a classic example of how philosophy (in principle at least) can assist in the practice of public affairs.

EVAN M. SELINGER

SEE ALSO *Democracy; Expertise; Georgia Basin Futures Project; Polanyi, Michael; Stakeholders.*

BIBLIOGRAPHY

Barber, Benjamin. (1984). *Strong Democracy: Participatory Politics for a New Age.* Berkeley: University of California Press. Critical assessment of the limits of liberal theory with respect to the possibility of genuine democratic practice.

Borgmann, Albert. (1984). *Technology and the Character of Contemporary Life.* Chicago: University of Chicago Press. Seminal analysis of how modern technological practices tend to undermine participation in skillful endeavors and communal activities.

Crease, Robert. (2003). "Fallout: Issues in the Study, Treatment, and Reparations of Exposed Marshall Islanders." In *Exploring Diversity in the Philosophy of Science and Technology*, eds. Robert Figueroa and Sandra Harding. New York: Routledge. One of the first philosophical analyses of problems associated with the authority of technical expertise in a multi-cultural context that is firmly rooted in empirical history.

Epstein, Steven. (2000). "Democracy, Expertise, and AIDS Treatment Activism." In *Science, Technology, and Democracy*, ed. Daniel Lee Kleinman. Albany: State University of New York Press. One of the definitive works on the sociology of aids activism.

Feenberg, Andrew. (1995). *Alternative Modernity: The Technical Turn in Philosophy and Social Theory.* Berkeley: University of California Press. Definitive demonstration of the value of Frankfurt-school critical theory with respect to discussions of public participation in technical decision-making.

Feyerabend, Paul. (1975). *Against Method.* London: Verso. One of the first monography length critiques of the logical posivist's treatment of scientific inquiry.

Feyerabend, Paul. (1978). *Science in a Free Society.* London: Verso. Highly influential work in which the authority of technical experts is condemned on ideological grounds.

Goldman, Steven. (1992). "No Innovation without Representation: Technological Action in a Democratic Society." In *New Worlds, New Technologies, New Issues*, ed. Stephen H. Cutcliffe, Steven L. Goldman, Manuel Medina, and José Sanmartín. Bethlehem, PA: Lehigh University Press. A succinct account of the fundamentally political character of technical innovation.

Hickman, Larry. (1992). *John Dewey's Pragamatic Technology.* Bloomington: Indiana University Press. The authoritative secondary source on John Dewey's philosophy of technology.

Ihde, Don. (1996). "Why Not Science Critics?" *International Studies in Philosophy* 1: 45–54.

Ihde, Don. (1998). *Expanding Hermeneutics: Visualism in Science.* Evanston: Northwestern University Press. A provocative philosophical attempt to get beyond the epistemic impasse of the expert-lay divide. Includes the 1996 article above.

Kitcher, Phillip. (2001). *Science, Truth, and Democracy.* New York: Oxford University Press. A normative theory of the ideal relation between public participation and scientific inquiry.

Kleinman, Daniel Lee, ed. (2000). *Science, Technology, and Democracy.* Albany: State University of New York Press. One of the few edited volumes on the topic.

Levitt, Norman, and Paul Gross. (1994). "The Perils of Democratizing Science." *The Chronicle of Higher Education* October(5): B1–B2. An important contribution to the contemporary "science wars" from the perspective of natural scientists.

McDermott, John. (2003). "Technology: The Opiate of the Intellectuals, with the Author's 2000 Retrospective." In *Philosophy of Technology: The Technological Condition*, ed. Robert Scharff and Val Dusek. Malden, MA: Blackwell Publishing. An influential critique of technocracy.

Mesthene, Emmanuel. (1970). *Technological Change: Its Impact on Man and Society.* Cambridge, MA: Harvard University Press. An influential defense of technocracy.

Mitcham, Carl. (1997). "Justifying Public Participation in Technical Decision Making." *IEEE Technology and Society Magazine* 16(1): 40–46. Perhaps the clearest presentation of normative arguments for the principle of public involvement in technical decision-making available.

Polanyi, Michael. (1951). *The Logic of Liberty: Reflections and Rejoinders.* Chicago: University of Chicago Press. One of the earliest treatments of the problem of participation in the philosophy of science.

Polanyi, Michael. (1962). "The Republic of Science." *Minerva* 1: 54–73.

Sclove, Richard. (1995). *Democracy and Technology.* New York: Guilford Press. An influential plea for strong democracy in which communities are empowered to participate in decisions concerning the adoption of technologies.

PARTICIPATORY DESIGN

Participatory design (PD) is an approach to engineering technological systems that seeks to improve them by including future users in the design process. It is motivated primarily by an interest in empowering users, but also by a concern to build systems better suited to user needs. Traditionally, PD has focused on the design of information systems, though the same approach has been applied to other technologies. In order to respect the social contexts in which users work, PD practitioners explicitly consider the practical demands workers must meet in order to do their jobs, as well as the political relationships that exist between workers, their management, and technology designers. As a design subdiscipline, PD directly addresses both technological and ethical issues in the design of systems. Because of this, some people have argued that PD can be used as a model for the "democratization of technology."

History

Participatory design has its roots in northern Europe with the combination of two research programs studying the empowerment of workers with respect to technology. It is generally seen as developing from the Scandinavian "collective resources" research program that focused on union empowerment in contract bargaining situations through the education of union officials and members about various production technologies (Bjerknes, Ehn, and Kyng 1987). The other program, "socio-technical systems design," was pursued primarily by British researchers at the Tavistock Institute and focused on the design of technologies to empower individual workers by enabling and supporting autonomous workgroups (Mumford 1987). Both research programs had in fact grown out of the Norwegian Industrial Democracy Project begun in the 1960s, though the British contribution to PD is often overlooked (Emery and Thorsrud 1976).

The second generation of the Scandinavian approach was marked by the Swedish-Danish UTOPIA project in 1981, the first recognized development project. Conceived in response to the discouraging results of the earlier trade union projects, which had found that existing technologies limited the possibilities of workers to influence workplace organization, UTOPIA targeted technology development as a prospective site for user involvement and influence. In cooperation with the Nordic Graphic Workers Union, the UTOPIA (both an acronym and an ideal) project studied a group of newspaper typographers working without computer support in order to develop a state-of-the-art graphics software product for these skilled graphics workers. The objective was to create a commercial product that the unions could then demand as an alternative to the deskilling technologies available in the market. In doing this, their goals came into alignment with socio-technical systems research. By 1985, the British and Scandinavian traditions had rejoined under a common banner of democratizing technological systems design. The consequence was a new focus on the participation of workers in technological design discussions, and this was to be the essential feature of the PD tradition from that point on (Greenbaum and Kyng 1991).

Politics of Participation

PD has come to be defined by its attempts to involve users in the design of information technologies, and research in the field has examined the various challenges that these attempts have faced. Depending on the different features of the various workplaces that have been engaged, problems of communication, workplace politics, and design politics have received the most attention. The differences in work contexts range across unionized and non-unionized workplaces, democratic and non-democratic countries, small and large organizations, public and private institutions, commercial and non-profit organizations, volunteer and paid workers, and various configurations of labor and management. The design projects also differ in the extent to which they try to use existing or off-the-shelf technologies, as opposed to custom tailored systems. Finally, the roles and responsibilities of design engineers and workers in the process of systems design can vary widely, thus influencing the politics of design.

The principle method used by PD to involve users in design is to have them participate in meetings with design engineers. It is this simple idea that makes this approach "participatory." Participation in this sense is usually taken to mean participation in discussions about a technology, as opposed to actual participation in the construction of a system as engineers or builders. While this might seem simple, it turns out that there are various sorts of problems that arise in these meetings, due mainly to problems of communication between people of differing knowledge and perspectives.

Simply allowing users to sit in on design meetings is insufficient to achieve participation because the politics of both the workplace and the design process can intervene. Sometimes managers are considered to be part of the user group, even though only the workers below them will ever deal directly with the technology in question. The politics of the workplace can then impinge on the process to the extent that managers may resist the participation of low-level workers, or intimidate them in the meetings, or act to discount their authority, skill, and knowledge. Even when managers are not present, the users themselves may not be fully aware of how best to articulate their knowledge of the workplace or what they need and desire from the new technology, or they may underestimate the value of their own skills and knowledge. The politics of the design process often gives engineers, with their expert knowledge, much greater authority in making design decisions. As such, it can be difficult for users to express themselves and not simply defer to the authority of these expert designers. All of these political forces tend to silence the voice of users in the design meetings, and a serious effort must be made to counteract these tendencies.

Design engineers can also find it difficult to communicate effectively with users. Engineers tend to express themselves in technical language, and usually discuss design ideas in terms of nuts-and-bolts internal operations, rather than how a technology relates directly to a user. As such, it can be a daunting task for an engineer to describe design alternatives in a way that users are able understand and respond to them with informed opinions. As a result of these problems, a great deal of energy is expended in PD to create visualizations and mock-ups of proposed systems so that they can be evaluated by users. It is also common to send designers to the workplace to observe users, or even train them to do the work of the users of a proposed system.

Gender poses an additional set of problems to effective participation in design. In many work contexts, the positions traditionally occupied by women are often viewed as being of lower value by management and unions. This undervaluing of women's work easily overflows into inequalities of participation in design activities, especially when combined with social prejudices that view technological design as a masculine pursuit. Moreover, unless gender issues in the design process are recognized and dealt with, there exists a strong possibility of reproducing these gender politics through the technology (Green, Owen, and Pain 1993). Even though PD shares many of its organizational ideals and goals with feminist philosophies and organizations, researchers have found special challenges to utilizing PD in feminist organizations. Ellen Balka (1997) reports that common features of feminist organizations such as decentralized organizational structures, high dependence on volunteer and transient workers, lack of adequate funding and resources, and lack of technological training among organization members pose particular problems for implementing PD in these organizations.

Ultimately, PD does not consist of a set of strict rules or methods for how to go about designing systems. Instead, PD prescribes an attitude of including users, encouraging their thoughtful participation, and being sensitive to the political and ethical challenges facing designers. Specifically, it encourages designs that empower users, respects and encourages their skills and job satisfaction, and protects their individual autonomy as much as possible given their jobs and work environment. It also provides case studies and techniques that have worked to varying degrees in various specific design projects as a resource to draw upon in future design projects. Several conferences and journals have brought together the results of many such projects (Bloomberg and Kensing 1998). For more on the politics of representing work, see Liam Bannon's 1995 article, "The Politics of Design."

Democratizing Technology

Some authors, such as Langdon Winner (1995), have proposed that PD stands as an example of a new kind of technological citizenship. Under the current forms of citizenship, there is very little room for individual voices to shape the design of the technologies that permeate society. Private companies driven primarily by commercial interests produce most of these technologies. PD does not offer universal participation, or democratic control over all technologies, but it is argued to be a step in the right direction by allowing some non-commercial values to influence some technologies.

It is crucial to note that arguments such as Winner's hold out a procedural notion of justice as the political ideal. It is the very participation of people in design that is democratic, just as the right of all citizens to vote makes a government democratic. Thus, democratizing technological systems raises many of the same problems facing democratic governmental systems. Just as the people in a democracy are free to elect a tyrant and the majority might use the system to exploit and repress minority groups. It is not clear that universal participation actually leads to a society or technology that is free or empowering. What PD can do is bring designers, users, and the technology itself into a process through which the technology can develop in useful ways.

A more detailed history of PD, its connections to broader social movements such as the quality of working life movement and Total Quality Management, and a consideration of the ethical and political issues it raises can be found in Peter M. Asaro's 2000 article, "Transforming Society by Transforming Technology."

PETER M. ASARO

SEE ALSO *Design Ethics.*

BIBLIOGRAPHY

Agre, Philip. (1995). "From High Tech to Human Tech: Empowerment, Measurement, and Social Studies of Computing." *Computer Supported Cooperative Work* 3(2): 162–195.

Asaro, Peter M. (2000). "Transforming Society by Transforming Technology: The Science and Politics of Participatory Design." *Accounting, Management and Information Technologies,* Special Issue on Critical Studies of Information Practice, 10: 257–290.

Balka, Ellen. (1997). "Participatory Design in Women's Organizations: The Social World of Organizational Structure and Gendered Nature of Expertise." *Gender, Work and Organizations* 4(2): 99–115.

Bannon, Liam. (1995). "The Politics of Design: Representing Work." *Communications of the ACM* 38(9): 66–68.

Bjerknes, Gro; Pelle Ehn; and Morten Kyng, eds. (1987). *Computers and Democracy: A Scandinavian Challenge.* Brookfield, VT: Avebury.

Bloomberg, J., and F. Kensing. (1998). "Special Issue on Participatory Design." *Computer Supported Cooperative Work: The Journal of Collaborative Computing* 7: 3–4.

Ehn, Pelle, and Morten Kyng. (1987). "The Collective Resource Approach to Systems Design." In *Computers and Democracy,* ed. Gro Bjerknes, Pelle Ehn, and Morten Kyng. Brookfield, VT: Avebury.

Emery, Fred, and Einar Thorsrud. (1976). *Democracy at Work: The Report of the Norwegian Industrial Democracy Program.* Leiden, Norway: Martinus Nijhoff.

Feenberg, Andrew. (1991). *Critical Theory of Technology.* New York: Oxford University Press.

Green, Eileen; Jenny Owen; and Den Pain; eds. (1993). *Gendered by Design? Information Technology and Office Systems.* London: Taylor & Francis.

Greenbaum, Joan, and Morten Kyng, eds. (1991). *Design at Work: Cooperative Design of Computer Systems.* Hillsdale, NJ: Erlbaum.

Holtzblatt, Karen, and Hugh R. Beyer, eds. (1995). "Special Issue on Requirements Gathering: The Human Factor." *Communications of the ACM* 38(5).

Mumford, Enid. (1987). "Sociotechnical Systems Design: Evolving Theory and Practice." In *Computers and Democracy,* ed. Gro Bjerknes, Pelle Ehn, and Morten Kyng. Brookfield, VT: Avebury.

Mumford, Enid, and Don Henshall. (1979). *A Participative Approach to Computer Systems Design.* New York: Wiley.

Suchman, Lucy. (1995). "Making Work Visible." *Communications of the ACM* 38(9): 56–64.

Schuler, Douglas, and Aki Namioka (1993). *Participatory Design: Principles and Practices.* Hillsdale, NJ: Erlbaum.

Winner, Langdon. (1995). "Citizen Virtues in a Technological Order." In *Technology and the Politics of Knowledge,* ed. Andrew Feenberg and Alistair Hannay. Bloomington: Indiana University Press.

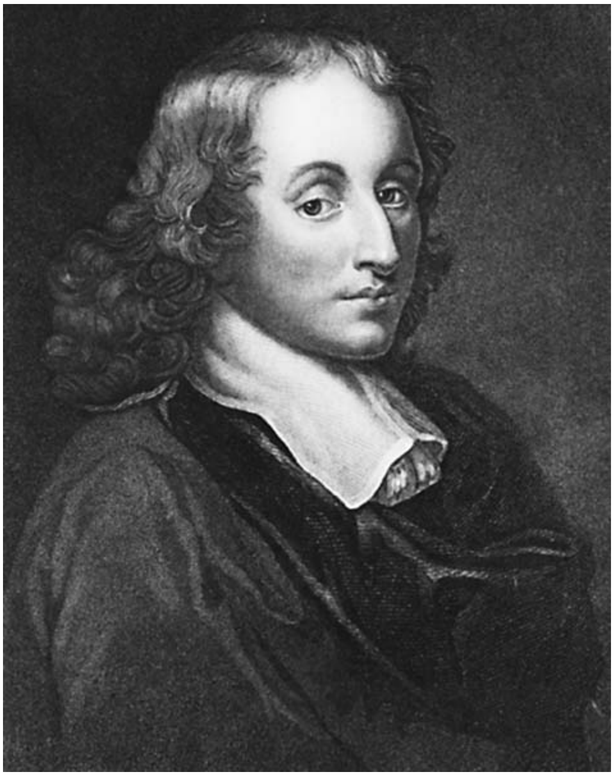
PASCAL, BLAISE

Mathematician, physicist, inventor, philosopher, religious thinker, and writer, Blaise Pascal (1623–1662) was born in Clermont-Ferrand, France, on June 19, 1623, the second of three children of Étienne Pascal, a government official and man of wide learning. His mother died in 1626, and in 1631 the family moved to Paris. His exceptional talents evident early on, Pascal was educated entirely by his father, who in 1635 introduced him to Marin Mersenne's newly founded *académie,* where the latest problems in mathematics, science, and philosophy were being discussed. At sixteen he wrote an original work on conic sections. At nineteen he invented a calculating machine, the *Pascaline*, that was awarded an early form of patent; a series of further machines were built and a few have survived. (Some letters were discovered in 1935 and 1956, written in 1623–1624 by the German scientist Wilhelm Schickard, which contained a description and sketch of a mechanical calculator he had developed, and the news that his model was destroyed in a fire.) There is now a programming language called *Pascal.*

Technology, Experiment, Theory

Hearing about Evangelista Torricelli's experiment with the barometer (a glass tube of mercury inverted in a bowl of mercury), Pascal undertook in 1646 to carry out variations of the experiment and then explained the results, showing that atmospheric pressure decreases (the mercury level drops) with increasing altitude. He discovered the basic principle of hydrostatics, *Pascal's Law:* In a fluid at rest in a closed container, a pressure change in one part is transmitted without loss to every portion of the fluid and the walls of the container. (The SI unit of pressure is the *pascal.*) He invented the syringe and the hydraulic press.

These developments had revolutionary impact on scientific thought, as they refuted the Aristotelian doctrine that there is no vacuum. Pascal asserted that in studying nature careful experiment and logical thinking must take precedence over respect for authority (*Preface*



Blaise Pascal, 1623–1662. The French scientist and philosopher was a precocious and influential mathematical writer, a master of the French language, and a great religious philosopher. *(The Library of Congress.)*

to the Treatise on the Vacuum [1651]). He gave a detailed exposition of scientific method, with the following thesis: A hypothesis is false if contradicted by a single experimental result, and only possible or probable if all observations are consistent with it (*New Experiments Concerning the Vacuum* [1647]).

A 1654 correspondence of Pascal with the mathematician Pierre de Fermat (1601–1665) concerning a gambling problem marked the birth of probability theory, the study of patterns of chance events and the formulation of laws governing random variation. Pascal solved the problem by means of the arithmetic triangle, a numeric structure that now bears his name, and in the process introduced the binomial distribution for equal chances and the method of mathematical induction (reasoning by recurrences) applied to expectations. In his studies of the cycloid, the curve traced by a point on a circle that rolls along a straight line, he anticipated the calculus. His 1658 treatise *On Geometrical Demonstration* shows that he was also far ahead of his time in recognizing the importance of the axiomatic method in mathematics.

Religion and Decision

At the forefront of science in technology, experiment, and theory, Pascal was drawn to religion in 1646, when his family came in contact with Jansenism, an austere Catholic movement with its center at Port-Royal, near Paris. On November 23, 1654, he had a profound religious experience that became the dominant force in his life; a parchment record of it, called *Pascal's Mémorial,* was found sewn into his coat after his death. He never formally joined the Jansenist community, but Port-Royal was henceforth his spiritual home. His *Provincial Letters* (1656–1657) were written in defense of a Jansenist theologian accused of heresy, and as such are mainly of historical interest. Their enduring popularity rests with the brilliance of Pascal's style, which set the tone for the development of modern French prose.

But Pascal is best known for his *Pensées*, a collection of nearly 1,000 fragments of writing for a projected defense of Christianity. With an incisive portrayal of the human condition in all its glory and misery, Pascal explores the limits of reason and the hope offered by faith in revelation. Especially famous is the fragment known as "Pascal's Wager," intriguing, but often misunderstood.

Pascal introduces mathematical concepts to address a theological issue. The question of God's existence is to be answered as if by the toss of a coin at the end of life. By analogy with a game of chance, Pascal presents an existential dilemma that calls for a decision, and in his approach foreshadows modern existentialist thought. In an imagined dialogue with a worldly skeptic, he employs what are key elements of decision theory, a product of the twentieth century concerning courses of action in the face of uncertainty.

Pascal proposes betting on God's existence and acting accordingly. If God exists, the gain will be eternal bliss in the hereafter—infinite gain for a finite risk. But he goes further, on the theory that practice yields insight. He submits that even if God does not exist, the rewards of a life of virtue will lead to the realization that nothing has been risked. At the end of the "Wager," Pascal explains that the arguments he used were inspired by his own faith, his passionate desire to show others the way.

In frail health from childhood, Pascal was, in his final years, too ill for sustained intellectual effort. He gave his belongings to the poor. In the last year of his life, he designed and inaugurated the first public transportation service, leaving the proceeds to charity. He died in Paris on August 19, 1662.

Pascal is a major figure in the history of ideas because of the range and intensity of his interests and his thought-provoking response to the uncertainties revealed in the expanding world of the seventeenth century. He accepted the skeptic's view that it is impossible to prove first principles. But he stressed the role of intuition, and across the spectrum of human experience pleaded for the full use of reason as the ethical norm: "Man is only a reed, the weakest in nature, but he is a thinking reed. . . . All our dignity consists in thought. . . . Let us then strive to think well; that is the basic principle of morality" (Pascal 1995, p. 66).

VALERIE MIKÉ

SEE ALSO *French Perspectives; Scientific Revolution; Virtue Ethics.*

BIBLIOGRAPHY

Davidson, Hugh M. (1983). *Blaise Pascal.* Boston: Twayne Publishers. Short general biography in Twayne's World Authors Series.

Guardini, Romano. (1966). *Pascal for Our Time,* trans. Brian Thompson. New York: Herder and Herder. Analysis of Pascal's life and work from a broad cultural and psychological perspective by a leading philosopher of religion and literature interpreter of the twentieth century.

Mesnard, Jean. (1952). *Pascal, His Life and Works,* trans. G. S. Fraser. New York: Philosophical Library, Inc. Classic biography by a Pascal scholar and editor.

Miké, Valerie. (2000). "Seeking the Truth in a World of Chance." *Technology in Society* 22: 353–360. Discusses the relevance of Pascal to problems of contemporary culture.

Pascal, Blaise. (1952). *The Provincial Letters; Pensées; Scientific Treatises.* In *Great Books of the Western World,* Vol. 33. Chicago: Encyclopedia Britannica. Contains six major scientific treatises, including those cited in the article, and the extant correspondence with Fermat on the theory of probability.

Pascal, Blaise. (1995). *Pensées* [Thoughts], trans. A. J. Krailsheimer. London: Penguin Books. Fine modern English translation, with introduction by the translator.

Pascal, Blaise. (2000 [1998]). *Oeuvres Complètes* [Complete Works], 2 vols., ed. Michel Le Guern. Paris: Gallimard. New edition of Pascal's complete works.

PAULING, LINUS

Linus Carl Pauling (1901–1994) was born in Portland, Oregon, on February 28, and his two Nobel Prizes symbolize his contributions to science and ethics: His Nobel Prize in Chemistry (1954) was awarded for his research

Linus Pauling, 1901–1994. The American chemist was twice the recipient of a Nobel Prize. He revealed the nature of the chemical bond, helped to create the field of molecular biology, founded the science of ortho-molecular medicine, and was an activist for peace. *(The Library of Congress.)*

on the chemical bond and the structures of complex molecules, and his Nobel Peace Prize (1962 but awarded in 1963) was given for his campaign to halt the atmospheric testing of nuclear weapons. Pauling's early life was spent in Oregon, where he received a bachelor's degree from Oregon Agricultural College and met Ava Helen Miller, his future wife, who would have an important influence on his ethical development. Pauling's education continued at the California Institute of Technology, from which he received a doctorate in 1925.

In the first two decades of his career Pauling made significant contributions to structural chemistry that included determining the structures of many molecules by using the techniques of X-ray and electron diffraction. He also developed a theory of the chemical bond based on the new field of quantum mechanics. In the 1930s he became interested in hemoglobin and antibody molecules. Pauling was conventionally patriotic during World War II, and for his military contributions, such as an oxygen meter widely used in submarines and airplanes, he was given the Presidential Medal for Meritin 1948.

Because of the development of nuclear weapons during the war Pauling, like many other scientists, became sensitive to the ethical consequences of scientific discoveries. At the urging of his wife, he included attacks on war and pleas for peace in his public speeches. After winning the Nobel Prize for Chemistry he began to use his increased prestige to convince people that nuclear testing was immoral because it caused birth defects and cancer. In the late 1950s Pauling became increasingly involved in the debate over nuclear fallout, especially through the Scientists' Bomb-Test Appeal, which he wrote and helped circulate. That appeal, along with his lawsuits and other activities, helped bring about the partial test-ban treaty of 1963. When the treaty went into effect, Pauling received the news that he had won the Nobel Peace Prize.

In the final decades of his life Pauling founded the new field of orthomolecular medicine to investigate the connection between good health and the proper proportion of various molecules, especially vitamins, in the body. That advocacy had an ethical component because Pauling felt that it was immoral for researchers and government agencies to keep that knowledge from the public, whose suffering could be minimized and whose health could be maximized by the correct intake of different vitamins. Like his stand against nuclear testing, Pauling's campaign for megavitamin therapy was controversial; many nutritionists believed that a balanced diet without vitamin supplementation was sufficient for good health. Ironically, both Ava Helen and Linus Pauling died—she in 1981 and he thirteen years later on August 19—of cancer despite their hope that their high vitamin intake would help them avoid that disease. Pauling died at his ranch on the Big Sur coast of California.

Orthomolecular medicine has enthusiastic advocates and opponents, but Pauling's contributions to science are incontrovertible. His discoveries in structural chemistry, molecular biology, and molecular medicine have been called the most illuminating body of scientific work of the twentieth century. His crusade for the nuclear test ban has resulted in smaller amounts of radioactive materials in the environment, with a consequent improvement in the health of many people. Finally, his example as an activist scientist inspired many others to use their scientific knowledge for the betterment of humanity.

ROBERT J. PARADOWSKI

SEE ALSO *Weapons of Mass Destruction.*

BIBLIOGRAPHY

Divine, Robert A. (1978). *Blowing on the Wind: The Nuclear Test Ban Debate, 1954–1960.* New York: Oxford University Press. Though concerned with the arguments of such participants as Linus Pauling and Edward Teller, Divine emphasizes the scientific and ethical complexities of this turbulent public debate.

Hager, Thomas. (1995). *Force of Nature: The Life of Linus Pauling.* New York: Simon & Schuster. The most detailed of the several Pauling biographies.

Pauling, Linus. (1983). *No More War!* (25th Anniversary Edition). New York: Dodd, Mead. The book that best reflects Pauling's views on war and peace in general and on the test ban debate in particular.

PEER REVIEW

Peer review is a term of art covering a set of practices that collect and apply the judgement of expert reviewers (identified as "expert," not just "knowledgeable"—so the designation is a political justification as well as a substantive one) to decisions about which manuscripts to publish, which proposals to fund, and which programs to sustain or trim. Peer review and its variants are preferred in science not only because they bring appropriate expertise to bear on decisions, but also because they assert the professional autonomy of scientists. The review of original ideas grounded in acceptable evidence certifies the accuracy, validity, and heuristic value of results. Peer reviewers are collegial critics who contribute uniquely to this competitive negotiation process by allocating scarce resources—money, time, space—and the career capital they help to generate. Outcomes based on peer review thus concentrate or disperse available resources over a pool of eligible competitors, advancing collective knowledge and practice, on the one hand, and individual careers, on the other.

Although peer review is a highly valued process, it nevertheless lacks careful or rigid definition. What constitutes a "peer" may be disputed, the factors to be considered by reviewers may vary, and the weights accorded their judgments are likely to be unequal. Moreover, there is probably an inverse relationship between knowledge and conflict of interest: the smaller a circle of peers the more sound and nuanced their knowledge of an area, but the more likely that these peers are friends or maintain potentially compromising relations with those being reviewed. How those relations are restrained to preserve balanced judgment is a challenge to peer review procedures.

For example, there are no hard-and-fast rules about how a peer reviewed journal, versus a non–peer reviewed journal, will decide what to publish. The former, however, are valued for the presumed standards of rigor and fairness that often carry scientific and academic prestige. Likewise, some peer review processes for grants are blind to reviewer and reviewed (proposer) alike, others only to the reviewed. Reviewers may vary widely in number and characteristics (demographic, intellectual, national, or organizational context) and may shade reviews in unanticipated ways. Finally, the collective judgment represented by peer review is sometimes deemed unassailable, often just advisory. Corporations and government agencies also employ peer review—internally or with external reviewers mixed in—to assess the quality of the science destined for reports, decisions, or policy recommendations. Peer review in scientific and technological contexts has been most subject to analysis, but also diminished in level of detail by preserving the anonymity and confidentiality promised by editors and agency stewards.

Origins and Purposes

Peer review of scientific manuscripts dates back to the *Philosophical Transactions of the Royal Society* of the mid-seventeenth century. The origins of peer review for grants are more recent and murky. The National Advisory Cancer Council, established in 1937, was authorized to review applications for funding and to "certify approval" to the surgeon general. The Office of Naval Research developed an informal variant of peer review, which may have been brought to the National Science Foundation (NSF) when Alan T. Waterman became its first director. Peer review is not mentioned in the NSF founding legislation, but the agency is known as its foremost practitioner (England 1983). The more widespread development and application of peer review processes has occurred episodically since the 1960s.

Understanding peer review requires reflection on both its purposes and values. Peer review circulates research ideas in their formative stages to key gatekeepers in a field. Sometimes this signals others to avoid duplication of effort. Other times it calls attention to a problem that is promising, attracting other researchers and setting off a race for priority (for example, work on cancer genes). Thus, by the time new research is finally published, aspects of its findings and methods may be generally familiar to many in the field, speeding its acceptance and utilization while drawing constructive criticism.

Peer review may also bring values beyond scientific or technical quality to research funding decisions. These values may be overriding or subtle, and they relate ways in which peer review is grounded in a democratic context. History attests to the political contamination of science and other forms of malpractice, such as Nazi attempts to control science in Germany or the manipulation of genetics in the Soviet Union by Trofim Lysenko (1898–1976) (Chubin 1985). Indeed after the cold war, many postsocialist countries sought to replicate peer review practices used in the West. In most cases, a system of government distribution of research funds was sought that favored quality of ideas over professional stature alone. In contrast, during the same period, the United States fine-tuned its peer review practices to achieve other goals. For example, NSF program officers try to balance their portfolios by taking account of geographic distribution, age, gender, or ethnicity of investigators; research participation of four-year colleges or historically black colleges and universities; or the hotness of a topic or method. At the National Institutes of Health (NIH), advisory councils are empowered to recommend some proposals for funding because they address urgent national needs (U.S. GAO 1999).

With the Government Performance and Results Act of 1993 requiring U.S. research agencies to show that their investments yield societal benefits, some wonder if scientific experts are the best qualified reviewers to render such judgments (NAPA 2001). At NSF, reviewers now must address two merit review criteria: scientific merit and broader social impact (two other criteria were dropped because they were routinely ignored or deemed too difficult to measure). The latter encompasses educational benefits ranging from precollege outreach to increased participation of students from underrepresented groups and enlarged undergraduate research experiences to ways to enhance public understanding of the scientific content of workaday processes and outcomes.

A relatively recent innovation allows more direct citizen participation in scientific and technical allocation decisions. The Dutch Technology Foundation, for example, has augmented traditional peer review with lay review by citizens. In the United States, activist and support groups for various diseases have applied similar pressure, especially at NIH (which uses a quantitative scoring system that leaves little room for study section or institute director discretion). Other federal agencies, such as the Office of Naval Research, the Defense Applied Research Projects Agency, and parts of the Department of Energy and the Department of

Agriculture, limit their use of external peer reviewers to the identification of more risky but potentially highly rewarding areas of research and development. In the end, who participates in the process redefines *peer* and alters the purpose of the review.

Peer review allows scientists to make recommendations in a privileged zone, apart from the general public. It creates the expectation that the principles of fair and ethical behavior embedded in professional culture will be observed. This may seem inconsistent with the principle of public participation, but should be understood as reflecting the role of peer review as a boundary process that demarcates the limits of authority based on credentials or power. When participation crosses borders, participants carry the distinctive characteristics of their professional region (Gieryn 1999, Guston 2000). A good review system thus preserves professional autonomy while permitting lay participation. This balances deference to expert evaluation against sensitivity to societal needs and extrascientific values (concerning research applications, risks and benefits to whom, and long- versus short-term consequences) (Atkinson and Blanpied 1985).

Ethical Dimensions

Precisely because peer review is a highly valued process that spans the boundaries of several social worlds—science and policy, research and practice, academe and bureaucracy, public and private—its purposes and meaning may be understood differently across communities and at different times in the history of a single community. Focusing primarily on peer review as a process for managing scientific publication and grant funding, what follows is a brief review of some of the value and ethics-related dimensions that often manifest themselves as competing understandings and aspirations. (For elaboration, see Chubin and Hackett 1990.)

OPENNESS AND SECRECY. Peer review is in principle open to the community of qualified scientists as proposers or reviewers. The process of peer review, as procedures, criteria, rating scales, and such, is knowable, transparent (or at least translucent), and held to account for its workings and outcomes. But the criteria are themselves seldom discussed.

Peer review is also secret. Confidentiality is sacrosanct, and anonymity is assured throughout much of the process. Meetings are typically closed, with proposals, reviews, and panel discussions deemed privileged information. To outsiders, who participates and how they are chosen can seem mysterious, and the identities of the reviewers—who represent the intellectual community-at-large—are generally not disclosed.

EFFECTIVENESS AND EFFICIENCY. Peer review is asked to be effective—to recommend projects that would advance knowledge and confer social benefit. But it is also asked to be efficient, to operate at low cost (e.g., for travel and reviewer compensation) and minimize the burden imposed on proposal writers and reviewers alike.

How realistic are these expectations? A thorough review might take half a day, but reviewers are usually not paid for their services. Of course, the reviewer is partly compensated by learning what constitutes a fundable proposal and gaining access to unpublished ideas and data.

Nonetheless, a low success rate—10 to 20 percent in many agencies these days—reduces the expected return (to proposers and agencies) for the investment of effort. Hence the invention of a two-stage proposal process with the first a preliminary proposal that can be screened into or out of the more competitive second stage.

SENSITIVITY AND SELECTIVITY. The peer review system is asked to be highly sensitive and highly selective of research projects at the same time. A sensitive review system would detect the merit in every worthwhile proposal, whereas a selective system would filter out all projects of dubious quality or significance.

But scientific research can be risky, and given the difficulties in communicating original ideas clearly and persuasively, it is possible that the phenomenon of interest may itself be in question (e.g., the Higgs process, the top quark, prions). A system acutely sensitive to scientific merit would probably support some projects that do not work out. One so selective that only projects beyond skepticism are chosen for funding would surely ignore some good ideas along with the rest. And inevitably, some researchers write better than others. Still others construct better proposals than conduct the research once funded. What is the review rewarding?

INNOVATION AND TRADITION. Peer review couples what Thomas Kuhn (1977) terms an "essential tension" between originality and tradition in science with what Robert Merton (1973 [1942]) defines as the norm of "organized skepticism." Promising new ideas are tested against the cumulative store of shared knowledge and established theory. Peer review challenges whether new ideas are truly novel and worth pursuing, and purports to distinguish between sound innovation and reckless speculation.

Reviewers defend tradition against claims of originality when they reject novel ideas as impractical, unworkable, or implausibly inconsistent with the established body of knowledge. Sharp disagreements among reviewers about the merits of an idea may indicate a promising but risky new research path. Consensus, in contrast, might indicate an insufficiency of important problems left to solve, the grip of a school of thought, an overbearing conservatism, or just plain risk-aversion.

An innovative review system would reward novelty and risk taking, whereas a traditional system would sustain the research trajectory established in the body of accepted knowledge by restraining bold excursions. Peer review is expected to identify, encourage, and support frontier work but to screen out fads and premature ideas (Stent 1972).

MERIT AND FAIRNESS. Peer review is expected to be meritocratic, judging proposals and manuscripts in accordance with the stated criteria. NIH instructs proposal reviewers to evaluate all the science, only the science, and nothing but the science. The rendered judgment is to extract the science from speculation, rhetoric, common sense, practical benefit, and whatever else the proposer orchestrated in the document.

Peer review is reputed to apply standards of fairness to ideas apart from consideration of a scientist's reputation, personal characteristics, or geographic or academic position; the economic potential of the proposed work; or its relevance to pressing national needs. Nevertheless, advantages accumulate over the course of a career, making it increasingly difficult to judge what one does apart from who one is (or has accomplished). In this way, the Matthew Effect prevails: In recognition and influence the rich get richer, the poor poorer (Merton 1973 [1968]).

It may thus be wrongheaded to assume that the best science simultaneously serves one's career, one's discipline, and the welfare of the nation. Just as the principle of equitable distribution might indicate that decisions at the margin should favor investigators who currently have inadequate funds, similar arguments could be advanced for criteria such as growing research capacity, increasing educational or economic investments, or making politically savvy allocations. Such decisions deviate from strictly meritocratic principles, yet are entertained by participants much of the time, leading to charges of earmarking, log-rolling, cronyism, and elitism (U.S. Congress 1991, Chubin 1990).

RELIABILITY AND VALIDITY. As an assessment tool, peer review must be both reliable and valid, that is, have little random error and measure what it is supposed to measure. To be reliable, ratings should show high levels of agreement between raters and consistency from one group of raters to another. To be valid, a measure must take account of the scientific merit of a proposal in all its complexity without becoming distorted by other properties of the proposal. But merit is both abstract and multifaceted. A valid evaluation of a proposal, therefore, is said to derive from the combined assessments of several diverse experts. How their reviews are weighed depends on the steward—the program manager or journal editor—and the mission that he or she serves.

Evaluating a proposal or manuscript from several divergent perspectives, not surprisingly, may yield low inter-rater agreement; different experts reach different judgments about quality as seen through their particular set of cognitive lenses (Cicchetti 1991, Harnad 1982). In this sense, peer review builds sound inferences upon a broad foundation. Given the limited number of reviews that can be elicited for any one proposal and the range of reviewer backgrounds necessary to cover the intellectual content of the proposal, divergent recommendations can result. Stewards and editors act on those recommendations when they decide whether or not to fund or publish (or to defer a decision until a revision addresses criticisms).

Conclusions

Clearly, peer review does many things and serves many values, but it cannot simultaneously deliver on all things equally well. Which purposes and which values are most important for which sorts of science? Who is to decide?

Similarly, involving the best researchers in the review process probably leads to better and more legitimate reviews—those that will be accepted by the community. But such experts are also the most likely proposal writers. Because it is unwise to allow people to review proposals for a competition in which they are also contestants, strategies for handling such conflicts of interest must be accepted by the community, or the legitimacy of the process will erode.

Because peer review sometimes can straddle disciplines, it may also cross the boundaries of knowledge production and professional practice, of research and policy. At one extreme, it will be highly particularistic by restricting the competitors to those with certain characteristics (through what is known as set-asides by age, gender, discipline, prior accomplishment, or location at an institution with a track record or facility to conduct the research). At the other extreme, peer review will be highly universalistic, resembling a lottery with the criteria of choice seemingly random and unrelated to properties of the chosen projects. In practice, review processes fall between these polar extremes, which competitors usually find to be fair and the outcome justified enough so they try again even after an unsuccessful submission.

Developing a review process that has widespread legitimacy entails building responsibilities, relationships, and trust. Together, these qualities add research findings to a body of knowledge, introduce conjectures into theories, and socialize researchers into a community that has moral as well as intellectual authority. In the end, peer review is expected to demand rigor and integrity, while stimulating new knowledge that ultimately makes a difference in people's lives. To do so, it must be responsive to emerging needs and possibilities. Ultimately, the flexibility of human judgment and the quality of collective imagination will determine which values and purposes are served by peer review.

DARYL E. CHUBIN
EDWARD J. HACKETT

SEE ALSO *Accountability in Research; Expertise.*

BIBLIOGRAPHY

Atkinson, Richard C., and William A. Blanpied. (1985). "Peer Review and the Public Interest." *Issues in Science and Technology* 1(4): 101–114.

Chubin, Daryl E. (1985). "Open Science and Closed Science." *Science, Technology, and Human Values* 10 (Spring): 73–81.

Chubin, Daryl E. (1990). "Scientific Malpractice and the Contemporary Politics of Knowledge." In *Theories of Science in Society*, ed. Susan E. Cozzens and Thomas F. Gieryn. Bloomington: Indiana University Press.

Chubin, Daryl E., and Edward J. Hackett. (1990). *Peerless Science: Peer Review and U.S. Science Policy*. Albany: State University of New York Press.

Cicchetti, Dominic V. (1991). "The Reliability of Peer Review for Manuscript and Grant Submissions: A Cross-Disciplinary Investigation." *Behavioral and Brain Sciences* 14(1): 119–186.

England, J. Merton. (1983). *A Patron for Pure Science: The National Science Foundation's Formative Years, 1945–57*. Washington, DC: National Science Foundation.

Gieryn, Thomas F. (1999). *Cultural Boundaries of Science: Credibility on the Line*. Chicago: University of Chicago Press.

Guston, David H. (2000). *Between Politics and Science: Assuring the Productivity and Integrity of Research*. London: Cambridge University Press.

Harnad, Stevan, ed. (1982). *Peer Commentary on Peer Review: A Case Study in Scientific Quality Control*. Cambridge, UK: Cambridge University Press.

Kuhn, Thomas S. (1977). *The Essential Tension*. Chicago: University of Chicago Press.

Merton, Robert K. (1973 [1942]). "The Norms of Science." Reprinted in *The Sociology of Science*, ed. Norman W. Storer. Chicago: University of Chicago Press.

Merton, Robert K. (1973 [1968]). "The Matthew Effect in Science." Reprinted in *The Sociology of Science*, ed. Norman W. Storer. Chicago: University of Chicago Press.

National Academy of Public Administration (NAPA). (2001). *A Study of the National Science Foundation's Criteria for Project Selection*. Washington, DC: Author.

Stent, Gunther S. (1972). "Prematurity and Uniqueness in Scientific Discovery." *Scientific American* 227(6): 84–93.

U.S. Congress. Office of Technology Assessment. (1991). *Federally Funded Research: Decisions for a Decade*. Washington, DC: U.S. Government Printing Office.

U.S. General Accounting Office (GAO). (1999). *Federal Research: Peer Review Practices at Federal Science Agencies Vary*. Washington, DC: Author.

PEIRCE, CHARLES SANDERS

Charles Sanders Peirce (1839–1914), pronounced "purse," was born in Cambridge, Massachusetts on September 10, and died in Milford, Pennsylvania on April 19. In the year of his birth, the first electric clock was built, ozone was discovered, and the growth of cells was charted, while the year of his death saw Robert H. Goddard (1882–1945) inaugurate his rocket experiments and J. H. Jeans (1877–1946) publish a paper on "Radiation and Quantum Theory." Peirce graduated from Harvard College in 1859, the year English naturalist Charles Darwin's (1809–1882) *On the Origin of Species* appeared. Peirce's life was thus framed by significant scientific and technological developments; its fruits included a multifaceted contribution to early twenty-first century philosophical understanding of scientific investigation and other human achievements. Trained as an experimental scientist, Peirce worked in this capacity for both the Harvard College Observatory and the U.S. Coast and Geodesic Survey. His contribution, however, was far more that of a philosopher than a scientist.

Philosopher of Semiotics and of Science

Peirce is best known in philosophy as the founder of pragmatism and, outside that discipline, as the theorist who, at roughly the same time as the Swiss linguist Ferdinand de Saussure (1857–1913), envisioned a comprehensive study of signs. But Peirce did far more than envision the possibility of such an investigation: He systematically elaborated, yet left ultimately unfinished, a theory of signs designed to provide indispensable resources for a normative account of objective inquiry and, beyond this, for a systematic analysis of the myriad forms of meaning—not just those observable in the practices of experimental or objective investigators. Saussure coined the word *semiologie* to designate this study, whereas Peirce used the term *semeiotics* (now more commonly spelled *semiotics*).

But the scope of Peirce's concerns is inadequately conveyed by calling attention to his role in the founding of pragmatism and semiotics. He tended to identify himself as a logician, but he vastly expanded the scope of logic. Moreover, he devoted considerable energy to defending an evolutionary cosmology informed by the monumental achievements of such classical metaphysicians as Plato, Aristotle, and Friedrich Schelling as well as by what he judged to be the most important implications of the greatest scientific discoveries of his own day.

While Peirce devoted a great deal of his intellectual energy to an understanding of science, he tended to ignore questions specifically concerning technology. This might seem ironic, given his pragmatic commitments. He tended, however, to draw a sharp distinction between theory and practice. He believed in a strict division of intellectual labor and that the very best work required a steadfast concern with a more or less delimited object of investigation. However, he conceived theory itself to be a historically evolved and evolving practice (or, more accurately, a family of such practices). Indeed, Peirce was keenly interested in preserving the integrity of theoretical practices, defining them ultimately in terms of the objective of simply discovering truths not yet known. At the heart of his pragmatism, then, one finds not only a refusal to subordinate theoretical practices to other forms of practices but also an insistence that theory itself is a unique form of human practice.

Peirce's account of science is distinguished by a number of factors, but most importantly by the role he accords abduction in the conduct of inquirers and the attention he pays to the history of science as a resource for understanding science. He identified abduction as one of the three modes of inference (deduction and induction being the other two). Abduction is that mode by which hypotheses are formulated or initiated. In classifying it as a form of inference, Peirce was refusing to leave the formulation of hypotheses as a mysterious, psychological process. The work of scientists involves the complex interplay of all three modes of inference, but abduction is clearly central to this work. Long before Thomas Kuhn's *The Structure of Scientific Revolutions* (1962), Peirce was acutely aware of how an adequate conception of science must be based upon a detailed acquaintance with the actual development of diverse experimental practices. Such acquaintance reveals the intimate relationship between theoretical discoveries and technological innovations. Thus, whereas Peirce did not make technology in general a focal object of his theoretical concern, he did devote attention to how technology operates *within* science.

Charles Sanders Peirce, 1839–1914. Peirce, one of America's most important philosophers, made important contributions in both philosophy and science. His work in logic helped establish the philosophical school of thought known as pragmatism.

The Normative Sciences

Somewhat late in his life Peirce came to an appreciation of the importance of what he called the normative sciences (logic, ethics, and esthetics) and, within this cluster of sciences and his broader classification of human practices, an appreciation of the pivotal role of ethics as both a cultural inheritance and a normative science. He came to see logic as a species of ethics. Whereas ethics offers a normative account of self-controlled conduct, logic provides a normative account of a species of such conduct, namely, self-controlled thought or inquiry. Just as logic in this sense depends upon a more general theory of self-controlled action, so ethics depends upon a critical theory of the intrinsically admirable or worthwhile ends of action. Peirce proposed *esthetics* as the name for this theory of the ends of action. A critical determination of the ends one espouses is at least as important as a critical assessment of the variable means available for the realization of a given objective.

Peirce's historically informed understanding of experimental inquiry is, arguably, one of the most complete, nuanced, and adequate accounts of science yet articulated. The centrality he accords to abduction distinguishes his account of science from most others and, in addition, more intimately connects his theoretical understanding of scientific investigation to the actual practices of scientific investigators than do rival accounts. Though he did not specifically concern himself with technology, his philosophy of science and theory of signs provide resources for illuminating numerous aspects of the diverse phenomena studied by philosophers of technology and others interested in such phenomena. His classification of the theoretical sciences is, in fact, embedded in a more comprehensive classification of human practices; this classification offers important suggestions for how to understand the relationships between the theoretical and technological undertakings of humankind.

Finally, even though he did not explore ethics or esthetics as deeply as he studied logic, his general conception of the normative sciences and his specific treatments of ethics and esthetics are sites yet to be mined by contemporary inquirers, especially ones interested in the interconnections among science, technology, and ethics.

VINCENT COLAPIETRO

SEE ALSO *Pragmatism; Semiotics.*

BIBLIOGRAPHY

Anderson, Douglas R. (1995). *Strands of System: The Philosophy of Charles Peirce.* West Lafayette, IN: Purdue University Press.

Eisele, Carolyn, ed. (1985). *Historical Perspectives on Peirce's Logic of Science: A History of Science.* New York: Mouton.

Kuhn, Thomas. (1962). *The Structure of Scientific Revolutions.* Chicago: University of Chicago Press.

Peirce, Charles S. (1957). *Essays in the Philosophy of Science.* New York: Liberal Arts Press.

Peirce, Charles S. (1998). *Chance, Love, and Logic; Philosophical Essays,* ed. Morris R. Cohen. Lincoln: University of Nebraska Press.

Peirce, Charles S. (1998). *Charles S. Peirce: The Essential Writings,* ed. Edward C. Moore.

Peirce, Charles S. (1998). *His Glassy Essence: An Autobiography of Charles Sanders Pierce,* ed. Kenneth Laine Ketner. Nashville: Vanderbilt University Press.

PERSISTENT VEGETATIVE STATE

Persistent vegetative state (PVS) was identified by that name in 1972 by the neurologists Bryan Jennett and Fred Plum (Jennett and Plum 1972). Both the name and the state have been a source of controversy since that time.

General Description

PVS results from the total lack of function of the cerebral cortex, the large outer part of the human brain. The size of the cortex in different species of vertebrates correlates with their respective levels of intelligence, with primates having the largest cortex among all genera and humans having the largest among all primates. Cortical activity is necessary for all types of cognitive states, from sight and hearing to speech and thought. The most common causes of loss of cortical function are traumatic injuries and anoxic-ischemic injuries. Traumatic injuries include those seen in car or motorcycle accidents, and anoxic-ischemic injuries include those seen in strokes, drowning accidents, and cardiac arrest, in which there is a loss of oxygen (anoxia) or blood flow (ischemia) to the brain. Either cause can lead to the same outcome, but because that outcome occurs by different routes, there are some distinctions in the diagnostic criteria.

Whether the origin of a brain injury is traumatic or anoxic-ischemic, the initial result of a severe injury is a coma. Patients in a coma look as if they were asleep, although they never open their eyes or have sleep-wake cycles. In fact, they are not in a sleeplike state but are deeply unconscious, as is evidenced by the fact that they cannot be awakened by even the most painful stimuli and do not exhibit reflex responses to such stimuli. However, comas are usually a temporary stage of response to injury. Generally a patient is in a coma for no more than two weeks. After that time coma patients progress to one of three alternatives: They regain consciousness, die (most commonly as a result of swelling of the brain that causes herniation of the brain stem and loss of brain stem function), or enter a vegetative state.

Some patients improve after emerging into a vegetative state. They subsequently may regain a normal level of consciousness or improve slightly and enter a minimally conscious state. However, the longer they remain in a vegetative state, the less likely it is that they will ever improve. Thus, a PVS is defined as having been in a vegetative state for a length of time that makes further improvement highly unlikely. If the cause is anoxic-ischemic, in which case there is a fairly uniform causal pattern of neural death, one needs to wait three months to make the diagnosis. If the cause is trauma, which has greater variability of intermediate causes of neural death, one needs to wait a year to achieve the same degree of certainty and thus make a diagnosis of PVS. The exact location of the blow, the degree of force, and even factors such as the condition of the brain and the skull at impact can be variables in the degree of brain damage.

The Concept of Vegetative

Why is the term *vegetative* used? In the classic terminology dating back to Aristotle humans are defined as uniquely rational, with emotional (or irrational) traits being shared with animals. Purely physiological functions such as digestion are called vegetative; they are neither rational nor irrational, and they have nothing to do with social interaction at any level. It is only these physiological functions that are preserved in patients in whom the brain stem is the only surviving part of the brain.

Therefore, in contrast to cases of death diagnosed by brain criteria, the vegetative state is characterized by the presence of all brain stem functions (autonomic nervous system regulation of body temperature, pulse, blood pressure, breathing, reflexes, and sleep-wake cycles) without any of the cortical functions. Thus, most or all brain stem reflexes typically are intact in PVS patients: cold calorics (cold water in the ear canal causes lateral eye movement toward that ear), papillary (response to light), corneal (light tough of the eyeball causes a blink), threat (a quickly approaching object causes blinking), gag, and painful stimuli (usually a sternal rub or pressure on the fingernail beds causes withdrawal). For all these reasons the verbal slip of calling a PVS patient brain-dead is a mistake that threatens family members' trust in doctors and other health-care professionals.

Although the definition of PVS is made clinically, that is, empirically, it is possible to use neuroimaging techniques such as computed tomography (CT) scans, functional computed tomography (FCT) scans, and positron emission tomography (PET) scans to build confidence in the prognosis at an earlier time. In cases such as an observed loss of oxygen for thirty minutes or when there is a loss of cortex replaced by cerebrospinal fluid that is documented on a CT scan, experienced neurologists may feel confident in making the diagnosis of PVS in less than the three or twelve months recommended in the American Neurological Association Task Force report (American Neurological Association 1993). For some families that do not want to wait, this can be very helpful. However, others may feel rushed and may become skeptical if they discover that the neurologist is making a diagnosis sooner than is recommended in the consensus statement.

Causes of PVS

The largest numbers of cases of PVS are caused by anoxic-ischemic injuries, and this diagnosis has increased in frequency. This is the case because it takes only four or five minutes without oxygen for a patient to begin to have permanent brain damage in the cortex, which requires very large amounts of oxygen. However, the inner parts of the brain, the brain stem and midbrain, require less oxygen and can return to function after much longer periods of oxygen deprivation. (One might picture the cortex as a softball wrapped around the golf ball–sized brain stem.) Thus, anything that causes the loss of some or all oxygen to the brain for more than five minutes may lead to PVS. The most common cause of that loss occurs when a patient "codes," that is, when the patient's heartbeat or breathing stops.

Why is this cause the source of a growing number of cases of PVS? In the United States and many other countries after the invention of cardiopulmonary resuscitation, it became routine for all patients to be "full code" unless they specifically requested otherwise. When a patient is discovered unconscious as a result of acute loss of cardiac or pulmonary function, a "code" is begun, starting with clearing the airway and beginning chest compressions and ending with cardioversion/defibrillation and endotracheal intubation and mechanical ventilation. The code ends either when a heartbeat is restored or when the physician who is running the code decides to "call" it (that is, to call an end to the code), which will be the time when death is declared.

A code typically is run for thirty to forty-five minutes. However, it is up to the physician, using clinical judgment, to determine how long to wait before calling, or ending, a code. In light of the nature of the brain, if a pulse does not return after fifteen to thirty minutes, there is the risk of permanent brain damage, including global loss of cortical function. The length of time a code is run cannot be determined precisely to avoid all cases of PVS because there is usually some oxygen going to the brain during the code as a result of the chest compressions applied by the physician. However, because of the nature of cardiopulmonary resuscitation (CPR) as an acute and heroic effort to save a life that is being lost, it is antithetical to try to "call" codes more conservatively to minimize the number of cases of PVS at the cost of not maximizing the number of lives saved.

In contrast, the number of cases of PVS resulting from trauma has decreased as a result of the greater use of seat belts and air bags in cars and the wearing of helmets by bicyclists and motorcyclists. There is no registry of patients in PVS, and so the number cannot be known with any degree of certainty. The most common guess is that there are 10,000 people in the United States in a PVS, although the number could be half or twice that.

Ethical Issues

The ethical issues raised by PVS are as complex as the neurology is. For example, three of the most publicized and controversial cases in medical ethics involved young women who were in a PVS: Karen Ann Quinlan in New Jersey in the 1970s, Nancy Cruzan in Missouri in the 1980s, and Terri Shiavo in Florida in the early 2000s. In each case the patient's family wanted to make the decision to stop life-sustaining treatment once their loved one's grim prognosis became evident.

At least two factors make decisions regarding PVS patients very difficult. First, observing these patients is an unnerving experience: Although awake during the day, they have some movements of the arms, back, neck, and head, including grimaces and smiles, and make sounds such as moans and grunts. This makes it almost inevitable that the family will have doubts about the diagnosis and about whether the patient may show improvement eventually. Second, although these patients require extraordinary around-the-clock nursing care to avoid bedsores and infections, they need relatively little medical intervention except a feeding tube to provide artificial nutrition and hydration. If this care is provided and the occasional infection is treated with antibiotics, PVS patients can have a normal life span. Thus, some have been kept alive for three or four decades. These two factors make it very difficult for families to stop the life-sustaining treatment for patients in a PVS even when they are confident that the patient would not want to live in such a condition.

When these issues first were addressed by the bioethics community in the 1980s, many people argued that feeding tubes and artificial nutrition and hydration should be considered a necessary component of humane treatment and be required to demonstrate respect for human dignity, comparable to being kept clothed and given some privacy. This view has become less common but still is held by some theologically oriented bioethicists in the Roman Catholic and Orthodox Jewish traditions. Support for the position that artificially provided nutrition and hydration constitutes necessary medical treatment was called into question as the nature of PVS became understood and, simultaneously, the hospice movement began to promote the idea of death with dignity. Although it still is not universally accepted, there is a broad consensus among clinicians, lawyers in the field of health law, and ecumenical and secular bioethicists that artificial nutrition and hydration should be consented to or refused on the basis of an evaluation of its benefits and burdens to patients on a case-by-case basis.

This is the ultimate controversy regarding PVS: determining how a patient would want to live. Perhaps the best philosophical clarification of the issue came when James Rachels (1986) summed up the sentiment that family members of PVS patients had expressed by saying that the life of PVS patients was over years before they died. Rachels distinguished between life in a biological sense and life in a biographical sense; put more colloquially, PVS patients no longer "have a life" even though they are still alive. Thus, the use of a living will or an advanced medical directive may be the only way to determine how a patient would want to be treated if found in a persistent vegetative state.

In light of the controversy surrounding PVS, it is clear that some medical conditions are not as easy to manage as others. Although the definition of PVS is relatively straightforward, the ethical issues are not. PVS continues to be an area of much debate, both ethically and legally, and the issues surrounding it are not easy to resolve. Because of this PVS will continue to be researched and discussed to help ease the discomfort involved in making decisions about patients in a persistent vegetative state.

JEFFREY P. SPIKE

SEE ALSO *Bioethics; Brain Death; Medical Ethics.*

BIBLIOGRAPHY

American Neurological Association Committee on Ethical Affairs. (1993). "Persistent Vegetative State." *Annals of Neurology* 33(4): 386–390. A succinct summary of both the clinical and ethical issues raised by PVS.

Brody, Baruch. (1992). "Special Ethical Issues in the Management of PVS Patients." *Law, Medicine, and Health Care* 20(1–2): 104–115. Discusses a wide range of ethical issues, including futility and the just allocation of resources.

Childs, Nancy L., and Walt N. Mercer. (1996). "Brief Report: Late Improvement in Consciousness after Post-Traumatic Vegetative State." *New England Journal of Medicine* 334(1): 24–25. There have been a few reports of improvement of patients in PVS such as this case.

Jennette, Bryan, and Fred Plum. (1972). "The Persistent Vegetative State after Brain Damage: A Syndrome in Search of a Name." *Lancet* 1: 734–737.

Lynn, Joanne, ed. (1989). *By No Extraordinary Means: The Choice to Forgo Life-Sustaining Food and Water*. Bloomington: Indiana University Press. A collection representing both sides of the debate on whether medical provision of nutrition and hydration through invasive procedures should be considered optional life-sustaining medical treatment or ethically required humane treatment. Much has been written since, but this may have appeared just at the point in the history of the debate when the tipping point was reached and a new consensus was developed.

Multi-Society Task Force on PVS. (1994). "Medical Aspects of the Persistent Vegetative State." *New England Journal of Medicine,* Part I: 330(21): 1499–1508; Part II: 330(22): 1572–1579. This report by the American Association of Neurology (AAN) and the American Academy of Neurology (ANA) defines the current standard of practice.

Rachels, James. *The End of Life*. Oxford: Oxford University Press, 1986. Chapter three, "Death and Evil," includes his famous distinction of biological versus biographical life, and other interesting observations on the conceptual and ethical problems that result when a life lacks the proper elements of a narrative.

PESTICIDES

SEE *Carson, Rachel; DDT*.

PETS

In contrast to wild animals living in zoological settings that have scientific value as representatives of particular species, or with domesticated work animals and those kept for their value as commodity producers, a pet is any domesticated animal or wild animal living in a domestic setting that is cared for, enjoyed, and valued for a unique set of characteristics that differentiates it from other members of the same species. Mitochondrial canine DNA evidence suggests that humans have kept dogs, the first animals to emerge as pets, for tens of thousands of years. Many pets are valued solely for their role as companions, treated by those who care for them with affection as though they were friends or family members. Some pets are also working animals: They hunt, herd, perform search and rescue operations, control traffic, protect homes from pests and strangers, or otherwise serve to extend human capacities, in versions of what Aristotle called *living tools* (Nicomachean Ethics VIII, 8). These animals, though, can be considered pets if and only if they are also valued for their companionship to humans.

Ethics of Pets

While numerous theories have been developed that focus on human beings and the environment as objects of ethical concern, no ethical theory deals specifically with how companion animals ought to be valued and viewed. The animal rights perspective popularized by philosopher Peter Singer, as well as theories of bioethics, may serve as starting-points for thinking about the ethics of keeping animals in zoos or consuming their meat; they are much less serviceable for thinking about human-pet relationships. Ethical relations toward pets as human companions can better be understood from within such moral perspectives as the Humean doctrine of moral sentiment, the obligation to *do no harm*, religious-based ethics, or the ethics of care. To the extent that scientific discoveries and technological innovations increase the mutual quality of life between pets and their human caregivers, they may be described as ethically positive; to the extent they lead to treating pets with decreased respect, kindness, and concern for the quality of their lives, as ethically negative.

Traditionally, ethical behavior toward pets has been synonymous with treating them humanely, that is, with care in providing them with healthful living conditions, compassion stemming from their status as dependent creatures, and respect for their dignity and well-being. Advances in science and technology have served this end in a number of ways. For instance, the growth of information technology has had a positive impact in extending and bettering the lives of pets. The use of radio collars and microchips with identifying information implanted under the skin now helps to reunite lost pets with their human companions; in the future, it is possible to imagine using devices with Global Positioning System (GPS) capabilities or nanoscale sensors to track the whereabouts of pets. Passports for pets, in effect in European Union countries from July 2004, include microchip identifiers that serve as a mechanism to allow cats, dogs, and ferrets with valid anti-rabies vaccination certificates to travel with their human companions without raising concerns about risks to public health.

The growth of the Internet has also led to improved living conditions for pets. Internet sites such as petfinders.com help facilitate the placement of abused and homeless pets, while other animal welfare organizations use the Internet to increase attention to the plight of former working animals (such as race horses and greyhounds) whose adoption as pets could prevent them from being destroyed, and of specific breeds of pets in need of a rescuing hand. By publicizing the needs of pets as well as opportunities for their adoption, the resources of the Internet have contributed to bettering the treatment of animals in shelters by leaving fewer unwanted pets to be euthanized, as well as to increasing global awareness of animal welfare and environmental ethics issues related to pets. These issues include international trade in exotic birds and other species, as well as the ongoing trade in and consumption of dog meat in some Asian countries despite government regulations making such practices illegal.

Raising Ethical Standards through Science and Technology

At the same time, advances in science and technology have been instrumental in encouraging a higher ethical standard for the treatment of pets than the minimal ethical standard of humane treatment or regard for animal safety and welfare. Because of the value that pets have in the eyes of their human companions, scientific or technological developments that help to extend the lives of individual pets or make these lives better are generally perceived as having a positive ethical dimension. Research in veterinary medicine and the application of human-related medical research to the veterinary sphere have led to the development of many measures to improve pet health and well being. These measures encompass a wide spectrum, including new types of immunizations, radiation treatments for pets with thyroid conditions, cataract operations to restore the sight of blind pets, MRI imaging technology and laser surgery for pets, and medications to prevent heartworm and other common but life-threatening parasites. Another development related to these innovations can be seen in the availability of therapeutic pet foods designed for animals with special health needs.

Such developments are not, however, always seen as morally benign. For example, the expense involved with obtaining many innovative health-related measures for pets has raised the question of whether it is moral to take such costly measures to extend the life of a single pet rather than applying the same resources to reduce human need and suffering.

Just as the birth of the cloned sheep Dolly in 1997 generated interest in cloning other kinds of livestock, it also sparked research into how cloning techniques might be applied for the purposes of cloning cats and dogs. In 2002 the first cloned kitten, aptly named "cc," was born at Texas Agricultural and Mechanical University to an adult cat acting as a surrogate mother implanted with cloned embryos formed by fusing denucleated feline egg cells with DNA from the nuclei of cumulus cells belonging to the original cat. Some researchers involved in this project have also been engaged in a similar but thus far (in 2004) unsuccessful endeavor, named the Missyplicity project, intended to clone Missy, a mixed-breed dog.

These efforts, and the potential for such cloning technologies to be transferred to commercial ventures, have prompted considerable moral controversy. Those who argue against cloning pets on ethical grounds have claimed that it is immoral to clone pets when there are so many homeless pets in shelters available for adoption, that the desire to clone a pet is based on the misguided idea that cloning could give it immortality, and that a cloned pet could be seen as less valuable than the original pet. At the same time, those who claim there is nothing morally wrong with pet cloning research stress that it could equally lead to more loving relationships between humans and their pets, as well as have important collateral benefits, such as the creation of better seeing-eye and search-and-rescue dogs. For those who see animals as technological devices, cloning, once perfected, could be perceived as merely a more effective production method.

Other attempts to apply new reproductive technologies to pets, such as genetic engineering, also give rise to ethical concerns. The development of zebra fish engineered with a sea coral gene so that they appear fluorescent under ultraviolet light raises the issue of whether, given that such fish are primarily appealing for their entertainment and novelty, it is consistent with respect for pets to commercially breed and market them. Additionally such fish might have potentially negative impacts on ecosystems should they (as have genetically engineered salmon) find their way into natural waterways.

Ethical issues further surround some conventional practices of breeding pets for certain characteristics such as small nostrils or prominent eyes that make them attractive representatives of particular breeds of animals at the expense of their health and welfare. The European Convention for the Protection of Pet Animals, first open for signature in 1987 and subsequently signed and ratified by a number of members of the Council of Europe, restricts the breeding of pets in such a way that would pass along defects, such as extremely small size, hairlessness, and other hereditary characteristics, that put them at risk for physical and mental diseases. A potentially suggestive avenue for the development of transgenic animals is one that could lead to pets whose blend of traditional aesthetic appeal with mitigated risk for disease might serve to allay ethical concerns regarding their existence.

While scientific and technological innovations have by and large been instrumental in enhancing the coexistence of humans and their pets they do not always lead to mutual flourishing, particularly in advanced industrialized countries. As in these settings the role of pets as companions to humans has grown, so has human interest in having pets whose welfare is otherwise not in question conform to human expectations and living patterns at the expense of their animal "otherness." In some locations, protective public policies have been introduced to prevent pets from being declawed, devoiced, or otherwise medically altered to accommodate the largely urban lifestyles of their owners. This interest can also lead humans to respond emotionally to their companion animals in ways that overemphasize their role as companions. For example, dogs historically bred to be involved in physical work alongside humans can suffer when, in a society dominated by developments in science and technology, their need to work goes unrecognized and unrewarded. In advanced technological society, insuring that human-pet relationships are to the mutual benefit of both partners can be seen as an ongoing ethical challenge.

Technology itself, in the form of robotic dogs and cats, or "cyberpets" such as the tamagotchi handheld video games that simulate feeding, training, playing, and other aspects of pet ownership, may serve as a means for meeting this challenge and for meeting at least some of the human needs now met by animal pets. If so, these technological pets might be a positive development. Many animal pets are mistreated by their owners, and this would not be a problem with mechanical pets under the assumption, which is probably safe at least for the near future, that they are not sentient. Furthermore, mechanical pets would presumably not breed, hence eliminating some of the vast number of killings of unwanted dogs, cats, and other companion animals.

DIANE P. MICHELFELDER
WILLIAM H. WILCOX

SEE ALSO *Agricultural Ethics; Animal Rights; Animal Welfare.*

BIBLIOGRAPHY

Beck, Alan M., and Aaron Katcher. (1996). *Between Pets and People: The Importance of Animal Companionship.* West Lafayette, IN: Purdue University Press. The authors' research concentrates on the significant role pets can play as therapeutic agents in bettering human physical and mental health.

Haraway, Donna. (2003). *The Companion Species Manifesto: Dogs, People, and Significant Otherness.* Chicago: Prickley Paradigm Press. Haraway looks at companion species who, much like the cyborgs in her earlier *Cyborg Manifesto* (1985) bring together technoscience and nature in novel ways, and suggest how people might better learn to live with significant otherness.

Journal of Applied Animal Welfare Science 5(3), 2002. This issue contains reflections, both pro and con, on the ethics of cloning pets. Contributiors include philosopher Hilary Bok ("Cloning Companion Animals is Wrong"), Mark Green ("New Dog, Old Tricks"), and Lou Hawthorne ("A Project to Clone Companion Animals"). Hawthorne serves as the lead scientist on the Missyplicity project.

Midgley, Mary. (1983). *Animals and Why They Matter.* Athens, GA: University of Georgia Press.

Rowan, Anthony, ed. (1988). *Animals and People Shaping the World.* Hanover, NH: University Press of New England. Includes articles on "Pet-Keeping In Non-Western Societies" and "The Emergence Of Modern Pet-Keeping."

Serpell, James. (1986). *In the Company of Animals: A Study of Human-Animal Relationships.* Oxford: Basil Blackwell. In this work, Serpell, director of the Center for the Interaction of Animals and Society at the University of Pennsylvania, takes a comprehensive look at the relationships between humans and their pets.

Tuan, Yu-Fu. (1984). *Dominance and Affection: The Making of Pets.* New Haven, CT: Yale University Press.

Varner, Gary. (1999). "Should You Clone Your Dog?: An Animal Rights Perspective on Somacloning." *Animal Welfare* 8: 407–420.

PHENOMENOLOGY

Phenomenology is an influential philosophical movement especially in relation to science and technology. It has developed critical studies of scientific rationality, artificial intelligence, electronic media, virtual reality, the Internet, and more. Leading contributors to the three waves of phenomenology are often drawn on in discussions of science, technology, and ethics: from the first wave of Edmund Husserl (1859–1938) through the second wave of Martin Heidegger (1889–1976) to the third wave of Maurice Merleau-Ponty (1908–1961). Even more prominent figures in debates about science, technology, and ethics discussions such as Hans Jonas (1903–1993), Emmanuel Lévinas (1905–1995), and Hannah Arendt (1906–1975) have also been strongly influenced by phenomenology, as have the critical assessments of science and technology to be found in later work by Albert Borgmann, Hubert L. Dreyfus, Andrew Feenberg, Michael Heim, Don Ihde, Langdon Winner, and others. Phenomenology nevertheless remains difficult to define, and its distinctive contributions not easy to pin down.

What Is Phenomenology?

It is difficult to define phenomenology in a way that will cover all its diverse traditions. In his monumental history of the phenomenological movement, not even Herbert Spiegelberg (1994) attempted a definitive formulation. In spite of this difficulty it is necessary to attempt some definition as a starting point—even if all phenomenologists do not accept it without qualification.

Initially, then, phenomenology may be described as an effort to disclose the transcendental features or presuppositions of the world as given in ongoing experience. Phenomenology takes as its basic concern our ongoing experiencing of the world within the unfolding horizon of temporality. Although the language of phenomenology often refers to "essences" in experience, it is not interested in some stable atemporal or a historical account of the world. For the phenomenologist essences do not stand outside of our ongoing existence. The transcendental horizon, the focus of its concern, is never divorced from the concrete experiences of everyday life. But at its foundation is the attempt to take the phenomena of human experience and subject them to deeper or broader examination than is done by the sciences, all of which, according to phenomenology, abstract from experience.

To extend this working definition, take the human experience of music and consider it phenomenologically. From the perspective of physics and physiology, music is constituted by a flux of waves of particular frequencies to which the inner ear may be sensitive. Indeed, once so analyzed, it is possible to create a technological device such as a tape recorder that is sensitive to these same sounds, and can even replay them on command. Human beings, however, when they hear sounds in everyday life never take them simply as a stream of sounds, rather they find themselves already listening to something particular—a cry for help, an automobile braking, construction noise, or a piece of music. Indeed it would take a very strange sort of attitude to hear sounds and take them as a flux of waves of particular frequencies. Listening is different than registering or recording; to listen is to already take sounds as this or that. In listening, the taking of sound as music implies an already existing sense of what music is, something that makes it possible for us to take these sounds as music rather than noise. Furthermore, in listening to music, this listening is informed by an ongoing sense (or unity) of movement, rhythm, tone, scale, style, and so forth. This ongoing active unity provides an active and ongoing framework that enables me, in the experience of listening (right now), to simultaneously "retain" the sounds I no longer hear (the past), and in anticipation to "fill in" the sounds I am not yet hearing, yet already anticipate (the future). As a phenomenological being I find myself listening to music, not merely recording sounds after the manner of a technological device. For phenomenologists the relevant question is: What is this ongoing framework that makes it possible for humans to listen to music rather than merely record sounds?

Even our encountering of mundane everyday objects takes as necessary an already existent sense or familiarity with the world. What makes it possible to encounter a chair—recognize it, see it, refer to it, use it as a chair rather than as a something else? Like sounds, we are always given it only in some one aspect. When we stand in "front" of it the "back" is not given to our senses as such. When we stand at the back the front is hidden from view. Yet when we approach the chair we do not take it as a confusing flux of sensation, but as that which it already is, a chair to sit or stand on.

What is it then that enables us to encounter music and chairs in their fullness even though we are always given, at any particular point in time, only some limited aspect of such phenomena? The answer of phenomenology is that it is the *transcendental horizon* that makes phenomena possible, where the transcendental is understood as "that which constitutes, and thereby renders the empirical possible" (Mohanty 1997, p. 52). In Don Ihde's words "phenomenology investigates the conditions of what makes things appear as such" (2003, p. 133). One could say that the transcendental is the background, or horizon, that makes the meaningful experience of the foreground possible. Yet insofar as such a formulation suggests a background that is somehow separate and "behind" that which appears in the foreground, it would be incorrect. Transcendental horizons or conditions are always and immediately already present in the very appearing as such—this is exactly what makes a horizon "disappear" or withdraw from our focal awareness. It is so evident that it simply does not come up as an issue.

It is this seemingly "forgotten" horizon that is the focus of phenomenology—indeed it is this horizon that phenomenologists want to call to our attention. All phenomenological "reductions" have as their purpose a "return" to this vital constitutive transcendental horizon. "Reduction" should be understood here in relation to its Latin root *re-ducere*, to lead back.

In place of the examples of listening to music or encountering a chair, we could also refer to engagements with such diverse phenomena as language, self, identity, sociality, and so forth. In the case of those phenomena known as science or technology we would attempt to provide an account of the transcendental horizons that constitute the scientific or technological and therefore render them possible in our everyday experience. What is it within our ongoing relation with the world that allows science or technology to show up as a way to structure that relationship? To this question phenomenologists have given many different and illuminating answers.

But what is the transcendental horizon? How and where do we find it? The answer differs from one phenomenologist to another. Husserl (1970, 1982, 1995) argued that it was the ongoing life of pure consciousness. For him the intentionality of consciousness allows things to appear as this or that thing. He thus proposed that we bracket out, or set aside, our normal everyday assumptions about the world—the natural attitude—and return to the life of pure consciousness.

By contrast, Roman Ingarden (1893–1970) maintained that the transcendental horizon is constituted by the *a priori* truths necessary for the factual world to be what we experience in ongoing experience. He proposed that we return to these truths, but also encouraged us to always ground ourselves in the real world as given in experience.

Heidegger (1962), in turn, argued that it is our always already immersion in the world of everyday life that is the transcendental or constituting horizon. For him active beings are always already busy in the world, and the world shows up precisely as that which it already is. We do not need a "bridge back to the world" from our concepts. We have never left the world of everyday life, and it is exactly this ongoing intimate relation with the world—our pre-ontological understanding of being as such—that is the very basis of all scientific knowledge. It is the "stuff" from which we construct all systems of logic, mathematics, and science.

Merleau-Ponty (1962) continues this discovery of transcendental horizons by focusing on the body, or more specifically on the always already embodiedness of our being. He calls on us to return to the already lived and situated body of our ongoing perception of the world. For him our scientific systems of orientation in time and space have their condition of possibility in our being a body—a lived body that is the ongoing horizon of orientation and meaning.

Despite their differences these phenomenologists all claim that the naturalistic empirical science (also referred to as objectivism or positivism) remains unreflective and uncritical of the importance of the ongoing constituting role of these various transcendental horizons. For example, scientists take the objects of their investigations—such as atoms, ozone layers, cultures, money, criminals, and so forth—as simply already given without considering the conditions that make it possible for them to encounter these phenomena as what they take them to be. In their emphasis on these already assumed objects of study the constituting horizons withdraw to be forgotten, thereby allowing them to move, in their analyses and arguments, way beyond the possibilities offered by the constitutive conditions of meaning. It is exactly the explication of these constitutive conditions or horizons of meaning that phenomenology seeks to call to our attention, in order to keep us from becoming lost in or misled by the abstractions of science and the powers of technology.

The Phenomenology of Everyday Encounters

To provide an illustration of the phenomenological approach it is useful to present in slightly more detail Heidegger's pivotal analysis of our everyday encounters. This presentation will then link to the work of Ihde, Borgmann, Dreyfus, and Lévinas.

For Heidegger the human encounter with things is fundamentally practical in orientation. We do not encounter chairs as chair objects—after the manner of designers or scientists—but as "possibilities for" sitting down or standing on or facing somebody, and so forth. Furthermore, the chair is a "possibility for" (what Heidegger called an "in-order-to") only within an already present referential whole including a multitude of possibility-for's. The transcendental horizon of meaning is the ongoing, unfolding referential whole in which every thing has its ongoing way of being that which it already is, while the whole draws on this very being to be the whole that it is. To describe this active and ongoing transcendental horizon of reference and meaning—in which the world and humans already implicate each other—Heidegger uses the notion of *being-in-the-world,* thus indicating the intimate relation between being and world. For Heidegger, any being whatsoever is a being only in an already assumed world—referential whole—that constitutes it as such. Heidegger argues that we humans-already-in-the-world (which he calls *Dasein*) exist in an ongoing structural openness toward the world in which the self and the world are always already a unity, a being-in-the-world (Heidegger 1962). Thus, we human beings (*Dasein*) have this unity as our ongoing way of being. That is why the world mostly makes sense rather than being mostly strange and unfamiliar.

Consider this example. Whenever we find ourselves or take note of ourselves, we do so already engaged in practical everyday activity in which things show up as "possibilities for" our practical intentions—as tools for this and that. When I switch on my laptop it already shows up as a possibility to write, communicate with my office, and so on. When we consider this world of practical activity we note that all the things we encounter already matter in some way or another—even if they matter only as useless, boring, or irrelevant. Heidegger claims that we, as *Dasein,* are always already "ahead" of ourselves—always already projected into the future as it were. In being ahead of ourselves things show up as this or that possibility-for. When we get up in the morning we already find ourselves acting in anticipation of the day ahead. When we get into our cars we already anticipate the journey. To put it rather abstractly, we are always and already projected as a necessary condition of that what we already are—as academics, politicians, managers, and so on. I did not so much decide to take up the project to write this entry as much as I found myself writing this entry as that which already made sense for an academic like me to do. Thus, as already projected beings, tools (opportunities) show up as tools (opportunities)—as possibilities-for. The world as possibilities-for shows up in particular ways to scientists (as scientists) that are different from that of artists (as artists) or managers (as managers).

This does not mean, however, that one can simply take the world any way one wants; the world—the scientific, art, or managerial world—is not simply of one's making. These tools are tools for this or that purpose only in as much as they already refer to other tools, which also already refer to them as their transcendental condition for being this or that tool. Here, "refer" is used in the sense of a necessary relation or reference for the tool to be what it already is taken to be when taken up in practical activity. The laptop I am working on, to be taken up as a laptop, rather than a piece of assembled plastic and silicone, refers to application programs, which refer to operating systems, which refer to hardware, which refer to a power supply—all of which refer to suppliers, which refer to maintenance services, and so forth. Dreyfus (1991) calls this recursively defining, necessary nexus of relations, the tool or equipment whole.

When we take up these tools, as tools, however, we do not take them up for their own sake; we take them up within an already present reference to our projects. I do not simply bang on keys; I use the laptop to type, in order to write, do e-mail, surf the Internet, and so forth. Moreover, the writing of this entry already refers to the possibility of an encyclopedia, of which it would be a part. This encyclopedia already refers to editors, which refer to a potential audience, which refers to potential publishers, and so on. Furthermore, the writing of this entry also already refers to the publication of my work, which refers to a publication record, which refers to academic status, which refers to the possibility for promotion, and so forth. Heidegger (1962) calls this recursively defining and necessary nexus of projects, or for-the-sake-of relations, the involvement whole.

The equipment whole and the involvement whole refer to each other and sustain each other as an ongoing referential whole, horizon of meaning. Heidegger calls this referential whole "the world." We humans always already dwell in the world in which the world is mostly familiar (it is simply already there, "ready-to-hand" in Heidegger's terminology). Now sometimes the world "breaks down," and then we tend to encounter it as objects or events as such—it becomes occurrent or present-to-hand in Heidegger's terminology. When we type and the key gets stuck then we notice it "as a key"; otherwise we merely type. If it remains stuck the computer becomes occurrent "as a broken laptop." But as we start to take it apart, in an attempt to fix it, it recedes back into the background as something I am fixing.

The point of Heidegger's account is "that things show up for us or are encountered as what they are only against a background of familiarity, competence, and concern that carves out a system of related roles [recursively defining references] into which things fit. Equipmental things are the roles [recursively defining references] into which they are cast by skilled users of them, and skilled users *are* the practical roles [recursively defining references] into which they [become] cast themselves" (Hall 1993, p. 132). The phenomenological meaning of the world of science, technology, and ethics can be understood only within the always already defining referential whole, the world we are already "in"—or more correctly the world we always already are. Grasping this phenomenological foundation is essential to making sense of some of the authors most important for science, technology, and ethics.

Phenomenology in Science and Technology

Phenomenology has been used to analyze a number of aspects of science and technology in ways that have implications for ethics. What follows is a consideration of three major cases: artificial intelligence, consumer devices, and human–technology relationships.

DREYFUS ON ARTIFICIAL INTELLIGENCE. In critiquing artificial intelligence (AI) Dreyfus (1979, 1992) argues that the way skill development has become understood has been wrong. He argues, using the work of Heidegger, that the classical conception of skill development, going back as far as Plato, assumes that we start with the particular cases and then abstract from these to discover and internalize more and more sophisticated and general rules. Indeed, he argues, this is the model that the early artificial intelligence community uncritically adopted. In opposition to this view he argues, with Heidegger, that what we observe when we learn a new skill in everyday practice is in fact the opposite. We most often start with explicit rules or preformulated approaches and then move to a multiplicity of particular cases, as we become an expert. His argument draws directly on Heidegger's account of humans as beings that are always already in-the-world. As humans in-the-world we are already experts at going about everyday life, at dealing with the subtleties of every particular situation—that is why everyday life seems so obvious. Thus, the intricate expertise of everyday action is forgotten and taken for granted by AI.

As a way to critique the program of AI, Dreyfus provides an account of five stages of becoming an expert. A *novice* acts according to conscious and context-free rules and generally lacks a sense of the overall task and situational elements. The *advanced beginner* adds, through experience, situational aspects to the context-free rules to gain access to a more sophisticated understanding of the situation. The relationship between the situational aspects and the rules are learned through carefully chosen examples, as it is difficult to formalize them. The *competent person* will have learned to recognize a multiplicity of context-free rules and situational aspects. This may lead, however, to being overwhelmed because it becomes difficult to know what to include or exclude. The competent individual learns to take a particular perspective on the situation, thereby reducing the complexity. Such "taking a stand," however, involves a certain level of risk taking that requires commitment and personal involvement. For the *proficient* most tasks are performed intuitively. As an involved actor the relevant situational aspects show up as part of the ongoing activity and need not be formalized. Nevertheless, a pause may still be required to think analytically about a relevant response. For the *expert* relevant situational aspects as well as appropriate actions emerge as part of the ongoing activity within which the expert is totally absorbed, involved, and committed. The task is performed intuitively, almost all the time. In the ongoing activity of the expert thousands of special cases are discriminated and dealt with appropriately.

With this phenomenological account of skill development in hand it is easy to see the problem for AI. Computing machines need some form of formal rules (a program) to operate. Any attempt to move from the formal to the particular, as described by Dreyfus above, will be limited by the ability of the programmer to formulate rules for such a shift—a shift forgotten by AI. Thus, what the computer lacks is an already there familiarity with the world that it can draw upon as the transcendental horizon of meaning to discern the relevant from the irrelevant in ongoing activity—that is, the computer is not a being-in-the-world in Heidegger's terms.

Dreyfus's critique pushed AI researchers into new ways of thinking. In particular it has led to the embodied cognition program of the Massachusetts Institute of Technology Artificial Intelligence Laboratory under the direction of Rodney Brooks. Nevertheless, even such programs of embodied cognition (or cog robots as they are called) would fail if AI cannot give an account of how a cog robot's own existence would be at stake—would matter. Without such a "stake"—without being ahead of itself—the cog robot would lack the fundamental transcendental horizon of intentionality and meaning, according to Heidegger. Phenomenology's call to a "return to the things themselves," to recover the supposed transcendental horizon of meaning, will continue to challenge the progress of AI. Moreover, it seems that many of our assumptions about the relationship between the technical and the social, even the supposition of such a relation itself, will continue to provide a multiplicity of opportunities for phenomenology to explore.

BORGMANN ON CONSUMER DEVICES. In thinking about our relationship with technology in modern contemporary life, Borgmann takes up the question of the possibility of a "free" relation with technology. He agrees with Heidegger that modern technology is a phenomenon that tends to "frame" our relationships with things, and ultimately ourselves and others, in a one-dimensional manner—the world as available resources for our projects. He argues that modern technology frames the world for us as "devices," and specifically as devices that hide the referentiality of the world—the worldhood of the world—upon which devices depend. Devices do not disclose the multiple conditions that are necessary for them to be what they are taken to be. Just the opposite is true: They try to hide the effort that is necessary for them to be available for use. Thus, a thermostat that we simply set at a comfortable temperature now replaces the process of chopping wood, building a fire, and maintaining it. Our relationship with the environment is reduced to, and disclosed to us as a control that we simply set to our liking. In this way devices de-world our relationship with things, in Heidegger's terminology. By relieving us of the burden of making and maintaining fires, our relationship with the world becomes disclosed in a new way—as one of disengagement. The world of things is not something to be engaged in, it is simply available for consumption.

Against such a disengaging relationship with things in the world, Borgmann argues for the importance of focal practices based on focal things. Focal things solicit our full and engaging presence. Compare, for example, the focal practice of preparing and enjoying a meal with friends or family to the solitary consumption of a fast-food meal. If one takes Borgmann's analysis seriously one might conclude that contemporary humans, being surrounded by devices, are doomed to increasingly relate to the world in a disengaged manner. Borgmann argues, however, that it is also possible to have a free relation with technology—even modern technology—if we imbed it in focal practices rather than use it, or accept it, as devices. Otherwise we will, as Heidegger (1977) argued, become the devices of our devices.

IHDE ON HUMAN–TECHNOLOGY RELATIONSHIPS. Phenomenology does not function only as an approach to critique our relationship with technology. Ihde (1990) has used the resources of phenomenology to give a rich and subtle account of our relationship with technology. In thinking about the human–technology relationship Ihde characterizes four different *I–technology–world* relationships. The first type he calls "embodiment relations." In this case technology is taken into subjective perceptual experience of the world, thus transforming the subject's perceptual and bodily sense. In wearing my eyeglasses I not only see through them, they also become "see through." In functioning as that which they are, they already withdraw into my own bodily sense of being a part of the ordinary way I experience my surrounding. He denotes this relationship as having the form (I–glasses)–world. This relationship, however, has a necessary "magnification/reduction structure" associated with it. Embodiment relations simultaneously magnify and amplify or reduce and place aside (screen out) what is experienced through them. The moon seen through a telescope is different from the moon perceived by the naked eye. The person at the other end of the telephone is brought to me across a great distance at the expense of being reduced to a voice.

The second type of human–technology relationship is what Ihde calls "hermeneutic." Here, the technology functions as an immediate referent to something beyond itself. Although I might fix my focus on a map, what I actually see—immediately and simultaneously—is not the map itself but rather the world it already refers to, the landscape suggested in the symbols. In this case the transparency of the technology is hermeneutic rather than perceptual. As I become skilled at reading maps they withdraw to become immediately and already the world itself. Ihde denotes this relationship as having the form I–(map–world).

The third type of human–technology relationship Ihde calls "alterity relations." In this case, technology is experienced as a being that is otherwise, different from myself—technology-as-other. Examples include things such as religious icons and intelligent robots (the Sony dog for example). In my interaction with these technologies they seem to exhibit a "life of their own," thus as I engage with them they tend to disengage me from the world of everyday life, hence their pervasiveness in activities such as play, art, and sport. Ihde denotes these as having the form I–technology–(world), indicating that the world withdraws into the background and technology emerges as a focal entity with which I momentarily engage—as I play with my robot dog for example.

Finally, Ihde recognizes a fourth type of human–technology relationship in which technology is not directly implicated in a conscious process of engagement on the part of the human. Ihde refers to these as "background relations." Examples include automatic central heating systems, traffic control systems, and so forth. These systems are "black-boxed" in such a way that we do not attend to them, yet we draw on them for our ongoing everyday existence. They withdraw as ongoing background conditions. Although he does not designate them as such, one might formalize these relations in the form: I–(technology)–world. These invisible background technologies can be powerful in configuring our world in particular ways, yet escape our scrutiny.

Ihde's phenomenological description of the human–technology relationship provides a useful way to give an account of many everyday relations of import to science, technology, and ethics. One can imagine a very interesting phenomenological analysis of the relationship between scientists and their instruments as done in the social study of science. Furthermore, the withdrawal of technology, into my body, into my perception, and into the background, has important political and ethical implications for its design and implementation, especially if one considers that every disclosure of the world "through" technology is also immediately a concealment of other possible disclosures. The car discloses possibilities for getting to places quickly, but also conceals, in its withdrawal, the resources (roads, fuel, clean air, etc.) necessary for it to be what it is—they act as devices in Borgmann's terminology. Indeed we often lose sight of the reduction/magnification structure as we simply use these technologies. As these technologies become more and more pervasive—almost a necessary condition of everyday life—it becomes more and more difficult to see that which has become concealed in their withdrawal. With Ihde's typology of I–technology–world relationships it might be possible to bring what has become concealed back to the foreground for critical attention and ethical reflection.

FURTHER CASES, AND LÉVINAS. There are many more authors that could be used to illustrate phenomenology's relevance and influence in the domain of science, technology, and ethics. For example there are Heim's studies of virtual reality (1993) and electronic writing (1999), or Richard Coyne's discussion of being in cyberspace (1995), Tony Fry's excellent essays on the televisual (1993), Terry Winograd and Fernando Flores's critique of the use of computers in organizations (1986), and many more. Nonetheless, it is the work of Lévinas (1969, 1991) that might serve as a final signpost on our phenomenological way. The reason for this is that Lévinas, although he starts within the phenomenological tradition, wants to turn our attention to the most basic encounter of all—that of the ethical.

Lévinas argues that Western philosophy, and phenomenology in particular, is a philosophy of what he calls the same, or the totality—a totality within which every otherness becomes "domesticated." By totality he means the expectation that all things will eventually "add up," will be accounted for; that somehow there is a larger whole or "system" in which everything will eventually find its place. For Lévinas this expectation already has its source in the ongoing synthesizing intentionality of consciousness itself. The transcendental horizon of meaning, opened up by intentionality, is already colonized by our individual self-ish will to be. The gravity of our everyday existential project does not allow the other, as profoundly singular, to remain at the margins of our constituting horizon. Through our will to be—our always already projectedness in Heidegger's language—we have indeed already taken the place "in the sun" of the other. We, in our already in-the-worldness, are already guilty of violating the otherness of the other; we are already responsible, therefore we must respond. For Lévinas, taking up our responsibility for the other is the only possibility for transcending the self-ishness of the will to be.

Thus, what Lévinas points to is that although phenomenology provides a path back to the very constitutive possibilities of experience it also immediately implicates us as already responsible for violating the otherness of the other in these very possibilities. In our quest for meaning we find ourselves at the dawn of ethics, but we find ourselves already guilty. For Lévinas the ethical has always and already called into question the projects of science and technology. With Lévinas one might say that the success of science and technology has always come at the expense of masking the plight of the singular—the singular that is the incidental, idiosyncratic, and random error excluded from consideration in a world in which things always have to add up. Thus, for Lévinas, the most profound question is not the what or how of science and technology but the always already suffering of my neighbor, the specific one closest to me, that the projects of science and technology obscure even if they try to do what is right. Obviously Lévinas is not saying we should abandon science and technology. He is rather saying that we should allow the ethical, the singular other, to continually question and interrogate the already supposed legitimacy of science and technology. It is only in the currency of the singular, this individual here and now, that ethics has any possibilities.

Some Critical Comments

Phenomenology provides a variety of resources for examining relationships among science, technology, and ethics. But phenomenology also has limits. It is often criticized for essentialism and failures to provide rich accounts of the particular and the situated, such as those provided by social studies of science, as in the work of Bruno Latour and Steve Woolgar (1986), Michel Callon (1986), or Andrew Pickering (1995). Phenomenology does not appear able to explain why some technologies become accepted and used rather than others in the way social constructivist accounts do, as in the work of Wiebe E. Bijker and colleagues (1987). This tension between phenomenology and social constructivism permeates the work of Feenberg (1995), whose analysis of technology retains important phenomenological insights while working with findings from social studies of technology.

Indeed, other "post" phenomenology authors in science, technology, and ethics retain insights from phenomenology while trying to move beyond its limitations. Don Ihde (1993, 2003) suggests a post-phenomenology that is not centered on the subject but on embodiment. With the notion of "embodiment" he problematizes the ongoing interrelation between the active and perceiving body (or thing) and its environment of action (or use). Likewise, although Latour rejects phenomenology, he retains Heidggger's insight that a thing or tool is what it is within a referential whole. It is this perspective that makes it possible to conceive a thing as an "actant," and therefore constitute the "network" as a network. It would therefore seem reasonable to expect that phenomenology will remain important for those seeking to make sense of our relation with the phenomena of science, technology, and ethics.

LUCAS D. INTRONA

SEE ALSO *German Perspectives; Heidegger, Martin; Husserl, Edmund.*

BIBLIOGRAPHY

Bijker, Wiebe E.; Thomas P. Hughes; and Trevor J. Pinch, eds. (1987). *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Cambridge, MA: MIT Press. This is a key text for social constructivism.

Borgmann, Albert. (1984). *Technology and the Character of Contemporary Life*. Chicago: University of Chicago Press. Borgmann's critique of technology in contemporary society.

Callon, Michel. (1986). "Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St. Brieuc Bay." In *Power, Action, and Belief: A New Sociology of Knowledge?* ed. John Law. London: Routledge and Kegan Paul. This is an important example of how science and technology becomes enrolled in political programs by different actors.

Coyne, Richard. (1995). *Designing Information Technology in the Postmodern Age: From Method to Metaphor*. Cambridge, MA: MIT Press. Applies phenomenology to the problem of information technology and design.

Dreyfus, Hubert L. (1979). *What Computers Can't Do: The Limits of Artificial Reason*, rev. edition. New York: Harper and Row. Dreyfus's devastating critique of artificial intelligence.

Dreyfus, Hubert L. (1991). *Being-in-the-World: A Commentary on Heidegger's "Being and Time," Division I*. Cambridge, MA: MIT Press. Good introduction to Heidegger's *Being and Time*.

Dreyfus, Hubert L. (1992). *What Computers Still Can't Do: A Critique of Artificial Reason*. Cambridge, MA: MIT Press.

Feenberg, Andrew. (1995). *Alternative Modernity: The Technical Turn in Philosophy and Social Theory*. Berkeley and Los Angeles: University of California Press.

Fry, Tony. (1993). "Switchings." In *RUA TV? Heidegger and the Televisual*, ed. Tony Fry. Sydney: Power Publications. Heideggarian account of our engagement with the televisual.

Hall, Harrison. (1993). "Intentionality and World: Division I of *Being and Time*." In *The Cambridge Companion to Heidegger*, ed. Charles Guignon. Cambridge, UK: Cambridge University Press.

Heidegger, Martin. (1962). *Being and Time*, trans. J. Macquarrie and E. Robinson. Oxford: Blackwell. Heidegger's most influential work.

Heidegger, Martin. (1977). *The Question Concerning Technology, and Other Essays*, trans. William Lovitt. New York: Harper and Row. One of the key texts in the philosophy of technology.

Heim, Michael. (1993). *The Metaphysics of Virtual Reality*. New York: Oxford University Press. An excellent and accessible account of the metaphysical assumptions of virtual reality.

Heim, Michael. (1999). *Electric Language*, 2nd edition. New Haven, CT: Yale University Press. A phenomenologicaly informed account of writing technologies in general and of word processing in particular.

Husserl, Edmund. (1970). *The Crisis of European Sciences and Transcendental Phenomenology: An Introduction to Phenomenological Philosophy*, trans. David Carr. Evanston, IL: Northwestern University Press.

Husserl, Edmund. (1982). *Ideas: General Introduction to Pure Phenomenology*, trans. W.R. Boyce Gibson. London: Allen and Unwin; New York: Macmillan.

Husserl, Edmund. (1995). *Cartesian Meditations: An Introduction to Phenomenology*, trans. Dorian Cairns. Dordrecht, Netherlands: Kluwer Academic.

Ihde, Don. (1990). *Technology and the Lifeworld: From Garden to Earth*. Bloomington: Indiana University Press.

Ihde, Don. (1993). *Postphenomenology: Essays in the Postmodern Context*. Evanston, Illinois: Northwestern University Press. Ihde's development of a postphenomenology for studying technology.

Ihde, Don. (2003). "If Phenomenology Is an Albatross, Is Post-phenomenology Possible?" In *Chasing Technoscience: Matrix for Materiality*, ed. Don Ihde and Evan Selinger. Indianapolis: Indiana University Press.

Latour, Bruno, and Steve Woolgar. (1986). *Laboratory Life: The Construction of Scientific Facts*. Princeton, NJ: Princeton University Press.

Lévinas, Emmanuel. (1969). *Totality and Infinity*, trans. Alphonso Lingis. Pittsburgh: Duquesne University Press. Important work of the "early" Levinas.

Lévinas, Emmanuel. (1991). *Otherwise than Being; or, Beyond Essence,* trans. Alphonso Lingis. Dordrecht, Netherlands: Kluwer Academic.

Merleau-Ponty, Maurice. (1962). *Phenomenology of Perception,* trans. Colin Smith. New York: Humanities Press. An important work for understanding the "embodied" literature in studies of technology.

Mohanty, Jitendranath N. (1997). *Phenomenology: Between Essentialism and Transcendental Philosophy.* Evanston, IL: Northwestern University Press. A good summary of some of the important ideas of phenomenology.

Pickering, Andrew. (1995). *The Mangle of Practice: Time, Agency, and Science.* Chicago: University of Chicago Press. Shows the reciprocal interrelation between technology, humans, society, and scientific knowledge as produced in scientific and technological work.

Spiegelberg, Herbert. (1994). *The Phenomenological Movement: A Historical Introduction,* 3rd edition. Dordrecht, Netherlands: Kluwer Academic. A vast survey of most of the important authors in phenomenology.

Winograd, Terry, and Fernando Flores. (1986). *Understanding Computers and Cognition: A New Foundation for Design.* Norwood, NJ: Ablex Publishing. The application of Heidegger's work to the design of organizations and computer systems.

PLACE

Attention to the idea of place has grown steadily since the 1980s in the context of an increased focus upon physical localities and new ways of organizing knowledge. These developments have been in part a response to the forces of globalization. The world has become an economic and cultural commons: Companies such as Wal-Mart and Starbucks have extended their reach worldwide, as have Hollywood films, which now earn the majority of their revenues overseas. Moreover, modern science, technology, and economics have not just homogenized space; in many respects they have annihilated it. Air travel has become ubiquitous, and both information and human identity now mutate within the hyperreal environment of cyberspace. As a result, there is a growing feeling that people inhabit a "Geography of Nowhere" (Kunstler 1993) not only in the sense of the homogeneity of shopping malls and suburban tract homes but also in terms of the uniformity that results from the relentless drive toward individuation.

Attention to the distinctiveness of places from the perspective of architecture, geography, philosophy, or personal narrative thus may be seen as a reaction to contemporary social and economic unifications. More basically, however, the focus on place marks the recognition of the irreducible fact that people attach themselves to and live out of particular landscapes, cultures, and bodily experiences (Tuan 1990). Abstractions—scientific, religious, or otherwise—must be complemented by the experience of lived, concrete existence. People construct their sense of identity through being born into or making a commitment to a landscape, a country, a culture, or a profession or "position." Attraction to place thus represents a persistent aspect of the human condition.

Recent attention to the concept of place also represents a response to deficiencies in the contemporary organization and use of knowledge. It is here that the term gains particular salience in relation to science, technology, and ethics. Environmental concerns offer especially good examples of place-based approaches to knowledge that strive to blend science, technology, and social concerns.

The Meaning of Place

The term *place* is used in several senses. It can identify a particular physical location such as the greater Yellowstone ecosystem, a mental location such as the Vietnam era, one's position in a social hierarchy, a field of research such as women's or Chicano studies, or a subject of controversy such as science wars. What all these senses share is participation in a part-whole relationship: A place is a delimitation within a larger geography, whether natural, cultural, or personal. However, to qualify as truly distinctive a location in some way must escape the terms that define all other spaces. This implies that there is something ineffable in the concept of place.

Place exists in an uneasy dialogue with the concept of space. In the early twenty-first century space is understood most commonly as a concept of physics, denoting the entirety of quantitative, mappable extension. In contrast, place typically is viewed as a psychological concept that highlights a person's subjective, affective response to a particular fragment of the world. This account, however, inverts the relation between place and space. Whatever powers science may have to describe extension, a person's initial experience of reality is always perspectival (Malpas 1999). Objective, mathematical accounts of space are derivative of people's embeddedness in particular places.

Place and Knowledge

Concerns with place have been particularly important in regard to the role of knowledge in society. Topical approaches to knowledge (from the Greek *topos*, meaning "place") challenge the traditional disciplinary manner of organizing and applying knowledge in terms of chemistry, history, and the like. This is not a trivial point: The way knowledge is organized determines the types of questions society asks as well as the way its questions are formulated. If, for instance, science and technology are viewed as forms of knowledge that are distinct from ethical and philosophical knowledge—or if ethics and philosophy are not considered "real" knowledge—it follows that the ethical consequences of the productions of scientists and engineers will be seen as quite distinct from their research.

Topical approaches to knowledge are part of a larger movement aimed at critiquing accepted practices within academia and other locations of knowledge production. In recent years interdisciplinary and transdisciplinary approaches to knowledge have become more prominent. Recent initiatives within Federal agencies such as the National Science Foundation (for example, funding for the IGERT, the Integrative Graduate Education and Research Traineeship program) highlight the increasing pressures on scientists and engineers from different disciplines to practice interdisciplinary collaboration in dealing with particular issues. Although place-based approaches are best seen as complementary to rather than in opposition to the disciplines, topical thinking nonetheless represents a new imperative, breaking through the logical space of disciplines to achieve a better purchase on human problems.

By its very nature a disciplinary approach to knowledge takes an analytic approach to its subject matter. The philosopher René Descartes (1596–1650) argued that people come to know a thing by breaking it into its smallest parts and thoroughly studying those parts. This is the analytic method. It is clear that this approach has a built-in bias in that it assumes that a problem can be subdivided into discrete units without a loss in understanding. Some issues, however, most notably environmental ones, are essentially holistic in nature. The Greater Yellowstone ecosystem, for instance, consists of something more than a series of "disciplines" (geologic, hydrologic, economic, and so on) worked on by different teams of professionals. As necessary as an understanding of these different systems is for improving the health of the ecosystem, environmental problems resist simple division into the categories of environmental science, economics, ethics, and the like. To address such problems effectively it is necessary to understand how those disciplines relate to and flow into one another at a particular location.

Topical thinking provides a means for tracing the ontological disruptions that occur when one attends to the holistic nature of a problem. Certainly a complex issue must be divided into pieces to understand its moving parts, but it also is necessary to retain a sense of the whole, seeking to understand the relation between and across the disciplines in a particular place. Otherwise one is left with a type of educated incoherence, with experts inhabiting their own privileged stances, largely failing to communicate with one another or with the public.

Place and the Environment

Environmental issues provide good examples for assessing the success of topical approaches to societal problems. This is the case in part because nature presents some of the most distinctive locations imaginable. Founding environmental documents such as the Endangered Species Act of 1973 reflect the importance people attach to the unique, as do attempts to eliminate "exotic" plants and animals to protect the distinctiveness of natural places.

Battles over issues such as the Arctic National Wildlife Refuge (ANWR) demonstrate the deeply interpretive nature of a topical approach to problems. Science has a reputation for providing objective information, but as Aristotle noted in the *Poetics*, there can be no science of the individual. When the U.S. Geological Survey attempted to determine oil reserves at the ANWR, its estimates varied from 4.3 to 11.8 billion barrels of oil, a range that was used to defend a variety of policy recommendations. Engineering questions were equally vexing, with some experts claiming that new engineering techniques could make drilling in the Arctic safe and others stating that the risks remained too great. Even the question of degrees of wilderness and natural beauty was debated: The ANWR was described as both pristine and having a long history of human modifications and as both stunningly beautiful and a boggy wasteland. Again, there is no science of the individual: Answers to the question of whether it is safe to drill in the ANWR cannot come through laboratory experiment or computer modeling, only through actual experiments.

Rather than seeing such results as repudiating claims about the usefulness of topical approaches to knowledge, one can view a topical approach as stripping the pretensions from types of knowledge that claim to escape the skein of interpretation. Science retains its claims to objectivity only by locking itself up in the laboratory. The clarity of disciplinary knowledge is bought at the cost of abstraction from the real world. Bringing knowledge into the field and to specific locations increases its relevance to people's lives.

ROBERT FRODEMAN

SEE ALSO *Environmental Ethics; Space.*

BIBLIOGRAPHY

Bachelard, Gaston. (1964). *The Poetics of Space*. Boston: Beacon Press. Classic treatment of human lived experience of space by a preeminent philosopher of science.

Casey, Edward. (1993). *The Fate of Place: A Philosophical History*. Berkeley: University of California Press. Traces the history of place and space from the Greeks to the postmodern theories of Foucault, Derrida, and Irigaray.

Kunstler, James Howard. (1993). *The Geography of Nowhere: The Rise and Decline of America's Man-Made Landscape*. New York: Simon & Schuster. A readable and provocative work that examines the role of the automobile in the destruction of American cities.

Light, Andrew, and Jonathan Smith, eds. (1999). *Philosophies of Place: Philosophy and Geography III*. Lanham, MD: Rowman and Littlefield. Includes the reflections of philosophers and geographers on the decline and attempted recreation of public spaces.

Malpas, J. E. (1999). *Place and Experience: A Philosophical Topography*. New York: Cambridge University Press.

Tuan, Yi-fu. (1990). *Topophilia: A Study of Environmental Perception, Attitudes, and Values*. New York: Columbia University Press. Influential book by a well-known geographer that explores the bonds between people and place.

INTERNET RESOURCE

Gross, Matthias, and Holgar Hoffmann-Riem. (2004). "Real-World Experiments: Strategies for Robust Ecological Design." Available from http://www.uni-bielefeld.de/iwt/realworld/index.html.

PLAGIARISM

Plagiarism is commonly defined as the unauthorized or unacknowledged appropriation of the words, graphic images, or ideas from another person. As such plagiarism can be a violation of intellectual property rights, although it is not in all cases illegal. It is in fact one of the most serious general issues in the practice of scientific scholarship, in part because its precise boundaries are not always easily determined and because concepts of plagiarism have evolved considerably over time. Opportunities for plagiarism and efforts to deal with it have also altered in conjunction with technological change.

Plagiarism overlaps yet is distinct from copyright infringement; the latter can occur with proper attribution, while plagiarism cannot, and the latter generally occurs with the failure to obtain permission to use copyrighted material (Lindey 1952). Further, while definitions of copyright infringement are based on statute, definitions of plagiarism—and their resultant interpretations—vary considerably across institutions (Myers 1998). According to a committee convened by the National Academies of Sciences and Engineering and the Institute of Medicine (1995), plagiarism and the falsification and fabrication of data or results constitute three forms of deceptive scientific misconduct that impede scientific progress as well as endanger foundational scientific norms. Data obtained from National Science Foundation and National Institutes of Health investigations into allegations of misconduct in the late 1980s and early 1990s suggest that plagiarism is the more common of these three (LaFollette 1992).

Historical Emergence

One interpretation of the evolving perspective on plagiarism holds that plagiarism was not discussed as an ethical issue until after the rise of individualism during and especially after the Renaissance. For instance, classical authors sometimes copied from each other without explicit acknowledgment, and occasionally attributed their own works to another author (a kind of reverse plagiarism) because they saw them as part of a tradition better represented by someone else. There are a number of pseudonymous works of Plato and Aristotle, and the first five books of the Bible, although attributed to Moses, were almost certainly written by someone else. In the area of graphic representation, all works of art from the studio of a master were commonly attributed to that master.

Such a view is nevertheless complicated by multiple factors, including classical understandings of originality, which significantly influenced sixteenth-century Italy and France (White 1935). Greek and Roman authors prized the imitation of previous works and considered established subject matter a common inheritance. Imitation was not synonymous with copying or piracy because classical authors often earned respect by identifying their esteemed sources. Further, established works were to be judiciously selected and reinterpreted via one's own experience specifically to expand and even surpass their prior treatment. To explain their notions of originality, classical writers such as Seneca and Plutarch used the metaphor of the bee, which draws nectar from many flowers yet transforms these into an altogether new creation. The classical notion of originality has influenced the modern scientific enterprise, as has the classical authors' general (though not universal) disdain for unattributed sources (White 1935).

The value placed on imitation also influenced literary and nonliterary texts written in early modern England (c. 1500–1800), a period in which views of plagiarism varied widely, from ethically venerable to venial or vile (Kewes 2003). This range of reactions stemmed in part from the complex interactions between plagiarism and "imitation, borrowing, adaptation, allusion, intertextuality, appropriation, copyright infringement," and other concepts (Kewes 2003, p. 2). Genre and intellectual context also mattered. For instance, some seventeenth-century religious figures did not acknowledge their debt to sources they copied or received inspiration from as they felt those covert sources could strengthen the power of their sermons. During the same period, Robert Boyle (1627–1691), often considered the father of modern chemistry, reprimanded those who had appropriated his experimental work without full attribution.

Technology shaped plagiarism perspectives considerably. General public disapproval of unacknowledged copying across contexts increased when printed texts (as opposed to handwritten ones) became more commonplace, in part because of publishers' desire to secure revenue. Moreover, after 1750 the value on imitation declined not coincidentally with an increased emphasis on originality (Kewes 2003) and the growth of individualism.

Contemporary Issues

Plagiarism is also a contemporary cultural issue. Because originality and individualism are viewed through cultural norms, perceptions of plagiarism vary widely across cultures and often contrast with the predominant Western view, especially among cultures that emphasize the community over the individual. Thus, in certain cultures "using the words and ideas of others without attribution is considered a sign of deep respect as well as an indication of knowledge" (Lunsford 2004, p. 169). By contrast, normative views in Europe and North America are embedded in the very origin of the word *plagiarism*, which derives from the Greek *plagios*, meaning crooked or treacherous, from which comes the Latin *plagiarius*, meaning kidnapper. Because the vast majority of scientific gatekeeping and production originates in Europe and North America, it is these notions of plagiarism and intellectual property that have been widely disseminated across cultures. Whether this dissemination constitutes linguistic and cultural hegemony has been debated (e.g., see Myers 1998; Scollon 1995).

Beyond its cultural aspects, plagiarism in the early twenty-first century is complicated by the difficulties in identification as well as the role of technology. Although identifying plagiarism may seem straightforward, context matters. For instance, paraphrased or summarized common knowledge does not require attribution, yet what is considered common knowledge varies among audiences. Further, whether the smallest unit of plagiarism should be the paragraph, sentence, or the phrase is open to debate (e.g., see St. Onge 1993). Also, if plagiarism is a deceptive form of scientific misconduct, it is important—yet sometimes complicated—to determine whether an act was malicious or unintentional.

Identifying plagiarism can also be intricate because scientific and technological works are frequently collaborative creations, with shaping influences from colleagues, coauthors, peer reviewers, journal referees, and editors. Although guidelines to distinguish various contribution levels help determine who should be referenced, acknowledged, or listed as a coauthor, these guidelines are far from universal (see NAS, NAE, and IOM 1995). Some researchers would define a given contribution as worthy of coauthorship, whereas others would classify the same contribution as worthy only of acknowledgment (see Buzzelli 1993).

Technological changes have created additional opportunities for plagiarism as well as its detection. For instance, multisite research collaborations involve significant electronic information sharing, which increases the amount and availability of information that can be plagiarized. Additionally, individuals raised with free Internet music, software, and other information have grown accustomed to easily accessible information, which may engender attitudes regarding plagiarism that differ from the previous few generations. The same information technologies that can facilitate plagiarism, however, are being used to expose plagiarists; Internet-based plagiarism prevention and detection services compare electronically submitted texts against massive information databases to identify unoriginal material.

Perhaps in part because contexts, definitions, and interpretations of plagiarism vary, consequences for plagiarizing also vary. Generally, cases of proven plagiarism can involve demotion, job loss, and varying degrees and types of loss of respect and ostracism from one's own field. Marcel C. LaFollette (1992) tells of a former director of the National Institute of Mental Health whose early-career plagiarism was detected, leading to his resignation from his academic positions and, several months later, reinstatement based on the merits of his overall career contributions. In another case, an award-winning malaria researcher at the Harvard School of Public Health was accused of plagiarizing portions of a National Institutes of Health (NIH) grant. After an investigation by both Harvard and the federal government's Office of Research Integrity, the accused assistant professor resigned and became ineligible to apply for federal funding for three years (Glenn 2004). A Spanish journal of micropaleontology stopped accepting manuscripts indefinitely from a researcher who for twenty years had allegedly plagiarized pictures of diverse organisms from other publications (Bosch 2004).

Consequences become particularly complex with plagiarism accusations between colleagues of different ranks. When a graduate student at Arizona State University accused his acclaimed mentor in plant biology of copying part of his work, the mentor stated that such practices were common in science and that he was justified because the graduate student was part of his research team. One-third of the mentor's article was reportedly taken directly from the student's work, which itself had appeared in an earlier publication. Shortly after the student contacted the editor who published his mentor's work, the student indicated that he experienced exclusion from major research projects. The mentor is a member of the National Academy of Sciences, formerly served on the editorial board of the journal *Science*, and was appointed by President George W. Bush to the President's Council on Science and Technology (Bartlett and Smallwood 2004b). In addition to the issue of power inequity between accuser and accused, rendering judgment in this case may have been complicated by the possibility that the university committee charged with the investigation perceived the reputation of the mentor (their colleague) as inextricably tied to the university's reputation. The consequences of plagiarism have become of increasing interest in an era in which a significant portion of scientific research is supported by public funds (Miller and Hersen 1992). Whether plagiarism is common or rare in science and technology research is a topic of debate (see LaFollette 1992, Miller and Hersen 1992, Bartlett and Smallwood 2004a).

Closely related to the issue of consequences are the mechanisms for addressing plagiarism allegations. Controversy exists over whether plagiarism cases should be handled by government agencies, university or other presses, professional societies, the legal profession, academic institutions, or some combination of these, and many are handled according to the specific attributes of the case. Because of the potential enormity of legal expenses, some professional societies have expressly refused any involvement in prosecuting plagiarism cases, and universities may also be wary of the costs of legal action (see Glenn 2004).

JON A. LEYDENS

SEE ALSO *Misconduct in Science.*

BIBLIOGRAPHY

Bartlett, Thomas, and Scott Smallwood. (2004a). "Four Academic Plagiarists You've Never Heard Of: How Many More Are Out There?" *Chronicle of Higher Education* 51(14): A8.

Bartlett, Thomas, and Scott Smallwood. (2004b). "Mentor vs. Protégé." *Chronicle of Higher Education* 51(14): A14.

Buzzelli, Donald E. (1993). "Plagiarism in Science: The Experience of NSF." *Perspectives on the Professions* 13(1): 6–7.

Glenn, David. (2004). "Judge or Judge Not?" *Chronicle of Higher Education* 51(14): A16.

Kewes, Paulina, ed. (2003). *Plagiarism in Early Modern England.* Basingstoke, Hampshire, UK: Palgrave Macmillan.

LaFollette, Marcel C. (1992). *Stealing into Print: Fraud, Plagiarism, and Misconduct in Scientific Publishing.* Berkeley: University of California Press.

Lindey, Alexander. (1952). *Plagiarism and Originality.* New York: Harper.

Lunsford, Andrea A. (2004). *The Everyday Writer,* 3rd edition. New York: Bedford/St. Martin's.

Miller, David J., and Michel Hersen, eds. (1992). *Research Fraud in the Behavioral and Biomedical Sciences.* New York: Wiley.

Myers, Sharon. (1998). "Questioning Author(ity): ESL/EFL, Science, and Teaching about Plagiarism." *Teaching English as a Second or Foreign Language* 3(2): 1–21.

National Academy of Sciences (NAS), National Academy of Engineering (NAE), and Institute of Medicine (IOM). Committee on Science, Engineering, and Public Policy. (1995). *On Being a Scientist: Responsible Conduct in Research,* 2nd edition. Washington, DC: National Academy Press.

Scollon, Ron. (1995). "Plagiarism and Ideology: Identity in Intercultural Discourse." *Language in Society* 24(1): 1–28.

St. Onge, K. R. (1993). "The Threshold of Plagiarism." *Perspectives on the Professions* 13(1): 2–3.

White, Harold Ogden. (1935). *Plagiarism and Imitation during the English Renaissance: A Study in Critical Distinctions.* Cambridge, MA: Harvard University Press.

INTERNET RESOURCE

Bosch, Xavier. (2004). "Plagiarism in Paleontology." *Scientist* September 22. Available from http://www.the-scientist.com.

PLANNING ETHICS

Planning is both a profession and a discipline that has at its foundation questions of how to best develop land, social programs, housing, parks, health services, and other aspects of human settlements. Planning ethics is focused on terms such as *best* as it appears in this characterization of planning, where ethics, or moral philosophy, provides a means of analyzing normative ways of responding to planning challenges.

Planning began largely as a community-led process focusing on aesthetics, safety, and health concerns at the neighborhood level. As planning became professionalized in North America in the late-1800s and early-1900s, urban design, economic vitality and order, beauty, and efficiency became prominent considerations. Planning issues later expanded to include environmental conservation and preservation, energy consumption, empowerment (including public participation), and heritage conservation (Hodge 1998, Krueckeberg 1994).

Historically the planning profession has evolved from an almost exclusive focus on the technical aspects of developing and conserving land to concern with a more holistic view of urban areas and regions. It has changed its disciplinary base from emphasizing engineering and architecture to striving for balance among the natural, physical, and social sciences. In addition, planning processes have shifted from focusing on technical, value-neutral expertise to addressing communicative processes, value-laden and normative analyses, and facilitation/mediation. Planning is thus often described as an art as well as a science (see for instance Canadian Institute of Planners 2004). While debates regarding these shifts are clear and progressive in academic circles, it is fair to say that society continues to view planners largely as technical experts in land development and, to a lesser extent, social and health programming.

Planning, Science, and Technology

Planning, science, and technology are connected in multiple ways. The use of science and technology by planning and planners is clear in the form of mapping techniques such as Geographical Information Systems (GIS), ecological theories, analytic and computing techniques, computer aided design, and others. Indeed one of the central criticisms of planning as an autonomous profession is the fact that it borrows methods, techniques, and tools from the social, natural, and physical sciences as well as the arts. This calls into question its independence as a field of inquiry, but is also often regarded as a strength in terms of underlining the inter- and multi-disciplinary nature of planning.

In addition to the use by planners of science and technology, technological advances have been linked to changing urban forms and activity patterns. Wireless communication, for example, calls into question the shape(s) of cities, transportation flows, and employment locations. Such phenomena have altered the perceptions and analyses of planners who help to shape these areas.

Conversely planning contributes to science and technology by demonstrating the effects of scientific theories and technological advances *on the ground* and can thus play a role in their refinement. Planners must, at the end of the day, develop a plan or make a recommendation, while scientists often study a given problem for an unlimited period of time. In this way, science and technology as used in planning has an immediacy that may lead to the adoption, adaptation, or abandonment of a given development.

Planning Ethics, Science, and Technology

Ethical aspects of planning, science, and technology may be discussed in terms of research as well as professional practice. Planning academics conduct research that contributes to the development of the field; planning practitioners also conduct research but their work is typically limited to issues with which they must deal in their everyday work. The ethical issues in both activities are similar, although particulars change. The following discussion includes examples from both fields of endeavor.

Ethics is used here as a synonym for moral philosophy; it does not replace other terms such as values, beliefs, morality, and morals. Instead it connotes a way of studying and addressing moral problems utilizing ethical theories and rigorous analysis. Ethical theories such as utilitarianism, Kantian thought, communitarianism, and rights-based morality, among others from sub-fields such as feminist ethics and environmental ethics, are used to help explore normative issues in planning and arrive at viable solutions.

Planning ethics, as part of professional ethics and, more generally, applied ethics, has been discussed in terms of five separate aspects of the field (Wachs 1985, Hendler 1995): everyday behavior; plans and policies; administrative discretion; the normative intent of the planning endeavor (planning theory); and planning techniques. Each category of ideas and action includes reference to issues of science and technology.

EVERYDAY BEHAVIOR. Everyday behavior refers to the actions of planners in the day-to-day context of their work. Conflict of interest is a typical ethical issue here. Should a land use planner accept a gift in return for expediting a development proposal? Should social planners bias a new service or program in ways that would help their family members? While such issues are commonly discussed in terms of planning ethics, they do not exhaust the field. As Joan Tronto argues, professional, including planning, ethics should be "about more than teaching [planners] that it is wrong to lie, to cheat or to steal (Tronto 1993, p. 134)."

Planners' behavior often includes their use of science and technology and the ethical aspects of that use. Most behaviors are linked to techniques and assessments that determine the efficacy of plans and policies. Some, however, include ethical issues that pertain directly to routine professional etiquette. For example, a bribe or a conflict of interest may pertain to the massaging of data (facilitated by such things as the sheer size of data sets that can be manipulated by computer programs), not only to the approval of a development proposal. Other concerns are equity, treatment of vulnerable populations (publics as well as colleagues), and relations with other professionals such as engineers and computer technologists. Included are such issues as sharing information with publics; for example, is communication via web sites and other means that require access to technology ethical when the target group is economically disadvantaged and may not have such access?

PLANS AND POLICIES. Plans and policies are inherently normative in that they allocate or reallocate resources among groups and individuals in a community or region. It is this normative content of plans and policies, as well as programs and projects, that is most strongly linked to ethics. Ethical theories and perspectives provide a conceptual basis for normative decisions in that a rights-based view of ethics, for example, directs plans and policies differently than would a utilitarian ethical theory. A plan that includes the provision of a transit route, or a park, in a particular neighborhood means that certain amenities will be part of this plan for particular people but not others. Such a distribution of *benefits* and *costs* is subject to ethical assessment.

Analyses of costs and benefits, as well as assessments of other ethical aspects of a plan or policy (such as social justice concerns), rest partly on the shoulders of science and technology. For instance, ecologists, environmental scientists, and other scientists, who study such things as carrying capacity, ecological stress, and environmental assessment, can determine whether a plan will result in the demise of a species or valued natural area. Similarly a transportation plan may be analyzed with regard to its ethical implications but one must understand the technical aspects of pollution generation and abatement, economic considerations, not to mention safety-related concerns pertaining to the materials used in road construction, the physical integrity of bridges, and traffic moderation, in order to conduct a rigorous ethical analysis. Further given the dearth of developable land in most urban centers, remediation of brownfield areas (lands on which polluting uses have occurred, thus necessitating corrective action) has become popular and the safety, cost, and efficiency of such action is subject to ethical, as well as scientific, analysis.

ADMINISTRATIVE DISCRETION. Administrative discretion pertains to the fact that planning roles are diverse and often ambiguous. This means that planners are often able to choose the role they wish to assume at any given time, where roles may vary from technician to mediator to advocate. This discretion gives rise to ethical considerations in that the selection of one role over another has implications for planners in their work. These implications pertain to clients, colleagues, employers, and publics in that all must know what to expect from the planners with whom they are working.

Planners may select roles that have more or less to do with science and technology. If they assume a role in which such expertise is required, they must ethically ensure that they have the necessary knowledge to act in this capacity. Most professional codes address this by referring to professional competence as a requirement for accepting, or carrying out, professional tasks. In addition to questions of competence, however, it is also possible that science and technology both broaden and restrict the role choices available. That is, some roles may be restricted when they require skills that are beyond the technical capacities of most planners. Conversely role choice might be broadened if such things as communication technologies make it easier for planners to collaborate with other experts, thus leading to more teamwork in planning.

PLANNING THEORY. Ethical aspects of planning theory pertain to the fundamental questions of why the planning profession should morally exist and how it is justified. Upholding individual rights, striving for maximum benefits for the greatest number of people, maintaining ecological integrity, ending oppression, and building community are all possible moral goals of the planning field (Beatley 1994, Hendler 1995, Howe 1994, Wachs 1985).

Science and technology enter into planning theory by indicating what is possible or feasible. It makes little sense to strive toward a goal that is, in fact, not physically achievable. Information provided by scientists indicates to planners what goals are reasonable in the face of available scientific knowledge. More specifically, an ethical analysis can suggest a way of life for society and, hence, to planners (for example, sustainable development). A scientific analysis can provide options as to how to achieve this goal and appropriate technology can assist in its implementation (solar energy, for example).

PLANNING TECHNIQUES. Planners use many analytic techniques ranging from statistical methods to economic forecasts to qualitative approaches. These are in addition to the methods inherent to each natural, physical, or social science that, together, make up the toolkit for most planning professionals. These techniques are connected to ethical ideas in that most make normative assumptions about their subject matter and such assumptions may be subject to ethical scrutiny. For example, assessing what is of sufficient value to count in a quantitative assessment of a particular development is an ethical, not a technical, question.

It is surprising to many scientists, as well as planners, to find that their methods and analyses are value-laden. This view of science and knowledge in general is consistent with a post-positivist perspective of the world in which it is recognized that experiencing the world from the perspective of a blank slate is not possible. Scientific knowledge is generated by people who perceive the world through particular lenses or filters. The best that science can do is to be as transparent as possible about this fact and its possible effect on decision making. The inherent subjectivity of knowledge is thus inescapable but this fact does not preclude critical assessment.

The choice of scientific techniques thus becomes subject to ethical inquiry, as do the data generated by such techniques or methods. Risk assessment, for instance, rests on definitions of risk, allocation of weights and probabilities to these risks, and normative conclusions as to what level of risk is appropriate. As already suggested, the same holds true for cost-benefit analysis, as well as environmental assessment. Forecasting methods and population projections, typically used in transportation planning, health planning, land use, and social planning are well-known for their often implicit value bases. More generally, certain methods can be linked to particular ethical theories; cost-benefit analysis, for instance, has been shown to be consistent with themes in utilitarianism—an ethical theory that holds that preferred actions should result in greater aggregate benefits. While entirely legitimate as one moral argument, the use of a method that rests solely on this sort of theoretical base can be problematic insofar as it neglects other values such as individual rights, community, and more. Analyses based on one restricted method may be criticized for ignoring other equally legitimate moral positions. Similarly computing techniques, such as mapping large quantities of data in order to show distributions of such things as literacy, poverty, and illness are useful in helping planners to distribute needed services. However in amalgamating these data (in true utilitarian fashion), minority populations and their needs are often left out, given the emphasis of utilitarianism on "the greatest good."

Related to these methods is the issue of norms and standards; many plans and planning processes include the use of quantitative guidelines such as X amount of parkland for Y number of people (for example, one acre of neighborhood park area per 1000 population). The efficacy and usefulness of such standards is a legitimate ethical question, especially because most are conventions that were developed in very different historical and socio-political contexts, often with little in the way of logical or empirical justification. Also of relevance here are such things as allowable, tradeable pollution levels that enable planners to plan differently than they would if there were standards that were *cast in stone*. Planners concerned about air pollution, for example, would need to write their development plans in a way that incorporated more in the way of uncertainty if industries within their jurisdiction were allowed to generate more or less pollution by trading their emission allowances with other industries and still staying within their permitted limits.

In a more positive vein, advances in computer technology enable public participation—a longstanding tenet of good (hence, ethical) planning, given its contemporary normative emphases on democracy, empowerment and diverse interpretations of 'the' public interest. Such technology, through video conferencing, instant messaging, listservs, and chat rooms, provides potentially accessible means for discussion of planning issues and, perhaps, arrival at consensus on such issues. This applies especially to remote areas in which residents are not concentrated in a single geographic locale. Issues of equity, however, arise in ensuring that the populations most sought after in terms of their participation are indeed those able to access the technology needed to have a voice in the planning issue at hand.

Planning Ethics, Science, and Technology in Practice

Within these five categories of planning ethics, the consideration of planning techniques displays the deepest connections to science and technology. Yet as also indicated, each aspect of planning includes reference to issues of science and technology and accompanying ethical concerns. Scientific and technological developments change the face of planning and of planning ethics by altering the analytic tools and descriptive information available to planners making decisions that will impact people's lives.

All of these themes are manifested in the professional codes of planning organizations. Such codes are vehicles for ethical analysis and direction in that they present practical guidance for planners facing ethical problems, while also providing a vision of what the profession should be trying to accomplish. Developments in science and technology, however, are often poorly addressed in professional codes; such developments occur at a pace that is difficult to maintain in terms of revising and adopting a code of ethics or a code of conduct (see, for example, Canadian Institute of Planners 2004, American Institute of Planners 1991). For example, fast-moving advances in computer technology, which facilitate the fraudulent manipulation of information and which can be adapted, with increasing ease, to circumvent safeguards, should be an important consideration in professional codes. However, because professional organizations revise their codes sporadically at best, practitioners are left to extrapolate solutions for emergent and rapidly changing problems from dated principles. Similarly, the positive contributions made by science and technology to planning and planners should be addressed in professional codes as an example of good professional practice. For example, and as suggested above, facilitating public participation with the use of computer technology could be cited as ethically appropriate in the sections of codes that deal with planners' responsibilities to various publics.

Whether codes of ethics and conduct will keep pace with the challenges provided by scientific and technological developments remains to be seen. That the work of planners rests on science and technology is clear; what is less clear is how and whether science and technology can assist planning and planners in addressing their basic ethical concerns or whether they simply add their own ethical issues to the mix. Either way, discussions in planning ethics mirror, and contribute to, fundamental debates in ethics, science, and technology. The interdisciplinary and applied nature of the planning field is a strength in this regard in that its analyses are far-reaching and pragmatic. The outcomes of the ethical decisions of planners, in their use of science and technology, become part of the lives of ordinary people in cities and regions. They thus become subject to scrutiny by all. Subsequent accountability by those accorded the status of *professional*, with all of the ethical implications of this label, necessarily follows.

SUE HENDLER

SEE ALSO *Management.*

BIBLIOGRAPHY

American Institute of Certified Planners. (1991). *AICP Code of Ethics and Professional Conduct*. Washington, DC: American Planning Association.

Beatley, Timothy. (1994). *Ethical Land Use*. Baltimore, MD: John Hopkins University Press.

Canadian Institute of Planners. (2004). *Statement of Values and Code of Professional Practice*. Ottawa: Author.

Frankena, William K. (1973). *Ethics*, 2nd edition. Englewood Cliffs, NJ: Prentice-Hall.

Hendler, Sue, ed. (1995). *Planning Ethics. A Reader in Planning Theory, Practice and Education*. New Brunswick, NJ: Center for Urban Policy Research. This is a collection of essays focused on the integration of ethics and planning. A wide variety of ethical theories and planning issues, including planning education, is represented.

Hodge, Gerald. (1998). *Planning Canadian Communities*, 3rd edition. Toronto: International Thomson Publishing.

Howe, Elizabeth. (1994). *Acting on Ethics in City Planning*. New Brunswick, NJ: Center for Urban Policy Research.

Krueckeberg, Donald, ed. (1994). *The American Planner: Biographies and Recollections*, 2nd edition. New Brunswick, NJ: Center for Urban Policy Research. This book represents a biographical approach to planning history in which notable men (and some women) are introduced to readers with emphasis on their contributions to planning cities and regions in the United States.

So, Frank; Israel Stollman; Frank Beal; and David Arnold. (1979). *The Practice of Local Government Planning*. Washington, DC: International City Management Association.

Tronto, Joan. (1993). *Moral Boundaries: A Political Argument for an Ethic of Care*. New York: Routledge.

Wachs, Martin, ed. (1985). *Ethics in Planning*. New Brunswick, NJ: Center for Urban Policy Research. As the first book-length discussion of ethics and planning, this collection includes discussions of ethical aspects of planning organizations, policymaking, administration and environment.

PLASTICS

Technologies have world-shaping powers. They have fundamentally changed ways of thinking as much as they influenced social practices. Plastics form a striking case.

Human beings are surrounded by plastics, in their computers, clothes, cars, kitchens, and beds, on their noses, and often in their bodies, in the form of hearing aids, hip replacements, and heart valves. In the early-twentieth century they were an odd curiosity; a century later a world without plastics is unthinkable and unlivable. They have permeated every conceivable practice and in most of these made themselves indispensable. It would, for example, be impossible to have twenty-first century supermarkets without plastic packaging, because the supermarket system is dependent on lightweight, airproof, and pre-packaged goods. In fact the transition from the traditional grocery store to the supermarket system was strongly encouraged by the emerging availability of plastic packaging materials in the 1950s and 1960s.

Plastics Science and Technology

The noun *plastics* is derived from the Latin *plasticus*, itself rooted in the Greek *plasein* meaning to mold; by connotation plastics are thus pliable, malleable, and adaptable. In scientific language, plastics are called polymers, a large and divergent group of materials with a wide range of properties. Their shared characteristic is that they consist of synthetically produced macromolecules, molecules about 1,000 to 100,000 times larger than, for example, the molecules of water or sugar. In a broad sense, synthetic rubbers and resins may also be called plastics. Some macromolecular materials (such as rubbers and resins) are found in nature, but the revolutionary thing about plastics is that they can be synthesized in the laboratory.

Launched in 1868 with the synthesis of celluloid by the American inventor John Wesley Hyatt (1937–1920), polymer synthesis was followed around the turn of the nineteenth century into casei formaldehyde (synthetic horn) and fenolformaldehyde, better known as Bakelite. These more or less accidental findings preceded the scientific understanding of macromolecular structures, which were first elucidated by the German chemist and Nobel Prize winner Hermann Staudinger (1881–1965) and his students in the 1920s. Chemistry thus opened the door to a riot in plastics design. New types that turned out to be especially successful included polyethylene (PE), polypropylene (PP), polyvinyl chloride (PVC), nylon, polystyrene (PS), and the synthetic rubber styrene butadiene rubber (SBR).

Cultural History

On top of this scientific and technological history is another even more exciting one concerning the public image and social embedding of plastics. As an exemplary case of the cultural response to controversial technology the history offers rich material for philosophical and ethical reflection. In all European and North American countries, the public appreciation of plastics exhibits a whimsical pattern, filled with opposite emotions and paradoxes, soaked with utopian and dystopian fantasies.

One peculiarity in the cultural history of plastics is that appreciation was out of step with development. Parallel to dramatic advances in quality and numbers of applications, the image of plastics deteriorated rapidly. The same qualities that were initially praised—such as their cheapness, lightness, unnaturalness, durability, moldability, imitative properties, ability to be mass produced, and resistance to wear and tear—subsequently became the basis of criticisms.

Jeffrey Meikle's *American Plastic* (1995) offers an excellent overview of this cultural transformation. The book is a gold mine of facts, stories, and opinions on plastics during the twentieth century, focusing on the United States but with some foreign perspectives as well. As an historian, Meikle does not articulate nor theorize the patterns of extreme and opposite public reactions, which call for philosophical interpretation. The public reactions from fascination to abomination cannot be explained by any simple irrationality or gut feelings on the part of the public, as is often claimed. Rather the ambiguous position of plastics in the cultural scheme is part of a deep-seated nature-culture dichotomy.

In the beginning, plastics were warmly embraced by scientists and the nonscientific public alike. Until World War II plastics existed mostly in chemical labs. Insofar as they were, like Bakelite, commercially produced, their quality and functions were rather poor, yet dreams of their potential were sky-high. Inventors and promoters portrayed plastics as unnatural or even supernatural substances. Plastics thus began with a positive reputation.

For the first time in history, human beings had been able to produce a raw material artificially. This was the general sentiment. Previously raw materials were products of nature that required human processing. Plastics were looked upon as unique exceptions to this rule, miraculous substances just waiting for human use. Their alleged unnaturalness gave rise to a widespread euphoria, their development considered a triumph of humans over nature.

At the end of World War I, Edwin Slosson, a journalist and director of the Science News Service, portrayed plastics chemists as *agents of applied democracy*. Rare and expensive materials, such as ebony and precious metals, which formerly had been "confined to the selfish enjoyment of the rich," were now "within the reach of every one" thanks to the imitative qualities of plastics. For Slosson "a state of democratic luxury" based on synthetic chemistry was at hand (Slosson 1919, p. 132–135). Fulfilling the ancient alchemists dream of transforming dirt into gold, chemists would gradually "substitute for the natural world an artificial world, molded nearer to its heart's desire" (Meikle 1995, p. 69).

Near the beginning of World War II, the applied chemists Victor Emmanuel Yarsley and Edward Gordon Couzens announced *The Expanding Age of Plastics* that would created a world brighter and clear than any previously known, "a world free from moth and rust and full of color" (Yarsley and Couzens 1941, p. 57). In such a world, *Plastic Man* would live in an abundance of safe, hygenic, strong, soft, and light objects, "a world in which man, like a magician makes what he wants for almost every need, out of what is beneath him and around him: coal, water, and air" (Yarsley and Couzens 1941, p. 68). Indeed, because of scarcities in traditional raw materials during World War II, war production of plastic or synthetic substitutes laid the base for postwar mass utilization.

But during the war the best plastics were reserved for the military and consumer plastics were often of inferior quality. As historian Meikle notes, U.S. civilians were faced with "shower heads of cellulose acetate that softened in hot water, with laminated products that separated when wet or stressed, with small moldings so devoid of resin that they shattered when dropped" (Meikle 1995, p. 166). Initial enthusiasm turned into ambivalence, as plastics came to connote inferior substitutes for real materials. When the war ended, the people felt free to demand *genuine* not *artificial* materials.

Yet postwar plastics were a booming business. Already in 1946, the average American used 3.5 kilos of plastics per year. Between 1950 and 1974, world production grew by an average 16 percent annually. Compared to other materials, plastics were the most expansive sector in many economies. At the same time, a growing call for "real," natural materials emerged. The quality of artificialness and unnaturalness now had become the essence of plastics supposed flaw. Plastics started to symbolize a fake, cheap, materialist world that would lead to human alienation, cultural decay, and loss of control over technology.

An early sign of this kind of discomfort was expressed by the young biologist and journalist Rachel Carson (the future author of *Silent Spring* [1962]) in a women's magazine in 1947: "The witchery the chemist performs, turns them first into something unearthly, that gives you the creeps. You feel, when you go into a chemical plant where plastics are made, that maybe man has something quite unruly by the tail" (Carson 1947, p. 127). Roland Barthes, the French literary critic, voiced a similar distrust after he saw a large exposition on plastics in Paris. After his visit, Barthes feared that the whole world would become plasticized, even life. "Even one has already begun to produce plastic aortas," he wrote with disgust (Barthes 1957). But meanwhile Barthes supposed that living materials would not be imitated adequately. Plastics would remain inferior to natural materials, he declared, ignorant of the high-quality biomedical materials that would follow.

Although science, technology, and industry worked to overcome the inferior qualities of consumer plastics—and were remarkably successful in doing so—the nadir in public image was yet to come. This occurred in the 1960s and 1970s as environmental concerns turned plastics, along with nuclear radiation, into central emblems of self-destructiveness in high-tech society. According to novelist Norman Mailer, for instance, plastics were spreading through the country "like the metastases of cancer cells" (Meikle 1995, p. 177). In this climate most viewers of the film *The Graduate* (1967) immediately recognized its praise of plastics as a cynical joke, as a metaphor for the phony, banal and materialist world the protagonist has entered. The unsolicited career advice given to the new college graduate Benjamin Braddock (played by Dustin Hoffman) is simple: "Plastics. There is a great future in plastics." The words came to reflect dense cultural irony, because, of course, the future of plastics was the problem of waste.

An early spokesman of the plastics waste problem was the American biologist and environmentalist Barry Commoner. According to Commoner, the strength of plastics was also their essential flaw, an inability to degrade when discarded as waste: Only "human beings are uniquely capable of producing materials not found in nature [such as] is synthetic plastic, which unlike natural materials is not degraded by biological decay.

It therefore persists as rubbish or is burned—in both cases causing pollution" (Commoner 1971, p. 127). Not being biodegradable had lost its meaning of triumph over nature; on the contrary, it made that plastics were perceived as a permanent threat to nature, and the durability of plastic became a permanent threat to nature.

Then in the 1980s and 1990s, the public response to plastics shifted again. The issues of acid rain and greenhouse gases replaced the emblematic status of plastics as a source of environmental problems (Hajer 1995). Instead of condemning all plastics wholesale, even strict environmentalists began to distinguish different types associated with different degrees of environmental burden. Several organizational and technical strategies emerged to cope with plastics waste—from recycling to decomposing polymer materials into oil-like products and the development of biopolymers that degraded in sunlight. The plastics waste problem was not solved, but with technological and organizational fixes it became manageable.

Toward an Anthropological Ethics

How can one account for the fierce and contradictory emotions and changes in perception about plastics during the last century? They cannot be explained by the improving qualities of the material. Neither can they be explained by the dimension of plastics waste risks in comparison with other environmental risks. Explaining the whimsical pattern of public fascination and disgust about plastics by appealing to the emotional approach of the public—as chemists and spokespersons of the plastics industry were apt to do in reaction to environmental criticism—is unsatisfactory as well.

A richer understanding calls for taking into account fundamental, cultural assumptions toward new technologies. Technologies must be appropriated in order to make them fit into people's lives and practices. During the appropriation process both technologies and existing social orders often have to shift and adjust to one another. Plastics are ambiguous substances that did not always fit into existing cultural, symbolic categories. Under such circumstances erratic reactions are common.

In her pioneering work on impurity ideas in traditional societies, the British anthropologist Mary Douglas (1966) has described how border-crossing phenomena that do not fit into the cultural orders cause extreme reactions both of fascination and fear. Such a dual reaction is especially strong when something fits into two categories that were previously considered to be mutually exclusive such as the human and animal, organism and machine, or nature and culture. The Nuer Tribe in Africa, for example experienced malformed babies as ambivalent beings, crossing the border between man and animal. Therefore they were treated as hippopotamus babies and put across the river. In the case of plastics, it is the nature–culture dichotomy that is decisive for its experienced ambivalence.

From the beginning, plastics were unlike natural raw materials, because they were artificially synthesized and therefore products of culture. This led to the interpretation of plastics as a miracle. Then in the climate of increasing environmental concern the nondegradability of plastics turned the miracle into monster. The coping strategies can be understood as attempts to put plastics in an acceptable cultural category. Product recycling brings the waste back into culture, while biodegradation makes *nature* out of it again. Although the waste problem is not solved, plastics have been culturally domesticated. They have become ethically accepted.

MARTIJNTJE W. SMITS

SEE ALSO *Artificiality*.

BIBLIOGRAPHY

Barthes, Roland. (1972). *Mythologies,* trans. Annette Lavers. New York: Hill and Wang. Original from Paris: Éditions du Seuil (1957).

Carson, Rachel. (1947). "Plastic Age." *Colliers* 120: 22, 49–50.

Commoner, Barry. (1971). *The Closing Circle; Nature, Man and Technology*. New York: Knopf.

Douglas, Mary. (1966). *Purity and Danger: An Analysis of the Concepts of Pollution and Taboo*. London: Routledge.

Hajer, Maarten A. (1995). *The Politics of Environmental Discourse: Ecological Modernization and the Policy Process*. Oxford: Clarendon Press; New York: Oxford University Press.

Meikle, Jeffrey L. (1995). *American Plastic: A Cultural History*. New Brunswick, NJ: Rutgers University Press.

Mossman, Susan, ed. (1997). *Early Plastics, Perspectives 1850–1950*. London: Leicester University Press; Washington, DC: Science Museum. Paperback edition from New York: Continuum (2000).

Slosson, Edwin E. (1919). *Creative Chemistry*. New York: Century.

Smits, Martijntje. (2002). *Monsterbezwering. De Culturele Domesticatie Van Nieuwe Technologie* [Taming monsters: the cultural domestication of new technology]. Amsterdam: Boom.

Sparke, Penny, ed. (1990). *The Plastics Age: From Modernity to Post-modernity*. London: Victoria and Albert Museum.

Published in the United States as *The Plastics Age: From Bakelite to Beanbags and Beyond.* Woodstock, NY: Overlook Press (1993).

Yarsley, Victor Emmanuel, and Edward G. Couzens. (1941). "The Expanding Age of Plastics." *Science Digest* 10(December): 57–59.

PLATO

Plato (428–347 B.C.E.), born in Athens, was a philosopher and founder of a school, the Academy. He was a student of Socrates and the teacher of Aristotle. Apart from a few letters, Plato's writing consists entirely of dialogues. These philosophical dramas display a mastery of composition, character, and action that rank him among the best of ancient poets. The range of philosophical problems treated in the dialogues and the quality of the treatment make this one of the most important bodies of work in the history of Western philosophy.

The chief character in most of the dialogues is Socrates, Plato himself never speaking. This raises two questions: First, to what extent does the Platonic Socrates correspond to the historical Socrates? And second, because Plato is silent, how can scholars determine what his views were? The standard answer is that Socrates or his occasional stand-in is always the mouthpiece of Plato, but that only the earlier dialogues present the authentic Socrates. There is no strong evidence for either conclusion. In this entry, the Socrates referred to is the character as he appears in Plato's dialogues.

Plato, 428–348 B.C. The Greek philosopher founded the Academy, one of the great philosophical schools of antiquity. His thought had enormous impact on the development of Western philosophy.

Socrates in the Early Dialogues

Plato's early dialogues present the reader with the Socrates who *brought philosophy down from the heavens*. Pre-Socratic philosophers had been largely preoccupied with the study of the heavens and the earth, and especially with the phenomena of change and generation. Socrates apparently turned away from natural science to investigate the moral and political opinions of his fellow citizens. His habit of questioning them eventually resulted in his indictment, trial, and execution by the city of Athens. Plato uses this background both to mount a political defense of Socrates and to explain the kind of wisdom Socrates laid claim to.

In the *Apology*, the presentation of his defense, Socrates explains himself. According to the Oracle at Delphi, no one was wiser than Socrates. This astounded Socrates, for his philosophical investigations had convinced him that he knew nothing at all. He decided to test the oracle by interrogating those who were reputed to be wise. The politicians, he discovered, neither knew nor produced anything of value. The poets composed beautiful works, but could not explain how they did so or what their compositions meant. The artisans by contrast both produced useful things and understood what they were doing. Because of this, however, they supposed themselves wise about beauty, justice, and virtue, when in fact they were ignorant of such things. Socrates concluded that he was indeed wise in this one thing: He alone knew the full extent of his own ignorance.

But how can this meager knowledge, which Socrates calls *human wisdom*, be of any use? First, Socratic questioning can teach fellow citizens humility by showing them that they do not know what they think they know. What do they think they know? They know that power and wealth are the most valuable things. By undermining *these* opinions, Socrates was in effect urging Athenians to care about their own souls more than their property and the city's virtue more than its power. Small wonder they killed him for it.

In the *Euthyphro*, Socrates encounters a young man who is prosecuting his own father, an act that amounts to a radical assault on Greek familial morality. Euthyphro's boldness turns out to be supported by a hubristic confidence in his own understanding of piety. Socrates' relentless questioning demolishes that confidence, with the apparent result that Euthyphro drops his suit. So even if the only knowledge that is available is knowledge of one's own ignorance, philosophy can still be useful to the city by encouraging political moderation.

The utility of Socratic questioning is not limited to undermining bad arguments. The *Crito* provides a more positive account. In the absence of knowledge, one is left with opinions; Socrates, however, draws a distinction between the opinions of the many and those of the expert. If someone wants medical advice, that person does not put the matter to a vote but consults a doctor. If Socrates wants to know whether to accept his sentence or escape from jail, he will not be swayed by popular opinion but will turn to the expert in moral and political matters, presumably himself.

An opinion is never more than a guess; but an art or expertise consists of a set of educated guesses, informed by a long practice of questioning the evidence and alternatives. Expertise differs from philosophy insofar as it does not aim at comprehensive knowledge of the whole of things. In a theoretical sense the expert does not necessarily know anything, but in practical matters knows what he or she is talking about and so can be relied upon. If Plato's early dialogues were all there were to go on, one would conclude that Socrates was a political scientist and ethicist, and that these were the limits of Plato's ambitions.

This picture is substantially modified in later dialogues. Whereas in the *Apology* Socrates strenuously denies that he has anything to do with the physical sciences, in the *Phaedo* he confesses that, as a young man, he had a wonderful enthusiasm for physics, cosmology, and biology. But he came to believe that the reductionism of Greek science blinded its practitioners to the true nature of the phenomena they studied. Anaxagoras, for example, would explain the fact that Socrates is in jail by the position of his bones and muscles while ignoring the most important cause: the fact that the philosopher had concluded that he was obligated to accept his sentence. Without that last reason, Socrates exclaims, those bones and muscles would be long gone from their prison.

This approach, applied to nature, obviously anthropomorphizes it. Socrates supposes that to explain the moon or the stars one must explain why it is best for them to be as they are. Perhaps the expert can get by with good guesswork, but real knowledge requires a consonance between human understanding and the world it seeks to understand. The mind looks for motives and justifications, and seeks answers in general ideas such as beauty and the good. What would have to be true of the world for such knowledge to be possible?

The Theory of Ideas

Socrates' most famous innovation was his theory of ideas. According to this principle the ideas by which human beings conceive of ordinary things are more real than the things themselves. Thus bigness is more real than a big tree, and unity and multiplicity more real than one person or the parts into which that person may be divided. Visible, tangible things are conceptually messy: relatively large and small; many and one at the same time; young and beautiful then, yet old and ugly now. But the idea of beauty is never ugly nor does the idea of one ever admit of division. That alone is real that simply is what it is, without contradiction, everywhere, and always.

Consider what happens when one approaches a mature oak tree from a distance. At first the tree appears so small that a person can cover it with one hand. Up close it is so large that it fills the horizon. But the tree cannot be both larger *and* smaller than an individual, nor does it really change as one approaches it. It is not what the eyes see but what the mind apprehends that is real. In the case of ordinary things, the true object is invisible, and what is visible is less than true.

Now compare the painting of a table with the fabrication of a table. The artist fashions an image of an image, at least twice removed from reality and bereft of dimension and substance. The artisan produces an actual table. He does so because he looks beyond any particular object to the idea or set of ideas that constitute the universal table. Just as images of a tree draw their reality from some object that is always, somehow, behind them, so human apprehension of various objects as one kind of thing—a tree or a table—draws on objects that are yet more universal and more real. It is in fact the ideas that generate reality, rather than vice versa.

Socrates' theory solves an impressive range of problems. It explains how human beings are able to perceive unities behind the otherwise chaotic manifold of sense impressions. It is also the basis of a theory of knowledge. Opinions are nothing more than temporal/spatial perspectives on things, and are therefore more or less unreliable. Knowledge is a grasp of ideas that never changes, for which reason it cannot fail.

This theory of knowledge in turn explains Socrates' moral perfection. How is it possible that Socrates alone seems never to succumb to temptation? Most people are guided by opinions about justice, and so are subject to changes in perspective. When one is owed money, justice means always paying debts. When one's luck changes, justice requires the forgiveness of debts. The philosopher by contrast is guided by the idea of justice. He is therefore perfectly steadfast in all circumstances. Even when confronted with his own imminent execution, Socrates says and does the same things in the same calm manner as he did before.

Political Philosophy

The theory of ideas is also the basis of Socrates' moral and political philosophy in the *Republic*. In that dialogue Socrates describes an ideal form of government consisting of three distinct classes. Philosophers rule, supported by a class of warriors called guardians. Both in turn are supported by a class of producers. The mores of the guardian class are shockingly radical. They practice a communism not only of property but of sex and reproduction, with no individual knowing who his or her own children are. Moreover women receive the same military training as men. In addition to these unprecedented social arrangements, the guardians' exposure to poetry, music, and religious teaching is tightly censored by the rulers.

The primary object of all these innovations is to prevent faction. The philosophers can rule because they alone are guided by the ideas of justice, moderation, and the good, and hence are incorruptible. A philosopher will never choose what is really bad because it looked good at the time. Because the guardians are not philosophers, their opinions about what is honorable and just must be scrupulously regulated by the ruling class, and private interest must be suppressed.

Socrates' ideal republic has been scathingly rebuked as both fantastic and totalitarian. But these criticisms forget the context. Its sole purpose is to provide a model of justice in the human soul. Like the republic, the individual soul is composed of distinct parts. If not, how could someone desire drink or revenge and at the same time want to resist such desires? In the well-ordered soul, intelligence governs the passions and the passions in turn discipline the appetites. When each part of the soul confines itself to its proper work, justice exists. By contrast, when passions or appetites take command of a person, injustice prevails.

The moral argument in the *Republic* seems to depend on the theory of ideas; however, in the *Gorgias* Socrates is able to derive much the same ethics from even the most jaundiced of moral opinions. Socrates' most frequent and persistent opponents in the dialogues were the sophists and orators. These men claimed to possess an art of persuasion whereby they could move an assembly or a jury to any conclusion someone might desire. Acquire that technology, either by learning it at a fee or by hiring one of its practitioners, and all the powers of state are at one's disposal. Even better, one may do whatever one desires without fear of prosecution. The young orator Polus knows exactly what the payoff is, the power to murder with impunity.

Socrates argues that sophism and oratory are not arts at all, but examples of flattery. An art, or *technē*, must be informed by some more or less correct notion of what is good for body or soul. Thus the arts of gymnastics and medicine aim to perfect the body and repair it, respectively, whereas the arts of politics and justice do the same for the soul. But just as cosmetics and gourmet cooking deliver what looks good, even if the person wearing the makeup or the food used to prepare the meal is in fact unhealthy, so sophism and oratory cater to vanity while doing harm rather than good.

The sophists held that the ends at which all human actions aim are unproblematic. Everyone wants the same things: wealth, reputation, beautiful lovers, and, occasionally, revenge. If one could rule other human beings, one could obtain an unlimited supply of these things and so be perfectly happy. Socrates argues that these ends are in fact problematic and may as easily bring ruin as happiness. No power is any good unless people know how to use it to get what is good for them; and that is not ruling over others but ruling oneself.

Platonism and Technology

Socrates' presentation of wisdom as expertise seems perfectly compatible with the development of technology. But the presentation was so overwhelmed by his theory of forms that it is almost invisible in the history of Platonism. There are good reasons to suppose that Socrates would have been at best indifferent to technological progress. He himself was so moderate in his appetites that he could live comfortably in *ten thousand-fold poverty*. In the *Republic* he suggests that the only city that is really natural is the city of sows, where human beings live very simple lives without any need for the arts and sciences.

The theory of forms provides powerful existential consolation, as the perfection of ideas is always available to the trained mind without need to modify the tangible world. During the Renaissance, Aristotle, whose philosophy was more oriented to practice, was popular whenever events seemed to be going well.

When foreigners invaded and governments collapsed, scholars turned back to reading Plato. A philosophy of consolation does little to encourage political or technological innovation.

KENNETH C. BLANCHARD JR.

SEE ALSO *Aristotle and Aristotelianism; Evolutionary Ethics; Evolution-Creationism Debate; Social Engineering; Virtue Ethics.*

BIBLIOGRAPHY

Guthrie, William K. C. (1975). *A History of Greek Philosophy*, Vols. 4 and 5. Cambridge, UK: Cambridge University Press. Guthrie's history is the best general work on Greek philosophy. Newcomers to the topic will find it especially useful.

Kraut, Richard, ed. (1992). *The Cambridge Companion to Plato*. Cambridge, UK: Cambridge University Press. A good collection of essays on various aspects of Plato's thought.

Plato. (1980). *The Laws of Plato*, trans. Thomas L. Pangle. New York: Basic Books. Very similar to Bloom's translation of *The Republic*.

Plato. (1991). *The Republic of Plato*, trans. Allan Bloom. New York: Basic Books. A very fine translation of this work, using consistent English terms and phrases for the same Greek terms. It also includes a challenging but very thorough essay.

Plato. (1998). *Gorgias*, trans. James H. Nichols Jr. Ithaca, NY: Cornell University Press. The best translation of one of Plato's most important ethical dialogues.

Plato and Aristophanes. (1984). *Four Texts on Socrates*, trans. Thomas G. West, and Grace Starry West. Ithaca, NY: Cornell University Press. An excellent translation of the most popular of Plato's short dialogues, with notes and brief commentary.

Rosen, Stanley. (1993). "*Techne* and the Origins of Modernity." In *Technology in the Western Tradition*, ed. Arthur M. Melzer et al. Cornell, NY: Cornell University Press. A profound treatment of the philosophical meaning of technology.

Strauss, Leo. (1963). "Plato." In *History of Political Philosophy*, ed. Leo Strauss and Joseph Cropsey. Chicago: Rand McNally. One of the best essays on Platonic political philosophy.

PLAYING GOD

The phrase, *playing God*, appears to be one a theologian might use. But in contemporary parlance it has taken on secular significance. It refers to the powers that science, engineering, and technology confer on human beings to understand and to control the natural world.

Celebration and Criticism

The playing God metaphor has been used in both celebratory and critical contexts. In celebration, H. G. Wells's novel *Men Like Gods* (1923) describes an advanced human civilization in which people lead the *life of demigods*, very free, strongly individualized . . . a practical communism." Indeed the communist movement sometimes described itself as realizing previously thwarted divinelike possibilities in human nature. Inventor R. Buckminster Fuller proclaimed the advent of *No More Second-Hand God* (1963) through science and technology. The psychologist Erich Fromm, in his book *You Shall Be as Gods* (1966), argued the need to assume responsibilities for many new powers that were once attributed to supernatural entities. And the alternative culture Whole Earth Catalog (1968) declared on its cover, "We are gods and might as well get used to it."

Among the followers of Ayn Rand, playing god has been declared a virtue. Science fiction writers sometimes describe themselves as playing god. And for Kevin Kelly (1999), *nerd theology* involves repeatedly playing god, as in a learning game.

More commonly, however, playing God has served as a metaphor for criticizing the human exercise of excessive scientific and technological powers. Early Romantic writers implicitly criticized human aspirations to play God insofar as they mourned the loss of a sense of the sacred in the wake of scientific and technological progress. In the contexts of both celebration and criticism, there are, nevertheless, three overlapping meanings that can be discerned.

Three Meanings

The first meaning is associated with basic scientific research wherein human beings *learn God's awesome secrets*. Some research elicits a sense of awe and wonder over the complexity and majesty of the natural world that the human mind can apprehend. Science is like a light shining down into the previously dark and secretive caverns of natural mystery, revealing what had been hidden. The revelatory power of science leads human beings to believe they are gaining godlike powers. Few would argue against continuing the investigation because *learning for learning's sake* remains the morality of scientific knowledge.

The second meaning of playing God arises primarily within the field of medicine where doctors seem to have gained the *power over life and death*. In a medical emergency, the patient feels helpless, totally dependent upon the scientific training and personal skills of the attending physicians. Doctors, and the scientific training they received in medical school, stand between the patient and death. Similarly large-scale research programs dedicated to finding cures for cancer or HIV/AIDS provide society with hope in the face of helplessness. Here playing God takes on a redemptive or salvational component. The genre of jokes about doctors who think of themselves as gods reflects the wider anxiety over powerlessness plus human dependence upon doctors and their skills.

Two assumptions are at work in the medical meaning of playing God. First is the assumption that decisions regarding life and death are the prerogative of God. The second follows from the first: When a human being has the power of life and death, society places that person in a godlike role. This elicits a second anxiety; namely, worry that the person in the godlike role will succumb to the temptation of pride, or hubris. The concept of hubris articulates the more inchoate fear that human beings will presume too much, overreach themselves, violate some divinely appointed limit, and reap destruction. Anxiety over hubris marks the overlapping transition from the second to the third meaning of the phrase playing God.

To alter life and influence human evolution is the third meaning of playing God. Here science and technology team up so that understanding leads to control. Control over nature places human beings where only God belongs, and humans are challenged by the choice between good and evil. In atomic physics, the discovery of how a nuclear chain reaction works led to both nuclear medicine and weapons of mass destruction with the attendant threat of self-extinction. Taming nature by pesticide use in order to increase food production threatens the life-sustaining potency of the planet. The Human Genome Project has enhanced understanding of DNA, confronting society with unavoidable decisions: The choices made to alter or avoid altering the human genetic code may affect the evolutionary future of the human race and perhaps even human nature itself. If DNA is the essence of a human being, then people take the ability to change their very nature into their own hands when they modify it. To alter what has evolved borders on creating a new human nature; this is a reminder of humankind's godlike powers and the awesome responsibility imposed by those powers. The human race of tomorrow will be the result of scientific and technological decisions made in the present. The scientific community becomes a microcosm of the entire human community. The fear is that if scientists give into the temptation of hubris, evil will result.

The God in Question

A close look shows that the God of playing God is not the God of the Bible but divinized nature. Nature has absorbed the qualities of sacredness; science and technology risk profaning the sacred.

Contemporary fear of playing God connotes the ancient Greek myth of Prometheus. While creating the world, the sky-god Zeus was in a cranky mood. The Olympian decided to withhold fire from Earth's inhabitants, leaving the nascent human race to live in relentless cold and darkness. The Titan Prometheus, whose name means *to think ahead*, saw the value of fire to warm homes. He anticipated how fire could separate humanity from the beasts by making it possible to forge tools. Prometheus craftily snuck into the heavens where the gods dwelt and where the sun was kept. He lit his torch from the fires of the sun and carried the heavenly gift back to earth.

The gods were outraged that their stronghold had been penetrated and robbed. Zeus was particularly angry over Prometheus's impertinence and exacted a merciless punishment on the rebel. Zeus chained Prometheus to a rock where an eagle could feast on the Titan's liver all day long. The head of the pantheon cursed the future-oriented Prometheus: "Forever shall the intolerable present grind you down." The moral of the story is this: Pride or hubris that leads humans to overestimate themselves and enter the realm of the sacred will precipitate vengeful destruction. The Bible provides a variant: "Pride goes before destruction" (*Prov.* 16:18).

In early-twenty-first-century culture, dominated by Western science, Zeus no longer plays the role of the sacred. Nature does. Nature strikes back in the Frankenstein legend and the more contemporary, geneticized version of it described in Michael Crichton's novel *Jurassic Park* (1990) and the films adapted from it. The theme has become common: A mad scientist exploits a new discovery and crosses the line between life and death; nature strikes back with consequent chaos and destruction.

Theological articulations of caution in the face of human pride mirror the wider culture. In a 1980 task force report, *Human Life and the New Genetics*, the Council of Churches of Christ issued a warning: "Human beings have an ability to do Godlike things: to exercise creativity, to direct and redirect processes of nature. But the warnings also imply that these powers may be used rashly, that it may be better for people to remember that they are creatures and not gods." A United Methodist Church Genetic Science Task Force Report to the 1992 General Conference stated similarly, "The image of God, in which humanity is created, confers both power and responsibility to use power as God does: neither by coercion nor tyranny, but by love. Failure to accept limits by rejecting or ignoring accountability to God and interdependency with the whole of creation is the essence of sin" (United Methodist Church 2000, Internet site). In sum, humans can sin through science by failing to recognize limits and, thereby, violate the sacred.

Although the proscription against playing God can be applied to many fields of science, it is found most often in the field of genetics because DNA has garnered cultural reverence. The human genome has become tacitly identified with the essence of what is human. A person's individuality, identity, and dignity are associated with his or her DNA. Therefore if humans have the hubris to intervene in the human genome, they risk violating something sacred. This tacit belief is called the *gene myth* as well as *the strong genetic principle* or *genetic essentialism*. This myth is an interpretive framework that includes the assumed sacredness of the human genome and the fear of Promethean pride.

Theological anthropology questions the gene myth, doubting the equation of DNA with human essence or human personhood. In 2002 the National Council of Churches of Singapore issued *A Christian Response to the Life Sciences* that stated, among other things, "It is a fallacy of genetic determinism to equate the genetic makeup of a person with the person" (National Council of Churches 2002, p. 81). Such anthropology combats the gene myth and opens the door to ethical approval of cautious genetic engineering.

Contemplating careful employment of genetic technology to alter human DNA leads to concern over the distinction between therapy and enhancement. At first glance, therapy seems ethically warranted, whereas enhancement seems Promethean and dangerous. *Gene therapy* is the directed genetic change of human somatic cells to treat a genetic disease or defect in a living person. With 4,000 to 6,000 human diseases traceable to genetic predispositions—cystic fibrosis, Huntington's disease, Alzheimer's, and many cancers among them—the prospects of gene-based therapies are raising hopes for dramatic medical advances. Few if any cite ethical reasons to prohibit somatic cell therapy via gene manipulation.

Human genetic enhancement is the use of genetic knowledge and technology to do more than heal disease. Enhancement seeks to bring about improvements in the capacities of living persons, in embryos, or in future generations. Enhancement might be accomplished in one of two ways, either through genetic selection during screening or through directed genetic change. Genetic selection may take place at the gamete stage, or more commonly by means of embryo selection during preimplantation genetic diagnosis (PGD) following in vitro fertilization (IVF). Genetic changes could be introduced into early embryos, thereby influencing a living individual, or by altering the germ line, thereby influencing future generations.

Modest forms of enhancement are becoming possible. For example, introduction of the gene IGF-1 (insulin growth factor) into muscle cells results in increased muscle strength as well as health. Such procedure is quite valuable as a therapy; yet, it lends itself to enhancement as well. For those who daydream of so-called *designer babies*, the list of traits to be enhanced would likely include increased height or intelligence as well as preferred eye or hair color. Concerns raised by both secular and religious ethicists focus on economic justice—that is, wealthy families are more likely to take advantage of genetic enhancement services leading to a gap between the *genrich* and the *genpoor*.

Serious concerns have been raised over germ line intervention for purposes of both therapy and enhancement. *Germ line intervention* is gene selection or gene change in the gametes, which in turn would influence the genomes of future generations. Because the mutant form of the gene that predisposes for cystic fibrosis has been located on chromosome 4, researchers can devise a plan to select out that gene and spare future generations the suffering caused by a debilitating disease. This would constitute germ line alteration for therapeutic motives. In principle scientists could select or even engineer genetic predispositions to favorable traits in the same manner. This would constitute germ line alteration for enhancement motives.

Both of these scenarios are risky, and for the same reason. Too much remains unknown about gene function. It is probable that gene expression works in delicate systems, so it is rare that a single gene is responsible for a single phenotypical expression. If one or two genes are removed or engineered, scientists may unknowingly upset an entire system of gene interaction that could lead to unfortunate consequences. The proscription against playing God serves here as a warning to avoid rushing in prematurely with what appears to be an improvement but could turn out to be a disaster. Ethicists often advise that scientists and researchers proceed with caution—the precautionary principle—until the scope of knowledge is adequate to cover all possible contingencies.

Note that the precautionary principle does not rely upon the tacit belief that DNA is sacred. Rather it relies upon a principle of prudence that respects the complexity of the natural world and the finite limits of human knowledge.

TED PETERS

SEE ALSO *Death and Dying; Fetal Research; Frankenstein; Gene Therapy; Genethics; Genetic Counseling; In Vitro Fertilization and Genetic Screening; Prometheus.*

BIBLIOGRAPHY

Bruce, Donald, and Ann Bruce, eds. (1999). *Engineering Genesis: The Ethics of Genetic Engineering in Non-Human Species.* London: Earthscan Publications. A collection of essays on the ethical implications of plant genetics and human genetics.

Chapman, Audrey R. (1999). *Unprecedented Choices: Religious Ethics at the Frontiers of Genetic Science.* Minneapolis, MN: Fortress Press. An overview of the challenges posed to public consciousness by the genetic revolution.

Council of the Churches of Christ. (1980). *Human Life and the New Genetics.* New York: Author.

Dutney, Andrew. (2001). *Playing God: Ethics and Faith.* San Francisco: HarperCollins. A warning to be cautious in genetic research based on religious convictions.

Kelly, Kevin. (1999). "Nerd Theology." *Technology in Society* 21(4): 387–392.

National Council of Churches of Singapore. (2002). *A Christian Response to the Life Sciences.* Singapore: Genesis Books. A brief and brilliant analysis of the science of cloning and stem cell research from a theological perspective.

Peters, Ted. (2002). *Playing God? Genetic Determinism and Human Freedom,* 2nd edition. London, New York: Routledge. A theological and ethical analysis of the gene myth, genetic determinism, the so-called "gay gene," cloning, stem cells, and genetic patenting.

Peters, Ted, ed. (1998). *Genetics: Issues of Social Justice.* Cleveland, OH: Pilgrim Press. A collection of essays by scientists and theologians analyzing the human genome project.

INTERNET RESOURCE

United Methodist Church. (2000). "Book of Resolutions of the United Methodist Church 2000: Developments in Genetic Science." Available at http://www.electronic-church.org/Genetics/UMC-Book_of_Resolutions_Genetic_Science_and_Cloning.pdf.

POLANYI, KARL

Karl Polanyi (1886–1964) was born in Vienna on October 25 of Hungarian parents and became a leading economic historian of the twentieth century. His understanding of the Industrial Revolution as dependent on a disembedding of the economy from the broader culture offers an important perspective on globalization and suggestive insights relevant to relationships between science, technology, and ethics. After studies in Budapest, work as a lawyer, radical political activity, service in World War I where he was imprisoned on the Eastern front, and postwar convalescence and work as a journalist, he immigrated first to Great Britain (1933) and then to the United States and Canada (1940s), where he taught first at Bennington College and then at Columbia University. Because of past involvement with Marxist radicalism, his wife, Ilona Duczynska, was denied the right to live in the United States and Polanyi was forced to live in Canada and commute to New York. He died in Pickering, Ontario, on April 23. He was survived by his younger brother, the scientist and philosopher Michael Polanyi.

The Great Transformation

Polanyi's *The Great Transformation* (1944) has been recognized as a central contribution to economic sociology. The basic argument of this analysis of the Industrial Revolution is that capitalism is historically unique in its separation of economic relationships from other social interactions. All previous human economies were embedded in the sense of being integrated into familial, kinship, social, religious, and other interactions and obligations. The great transformation was not simply the development of new sources of power (steam), machines, and systems of production (division of labor), but the disembedding of production and market distribution from all other modes of interaction.

One key feature of the disembedding process was turning land, labor, and capital into what Polayni calls *fictitious commodities*. In reality neither land (nature) nor labor (people)—and only to a limited extent capital (whether liquid or fixed)—can ever have their price freely determined by market relations in the same way as industrial products. The self-regulating market as conceived by neoclassical economics nevertheless requires such an assumption. What Polanyi's analysis seeks to demonstrate is the fictitious character of these assumptions, both in relation to previous historical practices and as revealed in the failures of market economy in the early twentieth century.

For Polayni the great transformation of his concern was actually two quite different historical events: the collapse of nineteenth century civilization associated with World War I and the creation of the self-regulating market economy through the collaboration of industrialists, neoclassical economists, and liberal politicians. In the first sense his diagnosis of the great transformation was precisely the opposite of that of his contemporary Friedrich von Hayek in *The Road to Serfdom* (1944). For von Hayek the collapse that terminated the nineteenth century was caused by a failure to extend the market system to its logical conclusion and more fully remove state regulation of the economy. For Polanyi the reactions of communism, fascism, and Keynesian economics were legitimate efforts to reaffirm the proper subordination of industrialist economics to society and culture.

Polanyi's argument has been subject to criticisms by both anthropologists and economists, each raising essentially the same question: Does Polanyi not romanticize premodern economic orders? Is there really any alternative to the market economy, which is a natural historical development? Following *The Great Transformation* Polanyi undertook extensive studies of premodern economic practices in order to further substantiate his claims about the historical uniqueness of neoeconomic assumptions. One of the more influential results of this research was the collaborative publication of *Trade and Market in the Early Empires: Economies in History and Theory* (1957).

Application and Assessment

From Polayni's perspective the market economy is a historical anomaly. Although forms of trade and exchange can be found in all human societies, economic exchange had never previously been so independent of all other relations. The pattern found in modern economies is, of course, also that exhibited in analogous ways in science and technology: the development of autonomous communities of practitioners operating according to sets of rules that apply only to quite limited aspects of human behavior (as in the practice of the scientific method). Under such conditions rationalist ethics is forced to play a more important role in criticizing and moderating disembedded behaviors (economic, scientific, and technological) than ever before—while at the same time disembedding creates conditions that make ethics ever more ineffectual. Ethics is thus forced to adapt policy as its handmaid in order to overcome its own impotence.

But is it not the case that Polanyi was fundamentally mistaken, if not about the past then about the collapse of the free market system that supported the civilization of the long nineteenth century? As his daughter Kari Polanyi Levitt admits, "Polanyi was certainly premature in dismissing 'market economy' and 'market society' from the stage of history" (McRobbie and Polanyi Levitt 2000, p. 10). From the end of the Cold War and into the beginning of the twenty-first century, neoliberalism reemerged with the forces of globalization stronger than ever before. But this world was also one in which, as Polanyi Levitt notes, "disasters of famines, wars, new diseases and environmental degradation threaten the destruction of the social, cultural and ecological fabric which sustains life on earth." Under such conditions, is it not possible that Polanyi's "analysis of the dangers inherent in the elevation of 'the economic instance' over all other aspects of human endeavor" deserves continuing consideration? (McRobbie and Polanyi Levitt 2000, p. 10).

CARL MITCHAM

SEE ALSO *Governance of Science; Merton, Robert K.; Science Policy.*

BIBLIOGRAPHY

McRobbie, Kenneth, and Kari Polanyi Levitt, eds. (2000). *Karl Polanyi in Vienna: The Contemporary Significance of "The Great Transformation."* Montreal: Black Rose Books. Thirty papers from a conference in Vienna on the fiftieth anniversary of the publication of *The Great Transformation.*

Polanyi, Karl. (1944). *The Great Transformation.* New York: Rinehart. Reprint, Boston: Beacon Press, 1957. Second edition, Boston: Beacon Press, 2001.

Polanyi, Karl. (1968). *Primitive, Archaic, and Modern Economies: Essays of Karl Polanyi,* ed. George Dalton. Garden City, NY: Doubleday Anchor.

Polanyi, Karl; Conrad M. Arensberg; and Harry W. Pearson, eds. (1957). *Trade and Market in the Early Empires: Economies in History and Theory.* Glencoe, IL: Free Press.

Stanfield, J. Ron. (1986). *The Economic Thought of Karl Polanyi: Lives and Livelihood.* New York: St. Martin's Press. The last chapter connects Polanyi's economic history to an assessment of industrial technology and the alternative technology response present in E. F. Schumacher, Wendell Berry, and others.

POLANYI, MICHAEL

A physician and physical chemist who became a philosopher in middle age, Michael Polanyi (1891–1976) was born in Budapest, Hungary on March 12, the youngest child in a liberal Jewish family that provided a broad humanistic education. After medical training and completing a dissertation in chemistry, Polanyi rose to be an eminent physical chemist (publishing more than 200 scientific papers in his career) in Berlin; in 1933, he fled Nazi Germany and took a position in Great Britain at Manchester University. He was elected Senior Research Fellow at Merton College, Oxford, in 1959. Polanyi died in Northhampton on February 22.

Science and Society

From the 1930s forward, Polanyi often wrote about the governance of science and the fragile relation between science and society. Marxist-influenced politics and philosophical discussions about the nature and justification of science challenged Polanyi to probe such issues. He found that most of the ideas about science and society put forth by Western scientists and philosophers of science were as inadequate as the Marxist ideas. In response, Polanyi early argued that freedom was a prerequisite for establishing a community of inquiry in which individuals pursued truth and openly stated their findings. He further criticized centrally planned scientific research, arguing that opportunities for individual initiative are critical and that civil liberties and a democratic society provide important foundations for science.

Polanyi's dissatisfaction with philosophical accounts of science thus led him gradually to shift his interest from scientific research to philosophy. By the mid-1940s, Polanyi began to put together his own comprehensive philosophical account in *Science, Faith, and Society* (1946).

Personal Knowledge

Personal Knowledge, published in 1958 and based on his 1951–1952 Gifford Lectures, is a much broader articulation of his philosophical stance. Later publications refine and extend the framework of this book. *The Tacit Dimension* (1966) is particularly important because it reflects the way in which Polanyi's earlier emphasis on commitment was recast and enriched by working out an account of the structure of tacit knowing.

In Polanyi's sometimes dense texts, his constructive philosophy is bound up with searching criticisms of much modern philosophy. In his early formulations in the syllabus for his 1951 Gifford Lectures, Polanyi summarized his constructive philosophical project as setting forth a "fiduciary philosophy" that overcame the "restrictions of objectivism" and rehabilitated "overt belief" (Papers of Michael Polanyi, Box 33, Folder 1, University of Chicago Library). All knowledge is based in belief, but this does not mean knowledge claims are necessarily without warrant. For Polanyi, a fully impersonal, objective knowledge is a false and destructive ideal embraced by modern western philosophy and science. In *Personal Knowledge,* he argues that doubt, celebrated since Descartes, is not heuristic and, in fact, is parasitical on belief. Knowledge must be understood in terms of the activity of a skillful and committed knower immersed in a community with a living tradition. Polanyi is a fallibilist and a metaphysical realist who argues for what he terms "personal knowledge," which is subject-grounded but not merely subjective. Truth claims are set forth with universal intent.

Polanyi's early interest in the administration of science led him to work out an epistemology of science that focuses on the person and discovery. His epistemology recasts ideas of Gestalt psychology in order to emphasize the active shaping of comprehension and the commitment of the knower. After *Personal Knowledge,* Polanyi came to better understand what he early called the "fiduciary" element in knowledge as he continued to explore the importance of the inarticulate. His later theory of tacit knowing claims all knowing involves an integration of subsidiarily or skillfully known elements to produce a focal comprehension. Thus, knowing has a from-to structure: It moves from subsidiaries or tacitly known particulars to a focus. Thought dwells, Polanyi argues, in its subsidiaries, and those subsidiaries function like parts of one's body that a person dwells in and skillfully coordinates in order to achieve certain objectives.

Some of Polanyi's ideas about science, and more generally about human knowing and the problems of modern society, parallel ideas developed by other thinkers in the mid-twentieth century. Several mid-century philosophers of science, such as Polanyi, backed away from narrow empirical approaches and took new interest in the practices of scientists and the history of science; philosophers such as Maurice Merleau-Ponty (1908–1961) wrote about the body and perception in ways that complement Polanyi's views.

Assessment

Polanyi's major constructive philosophical contribution is his theory of tacit knowing, which holds that all knowledge is grounded in tacitly held elements; a knower always relies on such unspecifiable elements to achieve focal awareness. This claim is a major break with the theory of knowledge developed in the modern philosophical tradition. Many of Polanyi's broader philosophical ideas about persons, communities, and the human project of exploring the universe are novel views that grow out of his new approach to the problem of knowledge. Taken as a whole, Polanyi offers a comprehensive philosophical vision that weaves together an epistemology, a philosophy of life, and an evolutionary cosmology.

Polanyi was deeply disturbed by what he regarded as the nihilistic tenor of modern culture; he aimed to restore confidence in the human capacity to discover meaning. His philosophical ideas are also sometimes linked with what is now called postmodern thought. But while he sharply criticized some elements of the Enlightenment tradition, Polanyi also affirmed Enlightenment values such as truth-seeking as necessary and worthy ideals. Polanyi was committed to the reliability of natural science, although he did not contend that only scientific knowledge was possible and important.

PHIL MULLINS

SEE ALSO *Liberalism; Participation.*

BIBLIOGRAPHY

Gelwick, Richard. (1977). *The Way of Discovery: An Introduction to the Thought of Michael Polanyi.* Oxford, UK: Oxford University Press. A clear basic introduction to Polanyi's philosophical ideas.

Grene, Marjorie. (1977). "Tacit Knowing: Grounds for a Revolution in Philosophy." *Journal of the British Society for Phenomenology* 8(3): 164–171. A brief account of the development and importance Polanyi's philosophical ideas by one of his major collaborators.

Polanyi, Michael. (1959). *The Study of Man.* Chicago: University of Chicago Press. Extends the account of *Personal Knowledge* to treat questions about historical knowledge.

Polanyi, Michael. (1964). *Science, Faith and Society.* Chicago: University of Chicago Press. First published in 1946, this is Polanyi's best early discussion of science, and includes a 1963 introduction by Polanyi that links early and later ideas.

Polanyi, Michael. (1966). *The Tacit Dimension.* Garden City, NY: Doubleday. The clearest statement of Polanyi's theory of tacit knowing.

Polanyi, Michael. (1969). *Knowing and Being: Essays by Michael Polanyi.* Chicago: University of Chicago Press. A collection edited and introduced by Marjorie Grene of fourteen Polanyi essays from the 1960s.

Polanyi, Michael. (1974). *Personal Knowledge Towards a Post Critical Philosophy.* Chicago: University of Chicago Press. First published in 1958, this is Polanyi's most comprehensive philosophical statement, which grew out of his 1951 and 1952 Gifford Lectures.

Polanyi, Michael, and Harry Prosch. (1975). *Meaning.* Chicago: University of Chicago Press. A late book, written with a collaborator, that attempts to extends Polanyi's epistemological framework to treat meaning in art, myth, and religion.

Polanyi, Michael. (1997). *Science, Economics and Philosophy: Selected Papers of Michael Polanyi,* ed. and introduced by R. T. Allen. New Brunswick and London: Transaction. Includes twenty-five Polanyi essays written from 1917 to 1972 as well as an annotated bibliography of Polanyi's publications on society, economics, and philosophy.

Polanyi, Michael. (1998). *The Logic of Liberty Reflections and Rejoinders.* Indianapolis, IN: Liberty Fund. Essays on science and politics, originally published in 1951.

Prosch, Harry. (1986). *Michael Polanyi: A Critical Exposition.* Albany: SUNY Press. An interpretation of Polanyi's philosophical work by one of his collaborators.

INTERNET RESOURCE

Polanyi Society. Available from http://www.mwsc.edu/orgs/polanyi/. Selected short essays by Michael Polanyi and other information.

POLICE

As members of a social institution which, like the military, is a legitimate employer of force in the service of the state, the police must adhere to strict standards of ethical conduct. The rapid pace of scientific and technological change has affected this ethically guided police work in two ways: The detective resources and enforcement powers at their disposal are altered by changes in science and technology; the powers available to illegitimate users of force, those whom the police are charged with opposing, are also altered. At several different levels, the law enforcement institution has adapted to these changes, which have brought both increased opportunity for improved service as well as challenges and controversies.

Police Ethics

Law enforcement officers represent the epitome of society insofar as they daily risk their lives to protect and serve the public and uphold the laws of the state. Their position of authority and their ability to legitimately use force in various contingencies, however, means that they must uphold the strictest of ethical standards in order not to abuse their power. Although it is unrealistic to hold law enforcement officers (or any human being) to standards of perfection, both citizens and the state expect the police to uphold certain values and norms. Although constitutional and other laws (for example, the U.S. Miranda rights of persons accused of crimes established in 1966) play a role in ensuring the ethical conduct of police, these measures are also supplemented by various codes of ethics drafted by professional law enforcement associations.

Two of the most important overarching codes are the Code of Ethics adopted in 1966 by the American Federation of Police and the Law Enforcement Code of Ethics adopted in 1957 (revised in 1989) by the International Association of Chiefs of Police (IACP 1992). The latter is often used as a model by individual police departments in crafting their own codes of conduct and ethics, which then serve as oaths taken by new officers. Another important document on the international level is the United Nations Code of Conduct for Law Enforcement Officials, adopted by the General Assembly in 1979. A key distinguishing feature of this code is the broad directive for police to protect human dignity and uphold human rights. *Criminal Justice Ethics,* a semiannual journal published by the Institute of Criminal Justice Ethics, and *Ethics Roll Call,* a quarterly journal published by the Center for Law Enforcement Ethics, serve as key resources for facilitating ongoing discussions in the field of law enforcement ethics, especially as changes in science and technology raise new questions about proper conduct.

Most codes of conduct and codes of ethics for police uphold certain general principles in order to prevent misconduct and abuse of power. These principles include: the duty to uphold the law and loyalty to the constitution; personal integrity, honesty, and honor; responsibility to know the law and understand the limits of one's power; and responsibility to use the least amount of force necessary to achieve the proper end. These principles (in addition to laws) are designed to guard against police deviance, or behavior inconsistent with norms and values. This can include misconduct (e.g., excessive or discriminatory use/non-use of force), corruption (forbidden acts involving misuse of office for gain), and favoritism (unfair treatment of friends or relatives).

One noteworthy point is the scarcity of references to the proper use of science and technology in most codes of ethics. As new technologies emerge and become available for both police and criminals (for example, improved surveillance mechanisms or more deadly weapons), so too do new ethical dilemmas that may or may not be adequately resolved by interpreting the general principles found in police codes of ethics.

Various forms of police deviance often have been exacerbated by inadequate accountability mechanisms. During the last half of the twentieth century, however, this was improved thanks in part to developments in communications and surveillance technologies that allow watchdog groups to monitor police behavior and record and share their findings. For the most part, the increased public scrutiny of police activities has helped to reinforce ethical conduct, but it can also interfere with police operations and unfairly stigmatize officers. One source of deviance is an incentive structure that attaches promotions to number and rate of arrests. This can distract officers from their principle duties of protecting and serving the public. Another common ethical problem is the tribal system of values that can evolve within such tight-knit communities as police departments. The "blue code of silence" sometimes leads to the cover-up of corruption and abuses of power.

Science and Technology in Police Work

Advances in science and technology have both improved the capabilities of law enforcement officers to perform their duties and raised several challenges and controversies. Transportation provides one example of how radically these developments have altered police work. Although foot and horseback patrols still play key roles in law enforcement, the introduction of police cars (first used in Akron, Ohio, in 1899 and popularized in the 1930s) has dramatically increased officer mobility. Now helicopters and motorboats complement ever more powerful police cars equipped with video cameras, laptop computers capable of accessing information systems, and global positioning systems (GPS). In addition to transportation, other areas of major scientific and technological change include identification and crime solving, computers and communication, monitoring and surveillance, and protection and control.

The discovery and utilization of deoxyribonucleic acid (DNA) has greatly improved the science of identifying people, which involves determining where they have been, what they did, and how they did it. With only a strand of hair, flake of dandruff, or drop of saliva, police laboratories are now able to positively identify individuals. Despite some debate on this issue, in 1996 the National Academy of Sciences determined there is no reason to question the reliability of DNA evidence. The creation of crime laboratories and advances in forensic science (e.g., the microscopic comparison of fibers, bullets, and other tangible evidence) has made identification of hard evidence a powerful means of detection. Fingerprinting, first widely used in the 1920s, is another technique that has vastly improved the ability of police to identify criminals.

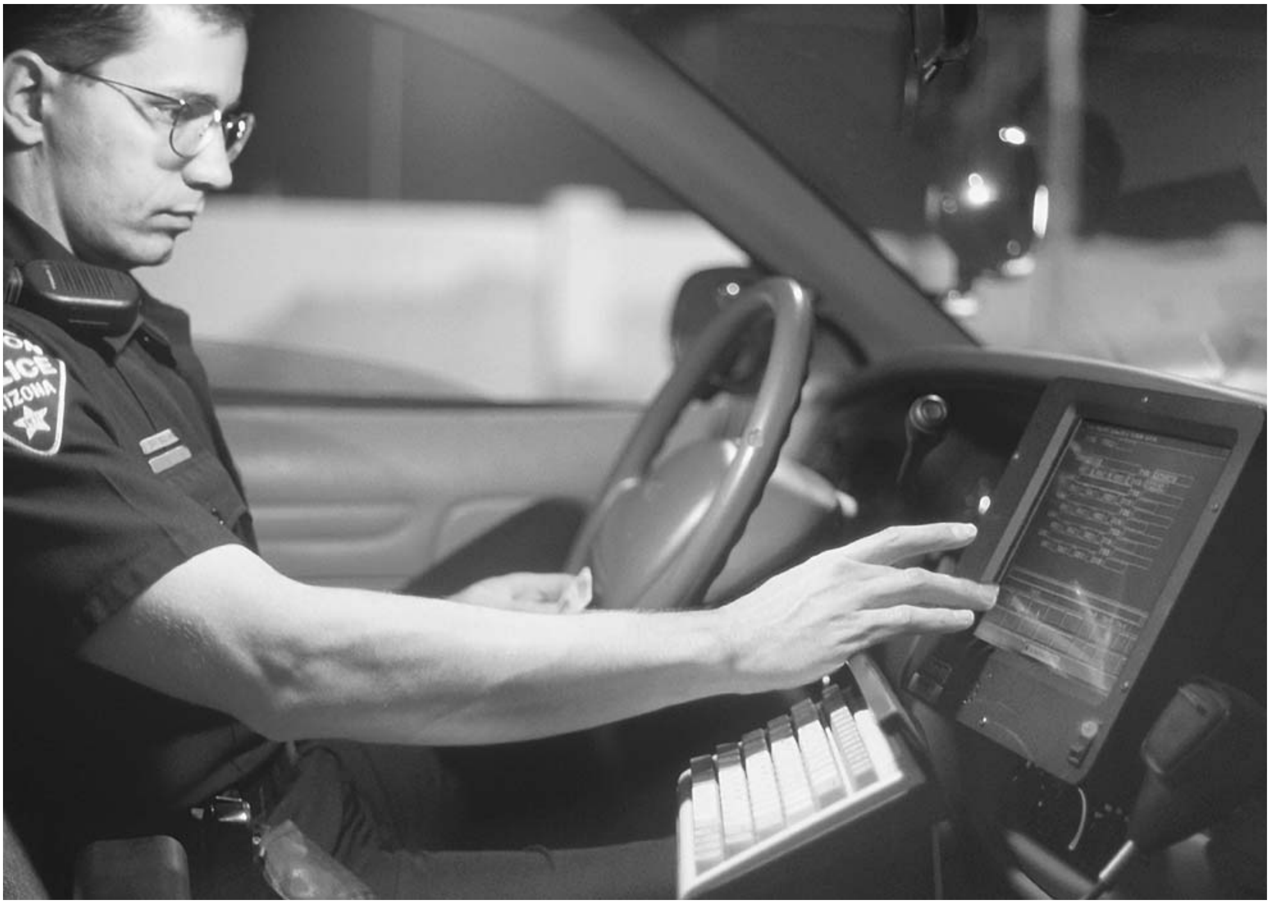
In 1967, the Federal Bureau of Investigation (FBI) created the National Crime Information Center

A police officer checks the tracking system on a helicopter. This system is another example of new policing technologies. *(AP/Wide World Photos.)*

(NCIC), the first nation-wide computer filing system. This helped spark the large-scale computerization of police departments in the United States in the 1970s. Integrated networks of computer databases allow different police departments and different sectors of law enforcement to rapidly share information. Improvements in information and communications technologies can enhance the effectiveness of identification technologies by building national databases of license plates, fingerprints, and even DNA. The 911 system, two-way radios, cell phones, and satellite phones have also increased the ability of police to respond to the public's needs.

Advances in computer and information technology have also improved police monitoring and surveillance. For example, police in the City of London utilize an information technology scheme called Police Informant Management System (PIMS), which allows them to target specific criminal activities and manage informants more effectively. Other monitoring technologies used by the police include camera systems and GPS. Police surveillance work focuses on specific individuals, places, or vehicles deemed suspicious. This more covert work can involve the recording and monitoring of telephone or in-person conversations as well as electronic correspondence. Three notable technologies are the Echelon surveillance program (used to monitor electronic correspondence), the FaceTrac system that "reads" faces, and the Digital Angel tracking chip, which—disguised as jewelry or implanted under the skin—can track the wearer anywhere in the world. For all the advantages these techniques confer on police, there is still no replacement for the proper training of officers to infiltrate criminal groups.

Finally, advances in protective equipment (such as bulletproof vests and helmets) and less-than-lethal technologies have greatly improved police work. Especially during the 1960s, there were many attempts to develop riot control technologies and use-of-force alternatives to guns and the standard side-handle baton. Tried and largely abandoned technologies included rubber, plastic, and wooden bullets, dart and tranquilizer guns, an electrified water jet, and strobe lights (Seaskate 1998). Taser guns, which shoot two wire-controlled darts into the victim and deliver a 50,000-volt shock, bean bag rounds for crowd control, and pepper spray have been more widely employed. Another major development is the RoadSpike, a strip of remote-controlled retractable



A police officer uses a computer in his squad car. The use of technology has led to many improvements in law enforcement methods. *(© DiMaggio/Kalish/Corbis.)*

spikes that allows police to more safely and effectively stop fleeing vehicles while minimizing unintended damage to others.

Police departments have often been slow in reaping the advantages made possible through progress in science and technology (Seaskate 1998). For example, even with massive federal funding, computerization happened slowly and unevenly, since it took a long time for many departments to figure out how information technologies like records management systems and computerized crime mapping could be usefully implemented. Furthermore, many technologies have been adopted from the private sector, but the police also have needs for specialized technologies, which are more difficult to develop and apply. In the United States, the Office of Science and Technology of the National Institute of Justice is responsible for determining and supplying the special technology needs of the nation's police force and for fostering technology research and development.

The use of emerging science and technology by the police can also raise controversies. Cyrille Fijnaut and Gary T. Marx (1995) have argued that the increased use of technical means by the police is one manifestation of the growing technicization of social control (enforcing norms by preventing violations). They suggest that the increased use of technology in social control can cause more problems than it solves. Other controversies stem primarily from specific technologies. Enhanced monitoring and surveillance abilities have raised privacy issues. The reliability of fingerprinting has been questioned (see Cho 2002), especially following one case of wrongful arrest and one of wrongful conviction in 2004 based on faulty interpretation of the fingerprint evidence. Taser guns have also sparked controversy as many concede that they can save lives but that officers may use them too early or too often. More than forty deaths have been linked to Taser guns.

Another important impact of science and technology has been the increasing specialization of law enforcement. Police negotiators, special weapons experts, and tactics teams are often relied on in various circumstances. Deferring to experts is usually the best way of handling a critical situation, but only when time allows. In moments of urgency that require quick judgment and action, this strategy can turn into passive policing possibly to the extent of cowardice. The most horrific example is the Columbine High School tragedy (April 20, 1999), where the first responding police officers, knowing there were children being killed inside, failed to enter the school building. These duty-bound officers, supplied with firearms, body armor, and the color of law, chose to wait for the SWAT team rather than risk their own lives in an attempt to save the students. In the aftermath and on nationwide news, the Jefferson County sheriff stated he did not order his men into the school building because he did not want them hurt.

Criminal Adoption of New Technologies

Much of the same technology used by the police to counteract crime has also been adopted by criminals. Computerization and wireless communications are radically altering some forms of crime. For example, drug trafficking organizations often surpass the communications abilities of law enforcement, and even street-level dealers have access to state-of-the-art communications technologies. Electronic correspondence, the Internet, and cellular communications have made illegal transactions of all kinds more difficult to trace (Seaskate 1998). These technologies also allow terrorist cells to be extremely mobile and highly networked. The development of police technology in the future will be largely set within the context of this evolving technology race with criminals.

Police are forced to deal with new and more sophisticated criminal acts while maintaining their traditional roles of handling traffic, mediating domestic disputes, and providing a range of public services. In order to do so, they must devote a substantial portion of their time to continuing education. Law enforcement officers must attend refresher courses, mandated use-of-force training sessions, and other compendious schools just to keep up with court decisions and novel tricks and tactics being created by the criminal mind. This is in addition to the constant development of hardware, software, and scientific means of detecting criminal activity, which criminals in turn work hard to elude, often through the use of technology.

Unlike the police, however, criminals seldom invest in scientific research or are able to use science to develop new technologies. They are more limited to the creative adaptation of existing technologies, after the manner of the creative consumer analyzed by Michel de Certeau (1984).

Assessment

It is important that the increased reliance on science and technology does not compromise the ethical standards of law enforcement officers. In order to avoid such a possibility, police departments and professional law enforcement societies should make any necessary updates to their codes of ethics. For example, given increased surveillance capabilities and powers (like those under the USA Patriot Act of 2001), police need to ensure that their conduct strikes the right balance between protection of civil rights (like the right to privacy) and the physical protection of citizens from harm. All such changes in science and technology are rapidly altering the context of police work, and law enforcement officers are continually challenged to find the proper use of new technologies to achieve the goals of protecting the public and upholding the law. The rational use of technology and force by the police requires active democratic involvement and citizen partnerships with the police in order to avoid the rise of a modern police state (see Stevens 2000, Wolfe and Zelman 2001).

Technology also plays a role in globalizing criminal activities. Transportation and communication technologies especially enable criminal and terrorist networks to operate and coordinate actions that span the globe. One possible response to this trend is a more central role for Interpol. Created in 1923, Interpol is the world's largest police organization with 182 member countries. It supports all organizations that combat international crime, and it facilitates and coordinates cross-border police cooperation. In this latter function, Interpol is dependent on communication and information technologies that allow multiple agencies to track criminal activities that cross political boundaries. Given the vital importance of technology for Interpol's mission, it may need to strengthen its budget to support research and development specifically targeted to its needs.

In fact, as science and technology become integral parts of police work, it is important that all governments establish rational bureaucratic structures capable of securing the necessary resources to develop and disseminate novel technologies and improved scientific practices. Furthermore, given the increased technological capabilities of criminals and terrorists, it is essential that police and other first responders are adequately trained and equipped to handle contingencies from hostage situations to attacks using weapons of mass destruction. These requirements became especially apparent for the United Sates in the aftermath of the terrorist attacks on September 11, 2001. One of the responses was the creation of the Department of Homeland Security (DHS) in 2002. A central element of the DHS is the Science and Technology Directorate, which works to counter terrorist threats by improving current technological capabilities and developing new technologies. This marks another step in the effort to coordinate and fund federal efforts and encourage industry in the task of providing police with the proper technologies to fulfill their vital mission. However, and in contrast, all of the science, technology and/or modern, crime-detecting gee-whiz gizmos are of no value if police conduct condones anything other than strict compliance to the highest of ethical standards.

CHUCK KLEIN
ADAM BRIGGLE

SEE ALSO *Forensic Science; Science, Technology, and Law; Security.*

BIBLIOGRAPHY

Barker, Thomas and Carter, David L. (1994). *Police Deviance,* 3rd edition. Cincinnati, OH: Anderson. Describes and analyzes many issues of police deviance and misconduct and offers recommendations for mitigation.

Cho, Adrian. (2002). "Fingerprinting Doesn't Hold Up as a Science in Court." *Science* 295(5554): 418. Reports that the U.S. Supreme Court found that fingerprinting does not uphold three of the four standards for federal rules of scientific evidence established in *Daubert v. Merrell Dow Pharmaceuticals.*

de Certeau, Michel. (1984). *The Practice of Everyday Life,* trans. Steven Rendall. Berkley: University of California Press. Marks a turning point in the study of culture from a focus on products and producers to consumers and their creative uses of products.

Fijnaut, Cyrille, and Gary T. Marx, eds. (1995). *Undercover: Police Surveillance in Comparative Perspective.* The Hague: Kluwer Law International. Argues from police surveillance to the larger thesis that social control is changing worldwide due to the functional needs of the modern state and common cultural beliefs.

Hansen, David A. (1973). *Police Ethics.* Springfield, IL: Charles C. Thomas.

Heffernan, William C., and Timothy Stroup, eds. (1985). *Police Ethics: Hard Choices in Law Enforcement.* New York: John Jay Press.

International Association of Chiefs of Police (IACP). (1992). "The Evolution of the Law Enforcement Code of Ethics." *Police Chief* 59(January): 14–17.

Stevens, Richard W. (2000). "What is a Police State?" In *Police State Polices Alert* Newsletter (Winter) Hartford, WI: Concerned Citizens Opposed to Police States.

Toffler, Alvin, and Heidi Toffler. (1993). *War and Anti-War: Survival at the Dawn of the Twenty-first Century.* New York: Little, Brown. Shows how technology alters the nature of conflict and argues that technology and innovation can be the wellsprings of a lasting peace.

Wolfe, Claire, and Aaron Zelman. (2001). *The State vs. The People.* Hartford, WI: Mazel Freedom Press. Defines and differentiates three different types of police-states (traditional, totalitarian, and modern authoritarian) and argues that the United States may be moving toward a form of modern authoritarian police state that grows organically out of fear about crime and terrorism.

INTERNET RESOURCES

Seaskate, Inc. (1988). *The Evolution and Development of Police Technology.* A technical report prepared for The National Committee on Criminal Justice Technology at the National Institute of Justice. Available from http://inventors.about.com/gi/dynamic/offsite.htm?site=http://www.nlectc.org/txtfiles/policetech.html. Contains a timeline of police technology and recommendations for federal decision makers on how to improve the technological capabilities of U.S. police.

POLICY

SEE *Science Policy.*

POLITICAL ECONOMY

Political economy is commonly defined as that branch of social science dealing with the production and distribution of wealth. The political economy of science and technology would thus focus on the production and distribution of scientific knowledge and technological capabilities that affect "who gets what." Although students of political economy sometimes claim to be objective, ethical issues are intrinsic to the subject.

Technology associated with the industrial revolution stimulated the pioneering political economic inquiries of Adam Smith (1723–1790) and David Ricardo (1772–1823). Smith and Ricardo were particularly interested in public policies that would maximize wealth creation. With the integration of science into the industrial value chain during the second industrial revolution of the late nineteenth century, it too became a subject of political economic scholarship.

From Ethics to Political Economy

The word *ethics* typically connotes issues of personal choice. In the context of science and technology, one might associate it with whether or not to use extraordinary means to extend life or to conceive a child. Yet society makes collective choices about science and technology as well, and these choices have profound moral implications. Many *extraordinary means* in medicine, for instance, emerged from research and development (R&D) projects that were supported directly by government funding or were subsidized indirectly through other policy measures.

In the absence of complete and unquestioned unanimity within a polity, collective choices involve the exercise of power. Persuasive or coercive authorities extract and redeploy resources or, equally important, determine how those who hold resources may use them. The U.S. government, to continue the example, spends nearly $30 billion per year on biomedical R&D. Its regulations, especially those of the Food and Drug Administration (FDA), further shape the flow of private biomedical R&D funding.

The prospect of action by the authorities induces the mobilization of interests. Individuals and organizations with a material, ideological, bureaucratic, or other stake in whether and how power is used seek influence. The potential recipients of biomedical R&D funding lobby governmental officials; think tanks advocate changes in the regulatory process; and groups representing patients work to enlarge the shares of the R&D pie devoted to the diseases with which they are most concerned.

Political economy embraces all of these activities: the intertwined exercise of public power and exertion of private influence to shape the allocation and use of societal resources. In the contemporary political economy of science and technology, money is the resource that is most visibly at stake, but it is not the only one. Property rights, access to markets, and skilled people are also very important.

Centralization and Decentralization

Technological innovation is an ancient and, some would argue, characteristically human process. The political economy of technology is nearly as old. Douglass C. North (1994), for instance, ascribes the invention of agriculture to the assertion of property rights over land. Agricultural production stimulated ancient industries such as metalworking only after centralized empires were established.

Yet highly centralized political economies, such as empires and communist systems, have fostered technological innovation only intermittently. They are vulnerable to bureaucratic ossification and the whims of leadership. During the Middle Ages, for instance, the Chinese Empire developed arts such as textile production and shipbuilding to a level that astonished European visitors. Then fifteenth-century emperors put an end to these endeavors, going so far as to impose the death penalty on any subject who dared to build a three-masted ship.

Capitalism has proven the most technologically fecund of all the great political economic systems, in large part because decision making about how technologically-relevant resources are used is largely decentralized. Competition among producers leads to experimentation with new ways of making things and with the making of new things, experimentation that is enabled by property rights and mediated by market prices (Rosenberg and Birdzell 1986). The results of these experiments are judged by a multitude of end users who, through their buying decisions, feed both resources and information back to the innovation system.

One must take care not to exaggerate the degree of decentralization. Capitalist enterprises are embedded in a larger framework of social institutions that depend on collective authority, albeit an authority that is circumscribed by constitution and culture. These institutions vary dramatically over time and across political jurisdictions, coevolving with the economic system and in response to military and other external challenges. The delicate balance of public and private power, of centralized control and decentralized experimentation, is a core theme of the political economy of science and technology.

Intellectual Property Rights

Intellectual property rights (IPR) exemplify the delicate balance. Patents, copyrights, and other forms of IPR allow holders to use the coercive power of the state to prevent others from using specific bits of knowledge for defined purposes for limited periods of time. This control over potential competition is designed to induce the substantial additional investment that is usually required to convert the protected knowledge into a commercially viable product or process. In the absence of IPR protection, potential innovators might be deterred by the prospect of rapid imitation. Yet very broad, very long, or very rigid IPR protection may be an equally powerful constraint on innovation, inhibiting cumulation and competition.

This basic theory of IPR has been articulated by Kenneth J. Arrow (1962), F. M. Scherer, and other economists, but it provides little practical guidance for setting the balance. This is left to political and legal processes. The historic contrast between Germany and the United States is striking in this regard. The German government has generally been much more tolerant of cooperation among rights-holders, building on the medieval guild tradition of exclusive control over the arts of production. The United States has often struck down such arrangements, not only when they take the form of contractual agreements, such as patent pools, but even when they result from single firms amassing market-dominating positions. Antitrust law has often been used to compel the licensing of intellectual property.

The political economy of intellectual property has become increasingly complex and contested as science and technology have grown in economic importance and the capacity to produce them have diffused globally. The pharmaceutical industry, for example, is more dependent than any other on patents. Pharmaceutical firms, not surprisingly, have lobbied and litigated to expand the scope and duration of IPR, with great success during the last decades of the twentieth century. New kinds of inventions, especially in biotechnology, have gained protection in the United States, and legislators, administrators, and judges have generally treated rights-holders more favorably than in the preceding decades.

Pharmaceutical firms were also at the forefront of an advocacy push that extended Euro-American principles of IPR protection to much of the rest of the international community through the agreement on trade-related aspects of intellectual property rights (TRIPS) within the World Trade Organization framework. TRIPS, however, seems to many actors and observers to have tipped the delicate balance too far in the direction of rights-holders. In response, a global movement has emerged to secure low-cost access to patented medicines for the treatment of diseases that are widespread in developing countries, such as tuberculosis and AIDS. Invoking the ethical principle that current human needs ought to be valued more than future corporate profits, this movement has for the moment stemmed the drift of international policy in favor of stronger IPR.

Trade

The association of IPR with the international trade regime is a new development in the political economy of science and technology. Traditional regulation of trade in goods, though, has long been understood to be a potentially powerful factor bearing on science and technology and the distribution of the benefits and costs associated with them. Indeed Adam Smith, one of the progenitors of the concept of political economy, argued in *The Wealth of Nations* (1776) that larger markets facilitate occupational specialization, which in turn fosters the development of science and technology. Among the specialized occupations to which Smith attributed economic significance was science itself: "philosophers or men of speculation, whose trade it is not to do anything, but to observe everything; and who, by that account, are often capable of combining together the powers of the most distant and dissimilar objects" (Penguin Classics ed. 1986, p. 115; or Book 1, Chapter 1).

The nineteenth-century German political economist Friedrich List (1789–1846) disputed the association that Smith made between *the extent of the market* and the development of scientific and technological capabilities. List argued that free trade allowed those who already had such capabilities to deepen them and reduced the odds that those who did not have them would acquire them. List's arguments have been cast in modern form by the theories of the *developmental state* and *strategic trade*. By striking a careful and dynamic balance between trade protection and openness to the world market, clever and powerful governments could—at least in principle and under particular circumstances—induce the creation of domestic high-technology industries that would not have flourished otherwise. The great inspiration for and proving ground of these theories has been East Asia, where first Japan and more recently the *four tigers* of Hong Kong, Singapore, South Korea, and Taiwan, joined the ranks of global high-technology powers.

An even greater test of these theories looms ahead as other developing countries, especially China and India, with more than a third of world population, seek to follow suit. China and India have both aggressively sought foreign direct investment since the 1980s, especially in areas such as semiconductor manufacturing and software development. They have also opened domestic markets to sales by foreign high-technology firms, but usually conditionally, using the leverage of market access to secure benefits from foreign firms for their own *infant* high-technology industries.

Whether these infants will mature into healthy adults that help to raise living standards in previously impoverished countries remains to be seen. Their growth could be stunted by, among other things, inept governance, capture of policy-making by narrow interests, or aggressive protectionist reactions in developed countries. The aspirations of billions of people for a better life hang in part on whether world trade policymakers can steer effectively between the perpetually inequitable Scylla of unregulated trade and the stifling Charybdis of ratcheting protectionism.

Human Resources

The effectiveness of strategic trade policy depends not only on the intelligence and agility with which it is implemented, but also on the capacity of an economy to absorb ideas from abroad and generate new ones. Access to the richest scientific literature and the best blueprints, even in the context of cleverly protected markets, is no guarantee that domestic enterprises will move to the cutting edge of global competition. Tacit knowledge, which cannot be written down but is acquired through experience in doing science or operating technological systems, is another necessary ingredient in the development of scientific and technological capabilities. The people who have such knowledge, or have the capacity and incentive to acquire it, are thus critical resources in the political economy of science and technology.

Karl Marx (1818–1883), who put science and technology at the center of his pioneering political economic analysis, claimed to the contrary that technological innovation under capitalism merely displaced human capabilities. This process of alienation, as he called it, would ultimately motivate revolutionary upheaval as workers came to recognize their interest in controlling the means of production. The threat of technological displacement has occasionally prompted workers to exercise their collective power, albeit never to the point of overthrowing governments. Trade unions have fought to have a voice in the process of technological change in the workplace. Labor victories in such contests have sometimes led to slowdowns in the pace of innovation, but (contrary to Marxist expectations) have also often allowed enterprises to tap more effectively into the expertise of workers and even accelerate the pace of change.

More important, the Marxist focus on particular labor processes ignores the broader transformation of the economy brought about by the development of science- and information-based industries that began to appear in the waning years of Marx's life. Even if technology displaces and *deskills* workers in older industries, the growth of newer industries that rely more heavily on *knowledge workers* more than counterbalances those losses in the long run. Such industrial transitions do not occur solely as a result of shifts in private investment. Public investments are typically critical catalysts as well. While the balance between worker voice and capitalist flexibility is important for the political economy of science and technology, the balance between current consumption and future-oriented public and private investments may be even more so, as suggested by the work of Robert Solow (1957), Paul Romer (1990), and others.

Universal public education at the primary and secondary levels, for example, seems to be a prerequisite for the development of a knowledge economy. The United States and Germany surpassed the United Kingdom in science and technology during the nineteenth century in part because they were willing to impose taxes (and break down social barriers) to provide education. The more recent East Asian *development miracle* similarly rests on a strong educational base.

Private investment enters the balance more forcefully at higher levels of education. University and graduate students may be able to recoup the costs of education through future earnings, even if they borrow funds to pay tuition. Responsibility for such an investment will tend to encourage diligence and attune students to the likely needs of future employers. Yet information about the future is sufficiently uncertain and the spillover benefits to society of a highly-trained workforce sufficiently great that significant public subsidies to higher education are justifiable. The U.S. university system has more private elements than most, but its rise to world leadership in the twentieth century coincided with an infusion of resources from taxpayers to students, such as scholarship grants, tuition loan guarantees, and publicly funded research assistantships.

The migration of highly skilled people complicates the political economy of science and technology. The immediate social benefits of graduates who emigrate spill over to their new neighbors, not those who paid for their education. The threat of a *brain drain* may prompt preventive or compensatory measures, such as controls on movement or exit taxes. In the longer run and under particular conditions, emigrees may nonetheless pay back the investment made by their places of origin by creating channels through which knowledge flows. Taiwanese *astronauts* in Silicon Valley, for instance, have helped to make their home country a global center for the information technology industry.

R&D Funding

Higher education is increasingly joined at the hip with scientific research in the institution of the research university. Involvement in research conveys tacit knowledge to students even as they produce formal knowledge, such as publications and patents, in conjunction with their professors and other researchers. The benefits of formal knowledge spill over even more easily than those of tacit knowledge. Indeed the academic scientific community has a distinctive political economy in which collective rewards in the form of prestige flow to individuals whose work has spilled over most broadly. This system discourages scientists from trying to appropriate the financial benefits that flow from an idea by keeping it secret or gaining IPR protection for it, because prestige can only be gained through widespread, low-cost diffusion of ideas.

Of course, as union organizers at Harvard once put it, "You can't eat prestige." Fortunately for scientists, material rewards tend to correlate with prestige, although less systematically than licensing fees correlate with intellectual property holdings. Private patrons inspired by the scientific spirit and the desire to bathe in reflected glory were a particularly important source of sustenance for scientists in the early-modern era. Private patronage continues in the early twenty-first century, but it is overshadowed by government and corporate support underlain by baser motives. Where the *communist* (as Robert Merton [1973] characterized it) or shared knowledge political economy of science meets the capitalist political economy of science and technology, sparks often fly.

The standard economic theory behind government funding of R&D carries forward the tradition of the noble patron: The financial burden of R&D with benefits that accrue to all in society should be shouldered by all. R&D that benefits only a few should be funded privately by those few. Economic research by Richard R. Nelson (1959) and Edwin Mansfield (1977), among others, suggests that many opportunities for socially valuable R&D go unrealized. Because the constituency for diffuse future benefits is usually weak, political processes tend to favor other uses of societal resources. In U.S. politics, a more specific and urgent mission, such as national defense or public health, must typically be marshaled to win significant government R&D funding, although those who manage and disburse these funds have often seen fit to support projects highly regarded by scientists but with only a distant relation to the stated mission.

That political forces impede the achievement of the socially optimal level of public investment presents no challenge to economic theory. A deeper problem is that prospective public and private benefits are more difficult to distinguish in practice than in principle; in fact some public benefits may be impossible to obtain unless people get rich providing them. The division of labor between the public and private sectors is not nearly so clean as the conventional categories of *basic research, applied research,* and *development* imply.

The biotechnology industry is the most prominent case in point. Publicly funded science underlies the industry, and publicly funded scientists routinely start firms to capitalize on their findings, often with investments from their own universities. Large pharmaceutical firms are major funders of academic researchers and entrepreneurial start-ups as well, making deals that may impose restriction on the free exchange of ideas in order to preserve the funder's pecuniary interest. At this flash point between the communist and capitalist political economies, hot debates have erupted over the rules that govern public funding as well as the norms that regulate the behavior of scientists and research universities.

As with property rights, access to markets, and human resources, the diffusion of scientific and technological capabilities globally has complicated efforts to find a workable balance in the allocation of R&D funding. Spillovers that accrue across borders, whether in the public or private sector, weaken incentives for governments to make public R&D investments. Collective action on behalf of the global public good is a tortuous process in the absence of a global authority capable of levying taxes. The largest multinational corporations have globalized their R&D infrastructures, drawing on brainpower from Barcelona to Bangalore to Beijing to Boston. But these firms do not yet form a cohesive constituency that lobbies for global public goods, nor should one expect that if and when they do their interests will coincide with the greatest good for the most people or any other broad ethical principle.

Creative Destruction

At any point in history, people who seek "to promote the progress of science and the useful arts" (U.S. Constitution, Article 1, Section 8) depend on access to ideas and materials to do their work. Access to these resources has never been free and unencumbered, but is instead conditioned by public power and private influence. Marx imagined an end-state to history in which all people would engage in creative work, but this utopia is, at best, far in the future. *Real existing socialism,* as the people's republics of the twentieth century were sometimes referred to, was far less efficient in its allocation of technologically-relevant resources than its capitalist competitor. It was also far less fair in allocating the costs and benefits associated with scientific research and technological innovation.

Capitalism, to borrow from Winston Churchill, is the worst political economy of science and technology, except for all the others. Critical resources, including property rights, access to markets, highly-skilled people, and R&D funding, are allocated through a messy mixture of market exchange and state action. The appropriate division of labor between the two mechanisms is clarified only somewhat by theory, and even these partial insights are honored in the breach. Some people get extraordinarily rich, and others are displaced, injured, or otherwise left out. The process of *creative destruction*, as Joseph Schumpeter (1950) famously labeled it, is intrinsically disruptive.

The political economy of science and technology is itself a continual work in progress. Globalization is forcing public authorities and private actors to reconsider priorities and rethink routines that were previously taken for granted. In this moment of transition may lie opportunities to nudge the system in more ethically satisfying directions.

DAVID M. HART

SEE ALSO *Capitalism; Economics and Ethics; Marx, Karl; Science, Technology, and Law; Smith, Adam; Socialism.*

BIBLIOGRAPHY

Arrow, Kenneth J. (1962). "Economic Welfare and the Allocation of Resources for Invention." In *The Rate and Direction of Inventive Activity: Economic and Social Factors*. Princeton, NJ: Princeton University Press. Fundamental neoclassical economic model of science.

Harhoff, Dietmar, Francis Narin, Frederic M. Scherer, and Katrin Vopel. (1999). "Citation Frequency and the Value of Patented Inventions." *Review of Economics and Statistics* 81: 511–515. Demonstrates the highly skewed distribution of value of inventions.

Mansfield, Edwin, et al. (1977). "Social and Private Rates of Return from Industrial Innovations." *Quarterly Journal of Economics* 91: 221–240. Shows how benefits spill over from innovations.

Merton, Robert K. (1973). "The Normative Structure of Science." In *Sociology of Science*. Chicago: University of Chicago Press. Originally published in 1942. Exposition of the value system of academic science.

Nelson, Richard R. (1959). "The Simple Economics of Basic Scientific Research." *Journal of Political Economy* 67: 297–306. Economic rationale for public support of science.

North, Douglass C. (1994). "Economic Performance Through Time." *American Economic Review* 84(3): 359–367. Links innovation process to institutional incentives.

Rosenberg, Nathan, and L. E. Birdzell. (1986). *How the West Grew Rich: The Economic Transformation of the Industrial World*. New York: Basic. Economic history from late middle ages centered on science and technology.

Romer, Paul M. (1990). "Endogenous Technological Change." *Journal of Political Economy* 98: S71–S102. Economic theory of increasing returns to knowledge.

Schumpeter, Joseph A. (1950). *Capitalism, Socialism, and Democracy*, Harper Colophon edition. New York: Harper and Row. "Creative destruction" as the core feature of capitalism.

Solow, Robert M. (1957). "Technical Change and the Aggregate Production Function." *Review of Economics and Statistics* 39: 312–320. Econometrically demonstrates importance of technological change in economic growth.

POLITICAL RISK ASSESSMENT

Support for scientific research and technological development, especially in developing countries, requires interstate and cross-border participation. Such development and technology transfer issues are subject not only to ethical evaluations but also to political risk assessments. The degree to which international investment projects, public and private, are attracted to or successful in many parts of the world is increasingly dependent not simply on technical but on social and political factors.

It has been argued that any engineering project worth $100 million or more is no longer a technical project, but a political enterprise. All political enterprises embody risks. Political risk—also known as country risk or sovereign risk—is most often defined as those conditions that a country can create *at home* that might undermine investment climate and cause investors to incur losses. Political risk also involves exposing a business to conditions *abroad* created by extra- and supranational political changes, policy decisions, social situations, inter-market relations of two or more regions, and global financial market oscillations, over which the country may or may not have control.

Political Risk Types

Developed countries as well as developing states generate political risks. More likely, such developed countries as the United States, Japan, and France can offer political risks of *regulatory* excesses, while developing countries such as Indonesia, Peru, and South Africa can offer *structural* risks such as regime instability, out-of-sync economic policies, and ethno-religious-cultural imbalances in development due to the monopoly of political power and economic wealth by a single dominant ethnic or religious group. Examples of regulatory risks are excessive environmental rules, market restrictions to favor or protect a certain domestic economic group (such as in the United States and Britain), or manipulating free market rules to promote national champion firms (such as in Japan, Germany, and France). Cases of structural political risks in the developing countries above all rest on the lack of the rule of law, an impartial court, the protection of private property, the sanctity of contracts, and transparency, as well as out-of-control corruption, excessive subsidies to state-chosen firms, and favored access to power and wealth by a state-favored ethnic or religious group. Developed countries engender fewer risks than developing countries, due to the better-developed legal institutions, norms, and practices for business. Also, multiethnic states tend to create more structural risks than countries with a single ethnicity. And a country with intractable economic and financial difficulties, whether developed or developing, runs greater risks for investors than a country with a prudently managed economy. In order to produce a carefully weighed assessment, risk variables must be quantitatively evaluated.

All countries generate and nurture five kinds of risks:

(1) political instability that can lead to regime change;

(2) macroeconomic and financial imbalances that can lead to a severe malfunctioning of the economy;

(3) social, cultural, and environmental risk that can affect human development;

(4) global linkages facilitate a country's integration into the global economy but insufficient ties can deny access to external capital, technology, resources, and markets, thus increasing the country's risks; and

(5) business environment risk, which allows the country to achieve the level of competitiveness against its neighbors.

Each of the five compartments or shells is self-defining and self-contained, while one or two inferior performances in the five shells can undermine the soundness of the other three or four, thus increasing the overall risk of a single entity, setting off a *contagion effect*. Conversely, two or three well-calibrated shells can lower the risks of the lesser shells, benefiting from a *free ride effect*. In brief, they are collectively interlinked and mutually reinforcing. A country framed in five well-balanced and well-reinforced shells offers little or no risk. And a country fraught with ethnic, racial, and religious strife as well as chronic economic crises and illiberal democratic practices will suffer from high political risk and discourage investors.

Political Risk Assessment Users

Avid users of political risk assessments are governments, global businesses, and increasingly nongovernmental organizations. Each needs to know the political, economic, sociocultural, and environmental conditions of a given country in which it seeks to successfully operate for profit, forge security and diplomatic alliances, cement friendly bilateral trade and financial relationships, or expand the participation of civil society in political processes. A visiting head of government needs to know about the strengths and weaknesses of the host country as well as his or her counterpart, while a global corporation must realistically assess the country's political risks before it commits millions of dollars to an investment project. A transnational nongovernmental organization needs to choose a right local partner in order to effect its global agenda, whether it be environmental, religious, scientific, developmental, or ethnocentric. Correctly assessing risks can increase the success of a state or corporate policy.

What constitutes a high risk for one country may be no risk for another. The United States may not be welcomed to certain countries due to historic policy differences, but Canada or Switzerland can watch over American interests. What is a risk for a bank may pose no risk for a mining or oil company. The U.S. foreign and defense policy in the post-9/11 era has increased risk for American businesses, due to escalating anti-Americanism around the world. A U.S. bank may not be welcomed in Sudan, a poor Muslin country that views with resentment Washington policies toward Islamic nations. But Sudan will welcome a U.S. oil company for its advanced technology and global market reach. Conversely, a Chinese firm can engage in a joint venture with IBM to access U.S. technology while reducing the political risks of hyperregulation and export control by the U.S. government, which considers China both a trading partner and security rival in the Asia Pacific.

Political risk is a dynamic phenomenon. Hence, political risk assessment requires a constant monitoring of all five categories of risks and fashioning of mitigation strategies. Multinational and global companies have come to manage their cash flows in a basket of currencies (dollars, euros, and yen) to mitigate the risk of the sudden devaluation and revaluation of a single currency, often a reflection of a country's fragile state of economy and unstable politics. In the contemporary globalized economy, sound assessment of political risk can save a company millions from regulatory or structural risks or can generate windfall profits, while a country can reduce security risk by engaging potential rivals in expanded trade and investment activities.

Some risks are *interstate*, others are *regional*, and still others are *global*. Before the days of regional free trading systems, such as the European Union, Mercado Comun del Sur (MERCOSUR), and the North American Free Trade Agreement (NAFTA), minor members wielded little influence in the global arena—politically, economically, and diplomatically. Today Portugal, Uruguay, and Mexico can wield more. To avoid an unpleasant showdown in bilateral relations, the United States often resorts to its formal and informal veto power in multilateral organizations such as the United Nations, the World Bank, and the International Monetary Fund to reject funding requests from less cooperative countries, thus reducing confrontational risks.

Political risk is therefore an outcome of policy choice; it can increase or decrease as the state chooses how to devise and implement its domestic and external policies. To maintain low political risk can lead to immeasurable loss of a country's independence, autonomy, and even sovereignty. In return, this can allow a country access to international capital, market, technology, and skilled labor. In the age of globalization, to insist on keeping independence, autonomy, and sovereignty can increase political risk and therefore be costly in both economic and political terms.

EUL-SOO PANG

SEE ALSO *Globalism and Globalization; Modernization; Risk Ethics; Science Policy.*

BIBLIOGRAPHY

Borner, Silvio; Aymo Brunetti; and Beatrice Weder. (1995). *Political Credibility and Economic Development*. New York: St. Martin's Press.

Moran, Theodore H., ed. (1998). *Managing International Political Risk*. Malden MA: Blackwell.

Pang, Eul-Soo, and Halim Saad. (2001). "Globalization, Regime Changes, and Political Risk." *Journal of Diplomacy and Foreign Relations* 3(2): 1–20.

Samuels II, Barbara C. (1990). *Managing Risk in Developing Countries: National Demands and Multinational Response*. Princeton NJ: Princeton University Press.

POLLUTION

Most often used in regard to the natural environment, the term *pollute* means to make foul or unclean, degrade ecological and/or human health, contaminate or defile, and, in a religious sense, render ceremonially impure or desecrate. The verb pollute derives from the Middle English *polute*, and this from the Latin *pollūt(us)*, the past participle of *polluere*, which meant to soil, defile. Pollution generally denotes an undesirable condition, where there is too much of something (the pollutant or contaminant) in a natural or other beneficial system. It is, then, not an objectively determined state of affairs. Rather decisions about pollution require both science (for example, identification, monitoring, and classification) and ethics and politics (such as debate about what is undesirable, what is acceptable, who should monitor pollutants, and who should be held accountable). Although pollution is, in a sense, an unavoidable by-product of human (and nonhuman) activity, it was not until the Industrial Revolution that it regularly occurred on a large-scale and became a public policy issue.

Measures have been taken to curb pollution, especially the public health activities in the 1800s and then again with the rise of the contemporary environmental movement in the 1960s. Largely due to political and economic incentives and advances in technology, many pollutants are declining. In several regions, however, pollution remains a serious problem threatening both human and environmental health. Pollution has long been seen as the most visible and costly reminder of a downside to the technological mastery of nature. The use of technologies to prevent and diminish pollution, however, may eventually eliminate this particular cause for technological pessimism.

Classifying and Describing Pollution

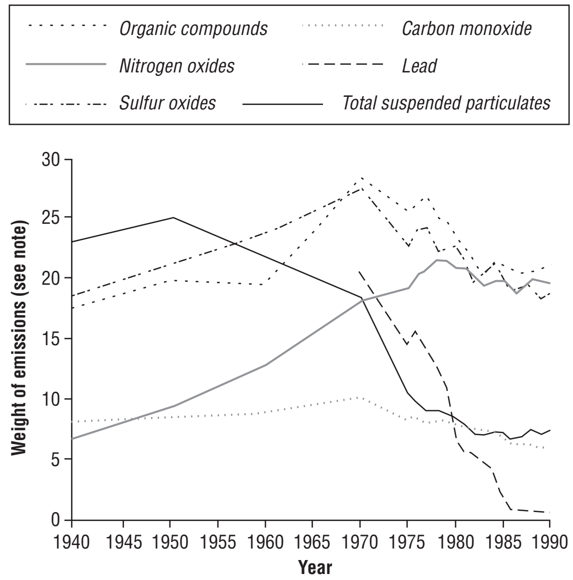
Environmental pollution can be either point source (such as emissions from factory smokestacks) or non-point source (for example, fertilizers and oil washed from lawns and parking lots into streams). It can occur suddenly, as in the massive radioactive plume released from a nuclear power plant in Chernobyl in 1986 or the 1.26 million barrels of oil spilled into Prince William Sound, Alaska, by the *Exxon Valdez* in 1989. However pollution usually stems from long-term emissions, as in the accumulation of carbon dioxide (CO_2) in the atmosphere resulting from fossil fuel combustion. Although most pollution is anthropogenic (human caused), some forms are naturally occurring. One example is radon gas that leaks from rocks into buildings and accounts for roughly 55 percent of the total radiation dose received by an average person in the United States. Anthropogenic and nonanthropogenic sources of pollution can also combine to produce deleterious environmental and health effects. One example is the combination of human-produced chlorofluorocarbons (CFCs) and naturally occurring ultraviolet radiation in the stratosphere, which initiates a reaction that depletes ozone. The methane gas produced by cows (and other farm animals) accounts for roughly 20 percent of all such global emissions. Although this is a natural source of pollution, the vast quantity of these animals would not exist without humans.

Any compound can be considered a pollutant if it is judged to exist either in excessive quantities or in the wrong place. For example, ozone in the stratosphere is regarded as beneficial, whereas ozone in the troposphere (the lowest layer of the atmosphere) is regarded as a pollutant because it contributes to smog, which causes harmful ecological, human health, and aesthetic effects. This is akin to exotic species, which can be considered pollutants, because they are located outside the boundaries of the area in which they evolved.

Pollution can be classified by economic sector (such as residential, industry, agriculture, transportation, and others), which can be helpful for regional governments implementing pollution reduction policies, but the relative contribution of each source varies markedly depending on the composition of regional economies. A more universalizable classificatory scheme groups pollutants according to the reservoir in which they are found: water, soil, air, and space. More detailed cataloging can then be carried out. Water pollution, for example, is typically sorted by type, including biological/pathogens, sedimentation, nutrients, toxic synthetic chemicals, and heat/cold. Water quality indicators include hardness (a measure of dissolved minerals), pH, temperature, dissolved oxygen, turbidity, and smell. The U.S. Environmental Protection Agency (EPA) has set national air quality standards based on six common (referred to as *criteria*) air pollutants: ozone, nitrogen dioxide, sulfur dioxide, particulate matter, carbon monoxide, and lead. Pollution in space (scraps from old satellites, rockets, or other spacecraft) is generally classified by size. The vast majority of the hundreds of thousands of human-produced particles in space are between one and ten centimeters in diameter, but even these small pieces have caused massive damage to satellites. Not included in the above list, but worthy of mention, is indoor air pollution (especially caused by smoking and the use of wood or coal-burning stoves), which poses grave health risks. Noise and even drugs can be considered pollutants insofar as they can have deleterious effects on the well-being of humans and other animals.

FIGURE 1

Emissions of Major Air Pollutants in the United States, 1940–1990



Note: In millions of metric tons per year, except lead in ten thousands of metric tons per year, and carbon monoxide in 10 million metric tons per year.

SOURCE: Council on Environmental Quality. (1992). *Environmental Quality, 22nd Annual Report*, p. 273.

The severity of a pollutant depends upon its chemical nature, concentration, and persistence. One important equation used by environmental scientists to understand pollution derives from biogeochemical cycling: *Residence time = Reservoir size/Sum of all fluxes* (*in or out of the reservoir*). A reservoir is simply any "compartment" that can serve as a storage place for pollutants. Examples include the ocean, atmosphere, and biosphere. Reservoirs can be defined more precisely depending on the pollutant or other compound of interest. For example, scientists interested in particulate organic carbon may choose to focus only on the upper ocean (where the majority of carbon is located). Flux refers to the rate at which the pollutant (or other compound of interest) moves in and out of the reservoir. Residence time is how long the pollutant stays in the reservoir of interest. CO_2, for instance, has a long residence time in the atmosphere, such that even if all emissions were immediately stopped, CO_2 levels would drop only very slowly. Sulfur dioxide (SO_2), by contrast, is water soluble, and because water has a relatively short residence time in the atmosphere (less than five days), SO_2 will quickly precipitate out.

This explains why CO_2 emissions pose problems on a global scale (because it stays in the atmosphere long enough to thoroughly mix around the globe), whereas SO_2 emissions pose problems on a regional scale (because it will precipitate out of the atmosphere somewhere within five days downwind of the source). The equation also helps explain why groundwater pollution is so much more difficult to clean up than surface water pollution. Groundwater aquifers have very low fluxes, meaning residence times for pollutants are quite high. Surface water systems, for the most part, have high fluxes, meaning that pollutants can be quickly flushed through the system.

Ethics and Deciding How Much is *Too Much*

Classifying and describing the behavior of pollutants in natural systems still leaves many questions unanswered, including: How much pollution should be allowed? What should count as pollution? How should societies determine the relative values of risks to people's health and other matters of concern (for example, ecosystem integrity and aesthetics), or, how should they determine when there is too much of something, thus turning simple presence into pollution?

Pollution may result in injustice, because its effects can be disproportionately suffered by the poor. For example, poor people can often only afford to live in neighborhoods that are crowded with polluting industries, yet they seldom have the resources to challenge polluters in the court system (the Erin Brockovich case is an exception to this rule). Similarly global climate change resulting from CO_2 emissions (significantly produced by wealthy nations) may have the most devastating impacts on poor nations unable to adapt to rising sea levels and other effects. Welfare economists conceptualize pollution as a problem of establishing the proper costs so that its effects are fairly distributed.

Despite these injustices and the more general detrimental effects of pollution, several economic theorists and philosophers have made a strong case that the proper reaction is not to eliminate pollution, but rather find the optimal amount of pollution. Julian Simon (1981) and his successor Bjørn Lomborg (1998) argue that economics correctly views pollution as a trade-off between cost and cleanliness. This has two main implications. First, the goal is not pristine, pollution-free environments, but rather an environment that is optimally clean in the sense that, at this point, citizens would rather pay for some other service or good than more pollution abatement (this is the willingness-to-pay criterion for determining optimal pollution). Second, measuring the goal of optimal pollution would best be accomplished by some metric of human welfare such as life expectancy.

Both Lomborg and Simon argue that pollution does not undermine human well-being in the long run. Although air pollution continues to worsen in developing nations, they are just making the same trade-offs that developed nations did during the Industrial Revolution. Indeed, as Lomborg (1998) states, "the environment and economic prosperity are not opposing entities: without adequate environmental protection, growth is undermined, but environmental protection is unaffordable without growth" (p. 210). Thus following the path of developed nations, as the developing world achieves higher levels of income, it will choose and be able to afford an ever cleaner environment.

William Baxter (1974) echoes Simon and Lomborg by contending that only humans should count in the calculus of determining optimal pollution. This does not mean that other species will be wantonly destroyed, he maintains, because humans both depend on them and enjoy them for aesthetic and recreational reasons. It does mean, however, that the claim "DDT use is damaging penguin populations" does not automatically mean that people must stop the use of DDT. In order for this result to follow, Baxter claims that it must be shown that the well-being of people would be less impaired by discontinuing the use of DDT than by harming penguins. This conclusion is rejected by theorists such as Aldo Leopold (1949), who argued that humans must take the *integrity, stability, and beauty* of the biotic community directly into account when making decisions that impact the environment. Indeed perspectives and values play an enormous role in how one perceives pollution and the state of the planet. For example, the controversies aroused by the works of Simon and Lomborg show that measuring pollution is as much a political as a technical endeavor.

From a traditional economic standpoint, pollution can be classified as an externality, that is, an unintended and unaccounted for spillover effect on an unconsenting third party. A good example is industrial activities in the Midwestern United States leading to acid rain in the Northeastern United States and Canada. This definition logically leads to attempts to fix market failures (instances where not all costs are appropriately taken into account). Thus environmental economists attempt to quantify the costs of pollution and integrate them into market transactions. Many models use the willingness-to-pay criterion or cost-benefit analyses to establish these costs. The philosopher Mark Sagoff (1988) argued this form of economics and its narrow notion of *physical spillover* would not rule out many projects or policies that might seem appalling, for example, the attempted conversion of Mineral King Valley in California into a Disney resort. Such a narrow notion leaves no room for many aesthetic and ethical values.

This led economists, especially since the 1970s, to replace the notion of physical spillover with that of transaction or bargaining cost in evaluating the efficiency of a project or a policy concerning pollution. The focus was thereby widened to cover any unpriced benefit or cost (that is, anything a person might be willing to pay for) even if markets do not typically price it correctly. However, as Sagoff also argues, if the wider, more recent notion of transaction or bargaining cost is used, then economic calculations establish policy goals, in the process reducing factual, moral, and aesthetic judgments to mere preferences. But economists have replied that these economic analyses are assessment tools, not decision-making mechanisms. Whatever method of analysis, policymakers need information and tools that will allow them to examine more explicitly and precisely, whether quantitatively or qualitatively, what those affected value about their programs, and how the value of these programs can be assessed. Even if cost-benefit analysis and willingness-to-pay are inadequate, the question remains: How to value?

Sagoff argues that traditional economic methods for determining optimal pollution are insufficient because they place individuals in the role of mere consumers or bidders. Instead he claims each individual should play the role of citizen or trustee of one's own and others' health and well-being. On this view, questions should aim to determine not what individuals would be willing to pay for their health and well-being, but what they would exchange these things for. That is, a willingness-to-sell criterion should be used. This implies that citizens have property rights to an unpolluted environment, thus assigning them the role of sellers and not mere bidders. As such, they may be unwilling to sell those rights or willing to sell them only at a much higher price than they would have been willing to pay for them. One question is whether this leaves room for consent and respect of property rights.

Smokestacks from a factory in Pittsburgh, Pennsylvania, belch black smoke into the atmosphere. (*© Bettmann/Corbis.*)

Solving Pollution Problems

The natural reaction to pollution problems by polities has been to use command-and-control style regulations and legislation. Indeed, around 300 C.E. local Roman magistrates passed laws regulating certain sources of air pollution in York, England, and in 1272 Edward I banned the use of *sea coal,* while parliament ordered punishment by torture and hanging of people who sold and burned the outlawed coal. The rise in environmental consciousness in the United States in the early 1970s saw the continuation of this trend as government legislation and agencies multiplied to prevent and decrease pollution. Some examples include the National Environmental Policy Act, 1969; the creation of the EPA, 1970; Clean Air Act Amendments, 1970 and 1977; the Clean Water Act, 1972 and amended in 1977; the Endangered Species Act, 1973; and the Toxic Substances Control Act, 1976.

Pollution does not respect political borders, however, and transboundary issues have increasingly required international cooperation in the development of pollution regulations. One notable example is the UN Framework Convention on Climate Change (Framework Convention), formally established in March

1994, which is a constitutive body specifying rules for making decisions about global climate change. Its major outcome is the 1997 Kyoto Protocol, which attempted to prescribe legally binding targets and timetables for emissions reductions. The most successful example of international cooperation to control pollution is the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer.

Although government approaches to pollution problems often result in important successes, they also betray the fact that there are governmental failures just as there are market failures. Several reasons for these failures exist. On the international level, bodies such as the Framework Convention often lack political power. Bureaucrats, like all people, are self-interested, and when governmental structures are not designed to link authority with responsibility for program outcomes, "decision makers have few incentives to consider the full social costs of their actions" (Baden and Stroup 1981, p. v). Furthermore decision makers have only a limited capacity to comprehend complex social and environmental interactions, which can constrain their ability to make wise regulatory decisions.

One response has been to improve the structure of government, but another reaction has been to improve the structure of markets by implementing what Terry Anderson and Donald Leal term *Free Market Environmentalism* (1991). The underlying philosophy of this regulatory approach is that markets and environmental concerns can be made compatible by internalizing costs and establishing the proper incentives. They write, "Instead of intentions, good resource stewardship depends on how well social institutions harness self-interest through individual incentives" (p. 4). Examples of utilizing market mechanisms for pollution abatement include green taxes, marketable emissions permits (for example, cap-and-trade systems), and the elimination of harmful government subsidies. Command-and-control and free market regulatory strategies can often be used in conjunction to achieve desired outcomes. One example is cost-effectiveness analysis, where courts or legislatures establish goals, but economists utilize cost-benefit analyses to establish the cheapest ways of attaining those independently set goals within the market.

Technological innovations have been a major force in pollution prevention and abatement as industry has been either forced to comply with regulations or more subtly incentivized to increase efficiencies and reduce pollution outputs. For example, smokestack scrubbers and catalytic converters in automobiles mitigate pollution problems originally caused by the technologies of electricity generation and automobile transportation. Although instances of technological fixes to pollution problems abound (as well as technological devices to monitor pollution), it is also true that technologies continually present novel pollution problems. This holds for the thousands of novel synthetic chemicals produced every year (of which very little is known about possible long-range health impacts) as well as potential future scenarios such as the emergence of *grey goo*, unrestrained nanobot replication, that could potentially wreak havoc on human and environmental health (see Joy 2000). Such devastating possibilities (not to mention the realities of disasters such as the deadly poison leaked from the Union Carbide insecticide plant in Bhopal, India in 1984) cause some to argue for the relinquishment of potentially harmful technologies or even the abandonment of industrial capitalism and the modern way of life (see for instance Bradford 2001). Others claim that society must develop defensive technologies in an arms race to stay ahead of destructive technologies. For example, Ray Kurzweil (2003) envisions *blue goo*, police nanobots that combat the bad nanobots, as the solution to potential unrestrained nanotechnology self-replication.

For the most part, society has come a long way from the 1952 killer smog in London, which caused an estimated 4,000 deaths in a three-day period. As Lomborg (1998) asserts, London has not been as clean as it is now since 1585. Systems thinking is also catching on in the form of industrial ecology, material flows assessments, and product life-cycle analyses. Yet all is not well. Developing nations are at least temporarily experiencing high levels of pollution as they begin to industrialize. Poor peoples, even in developed nations, continue to suffer disproportionate hazards from pollution. Radioactive waste and CO_2 emissions remain long-term issues with potentially disastrous outcomes. In both of these cases, it has become apparent that the political challenges of altering behavior, making trade-offs between competing goods, and finding common ground in contexts marked by a plurality of values is even more daunting than the technical challenges presented by pollution. Work is needed in crafting flexible, democratic mechanisms for deciding optimal levels of pollution.

A. PABLO IANNONE

SEE ALSO *Automobiles; Aviation Regulatory Agencies; Conservation and Preservation; Dams; Ecology; Environmental Ethics; Environmental Regulatory Agencies; Global*

Climate Change; Three Gorges Dam; United Nations Environmental Program; Waste; Water.

BIBLIOGRAPHY

Anderson, Terry, and Donald Leal. (1991). *Free Market Environmentalism*. San Francisco: Westview Press. The first comprehensive treatment of the idea that free markets can achieve environmental goals.

Baden, John, and Richard Stroup. (1981). *Bureaucracy vs. Environment: The Environmental Costs of Bureaucratic Governance*. Ann Arbor: University of Michigan Press. Outlines the failures of bureaucratic solutions to environmental problems and offers suggestions for reforms based on aligning incentives with valued outcomes.

Baxter, William F. (1974). *People or Penguins: The Case for Optimal Pollution*. New York: Columbia University Press. Argues that a pollution-free society cannot exist without harming people.

Bradford, George. (2001). "We All Live in Bhopal." In *Environmental Ethics: Readings in Theory and Application*, 3rd edition, ed. Louis P. Pojman. Belmont, CA: Wadsworth.

Joy, Bill. (2000). "Why the Future Doesn't Need Us." *Wired* 8(4): 238–262. Also available from http://www.wired.com/wired/archive/8.04/joy.html. A pessimistic outlook on the impending loss of human control as genetics, nanotechnology, and robotics develop the ability to self-replicate.

Kurzweil, Ray. (2003). "Promise and Peril." In *Living with the Genie: Essays on Technology and the Quest for Human Mastery*, ed. Alan Lightman, Daniel Sarewitz, and Christina Desser. London: Island Press. Examines mid- and long-term hopes and dangers presented by technologies in the field of genetics, nanotechnology, and robotics.

Leopold, Aldo. (1949). *A Sand County Almanac: And Sketches Here and There*. London: Oxford University Press. Articulates the Land Ethic, which has inspired much thinking in nonanthropocentric or biocentric and systems-thinking in environmental ethics.

Lomborg, Bjørn. (1998). *The Skeptical Environmentalist: Measuring the Real Sate of the World*. Cambridge, UK: Cambridge University Press. A well-documented account of the positive trends in human welfare, including a section devoted to the decline in pollution problems.

Sagoff, Mark. (1988). *The Economy of the Earth*. Cambridge, UK: Cambridge University Press.

Simon, Julian. (1981). *The Ultimate Resource*. Princeton, NJ: Princeton University Press. Attacks the neo-Malthusians by arguing that human ingenuity effectively makes resources unlimited in the long run.

POLYGRAPH

The polygraph or so-called *lie detector* measures physiological responses to stress experienced by a subject during the course of an interrogation. The instrument monitors three physiological states: (a) cardio-vascular responses manifested by changes in blood pressure and pulse rate; (b) galvanic skin resistance that lowers as perspiration increases; and (c) breathing patterns that respond to changes in tension. Changes in any of these patterns can be detected as the subject experiences emotional reactions. The theory behind the polygraph assumes that people encounter measurable physiological changes in the act of deception. The heartbeat increases, blood pressure goes up, breathing rhythms change, and perspiration increases. All of these reactions are recorded on a moving chart for analysis by a trained polygraph technician.

The physiological connection with deception was assumed in the eighteenth century. English novelist Daniel Defoe suggested that "Guilt always carries fear around with it, there is a tremor in the blood of a thief, that, if attended to, would effectually discover him" (Gale 1988, p. 158). In 1915 Harvard psychologist William Marston devised an instrument to monitor the blood pressure of a subject under interrogation. In 1921 medical student John Larson came up with the first true polygraph, adding a measure of respiration along with blood pressure. In the 1930s, Leonarde Keeler integrated Larson's instrument with measurement of electrical skin conductivity into a single machine (Block 1977). Keeler's instrument remains in controversial use in the early twenty-first century in forensic and employment practice.

Supporters of the polygraph claim that it "is one of the most accurate means available to determine truth and deception" (American Polygraph Association 2002, Internet site). But polygraph credibility has yet to become accepted by the scientific community. A major study by the National Academy of Sciences (NAS) in 2002 found that while polygraph data is reliable, it lacks validity. *Reliability* is a measure of consistency, suggesting that the results are the same across different times, places, subjects, and conditions. *Validity* is a measure of appropriateness, suggesting that the test actually measures what it purports to measure. The NAS study found that if there were ten spies among 10,000 government employees, the lie detector would catch eight of them, but 1,598 loyal staff workers would also be falsely accused of deception. If the polygraph tests were adjusted to a much lower sensitivity, only forty-one people would be wrongly accused, but eight of the ten spies would escape detection (Moore et. al 2002). In other words, the polygraph is highly prone to type ii errors or false positives.

Because of such problems, use of the polygraph is practiced only at the fringes of legal and forensic practice, but it is in active use. The polygraph is utilized more for its utilitarian value to extract information than for its ability to measure truth or lies (Lykken 1984). Armed with a deceptively *scientific* instrument, an investigator may be perceived as able to *read the mind* of a subject. The ethical use of lie detection has been rationalized for its ability to extract information, even though the instrument cannot accurately discriminate between truth and lies. In this sense, Immanuel Kant's categorical imperative yields to John Stuart Mill's utilitarian ethic. The end of truth justifies for the modern detective the means of lying. Technical deception is practiced as a means of extracting reluctant truths.

MARTIN RYDER

SEE ALSO *Biometrics; Crime; Justice; Police.*

BIBLIOGRAPHY

Block, Eugene G. (1977). *Lie Detectors: Their History and Use*. New York: David McKay.

Gale, Anthony, ed. (1988). *The Polygraph Test—Lies, Truth and Science*. London: Sage.

Lykken, David Thoreson. (1984). "Polygraphic Interrogation." *Nature* 307: 681–684. Professor of psychology at the University of Minnesota and past president of the Society for Psychophysiological Research, David Lykken has been a leading critic of polygraph industry-sponsored research studies that claim high levels of accuracy.

Marston, William. (1924). "A Theory of Emotions and Affection Based upon Systolic Blood Pressure Studies." *American Journal of Psychology* 35: 469–506.

Moore, Mark H.; Carol V. Petrie; and Anthony A. Braga, eds. (2002). *The Polygraph and Lie Detection.*.Washington, DC: National Academy Press. This publication from the National Academy of Sciences is a report of the Committee to Review the Scientific Evidence on the Polygraph, chaired by Stephen E. Fienberg, professor of statistics at Carnegie Mellon University. The committee's charge was to review research on polygraph examinations with specific focus on the reliability and validity of polygraph test results.

INTERNET RESOURCE

American Polygraph Association. "What is a Polygraph?" Available from http://www.polygraphplace.com/docs/information.shtml#polygraph. The American Polygraph Association represents the position and the interests of the polygraph industry.

POPPER, KARL

Karl Raimund Popper (1902–1994) was a philosopher of science and politics best known for advancing falsifiability as the criterion for distinguishing science from nonscience and for a defense of what he termed the *open society*. Born in Vienna on July 28, Popper received his Ph.D. in philosophy from the University of Vienna in 1928. After teaching secondary school from 1930 to 1936, he fled the rise of Nazism and the impending *Anschluss* by emigrating to New Zealand, where he lectured in philosophy at Canterbury University College. In 1946 he moved to England, and three years later became professor at the London School of Economics, which he developed into a leading center for philosophy of science. He was knighted by Queen Elizabeth II in 1965 and elected fellow of the Royal Society in 1976. Popper remained active as a writer and lecturer until his death in Croydon, Surrey, on September 17.

Philosophy of Science

Popper's philosophy of science emerged in the context of Vienna Circle logical positivism, which held that scientific *and therefore all meaningful statements* are of two kinds, with their truth or falsity accordingly verifiable in one of two ways. Analytic statements (for example, Triangles are three-sided plane figures) are true or false simply on the basis of their conceptual and logical structure; synthetic (empirical) statements (such as The tree is green) are *verifiable* insofar as they can be *tested* by positive sense experience. Any statement that did not fit into one of these categories could not be counted as part of science and was considered cognitively meaningless.

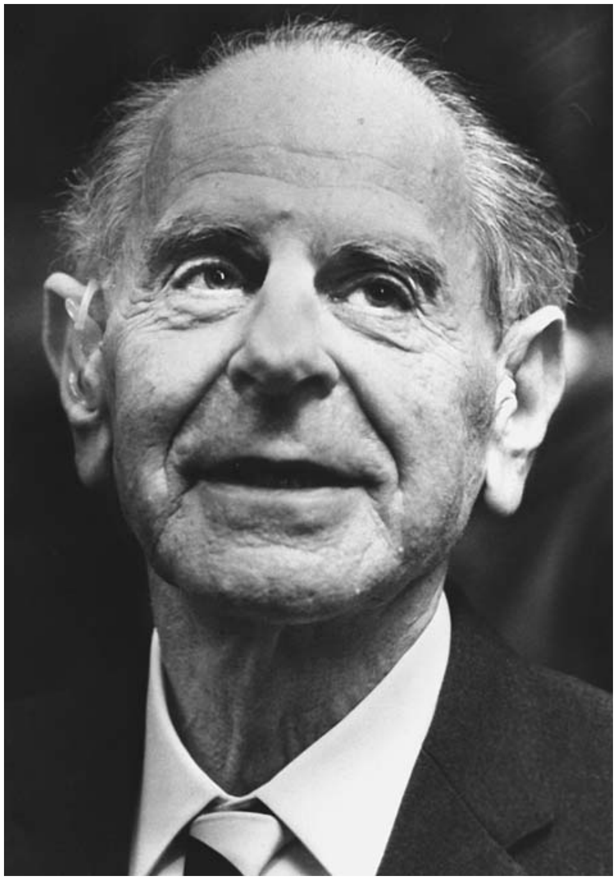
Like the logical positivists, Popper was interested in distinguishing science from nonscience, but rejected its verification theory of meaning. Like others, he wanted to assess the theories of physics, Marxism, and psychoanalysis scientifically, but recognized that for abstract or general synthetic statements in physics (for example, The electron has a negative charge or F = ma) as much as in Marixism or psychoanalysis, it was often difficult to specify their direct derivation from sense experience. But upon hearing a lecture on the theory of relativity by Albert Einstein, Popper, then 17 years old, recognized a unique epistemic feature of Einstein's work, namely, that his theory clearly made some unexpected predictions that, if not observed, would falsify it. This contrasted with the theories of Karl Marx and Sigmund

Freud, which, despite many positive confirmations, were not subject to any straightforward falsification.

Thus in his first book, *Logik der Forschung* (The logic of scientific discovery) (1934), Popper argued that no number of positive confirmations at the level of empirical observation could establish a theory as true or probably true, although a single genuine counterinstance could refute a theory. This asymmetry between verification and falsification—one that could never be definitive, the other that could—provided the basis for a clear demarcation between science and nonscience, and became central to Popper's philosophical analysis of scientific rationality. While recognizing the meaningfulness of nonscientific statements in ethics and metaphysics in ways that logical empiricists refused to do, Popper nevertheless emphatically rejected Marxist and psychoanalytic theories as pseudoscience because he found them nonfalsifiable.

Without verification through confirmation, however, it was difficult to explain how scientific knowledge can accumulate or grow. But, for Popper, a "theory is comprehensible and reasonable only in its relation to a given problem-situation" (Popper 1963, p. 139). His proposed metric of scientific progress was that "the best tentative theories (and all theories are tentative) are those which give rise to the deepest and most unexpected problems" (Popper 1972, p. 286). Thus a rationally acceptable theory is one that can withstand criticisms as a proposed answer to questions posed by a problem-situation shared by members of a scientific discipline.

In short, Popper's response to issues regarding the growth of knowledge was this: Because a theory may be false, the appropriate rational response is to look for its weaknesses in order to get rid of them. Science progresses by the conjecture of bold (more general and falsifiable) theories proposed as solutions to the problems identified in prior theories. This analysis was a major influence on subsequent work in the philosophy of science, especially the turn toward philosophical analyses of the history of science by Thomas Kuhn and others.



Karl Popper, 1902–1994. The Austrian philosopher offered an original analysis of scientific research that he also applied to research in history and philosophy. *(Hulton Archive/Getty Images.)*

Closed and Open Societies

Popper's problem-solving model led him to develop an evolutionary epistemology that accepted true theories and useful technologies as dual aims of science, while denying that either truth or utility can ever be determined definitively. In his effort to lay out the framework in which this evolutionary problem solving takes place, Popper developed a three-world ontology. World 1 is constituted by physical objects, world 2 by subjective experience, and world 3 by objective experience that presents in science, art, ethics, and politics. Popper argued that the world of science, which bears on world 1, evolves in ways analogous to organic evolution.

Popper further contrasted the growth of theory, which tended toward unifying explanations, and technology, which advanced through increased differentiation and specialization. This distinction enabled Popper to extend his critical thinking on theory and praxis to technics, and to balance the judgment that "the critique of technology . . . is urgently necessary," often from the outside, with the insight that it would be dogmatic and irresponsible "to attack science and technology as a whole, when they alone permit the necessary corrections to be made" (Popper 1999, p. 101).

This ability to criticize science and its applications is, for Popper, the central feature of an open society where knowledge is freely available to all. Liberal democracy protects the identity and agency of individuals and allows for the peaceful removal of leaders. It is founded on critical rationalism, in that individuals are free to critique systems of thought and work incrementally through democratic processes toward better conditions.

"This is why rationalism is closely linked to the political demand for practical social engineering—piecemeal engineering, of course—in the humanitarian sense, to the demand for the rationalization of society, to planning for freedom, and to the control of freedom by reason. Such societal goals are not governed by *science,* or by a Platonic, pseudorational authority, but by Socratic reason that is aware of its limitations, and that therefore respects others and does not aspire to coerce anyone—not even into happiness." (Popper 1962, vol. 2, p. 238).

Popper believed that society is no more or less than the aggregate of individuals, and that history is indeterminate because it is driven by the consequences of individual choices rather than intrinsic laws. Thus the link between Popper's philosophy of science and social philosophy is fallibalism. Just as scientific progress is made by subjecting theories to critical scrutiny, so too the open society can be sustained only if individuals are free to critically evaluate government decisions and technological change and to modify each in light of such evaluation. Just as in scientific communities, differences in the open society should be resolved by critical discussion rather than force.

By championing the open society, Popper was primarily refuting the dangerous presuppositions at the heart of closed (totalitarian or authoritarian) societies rather than defending a libertarian ideology. As he argued in both *The Open Society and its Enemies* (1945) and *The Poverty of Historicism* (1961), the closed society is predicated on the related postulates of holism and historicism. Holism is the belief that societies are greater than the sum of their members and that society inexorably influences individuals to shape the course of history. Historicism, in Popper's usage, is the belief that history develops according to certain intrinsic principles toward a determinate end. The most significant implication of historicism is that a scientific method can be used to study history and formulate theories to predict social and political developments.

Popper believed historicism to be theoretically erroneous and socially dangerous. History, he contended, is unavoidably indeterminate and not amenable to predictive theories that can lead to falsifiable claims. Yet the view of history as the unfolding of an internal and knowable logic inevitably leads to totalitarian, centralized regimes. These governments feel justified in carrying out massive social engineering programs in order to fulfill a logic of history. Popper's position is that science must be demarcated from nonscience not only to guarantee the growth of knowledge, but also to guard against a tyrannical regime and the authority it could derive from an erroneous interpretation of history as scientific. For Popper, "The fact that we predict eclipses does not, therefore, provide a valid reason for expecting that we can predict revolutions" (Popper 1963, p. 340). Popper's political philosophy shows that the theoretical task of demarcating and limiting the sphere of science and its influence on human affairs is just as ethically important as the physical and political restraint of dangerous technologies.

Popper also derides the absurdity of a "scientific ethics" that would construct "a code of norms upon a scientific basis, so that we need only look up the index of the code if we are faced with a difficult moral decision" (Popper 1962, p. 237). Setting up scientific criteria of ethics relieves human beings of responsibility and therefore all ethical concerns. Thus scientific ethics (which includes ethical naturalism and its attempt to define human nature or the good) is actually an escape from the urgent problems of the moral life. The escape from personal responsibility is compounded and made more dangerous by the tendancy of tyrants to utilize some concept of scientific ethics (i.e., a knowable, natural law) to develop sociological laws and enforce programs of social engineering based on them. For Popper, then, it is crucial for the open society that moral laws remain distinct from natural laws. Only in this way will human choice, freedom, and rationality be entitled to enter the political realm.

Assessment and Extension

Popper's work has been a major stimulus for ongoing discussions regarding the philosophy of science and political philosophy. Popper's students Imre Lakatos (1922–1974) and Paul Feyerabend (1924–1994) became leading philosophers of science. The former defended Popper's critical and cumulative rationalism against the challenges of Kuhn's historically discontinuous paradigms by interpreting paradigms as research programs. The latter repudiated Popper's critical rationalism in the name of an epistemological anarchism that, he argued, was an extension of Popper's own creative openness. In political philosophy, Popper's historical interpretations of Plato, Hegel, and Marx have been hotly contested, but his overall influence has been salutory in its promotion of democracy and the critical assessment of technology.

One interpreter, Paul Levinson, has sought to bridge Popper's philosophy of science and political philosophy by means of the philosophy of technology. For Levinson, Popper's world 3 is too limited. In Levinson's technomaterialist reformulation of Popper's three-world ontology, the human mind (world 2) acting in and on the material world (world 1) forges technology (world 3). Technology thus "enjoys a unique ontological status commensurate with its unique role in the universe: with the execption of humans themselves, nothing is as special . . . or as different from all other things" (Levinson 1988, p. 80). The practical criticism and revision of technology is for Levinson a material parallel to critical rationalism in science.

DOMINIC BALESTRA

SEE ALSO *Incrementalism; Liberalism; Social Engineering.*

BIBLIOGRAPHY

Levinson, Paul. (1988). *Mind at Large: Knowing in the Technological Age*. Greenwich, CT: JAI Press.

Popper, Karl. (1934). *Logik der Forschung* [The logic of scientific discovery]. Vienna: Julius Springer Verlag. English translation, *The Logic of Scientific Discovery*. London: Hutchinson, 1959.

Popper, Karl. (1961). *The Poverty of Historicism*, 2nd edition. London: Routledge. Revised book version of original articles from 1944.

Popper, Karl. (1962). *The Open Society and Its Enemies*, 2 vols. Originally published London, 1945.

Popper, Karl. (1963). *Conjectures and Refutations: The Growth of Scientific Knowledge*. London: Routledge. The basic statement of Popper's principle of falsifiability.

Popper, Karl. (1972). *Objective Knowledge: An Evolutionary Approach*. Oxford: Clarendon Press.

Popper, Karl. (1999). *All Life is Problem Solving*. London: Routledge. An autobiography.

POPULAR CULTURE

The term *popular culture*, often shortened to *pop culture*, crystallized around the middle of the twentieth century in recognition of the definitive emergence in European and especially North American society of mass-produced and -consumed cultural goods (including novels, recorded music, radio programs, motion pictures, and advertisements). Popular culture products are usually created by people who do not classify themselves as artists, and they are accepted by people who do not think of themselves as exercising aesthetic judgments. Other, more pejorative terms that have been used to refer to this phenomenon are *mass culture* (José Ortega y Gasset and others) and the *culture industry* (Theodor W. Adorno). The term was fashioned after the *pop art* ("popular art") movement that emerged in the late 1950s—a movement that saw artists appropriate images and commodities from consumerist culture as their subject matter. One of the most famous pop artists was the American Andy Warhol (1928?–1987), who created paintings and silk-screen prints of commonplace objects, such as soup cans, and pictures of celebrities, such as the actress Marilyn Monroe. Pop culture involves the representation of any aspect of consumerist society, not just visual, emphasizing the powerful impact of consumerism and materialism on contemporary life. Pop culture rejects both the supremacy of the "high art" of the past and the pretensions of avant-garde intellectualist trends of the present. It is highly appealing for this very reason. It bestows on common people the assurance that artistic texts are for mass consumption, not just for an elite class of cognoscenti. It is thus populist, popular, and public.

"High," "Low," and "Pop" Culture

Culture is a system of shared meanings. The Estonian semiotician Yuri M. Lotman (1922–1993) used the term *semiosphere* to encapsulate that very fact and to emphasize that the ways in which people come to understand the world is through the semiotic filters of the language, music, myths, rituals, and other codes that they acquire in cultural context (Lotman 1990).

The adjectives *high*, *low*, and *popular* have been used with *culture* to differentiate between levels of representation within the semiosphere. "High" culture implies a level considered to have a superior value, socially and aesthetically, than other levels, which are said to have a "lower" value. Traditionally, the high and low levels were associated with class distinctions—high culture was associated with the church and the aristocracy in Western Europe; low culture with "common folk." "Pop culture" emerged in the twentieth century, obliterating this distinction. As John Storey (2003) argues, the idea of pop culture replaced that of "folk" culture, becoming a target of autonomous academic study in the late 1950s when the French semiotician Roland Barthes (1915–1980) showed the importance of studying such things as wrestling and blockbuster movies in terms of how they generate cultural meanings. By the early twenty-first century, the study of pop culture had become a flourishing interdisciplinary area of investigation that had several important journals, including the *Journal of Popular Culture* (founded in 1967).

As Jean Baudrillard (1998) has emphasized, pop culture engages the masses, rather than the cognoscenti, because it takes the material of everyday life and gives it expression and meaning. Everything from comic books to fashion shows have mass appeal because they emanate from within the culture, not from sponsors or authority figures. As such, the makers of pop culture make little or no distinction between art and recreation, distraction and engagement.

The spread of pop culture as a kind of mainstream culture has been brought about by developments in cheap technology. The rise of music as a mass art, for instance, was made possible by the advent of recording and radio broadcasting technologies at the start of the twentieth century. Records and radio made music available to large audiences, converting it from an art for the elite to a commodity for one and all. The late-twentieth-century advent of satellite technology is responsible for the spread and appeal of pop culture throughout the globe. Satellite television, for example, is often cited as bringing about the disintegration of the former soviet system in Europe, as people became attracted to images of consumerist delights by simply tuning into American television programs. The Canadian communications theorist Marshall McLuhan (1911–1980) went so far as to claim that the diffusion of pop culture images through electronic media has brought about a type of "global culture" that strangely unites people in a kind of "global village" (McLuhan 1964). Clearly, the pop culture distraction factory has had an impact on the world far greater than that of the material it communicates.

Pop Culture as a Mythological System

Barthes (1957) claimed that a large part of the emotional allure of pop culture is due to the fact that it is based on the recycling of deeply entrenched mythical meanings. To distinguish between the original myths and their pop culture versions, Barthes designated the latter *mythologies*. In early Hollywood westerns, for instance, the mythic struggle of good versus evil manifested itself in various symbolic and representational forms—heroes wore white hats and villains black ones; heroes were honest and truthful, villains dishonest and cowardly; and so on. The Superman character of comic book and cinematic fame, to cite another example, is a perfect example of a recycled hero, possessing all the characteristics of his mythic predecessors but in modern guise—he comes from another world (the planet Krypton) in order to help humanity overcome its weaknesses; he has superhuman powers; but he has a tragic flaw (exposure to the fictitious substance known as kryptonite takes away his power). Barthes claimed that pop culture is an overarching "mythological system." And because of this it imbues its own representations and spectacles with an unconsciously felt cogency.

As a consequence, Barthes argued, pop culture has had a profound impact on modern-day ethics. In the historical development of ethics, three principal standards of conduct have been proposed as the highest good: happiness or pleasure; duty, virtue, or obligation; and perfection, the fullest harmonious development of human potential. In traditional cultures, these standards were established through religious and philosophical traditions. In pop culture, they are shaped by spectacles, performances, and especially media representations. Ethical issues that are showcased on television, for example, are felt as being more significant and historically meaningful to society than those that are not. Television imbues them with significance and salience.

The power of the media to affect the interpretation of ethical behavior has inevitably led people to stage events for the cameras. The social critic Walter Truett Anderson (1990) calls these appropriately "pseudoevents," because they are never spontaneous, but planned for the sole purpose of playing to pop culture's huge audiences. Most pseudoevents are intended to be self-fulfilling prophecies. The media are thus the vehicles through which people come to grips with issues of lifestyle, ethics, and morality. The understanding of them, however, is fragmentary and ephemeral because the images of media are constantly in flux. The only constant in pop culture is, in fact, constant change. With few exceptions, most pop culture products and styles come and go quickly. Thus, while it has great appeal, pop culture has also had a powerful negative impact on traditional approaches to ethics.

Summary

Pop culture has become virtually mainstream culture, having obliterated the distinction between high, low, and folk culture. It has become a powerful force in modern-day society because it has great emotional appeal and because of its built-in tendency for constant change. The comic-book art of Charles Schulz (1922–2000) is a case in point. His comic strip *Peanuts*, which was originally titled *Li'l Folks,* debuted in 1950, appealing to mass audiences. Through the strip Schultz dealt with some of the most profound religious and philosophical themes of human history in a way that was unique and aesthetically powerful.

The movie *Amadeus* is another case-in-point. This 1984 work directed by Milos Forman (b. 1932) became a pop culture phenomenon in the decade of the 1980s. It is based on the 1979 play by British playwright Peter Shaffer (b. 1926) about the eighteenth-century rivalry between Austrian composer Wolfgang Amadeus Mozart and Italian composer Antonio Salieri. The play plumbs the meaning of art, genius, and the important role of music in the spiritual life of human beings. The film captures these themes visually and acoustically by juxtaposing the emotionally powerful music of Mozart against the backdrop of dramatized events in his life and the truly splendid commentaries of Salieri, who guides the audience through the musical repertoire with remarkable insight and perspicacity. Forman's camera shots, close-ups, angle shots, tracking shots (which capture horizontal movement), and zooming actions allows the viewer to literally see Mozart's moods (his passions, his tragedies, and so forth) on his face as he conducts or plays his music, as well as those of his commentator Salieri (his envy, his deep understanding of Mozart's art) as he speaks to his confessor. In effect, Mozart became a pop culture hero, so to speak, through the power of cinema.

MARCEL DANESI

SEE ALSO *Consumerism; Critical Social Theory; Entertainment; Information Ethics; Movies; Music; Robot Toys; Technocomics; Television.*

BIBLIOGRAPHY

Anderson, Walter Truett. (1990). *Reality Isn't What It Used to Be: Theatrical Politics, Ready-to-Wear Religion, Global Myths, Primitive Chic, and Other Wonders of the Postmodern World.* San Francisco: Harper and Row.

Barthes, Roland. (1957). *Mythologies*. Paris: Seuil. A critical analysis of the mythological structure of pop culture performances, from wrestling matches to blockbuster movies.

Baudrillard, Jean. (1998). *The Consumer Society.* Thousand Oaks, CA: Sage. An acerbic critique of the image-making techniques of consumerist culture and their effect on human cultural development.

Lotman, Yuri M. (1990). *Universe of the Mind: A Semiotic Theory of Culture.* Bloomington: Indiana University Press. A groundbreaking study of the semiosphere, showing that human psychic life is governed by sign-making tendencies that are tied to social context in the same way that human biological life is governed by organic tendencies that are tied to physical context.

Ortega y Gasset, José. (1932). *The Revolt of the Masses.* New York: Norton. Originally published in Spanish, 1929.

McLuhan, Marshall. (1964). *Understanding Media.* New York: McGraw-Hill. The classic study of the effects of technology and media on cultural evolution. The basic idea presented here is that media are extensions of sensory processes and thus felt to be emotionally powerful.

Storey, John. (2003). *Inventing Popular Culture: From Folklore to Globalization.* Malden, MA: Blackwell. In-depth analysis of the ideological structure of pop culture and its manifestations in the political and social spheres.

POPULATION

Population often is said to be the biggest problem facing the world. However, precisely what this problem is varies, depending on whether the issue is meeting basic human needs, the stress placed on the natural environment by increased consumption, changes in family structures, or demographic transitions within nations. Population is at once a conceptual, scientific, technological, ethical, and political issue.

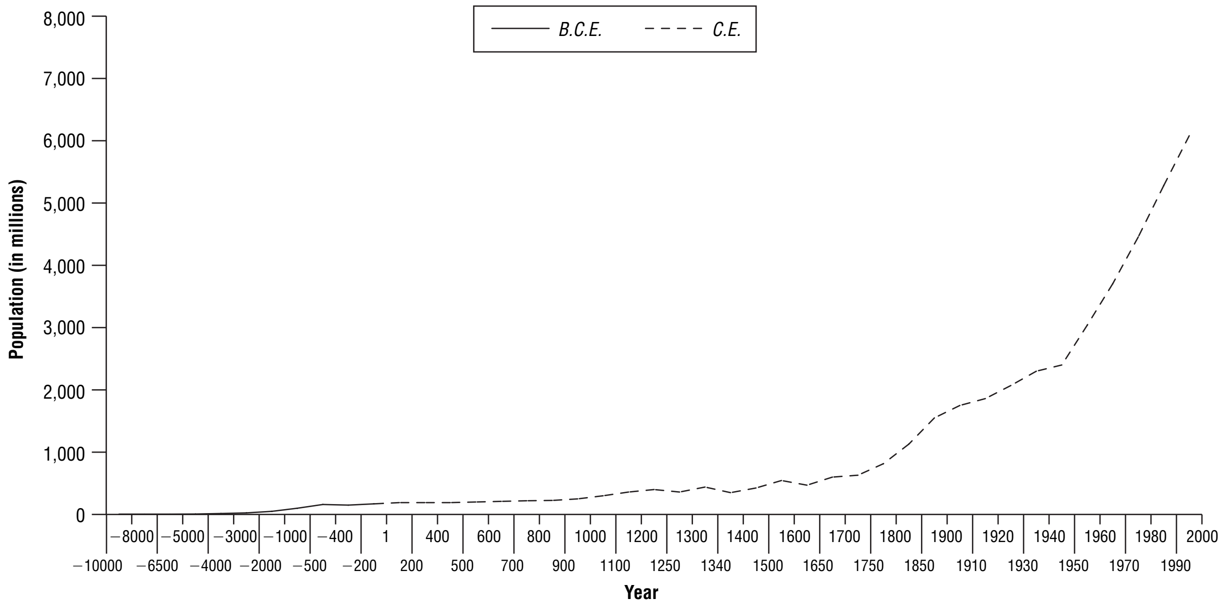
Definitions

The simple definition of population as the total number of persons in a geographic area indicates the relativity of population to sometimes arbitrary boundaries. Other relevant factors in population studies are fertility, mortality, and mobility; empirical studies of those factors are often difficult to pursue and are subject to contentious interpretative frameworks. Scientific theories of population growth and its relationship to social stability or economic development often rely on intuitive or "commonsense" views that have not proved reliable. The influence of technologies on population growth or delimitation similarly is lacking in specificity.

Indicative of the complexity of this issue, the entry "Population Ethics" in the third edition of the *Encyclopedia of Bioethics* is the largest single composite, with more companion pieces than any other entry. Under the general title there are three entries on the elements of population ethics, an analysis of normative approaches, and eight entries describing the perspectives of different religious traditions. In this entry a brief review of how population became an issue is followed by an overview analysis of major ethical assessments that emphasize science and technology.

FIGURE 1

Historical Estimates of World Population



SOURCE: U.S. Census Bureau, Population Division, International Programs Center.

Population Issues

What is experienced directly is not population but people. Before the modern period there were only informal political-philosophical discussions of how different numbers of people in a state can affect its character, and Christian traditions sometimes highlight the biblical injunction to "be fruitful and multiply" (Genesis 1:27). For population to become a subject of debate and inquiry the modern techniques of political economics had to be brought to bear on issues related to both aggregate production and consumption, a process that began in seventeenth-century England and reached its first peak in the work of the economist Thomas Robert Malthus (1766–1834) (Glass 1973).

Before Malthus most early modern population theorists argued for the simple stimulation of population growth (the political philosophers Baron de Montesquieu [1689–1755] and Jean-Jacques Rousseau [1712–1778]) or predicted that in the near future, because of good health and long life, human commitments to procreation would be moderated in favor of more liberal pursuits (the political philosophers William Godwin [1756–1836] and the Marquis de Condorcet [1743–1794]). Malthus attacked both views in his *Essay on the Principle of Population*, which appeared anonymously in 1798 and was revised with acknowledged authorship in 1803 and given the subtitle "Or a View of Its Past and Present Effects on Human Happiness; with an Inquiry into Our Prospects Respecting the Removal or Mitigation of the Evils Which It Occasions." Malthus continued to revise this work, with five more editions appearing during his lifetime.

It was Malthus who formulated what may be considered the classical form of the population problem. Malthus's argument was that population, by increasing when unchecked at a geometric rate (2, 4, 8, 16, etc.), outruns food supply, which grows only at an arithmetic rate (2, 4, 6, 8, etc.). What is known as a Malthusian catastrophe occurs when this happens and starvation forces some of the population back to a subsistence level. For Malthus this catastrophe can be prevented only through self-restraint or technology, meaning contraception or abortion. In later editions of his *Essay* Malthus further noted that increased wealth was correlated with reductions not only in mortality but also in fertility; this suggested that technological development could meliorate the problem more indirectly. However, Malthus did not foresee the ways in which advances in science and technology might alter growth in the food supply.

The central problem for the classical Malthusian view may be described as the extent to which human population increase becomes unchecked through scientific progress. For thousands of years the human population remained relatively stable, checked largely by the vicissitudes of nature. Over the course of the agricultural revolution (roughly 10,000 to 5000 B.C.E.) the human population rose to about 150 million worldwide. Only very slowly, over the next 1,500 years, did it increase to over 300 million. However, by 1700 world population had risen to 600 million, by 1800 to 900 million, and by 1900 to 1.6 billion (see Figure 1). These dramatic increases resulted from decreases in infant and adult mortality brought about by advances in public health technology and medicine as well as in scientific agriculture. In 2000 world population reached more than 6 billion. Food production was able to keep up with population growth as a result of radical developments in agriculture, from the industrialization of agriculture to the Green Revolution.

A second form of the population problem arose in the 1960s in association with the environmental movement. The first population problem was based on doubts that people could extract enough from the earth to support themselves. The second population problem arose from the concern that they would be so successful that they would alter the character of the natural world. The first problem focused primarily on whether humans would be able to sustain themselves, and the second on whether the earth was sustainable in the face of human abilities, through science and technology, to transform the world. The possibility that destruction of the earth might rebound on humans was, of course, a supporting worry.

Central to articulating the second form of the population problem, and thus playing a role similar to that of Malthus in regard to the first form, was the Club of Rome's study *The Limits to Growth* (Meadows, Meadows, Randers, and Behrens 1972). According to the limits to growth argument, which has been argued in equally dramatic fashion in Paul Ehrlich's *The Population Bomb* (1968) and Garrett Hardin's *Living within Limits* (1993), high-affluence industrial societies cannot indefinitely expand the exploitation of inherently limited natural sources such as oil and fresh water or pour wastes into inherently limited ecological sinks such as the oceans and the atmosphere. At some point the resources will run out, the ecological sinks will be full or destroyed, and the societies based on their consumption and pollution will collapse.

In response to this limitationist argument, Julian Simon and other expansionists have argued that science and technology are capable of expanding the resource base indefinitely and transforming pollution into raw materials that can be used for further productive activity. Simon's argument in *The Ultimate Resource* (1980) is that population itself and the human ingenuity manifested in the individuals who make up a free society are a more important resource than is any combination of minerals or vegetables on the planet. Under conditions of economic and political liberty human beings, through science and technology, can create the resources necessary for their indefinite expansion.

Population Ethics

According to Donald Warwick, "Those stating that there is a population problem base their assertions on three elements: perceived threats to social, moral, or political values; factual evidence; and theories explaining how population creates the conditions that threaten values" (Warwick 2004, p. 2035). For Warwick the primary need in population ethics is to distinguish these values, evidence, and theories and carefully adjudicate their interactions. Population ethics depends on an ethics of analyzing population issues that would eschew quick ideological appeals and emotional rhetoric. Those who argue for particular interpretations of population as a problem should state their values, sources of evidence, and theories explicitly. Conclusions and policy recommendations should follow from the careful analytic interrelation of those different elements.

With regard to overarching values Warwick further proposes respect for four fundamental rights: the rights to life, freedom, welfare, and fairness. As for evidence, many people would argue that scientific knowledge should trump other ideas about what should count as data. Theories about the relationships between values and evidence remain fundamentally problematic in relation to population, as they are in many other areas. What is important is to acknowledge the problematics even when conclusions and policy recommendations cannot be avoided because failure to reach a conclusion or make a recommendation will function as a conclusion or recommendation.

Against this background it is nevertheless useful to highlight at least three basic ethical arguments regarding population: what may, for want of better terms, be called limitationist ethics, libertarian ethics, and management ethics. The first two grow out of the limitationist and expansionist interpretations of the problem. The third is more the consensus view of the international development community.

LIMITATIONIST ETHICS. Garrett Hardin (1974) devised the term *lifeboat ethics*, suggesting that because the planet has limited resources, humanity should be thought of as having been cast adrift in space like survivors in a lifeboat. If there are too many passengers, the lifeboat will run out of supplies for those passengers. Using this logic, Hardin states that providing food aid to countries in crisis does not address the problems that created the need for such aid. Hardin's limitationist thesis is that people in poor countries should be allowed to starve because the net result of helping them would be negative for the planet as a whole. In his opinion, extensive food aid would court disaster. Another version of limitationist ethics would argue for limitations on consumption and the practice of voluntary simplicity in the lifestyles of people in wealthy countries.

LIBERTARIAN ETHICS. Julian Simon (1980) argued that the population problem has been fundamentally misperceived. Population growth is a good thing as long as you allow individuals freedom of choice, and grant them the economic and political freedoms to be creative in their uses of science and technology. "Human beings," he wrote, "are not just more mouths to feed, but are productive and inventive minds that help find creative solutions to man's problems, thus leaving us better off over the long run." For Libertarians like Simon, population is not the cause of our problems but the generator of solutions to all of our problems. The more people addressing problems the quicker they will be solved. Thus, population growth is a resource and not a threat to our future. Arne Naess referred to this view as the Cornucopian position.

MANAGEMENT ETHICS. Between the limitationist and libertarian positions is the Management ethics viewpoint. Proponents of this position, like the World Bank, are not as pessimistic as Hardin and the limitationists, nor as optimistic as Simon and the libertarians. The view that population is more of a two edge sword. Managed properly it can be a resource, a boon to the world. Left uncontrolled, it can have disastrous effects.

In a radically different take on the issue Barbara Duden (1992) questions the concept of population as a variable for economic problem solving. For Duden population is such an abstract concept that it creates situations in which human beings are deprived of their humanity as they are transformed into statistics to be manipulated by others. The problem of population is not its role in issues involving environmental resources (the limitationist perspective) or in fostering major misperceptions of problems (the libertarian perspective) but the tendency to lose sight of people in their existential reality as models are created to manage problems.

FRANZ ALLEN FOLTZ

SEE ALSO *Consumerism; Chinese Perspectives: Population Policy; Social Darwinism.*

BIBLIOGRAPHY

Duden, Barbara. (1992). "Population." In *The Development Dictionary: A Guide to Knowledge as Power,* ed. Wolfgang Sachs. London: Zed Books.

Ehrlich, Paul R. (1968). *The Population Bomb.* New York: Ballantine. Revised edition, 1971. Rewritten, with Anne H. Ehrlich, as *The Population Explosion* (New York: Simon & Schuster, 1990).

Glass, David Victor. (1973). *The Population Controversy: A Collective Reprint of Material Concerning the 18th Century Controversy on the Trend of Population in England and Wales. Compiled With an Introduction By D. V. Glass.* Farnborough, UK: Gregg International.

Hardin, Garrett. (1974). "Living on a Lifeboat." *BioScience* 24(10): 561–68.

Hardin, Garrett. (1993). *Living within Limits: Ecology, Economics, and Population Taboos.* New York: Oxford University Press.

Meadows, Donella H.; Dennis L. Meadows; Jürgen Randers; and Williams H. Behrens. (1972). *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind.* New York: Universe Books. This book has been revised or extended as *Beyond the Limits: Confronting Global Collapse, Envisioning a Sustainable Future* (Post Mills, VT: Chelsea Green, 1992) and *The Limits to Growth: The 30-Year Update* (White River Junction, VT: Chelsea Green, 2004).

Simon, Julian L. (1980). *The Ultimate Resource.* Princeton, NJ: Princeton University Press. Revised and enlarged as *The Ultimate Resource 2* (Princeton, NJ: Princeton University Press, 1996).

Simon, Julian, and Herman Kahn. (1984). *The Resourceful Earth.* New York: Basil Blackwell.

POPULATION POLICY IN CHINA

The People's Republic of China (PRC) has the largest population in the world. At the end of 2002, the population in China (excluding Hong Kong, Macao, and Taiwan) was 1.284 billion, and the birthrate was 12.86 births per year per 1,000 population, which results in a doubling every fifty-five years.

Historical Background

The large Chinese population is a result of historical factors. Before 1900 China had a predominately agricultural economy dependent primarily on manual labor, with a standard of living closely tied to the number of working children in a family. Traditionally, having many children brought higher welfare and happiness. As a result, China had a high birthrate.

In the twentieth century, with the gradual improvement of medicine, people's health improved, and as a result, the death rate decreased continuously, from 20 deaths per year per 1,000 population in 1945 to 9.5 in 1965. Since 1980 the death rate has remained constant at close to 6. Because of the huge population base, the number of people in China rapidly increased from 601.9 million in 1953 to 1.0318 billion in 1982. At the same time, employment shifted from agriculture to industry. If China had not instituted family planning policies, a great portion of resources would have had to go to supporting a now nonproductive segment of the population (children), slowing the pace of social development, which would be unfair to present and future generations.

Because high population growth strains societal resources in education, employment, and medical care, as well as other areas, the Chinese government implemented a policy of family planning that considers the interaction of science, technology, economics, and society. For instance, improvements in technology should increase the quality of life, advances in medicine will allow people to live longer lives, but too rapid a decline in the birthrate would mean that younger generations would eventually have to support too large an elderly population.

Policy Guidelines and Their Development

The PRC has adopted the following family planning policies: It encourages late marriage and late, fewer, but healthier babies. It seeks to avoid genetic and other birth defects, which are a disproportionately large drain on societal resources. It advocates a "one couple, one child" policy. It encourages rural couples who have a need for more children to space them properly. The government also provides strong support for family planning policies to raise the level of health among women and children. In 1981 the government established the State Family Planning Commission—now the State Family Planning and Population Commission—which seeks to provide a service-oriented approach to family planning.

Chinese family-planning policy is tailored to meet the practical living needs of people in different regions of the country. Provinces and autonomous regions decide specific family planning measures and regulations for minorities in accord with local conditions. China is also making strides in getting citizens to understand and accept its family planning policies. To this end some politicians and scholars have made great contributions. For example, in 1957 Ma Yinchu, a renowned economist, became a pioneer advocate of family planning when he presented to the National People's Congress his new population theory, in which he recommended controlling population size so as not to impede economic development. Yet Ma was ahead of his time, for he was soon criticized as a representative figure of erroneous idea. He was not able to publish his *New Population Theory* until 1979. In the early 1970s Premier Zhou Enlai also overcame diverse difficulties to promote stable family planning.

Since 1980 many academic societies for research on population and family planning policy have been established. In 1980 the Chinese Academy of Social Sciences created the Institute of Population Research. In 1981 the China Population Society was founded. Institutes for research on the population were in turn set up at Beijing University, Renmin University of China, and Xiamen University. These efforts of the government and research institutes have led to many publications. The government started publishing the *China Population Statistics Yearbook* in 1985 and the *China Population Paper* in 1988. In the late 1990s several important academic publications appeared, including the *Encyclopedia of Chinese Family Planning* (Peng Peiyun 1997). Subsequently, scholars made efforts to relate China's population policy to issues of sustainable development (Qin, Zhang, and Niu 2002), and a number of authors reflected on the importance of limiting the population not just for social development but also for preserving the quality of the environment (Li Shuhua 2003, Peng Keshan 1994, Zhou Yi 2003).

As a result of this research, the significance of family planning policy in the development of science, technology, economics, and society was now generally well recognized and accepted by the early 2000s. The implementation of a family planning policy has effectively controlled the rapid expansion of the population in the PRC, improved the quality of life and health, and made possible the greater development of science, technology, and society.

The Ethics of Population Control

Chinese population policy has been very controversial outside of China. The most common criticism is that the policy deprives people of their right to bear children and to decide for themselves how many children they will have. Another criticism is that because of a traditional desire for male children, the one-child policy encourages parents to abort or abandon female offspring. Within the historical and social context of China, however, the implementation of the "one couple, one child" policy during the 1980s represented a major shift from the much more coercive practices of the Cultural Revolution (1966–1976). Moreover, under some circumstances, Chinese policymakers argue, concerns for the common good should outweigh individual freedoms. Finally, as Margaret Pabst Battin (2004) has argued, although the Chinese policy may be "the most coercive population-limitation policy in any country, it is also the most fair" (p. 2095). Unlike the population-limitation policies of India, for instance, the Chinese policy applies equally to all groups.

WANG QIAN
QIAN QIAN

SEE ALSO *Chinese Perspectives; Eugenics.*

BIBLIOGRAPHY

Banister, Judith. (1987). *China's Changing Population*. Stanford, CA: Stanford University Press.

Battin, Margaret Pabst. (2004). "Population Policies, Strategies for Fertility Control In." In *Encyclopedia of Bioethics*, 3rd edition, ed. Stephen G. Post. New York: Macmillan Reference.

Conly, Shanti R., and Sharon L. Camp. (1992). *China's Family Planning Program: Challenging the Myths*. Washington, DC: Population Crisis Committee.

Li Shuhua. (2003). "Renkou kongzhi yu huanjing lunli" [Population control and environmental ethics]. *Nankai xuebao* (*Zhexue shehuikexue ban*) 2: 97–103.

Ma Yinchu. (1979). *Xin renkou lun* [A new population theory]. Beijing: Beijing chubanshe.

Peng Keshan. (1994). "Kongzhi renkou zengzhang, gaishan shengtai huanjing" [Controlling population growth, improving the ecological environment]. *Kexue xue yu kexue jishu guanli* 12: 10–14.

Peng Peiyun. (1997). *Zhongguo jihua shengyu quanshu* [Encyclopedia of Chinese family planning]. Beijing: Zhongguo renkou chubanshe.

Peng Xizhe and Zhigang Guo, eds. (2000). *The Changing Population of China*. Oxford: Blackwell.

People's Republic of China. State Council. (1994). *China's Agenda 21: White Paper on China's Population, Environment, Development in the Twenty-First Century*. Beijing: China Environmental Science Press.

Poston, Dudley L., Jr., and Baochang Gu. (1995). "Socioeconomic Development, Family Planning, and Fertility in China." In *Developing Areas: A Book of Readings and Research*, ed. Vijayan K. Pillai and Lyle W. Shannon. Oxford: Berg.

Qin Dahe, Zhang Kunmin, and Niu Wenyuan. (2002). *Zhongguo renkou ziyuan, huanjing yu ke chixu fazhan* [Chinese population resources, environments, and sustainable development]. Beijing: Xinhua chubanshe.

Scharping, Thomas. (2002). *Birth Control in China, 1949–2000: Population Policy and Demographic Development*. London: Routledge.

Sung Chien. (1985). *Population Control in China: Theory and Applications*. New York: Praeger.

Tang Re-Feng. (2004). "Chinese Population Policy." In *Bioethics: Asian Perspectives*, ed. Ren-Zong Qiu. Dordrecht, Netherlands: Kluwer Academic.

Wang, Gabe T. (1999). *China's Population: Problems, Thoughts, and Policies*. Brookfield, VT: Ashgate.

Zhou Yi. (2003). "Renkou yu huanjing ke chixu fazhan" [The sustainable development of population and environment]. *Guizhou shifan daxue xuebao* (*Shehui kexue ban*) 2: 23–31.

POSITIVE EUGENICS

SEE *Eugenics.*

POSITIVISM

SEE *Comte, Auguste.*

POSTCOLONIALISM

SEE *Colonialism and Postcolonialism.*

POSTHUMANISM

The posthumanist (sometimes called transhumanist) views human dignity as a matter of seizing the opportunity to modify and *enhance* human nature in ways that include the deceleration or arresting of aging, genetic engineering, the bodily introduction of nanotechnology and cybernetics, reproductive cloning, and even the *downloading of mind* into immortalizing computers. The anti-posthumanist responds that human dignity lies chiefly in accepting the existing contours of human nature as a gift, and that biotechnological efforts to recreate human nature according to inevitably arrogant and short-sighted images of *perfectability* should be greeted with severe skepticism. The debate between posthumanists and their critics over *the future of human nature* is rhetorically sharp; any resolutions can emerge only from inclusive discourse, with significant consensus on specific technologies of human modification arrived at only in the full light of disparate ethical self-understandings of the meaning of humanness both secular and sacred (Habermas 2003).

Radical vs. Qualified Posthumanism

The posthumanist, it is argued, has the superficial enthusiasm of the adolescent convert to some new image of the human, yet has little or no insight into the human condition or the narrative of history. Rather than free humans of biological constraints in a misplaced effort to transcend humanness by technology, the anti-posthumanist urges, to quote Leon Kass's 1985 publication title, "a more natural science."

But many posthumanists are deeply reflective. The 1974 Nobel Laureate in Medicine, Christian de Duve (2002), thoughtfully urges pursuing the goal of a *superorganism* as humans *reshape life,* and raises the question "After us, what?" De Duve warns against fearing the consequences of genetic engineering, or the seduction of a *return to nature* philosophy. De Duve contends that before even thinking of genetically modifying humans, society should focus on improving the chances of all its members to realize the potential they are born with (through suitable economic, social and family conditions). Fears should be focused on resource exhaustion and catastrophic epidemics. Nevertheless future generations will increasingly interfere with the human genome, he argues, and hopefully the decisions will not be left to a powerful bureaucracy, although a *genetic supermarket* using the individual choices of parents is not likely to exert more favorable effects on the gene pool.

Posthumanism as Technological Millennialism

Posthumanists embrace decelerated and even arrested aging, but only as part of a larger vision to re-engineer human nature, and thereby to create biologically and technologically superior human beings, as the narrative history of posthumanism by N. Katherine Hayles (1999) makes clear. Genetics, nanotechnology, cybernetics, and computer technologies are all part of the posthuman vision, including the downloading of synaptic connections in the brain to form a computerized human mind freed of mortal flesh, and thereby immortalized (Noble 1997). This last scenario of immortalized minds liberated from any biological substrate makes the biogerontological goal of *prolongevity* appear conservative.

Posthumanists do not believe that biology should in any sense be destiny, and seek a new sort of entity for whom human nature has been more or less overcome (Hook 2003). They urge humans to take human nature into their own re-creative hands as the next great step in evolution, achieving a post-modern morphological freedom. Their argument begins with the claim that, within the boundaries of technology, humans have always been reinventing themselves through applied technologies. Where should the lines be drawn? Besides as the Princeton University physicist Freeman Dyson writes, "the artificial improvement of human beings will come, one way or another, whether we like it or not," as scientific understanding increases, for such improvement has always been viewed as a "liberation from past constraints" (Dyson 1997, p. 76).

What is natural and what is unnatural, anyway? Homo sapiens long ago embarked on the human phase of evolution through technological prowess, and in the future lies nothing more monumental than increased novelty. At one time the very idea of human beings trying to fly was deemed heretical hubris in the light of eternity—*sub specie aeternitatis*. It would be a repetition of this error to argue that redesigning human nature runs afoul of the precautionary appeal to the complexities of evolution—*sub specie evolutionis?* Should people not set aside trepidation and with confidence rethink themselves in the light of human creativity? The postmodernists have paved the way by purportedly demonstrating that there is no essential aspect to human nature, and *vive le difference*. So it is that Gregory Stock (2002) introduces the idea of *superbiology* as human beings take full control of their own biology in turning toward perfection.

Technological Millennialism as Secularized Religion

David F. Noble (1997) has argued with some plausibility that the roots of this posthumanist project lie in Western European religion, and especially in the ninth century, when the *useful arts* came to be associated with the concept of human redemption. As a result, there exists a *religion of technology* that promotes the uncritical and irrational affirmation of unregulated technological advance. In essence technological advance is always deemed good. Noble hopes people can free themselves from the religion of technology, from which they seek deliverance, through learning to think and act rationally toward humane goals.

Millennialist religion is certainly relevant to the posthumanist vision. As Gerald J. Gruman has pointed out, the modern concern with enhancing longevity "stems from the decline since the Renaissance of faith in supernatural salvation from death; concern with the worth of individual identity and experience shifted from an otherworldly realm to the *here and now,* with intensification of earthly expectations" (Gruman 1966, p. 88).

With the transition to a this-worldly millennialist human horizon, a powerful current of thought emerged in which the goal of significantly extending the length of human life through biomedical science was affirmed. Gruman termed the concept prolongevity as "a subsidiary variant of meliorism, the belief that human effort should be applied to improving the world" (Gruman 1966, p. 89). Carl L. Becker, in his classic work, *The Heavenly City of the Eighteenth-Century Philosophers* (1932), had similarly interpreted the great ideas of the Enlightenment and the merging goals of science as based on a secularization of the medieval idea of otherworldly salvation, resulting in an advance toward a heaven on earth.

Indeed, Francis Bacon (1561–1626), a founder of the scientific method, in his millennialist and utopian essay "The New Atlantis" (1627), set in motion a biological mandate for boldness that included both the making of new species or *chimeras,* organ replacement, and the *Water of Paradise* that would allow the possibility to "indeed live very long" (Bacon 1996, p. 481). Three centuries before Francis Bacon, the English theologian Roger Bacon (c.1220–1292) argued that in the future the 900-year-long lives of the antediluvian patriarchs would be restored alchemically. Like many Western European religious thinkers, both Bacons saw death as the unnatural result of Adam's fall into sin. These dreams of embodied near-immortality could only emerge against a theological background that more or less endorses them. There are various other cultural and historical influences at work besides religion, but the initial conceptual context for a scientific assault on aging itself is a religious one (Barash 1983).

The modern goals of anti-aging research and technology, then, are historically emergent, at least in part, from a pre-modern religious drama of hope and salvation, Renaissance science transferred the task of achieving immortality from heaven to earth in the spirit of millennial hopes. The economy of salvation presented by the Italian poet Dante Alighieri was replaced by the here and now. There is a vibrant millennialist enthusiasm in the responsible biogerontologists, who have proclaimed aging itself to be surmountable to degrees through human ingenuity.

The Anti-Posthumanist Appeal

For every utopian there is a dystopian. Should individuals, viewing their own prospects for deceleration of aging, pursue such anti-aging treatments when and if they actually become available? Perhaps yes, if this assures one that diseases for which old age is the overwhelmingly significant risk factor can be avoided. But there is an important school of thought that cautions against the development of treatments to slow aging.

Individuals, when confronted with the availability of deceleration, ought to reflect carefully about the choice at hand, raising every question of relevance to themselves and to humanity. One of the wiser minds of the last century, Hans Jonas (1903–1993), an intellectual inspiration for contemporary anti-posthumanists, articulated these questions quite thoroughly. He wrote in 1985 that "a practical hope is held out by certain advances in cell biology to prolong, perhaps indefinitely extend, the span of life by counteracting biochemical processes of aging" (Jonas 1985, p. 18). How desirable would this power to slow or arrest aging be for the individual and for the species? Do people want to tamper with the delicate biological "balance of death and procreation" (Jonas 1985, p. 18), and preempt the place of youth? Would the species gain or lose? Jonas, by merely raising these questions, meant to cast significant doubt on the anti-aging enterprise. "Perhaps," he wrote, "a nonnegotiable limit to our expected time is necessary for each of us as the incentive to number our days and make them count" (p. 19). Jonas's later essays raising many of these same questions were published posthumously in 1996.

Many of the these issues are echoed in the writings of Leon Kass. Kass for the most part accepts biotechnological progress within a therapeutic mode; his issue is chiefly with efforts to enhance and improve upon the givenness of human nature. He draws on the technological dystopians, such as Aldous Huxley, as well as on the writings of C. S. Lewis (1898–1963). An early anti-posthumanist, Lewis wrote *The Abolition of Man* (1944) to defend a natural law tradition: What is, is good, and people should live within their God-given limits. He cautioned against a world in which one class of enhanced human beings would dominate and oppress the other. One might ask, then, if those freed from the decline of aging would become the superior and elite humans, while those who age would be deemed inferior.

In a creative essay, "L'Chaim and Its Limits: Why Not Immortality?" (2001) Kass argues against prolongevity in ways mostly raised by Jonas. He asserts, for example, that the gradual descent into aged frailty weans people from attachment to life and renders death more acceptable. He contends that numbered days encourage a creative depth in human nature—a depth that escaped so many of the immortal Greek gods and goddesses, whose often debauched and purposeless behavior made Plato wish to ban them from the ideal Republic. In addition, says Kass, a preoccupation with the continuance of life is a distraction from that which is best for the human soul. Finally Kass writes that in a world transformed by anti-aging research, youth will be displaced rather than elevated, and the parental investment in the young will give way to *my* perpetuation; and that in such a new world people will grow bored and tired of life, having *been there* and *done that*. These assertions are all thoughtful, creative, and appropriately cautionary, because the implications of slowing or arresting aging itself are obviously monumental and mixed. Responsibility to future generations precludes clinging to youthfulness. There is wisdom in simply accepting the fact that humans evolved for reproductive success rather than for long-lived lives Without such wisdom will people lose sight of their deepest creative motives? Possibly.

Another leading anti-posthumanist, Francis Fukuyama challenges those who would march society into a posthuman future, characterized by cybernetics, nanotechnology, genetic enhancement, reproductive cloning, life span extension, and new forms of behavior control. Undoubtedly the ambitions of posthumanists to create a new posthuman who is no longer human are arrogant, pretentious, and lacking in fundamental appreciation for natural human dignity. Fukuyama is also drawn to the dystopian genre and sees much more bad than good in efforts to significantly modify human nature. He argues powerfully that the anti-aging technologies of the future will disrupt all the delicate demographic balances between the young and the old, and exacerbate the gap between the haves and the have-nots. The concerns raised by political scientists such as Fukuyama are ones that the individual decision maker ought certainly to have in mind.

Conclusion

The anti-posthumanists often appeal to nature and character as morally valuable categories. They understand the proper human attitude toward evolved nature as one of humility, awe, and appreciation. Clearly the emerging technological power to control nature does not always constitute progress. The anti-posthumanist exhorts us to work with human nature to get the best out of it, rather than to seek cavalier domination in an effort to recreate what is already good. Better to accept natural limits, or so, anyway, is the spirit of anti-posthumanism. The perfectibility of humankind lies not in modifying the human vessel, but in developing the treasures within, such as compassion, virtue, and dignity.

In summary the natural law traditions represented by anti-posthumanists exhort people to live more or less according to nature, and warn that efforts to depart from that will result in new evils more perilous than the old ones. How can society presume that the brave new world will be a better world? Should not the burden of proof be on the proponents of radical change? What right have people in the early 2000s to impose their own arbitrary images of human enhancement on future generations?

Posthumanist beliefs in the inevitability and desirability of transforming human nature see human beings as essentially technological beings who now have the opportunity to redirect the technological powers that they have been exercising on the nonhuman world onto human nature itself. Just as humans have made the world better through technological mastery, so will they be able to do with human nature, in the first instance by prolonging human life as it currently exists but then ultimately by transforming human life. Such a posthumanist future is the natural outcome of all previous human history and the specific form that a respect for human dignity takes in the twenty-first century.

By contrast, anti-posthumanists suggest that the proper human attitude toward evolved nature is one of humility, awe, and appreciation. Just as past technological manipulations of nonhuman nature have not always been beneficial, so the emerging technological power to control human nature does not always constitute progress.

STEPHEN G. POST

SEE ALSO *Aging and Regenerative Medicine; Artificiality; Bioethics; Cybernetics; Cyborgs; Dignity; Freedom; Future Generations; Human Cloning; Human Nature; Nanoethics; Utopia and Dystopia.*

BIBLIOGRAPHY

Bacon, Francis. (1996). *The New Atlantis*. In *Francis Bacon: A Critical Edition of the Major Works*, ed. Brian Vickers. Oxford: Oxford University Press.

Barash, David P. (1983). *Aging: An Exploration*. Seattle: University of Washington Press.

Becker, Carl L. 2003 (1932). *The Heavenly City of the Eighteenth-Century Philosophers*. New Haven, CT: Yale University Press.

de Duve, Christian. (2002). *Life Evolving: Molecules, Mind, and Meaning*. Oxford: Oxford University Press.

Dyson, Freeman J. (1997). *Imagined Worlds*. Cambridge, MA: Harvard University Press.

Gruman, Gerald J. (1966). "A History of Ideas About the Prolongation of Life: The Evolution of Prolongevity Hypotheses to 1800." *Transactions of the American Philosophical Society* 56 (Part 9). Philadelphia: American Philosophical Association.

Habermas, Jurgen. (2003). *The Future of Human Nature*. Cambridge, England: Polity Press.

Hayles, N. Katherine. (1999). *How We Become Posthuman: Virtual Bodies in Cybernetics, Literature and Informatics*. Chicago: University of Chicago Press.

Hook, C. C. (2003). "Transhumanism & Posthumanism." In *The Encyclopedia of Bioethics*, 3rd edition, ed. Stephen G. Post. New York: Macmillan Reference.

Jonas, Hans. (1985). *The Imperative of Responsibility: In Search of an Ethics for the Technological Age*. Chicago: University of Chicago Press.

Jonas, Hans. (1996). *Mortality and Morality: A Search for the Good after Auschwitz,* ed. L. Vogel. Evanston, IL: Northwestern University Press.

Kass, Leon R. (1985). *Toward a More Natural Science: Biology and Human Affairs*. New York: The Free Press.

Kass, Leon R. (2001). "L'Chaim and Its Limits: Why Not Immortality?" *First Things* 113(May): 17–24.

Lewis, C. S. (1996 [1944]). *The Abolition of Man*. New York: Simon and Schuster.

Noble, David F. (1997). *The Religion of Technology: The Divinity of Man and the Spirit of Invention*. New York: Penguin.

Pepperell, Robert. (2003). *The Posthuman Condition: Consciousness Beyond The Brain*. Bristol, CT: Intellect.

Stock, Gregory. (2002). *Redesigning Humans: Our Inevitable Genetic Future*.

INTERNET RESOURCE

Kass, Leon R. (2003). "Beyond Therapy: Biotechnology and the Pursuit of Human Improvement." President's Council on Bioethics. Available from http://www.bioethics.gov/background/kasspaper.html.

POSTMODERNISM

A movement in the arts and humanities known as *postmodernism* gained a foothold in Western society in the 1980s and 1990s. The term was coined originally by architects in the early 1970s to designate an architectural style that aimed to break away from the dominant modernist style, characterized by indistinct boxlike skyscrapers, apartment complexes, and government buildings that had degenerated into a sterile and monotonous structural formula. Postmodern architects called for greater individuality, complexity, and eccentricity in design, along with the use of symbols with historical value. Shortly after its introduction into architecture, the term started to catch on more broadly, adopted by many in other arts and the humanities.

Philosophical Roots

Postmodernism became fashionable as the articulation of a continuing cultural reaction against "scientific modernism" that initially emerged in Europe during the Romantic period. The origin of scientific modernism is generally traced to the scientific revolution and the Enlightenment, also known as the "Age of Reason." Enlightenment philosophers believed that scientific reason was the best method for discovering truth and that science could eventually solve all the mysteries of life. In the early nineteenth century, the dizzying growth of technology and the constantly increasing belief that science would triumph over religion further entrenched scientific modernism into Western culture. By the end of the century, Friedrich Nietzsche's famous assertion that "God is dead" encapsulated the radical worldview of modernity. This modernist triumph was manifest in architecture and design. Buildings were constructed with new industrial materials such as steel and concrete, and many consumer goods were given a streamlined design. (Modernism in literature, however, was more ambiguous. It both imitated science and technology in some areas, as with experimentation in form and adapting techniques influenced by cinematic montage, while often criticizing science and technology in its content, as in T. S. Eliot's *The Waste Land*.)

Actually, Nietzsche's assertion signaled at the same time the beginning of a reaction against modernism itself. By the early decades of the twentieth century, artists and composers en masse started to express this very reaction through new and unorthodox forms of representation—forms that came to have wide appeal, no matter how different from tradition. When architects rejected the sterile formulas of modernist style, their coinage of the term *postmodern* (literally "after the modern") caught on widely, because it expressed what had, in effect, been happening in the content of other arts for a considerable period of time.

In postmodernism, nothing is for certain. Even science and mathematics are perceived to be constructs of human invention, as subject to human vagary as are the arts. The essence of the postmodern perspective is irony. This is why it is often described as a "deconstructive" approach to knowledge and representation. As the sociologist Zygmunt Bauman has perceptively remarked, postmodernism constitutes "a state of mind marked above all by its all-deriding, all-eroding, all-dissolving *destructiveness*" (1992, pp. vii–viii). By the early twenty-first century, postmodernism had become a topic of study under various academic rubrics, from semiotics and philosophy, to popular culture studies. Among those who are considered to provide significant critical frameworks for any discussion of postmodernism are Jean-François Lyotard (1984), Frederic Jameson (1991), and Jean Baudrillard (1998).

Postmodernity versus Postmodernism

By the early 1980s Western society itself was being labeled increasingly as being "postmodern." For this reason, a distinction emerged between *postmodernity* and *postmodernism*. The former was coined to refer to the social tendency to view absolute systems of truth (such as religious ones) with skepticism, and the latter to any representational technique that exemplifies this tendency. An often-cited example of the latter is Godfrey Reggio's brilliant 1983 film *Koyaanisqatsi*. The movie shows how fragmented the postmodern world is through a series of discontinuous, narrativeless images of cars on freeways, atomic blasts, litter on urban streets, people shopping in malls, housing complexes, buildings being demolished, and so on, all of which mirror the world's spiritual fragmentation. The collage of images paints a turgid, gloomy world populated by countless cars, decaying buildings, and crowds bustling aimlessly about. Reggio incorporates the mesmerizing music of Philip Glass (b. 1937), which reflects the images tonally. Glass's slow rhythms tire viewers with their heaviness, and his fast tempi—which accompany a demented chorus of singers chanting in the background—assault viewers' senses.

Implicit in Reggio's movie is the view that technology has been a destructive force in Western society, rather than constructively—a postmodern theme that runs through many contemporary movies such as *The Matrix* (1999). The struggle of humanity against its technological machinery is seen by postmodernists as part of the contemporary human condition, as is its struggle against deviance and abnormality, portrayed in such postmodern movies as *Blade Runner* (1982), directed by Ridley Scott and *Blue Velvet* (1986), directed by David Lynch.

Ultimately, the aim of postmodernism is to critique the contemporary world and its overreliance on scientific approaches to human behavior, such as psychology. As a critical movement, therefore, it has had an important impact on how people perceive science and all kinds of approaches based on reason and logic. In postmodern representations, human beings are typically portrayed as fulfilling no particular purpose for being alive, and life is depicted as a meaningless collage of actions on a relentless course leading to death and a return to nothingness. But this bleak portrait of the human condition somehow forces a person to think about that very condition, paradoxically stimulating a profound reevaluation of the meaning of life.

Summary

Postmodern ideas have been destabilizing the rationalistic and logocentric (language-influenced) worldview that took shape in the Renaissance. As a cultural movement, postmodernism has made people more inclined to question belief systems in every domain of society, including the scientific one. (Scientists have entered the postmodern debate, either supporting the basic principles of postmodern ideology or rejecting it outright. The principle of indeterminacy in physics, for example, is based on an implicit postmodern tenet—namely, that the observer's interpretation of a physical phenomenon cannot be eliminated from the observation itself. Physics became unconsciously postmodern when it transformed itself into a study of quantum phenomena which entail participation of the observer in the observed.) The main reaction against postmodernism is the age-old one against the concept of relativism—that all truths are constructed—vs. the notion of an objective world where truth can be discovered by reason alone.

This does not mean, however, that postmodernity is devoid of ethics or a sense of truth and reality. As mentioned, postmodern artists ask the fundamental questions of life: What is a human being? What is real? Is there any meaning to existence? It is true, however, that they approach these questions in ways that are radically different from previous ethical traditions. Postmodern discourse has had a great impact on modern-day society, influencing the ways in which people perceive such issues as right and wrong, real and unreal, and so on. But the postmodern way of seeing things seems to be losing its social grip during the first decade of the twenty-first century. Like all ideological and intellectual movements of the past, postmodernism has probably run its course, as new social and intellectual trends now embrace a reinvigorated sense of purpose beyond the purely ironic.

MARCEL DANESI

SEE ALSO *Lyotard, Jean-François; Semiotics: Language and Culture.*

BIBLIOGRAPHY

Baudrillard, Jean. (1998). *The Consumer Society*. Thousand Oaks, CA: Sage. An acerbic critique of the image-making techniques of consumerist culture and their effect on human cultural development, inducing a generic postmodern worldview in society at large.

Bauman, Zygmunt. (1992). *Intimations of Postmodernity*. London: Routledge. A classic study of the ironic and destructive fabric of postmodernity.

Jameson, Frederic. (1991). *Postmodernism; or, The Cultural Logic of Late Capitalism*. Durham, NC: Duke University Press. The most-quoted critique of capitalism from the standpoint of postmodern theory, deconstructing the social texts that capitalist culture produces on a regular basis.

Lyotard, Jean-François. (1984). *The Postmodern Condition: A Report on Knowledge,* trans. Geoff Bennington and Brian Massumi. Minneapolis: University of Minnesota Press. An in-depth study of postmodernism, postmodernity and its consequences on social processes. It is both a praise of postmodern thought and an implicit warning of its overall destabilizing effects.

POVERTY

The elimination of world poverty, along with such concerns as the protection of the biosphere and the maintenance of peace, is generally counted among the global challenges facing humankind in the twenty-first century. In the mainstream account, poverty is the state of individuals who lack sufficient money or material possessions required for a dignified life. It usually implies living under the constant threat of starvation, sickness, and social exclusion. Global poverty is intolerable for societies oriented toward the achievement of material affluence and freedom; its eradication is therefore an ethical imperative for world economic policy. The role of science and technology, however, is a contested terrain; whether they are part of the problem or the solution depends on how poverty is understood and acted upon.

Disputed Definitions

Global poverty, understood as a category that comprises nations with low income, is a statistical construct. It is based on the comparison of aggregate national income figures, an operation that was first performed in the early 1940s. As societies are ranked according to a single quantitative scale, each nation is assigned a position in the hierarchy of income, which, below a certain poverty line, may be classified as poor. Likewise, global poverty as a category for classifying households worldwide is based on the ranking of household incomes, which, below a certain poverty line (for example, one or two dollars a day) are defined as poor. In both cases, the multidimensional diversity of living conditions on the globe is thus reduced to a unidimensional difference between income levels. Such a model of the world, while providing order and orientation, rests on a belief in the primacy of economic success over any other civilizational achievement. It had emerged during the rise of national economies in Europe and the United States; its projection upon the rest of the world triggered the rise of the development epoch after World War II (Sachs 1992).

Since the 1970s, however, the income definition of poverty has been recurrently contested, reflecting profound disagreements about the socially good and desirable. On a first level, measurements of objective poverty disregard subjective poverty. Yet how people perceive themselves is an important dimension of poverty. Calling people poor who do not think of themselves in this way may be misleading, offensive, or both.

On a second level, indicators that focus on absolute income fail to account for the relative nature of poverty, the experience of which varies according to context. As a general standard of living rises, a given amount of income may buy less well-being, because consumption items, such as automobiles, that were once viewed as luxuries may have become necessities, or because activities, such as child care, which were once available free of charge, may have come to involve expenditures. So the modernization of poverty tends to offset the income gains lifting people above the poverty line.

On a third level, income indicators ignore the importance of nonmarket goods and services for well-being. Two households that are equally poor in monetary terms may have quite different levels of well-being depending on access to community networks, environmental assets, and public services. In other words, common wealth is an important source of well-being; neglecting it renders any statement about poverty contestable.

Finally, on a fourth level, because income indicators are usually based on household measurements, they ignore gender inequality within households. But income is seldom equally distributed among family members;

increases in household income tend to favor men over women.

Given the limitations of income as a measurement of poverty, social indicators have been put forth to capture information about a broader range of living conditions (Kanbur and Squire 2001). This approach, which has been particularly promoted by the United Nations Development Programme (UNDP), views income merely as an instrument for achieving desired outcomes. Money matters, but not alone; well-being may be only loosely correlated with income. In this perspective, the poor are seen as deprived of basic capabilities, such as education, health care, longevity, economic opportunities, and legal entitlements, that would permit them to lead the kind of life they value (Sen 1999). How capabilities are shaped depends only partly on household income; variables of age, gender, availability of public goods, market opportunities, and legal security may be equally important.

UNDP's human poverty index, for instance, concentrates on three aspects of human deprivation: longevity, literacy, and living standard. Longevity is measured by premature deaths, literacy by the percentage of adults who are literate, and living standard by the percentage of the population with access to health services and safe water, and the percentage of malnourished children. As it turns out, national income is not necessarily correlated to quality of life. For example, despite their rather low levels of income, the people of China, Sri Lanka, or Kerala, India, enjoy enormously higher levels of life expectancy than do much richer populations of Gabon, Brazil, Namibia, or, for that matter, African Americans in the United States (Sen 1999).

Furthermore, given the limitations of quantitative measurements in general, efforts have been made to represent conditions of poverty through the voices of the poor themselves, using participatory and qualitative research methods (Narayan et al. 2000). How do poor people view poverty and well-being? Again, the picture of poverty shifts; many poor are not primarily concerned about lack of money or services, but lack of security and political voice. Poverty is associated with a state of vulnerability, both as precariousness in the economic sense and as powerlessness in the political sense. Having secure livelihoods is perceived as more important than maximizing income, just as having voice and influence is seen as more relevant than the delivery of services. Such accounts of lived poverty suggest conceptual implications: Poverty results from a lack of power rather than lack of income. It is the outcome of social relationships that are structured in a way in which benefits accrue consistently to one group and costs to another. As aspirations for wealth and power are acted out in society, some groups of people are unable to gain access to life-supporting assets, be they productive, environmental, or cultural, whereas others succeed in securing conditions for stable, productive lives. Poverty can thus be defined as relative powerlessness; its mitigation calls for basic-rights rather than basic-needs strategies. Poverty, in the early twenty-first century, has turned from an issue of economic growth into an issue of human rights.

Contentious Strategies and the Relation to Science and Technology

It is commonplace to call for poverty alleviation, but opinions divide sharply as to how and by whom. Looking back at decades of conflict, a growth-based perspective may be distinguished from a people-based perspective. In the first perspective, poverty alleviation is seen as the collateral benefit of aggregate economic growth, spurred by world market integration and accompanied by redistributional policies. Investors, transnational companies, and planners figure highly as agents of development. In the second perspective, overcoming poverty calls for stronger rights of the poor to land, capital, culture, and participation. The poor themselves are seen as actors capable of shaping their lives, yet constrained by a lack of entitlements and political leverage.

Both perspectives differ also in terms of time and direction. Growth strategies trust in the trickle-down effect, which is expected to eventually spread the benefits of growth throughout society down to the poorest strata. The social and environmental costs of growth in the present are regarded as the price for benefits in the future. In contrast, in the people-based perspective, growth often fails to trickle down; consequently, there is no point in sacrificing human lives and natural resources in the present for speculative gains in the future. Instead, it is regarded as crucial to empower the poor for a dignified life here and now.

As to the direction of poverty alleviation, the growth perspective aims for higher purchasing power, without taking into account nonmonetary sources of well-being. It therefore tends to confuse frugality and destitution, lumping both together under the rubric of poverty (Rahnema 2003). A people-based perspective, however, considers communities that are poor in money capital, yet rich in natural and social capital, as a base of livelihood to build on. But as dams displaced people or cash crops replaced subsistence crops, livelihood economies have time and again been squashed in favor of the money economy. As a consequence, growth, in the name of poverty eradication, has often turned frugality into wealth for a few and destitution for many.

Similar lines of conflict pervade the use of science and technology in poverty alleviation. In a growth perspective, technology appears as crucial factor for raising the productivity of national economies, in particular through infrastructure investments in areas such as transportation, energy, and communications. Predominantly science-based, capital-intensive, and centrally controlled technological systems are expected to deliver growth and are viewed as the royal road to reducing poverty (ADB/OECD 2002).

Any technology, however, has an impact on the structure of social relationships; it allows some to capture the benefits and condemns others to carry the costs. To the extent that dams or highways, hybrid seeds or water supply systems, boost opportunities for the well-off and powerful while shifting additional burdens onto the poor and powerless, technologies have helped deepen poverty. Against this background, people-based strategies attempt to disseminate human-scale technologies that are designed to enhance the power of the weak (ITDG ET.AL 2003). Low-input agriculture, micro-power systems, rainwater collection, and hand-driven radios are examples of alternative technologies that are comparatively low in investment costs, are operated decentrally, and empower the poor in their daily activities. Whether or not technology is up to the ethical challenge of relieving the burden of poverty thus depends in the last instance on the degree of agency they give to the poor. Insofar as technologies enable the poor to broaden their scope of action at low financial, environmental and social cost, they may serve as stepping stones out of powerlessness.

WOLFGANG SACHS

SEE ALSO *Development Ethics; Digital Divide; Green Revolution.*

BIBLIOGRAPHY

Asian Development Bank, and Development Centre of the Organisation for Economic Co-operation and Development (ADB/OECD). (2002). *Technology and Poverty Reduction in Asia and the Pacific*. Paris: Author.

Intermediate Technology and Development Group (ITDG)/UNESCO/Television Trust for the Environment. (2003). VHS and booklet, *Small Is Working: Technology for Poverty Reduction*. London: Author.

Kanbur, Ravi, and Lyn Squire. (2001). "The Evolution of Thinking about Poverty: Exploring the Interactions." In *Frontiers of Development Economics: The Future in Perspective*, ed. Gerald M. Meier and Joseph E. Stiglitz. New York: Oxford University Press.

Narayan, Deepa; Robert Chambers; Meera K. Shah; and Patti Petesch. (2000). *Voices of the Poor*, Vol. 2: *Crying Out for Change*. New York: Oxford University Press.

Rahnema, Majid. (2003). *Quand la misère chasse la pauvreté* [When misery drives out poverty]. Paris: Fayard/Actes Sud.

Sachs, Wolfgang, ed. (1992). *The Development Dictionary*. London: Zed.

Sen, Amartya. (1999). *Development as Freedom*. New York: Knopf.

POWER SYSTEMS

Power systems represent the class of technologies used to generate electricity. The cost-effective generation, distribution, and use of electricity since the early twentieth century have changed ways of life in developed and developing countries alike. Electricity has made possible a special kind of economic and technological development, including conveniences at home and increased productivity at work. It is what drives modern society and is the foundation upon which the digital age is being built.

However electricity production has also had major impacts on the biosphere. The production of electricity, which is generated primarily from carbon-based fuels, has contributed largely to the increase in greenhouse gases. Electricity production is also responsible for acid rain and smog precursors, as well as mercury and other toxic air pollutants. In addition, two-thirds of electricity production globally is from nonrenewable resources. Thus an electrified society places future generations at risk by both destroying the biospheric services on which they depend for survival, and depleting natural resources. If one accepts a moral obligation for the health and happiness of future generations, the current power system model should be reconsidered.

Production Developments

A curiosity before the 1880s, electricity entered the mainstream in 1882 when Thomas A. Edison began generating and distributing direct current (DC) electricity from his Pearl Street station in New York City. This was soon followed by a host of other generation and distribution systems, most notably by George Westinghouse, who in 1895 began to produce alternating current (AC) electricity from a power plant at Niagara Falls. Soon after AC electricity became the dominant form used in homes and businesses. From 1900 through the 1930s, new appliances, such as vacuum cleaners, washing machines, refrigerators, radios, and televisions, found their way into U.S. and European homes; the Electric Age had begun.

The first electric power plants burned coal or wood to produce steam to power electric generators. In the United States and Europe fossil fuels dominated power markets throughout the first half of the twentieth century. For example, in the United States in 1950, production of electricity from coal, oil, and gas was 46 percent, 10 percent, and 13 percent respectively, while hydroelectric dams produced about 30 percent of the total.

In the 1960s, nuclear power was harnessed to generate the heat needed to power steam turbines. In the early twenty-first century in some countries, such as France, nuclear power contributes a majority of electricity. In the United States, fossil fuels still dominate, as shown in Tables 1 and 2.

The electrification of the industrial world is almost complete. However many people in the developing world still live without electricity. As these nations develop, electricity will surely play an increasingly important role. Even with advancements in energy efficiency and flattened population growth projections, one would expect significant increases in electricity consumption in the developing world throughout the twenty-first century.

Electrification of highly populated developing countries, particularly China and India, may have significant global repercussions. If the electrification of these countries occurs using fossil fuels such as coal, there are grave concerns about the impacts on greenhouse gas emissions and global warming. Similarly, if these countries move toward a nuclear future, concerns about weapons proliferation, safety, and nuclear waste management present additional challenges.

TABLE 1

U.S. Fuel Use for Electricity, 2002

Fuel Type	Percentage
Coal	50.2%
Petroleum	2.3%
Natural Gas	17.9%
Nuclear	20.3%
Hydro	6.9%
Other Renewables	2.2%

*Percentages may not add to 100% due to rounding.

SOURCE: U.S. Energy Information Administration.

Future Assessment

Those in the developed world cannot expect developing countries to forego electrification as they move along the development path. However technical solutions may exist to limit the global problems associated with electricity production. One such solution is renewable energy. Although new hydroelectric dam sites are becoming scarce, electricity opportunities from wind, solar, and biomass are increasing. Wind power is now competitive with fossil fuels in many areas, while solar technologies are currently cost effective in some remote locations or niche applications. Issues such as energy storage and delivery currently plague these technologies, but with appropriate technological advancements and economic assistance, the developing world may be able to achieve a future that has eluded the industrialized world—carbon-free electrification.

Another energy source that looks promising and would support a renewable electric future is hydrogen. Because hydrogen can be produced from the electrolysis of water, one could envision a system whereby electricity produced from a renewable resource, such as solar photovoltaics, could be used to generate hydrogen. This hydrogen could be stored and transported, and ultimately used in fuel cells to produce electricity where needed. However, despite recent media attention on hydrogen and the so-called hydrogen economy, the current state of technology and costs suggest that hydrogen will not become a genuine competitor to fossil fuels before the mid-twenty-first century.

The development of carbon sequestration technologies may provide another solution to biospheric problems posed by carbon-based power systems. These technologies are able to capture carbon emissions from power plants and transform or store this carbon to prevent atmospheric discharge and greenhouse gas buildup in the atmosphere. Considerable research is also being invested in other ways to reduce carbon emissions from coal-fired power plants.

Ethical Issues

The ethical implications of power production rest on the seriousness with which society holds its responsibilities to future generations. Since energy markets cannot adequately internalize the costs of fossil-fuel power generation (both in terms of current and future environmental externalities), many argue that government poli-

TABLE 2

World Electricity Production by Fuel, 2000

(Billion Kilowatt-hours)

Region	Thermal	Hydro	Nuclear	Geothermal and Other	Total
North America	2,997.1	657.6	830.4	99.0	4,584.0
Central & South America	204.1	545.0	10.9	17.4	777.4
Western Europe	1,365.4	557.5	849.4	74.8	2,847.1
Eastern Europe & Former U.S.S.R.	1,043.7	253.5	265.7	3.9	1,566.9
Middle East	425.3	13.8	0.0	0.0	439.1
Africa	333.7	69.8	13.0	0.4	416.9
Asia & Oceania	2,949.2	528.7	464.7	43.1	3,985.7
World Total	**9,318.4**	**2,625.8**	**2,434.2**	**238.7**	**14,617.0**

SOURCE: U.S. Energy Information Administration.

cies and international agreements are needed. However there is still uncertainty surrounding the distributional impacts of global warming (across space and time). This uncertainty has been used to thwart regulatory actions aimed at curbing carbon emissions from fossil-fuel power plants. Assuming continued uncertainty about the long-term impacts of greenhouse gas emissions, one would expect governments to be slow to take action in the near term. The development of marketable, cost-effective competitors to fossil fuels will likely be needed to displace early-twenty-first-century power systems. Thus far such technologies do not seem imminent.

JAMES J. WINEBRAKE

SEE ALSO *Alternative Energy; Alternative Technology*.

BIBLIOGRAPHY

Smil, Vaclav. (2003). *Energy at the Crossroads*. Cambridge, MA: MIT Press.

Winebrake, James J., ed. (2004). *Alternate Energy: Assessment and Implementation Reference Book*. Lilburn, GA: Fairmont Press.

INTERNET RESOURCES

Energy Information Administration. U.S. Department of Energy. Available from http://www.eia.doe.gov.

IEEE. (2005). "How Electricity Came to Be." Available at the IEEE Virtual Museum http://www.ieee-virtual-museum.org/.

PRAGMATISM

"Pragmatic" seems to have been used for the first time in the modern Western philosophical tradition by Immanuel Kant (1724–1804); for him, there was some connection with ethics, but little with science or technology in the modern sense. In the early twentieth century, pragmatics turns up as a third subdivision of a formal semantics triad (see Morris 1938), but it has only a remote connection to science by way of mathematics, and none to ethics or technology.

In most introductory accounts, "pragmatism" as a term for a philosophical approach is usually taken to be synonymous with a "pragmatic theory of truth." We can be sure about something if it has practical or real-world consequences. Enemies of philosophical pragmatism even caricature this as meaning that the test of the truth of a statement—even about ethics—is whether or not it works. Such characterizations are unfair to the nuanced thought of philosophers who have been willing to call themselves pragmatists—as has occurred during two periods: in the period of "classical American philosophy" (see Stuhr 2000) at the beginning of the twentieth century, and again at the end of the twentieth century.

Classical Pragmatists

In the early twentieth century, a number of philosophical pragmatisms sprang up, for example, that of Giovanni Papini (1881–1956) in Italy and Edouard Le Roy (1870–1954) (see Stebbing 1914) in France; but the best known of these was the school (in the loose sense) of American pragmatism, beginning with Charles Sanders Peirce (1839–1914) (who chose to call his approach "pragmaticism") and William James (1842–1910). But the best known of the American pragmatists was John Dewey (1859–1952), whose ideas were closely paralleled by those of his friend and colleague, George Herbert Mead (1863–1931). (On the classical pragmatists, their relationships with one another and with the term, see Menand 2001.)

The basic move of the classical pragmatists was to seek to replace what may be termed the epistemological account of knowledge as justified true beliefs (a definition that can be traced back to Plato [427–347 B.C.E.]) with an analysis of beliefs in terms of relationships to human action. Traditional epistemologies sought to identify the foundations of knowledge in some special cognitive activity or method. Peirce, however, adapting the suggestion of Alexander Bain (1818–1903)—a Scottish philosopher and friend of John Stuart Mill (1806–1873)—argued that beliefs are more properly interpreted as habits of acting than as representations of reality, and so not in need of some special foundations. All pragmatists reject both conceptual reference (concepts are true if they refer to real things) and coherence (concepts are true if they fit together logically) theories of knowledge prominent in empiricism and rationalism, respectively, in favor of some interpretation of inquiry that unites theoretical and practical knowledge as grounded in forms of learning to operate more effectively in the world. Such an approach easily ties knowing into science and technology, and in some instances to ethics, although this happens in different ways in different pragmatisms.

In this respect, the pragmatism of Dewey and Mead exhibited a special relationship to science, technology, and ethics. For Mead and Dewey, ethics is not a theoretical discipline but simply social problem solving using "the scientific method." What this meant for them was applying expert knowledge from *all* the sciences—from the natural sciences and engineering to sociology or social psychology—in democratic efforts of particular communities to solve urgent social problems. The communities in question ran the spectrum from families and technical communities all the way up to the world community, in the former League of Nations. As one of the best of recent interpreters of Dewey, Larry Hickman (2001, p. 51; see also Hickman 1990), puts the matter, Dewey thought that it is possible "to articulate a general method of intelligence that takes into account successful inquiry in many different areas of human activity," including various sciences, the arts, politics, jurisprudence, and so on. Yet while contemporary science-based technologies have made major contributions to this general method of intelligence, they are only one of many sources. In this way, Hickman thinks, Dewey avoids the charge that he favored scientism. Mead's version of the same general approach can be seen in the title of his "Scientific Method and the Moral Sciences" (1964).

Both Mead and Dewey had lifelong contacts with colleagues in the science departments of their universities and kept abreast of developments in the sciences, perhaps especially in physiological psychology but also in physics and biology and other fields. (On this aspect of Dewey's work, see Dalton 2002.) As for technology, both Mead and Dewey were highly critical of the then-new corporations, with their research and development laboratories. The problem was that the corporations were so often involved in what amounted to private wars to break the power of the new labor unions. For Dewey,"We must wrest our general culture from an industrialized civilization" in which science "is ultimately a reflex of the social conditions under which science is applied [in industry] so as to reach only a pecuniary fruition" (Dewey 1930, pp. 133–134). Mead's work with progressive reformers—for example, trying to mediate the struggle between strikebreaking corporate managers and the unions in Chicago in the early twentieth century—can be seen in Andrew Feffer's 1993 work *The Chicago Pragmatists and American Progressivism*.

Others among the early American pragmatists in some cases had similar views, but there were also many differences. James, for example, credited Peirce with the originating idea of American pragmatism, referring to Peirce's famous "pragmatic maxim": "A conception can have no logical effect or import differing from that of a second conception except, so far as . . . it might conceivably modify our practical conduct" (from his "Lectures on Pragmatism," 1903). But Peirce was primarily a scientist, mathematician, logician, and philosopher of science, not a social reformer.

James accepted the pragmatic maxim, which he rendered this way: "Grant an idea or belief to be true," then, "what concrete difference will its being true make in one's actual life?" (James 1907; see also James 1909). He was certainly pro-science enough to have founded the experimental psychology program at Harvard, but he also dabbled in spiritualist theories in ways that alienated other experimental psychologists. Moreover, though James was progressive in a patrician sort of way, he seems never to have given a thought to union organizing, and watched the "Chicago school's" activism in, at best, a detached sort of way (see McDermott 1967 and Gale 1999).

In summary, among these early American pragmatists, Peirce was primarily a philosopher of science interested in doing away with any certainty-seeking foundationalism of a Cartesian sort. James was the suave elder statesman, interested in pushing science, especially evolution, as a new cultural force, while maintaining a place for a liberal religion in this new culture. Mead and Dewey pushed pragmatism in the direction of progressive social reform, including a critique of the newly-powerful science-based corporations, basing their reforms on "the scientific method." This meant primarily a respect for expertise of all kinds, as long as it was combined with a democratic citizen activism aimed at challenging old verities while working out new and better social arrangements. Dewey was explicit that the only contribution of theoretical philosophizing in the traditional sense (however important on other grounds) was in "divesting ourselves of the intellectual habits we take on and wear when we assimilate the culture of our own time and place" (1925, p. 40; the view is best represented in *The Quest for Certainty*, 1929, and *Reconstruction in Philosophy*, 1920).

John Stuhr (2000) places the early pragmatists within a tradition of "classical American philosophy," and in doing so he adds context. Their works appeared among and were related to writings of significant American women writers (Jane Addams [1860–1935]), American idealists and personalists (Borden Parker Bowne [1847–1910]), African-American philosophers (Alain Locke [1886–1954]), and non-pragmatist naturalists. (Stuhr, p. 695, cites John Herman Randall, Jr. [1899–1980], as an example.) A similar, equally controversial contextualizing, appears in Cornel West's *The American Evasion of Philosophy* (1989).

Late Twentieth Century Pragmatism

Joseph Margolis (2002) characterizes all the above as the "early" American pragmatism, with which he contrasts the "revival" of pragmatism in American analytic philosophy after about 1980. The main representatives of this revival are Willard Van Orman Quine (1908–2000), Donald Davidson (1917–2003), Hilary Putnam (born 1926), and Richard Rorty (born 1931). In the revived version of American pragmatism, the focus is not on Mead and Dewey's "meliorizing" progressivism, with its suspicion of large science-based corporations, but on quarrels over different versions of epistemology. With the exception of Rorty, who wants his pragmatism (he says it is more literary than philosophical) to join in leftist causes (1998), none of the revived pragmatists have much interest in ethics, less in technology, and an interest in science that is reducible to a scientistic model of human knowing—or opposition to it.

Margolis's is the best summary of these disputes, which he characterizes as involving two challenges to pragmatism: naturalism and postmodernism. The primary debate is between "pragmatism" and "naturalizing"—especially several debates between Rorty (claiming to speak for Quine and Davidson as well as himself) and Putnam. The conflict has to do with how to safeguard a "true" pragmatism from relapsing into a Cartesian quest for a guaranteed foundation of knowledge in science.

To summarize the account, at some cost to nuances, Margolis argues that although they call themselves pragmatists, Quine, Davidson, and Putnam are all concerned with essentially epistemological issues, and that they approach these in ways that are ultimately unfaithful to pragmatist inspirations. Insofar as Quine and others attempt to understand knowing in naturalistic or scientific terms, and turn epistemology into an empirical examination of cognition, they tend to put forth a new kind of foundationalism, which was just what the original pragmatists were at pains to avoid. The late-twentieth-century epistemological pragmatists tend toward realism rather than instrumentalism: that is, they want to defend a view of scientific knowledge as providing a privileged view of the world rather than the process of science as a privileged means or method for living in the world.

Margolis's account of the challenge of postmodernism and its manifestation in Rorty is easier to state. Postmodernism rejects not just science as a privileged form of knowing but science as a privileged method for living. Rorty's postmodernism is thus incompatible with classical pragmatism and its reliance on (but not idolization of) science specifically and expertise generally. For classical pragmatism, the need for the democratic governance of expertise does not reject or deny its benefits.

In the end, Margolis derives his own version of pragmatism from the failures of naturalism and postmodernism. This version places constructivism at the center of pragmatism. In Margolis's words, "questions of knowledge, objectivity, truth, confirmation, and legitimation are constructed in accord with our interpretive conceptual schemes." Thus, "though we do not construct the actual world, what we posit (constructively) as the independent world is epistemically dependent on our mediating conceptual schemes" (p. 22).

Future Prospects

At the end of his analysis, Margolis confesses doubt as to whether even his constructive pragmatism, with its unique combination of the best in pragmatism with the best in recent European philosophy, will succeed in the twenty-first century. (On European, especially German, interest in pragmatism, see Aboulafia, Bookman, and Kemp 2002.) Instead, Margolis fears that the naturalizers will continue to dominate analytical philosophy, especially in neo-Darwinism viewed as the best reductive model of the cultural world; in extreme linguistic views (originating with Noam Chomsky); and in a computational analysis of every form of human perception and intelligence. But Margolis still has hope, though he says at the end that pragmatists have little more than their original intuition to rely on. Other pragmatists would argue that pragmatisms are not based on mere intuition; that pragmatists have good arguments, for example, against reductionism.

All of this epistemological nitpicking among recent pragmatists would leave the earlier pragmatists shaking their heads. Mead and Dewey, and probably also James and Peirce, thought they had good reason to reject any epistemology based on foundationalist projects; such epistemologies are simply inconsistent with their scientific and progressive project (Palmer 2002). Mead (1934, p. 94), as one example, rejected all epistemology as "riff-raff"; and he pointed out, one by one, how all traditional epistemologies (traditional at the time of his writing) depended on individualist assumptions that are incompatible with a view of science as a social undertaking, dependent on a world taken for granted within particular science communities (Mead 1964).

Moreover, the earlier pragmatists have their non-analytic followers; examples include Larry Hickman (1990, 2001) on technology; Sharyn Clough (2003) on feminist science studies; and Glenn McGee (1997), providing a pragmatic ethics of genetic engineering.

Still, it is true that even the earlier version of American pragmatism has difficulties to face—in addition to Margolis's claim that it is analytically naïve and unsophisticated. Some criticisms of a Deweyan philosophy of technology have been collected in Paul Durbin's special issue of *Techne* (2003), and they come from Heideggerians and neo-Heideggerians, from critical theorists and neo-Marxists, among others. In the end, it should be obvious that even the best philosophical version of pragmatism will continue to have its detractors.

PAUL T. DURBIN

SEE ALSO *Democracy; Dewey, John; Expertise; Pierce, Charles Sanders; Science Policy.*

BIBLIOGRAPHY

Aboulafia, Mitchell; Myrna Bookman; and Cathy Kemp, eds. (2002). *Habermas and Pragmatism*. London: Routledge.

Clough, Sharyn. (2003). *Beyond Epistemology: A Pragmatist Approach to Feminist Science Studies*. Lanham, MD: Rowman & Littlefield.

Dalton, Thomas C. (2002). *Becoming John Dewey: Dilemmas of a Philosopher and Naturalist*. Bloomington: Indiana University Press.

Davidson, Donald. (1986). "A Coherence Theory of Truth and Knowledge." In *Truth and Interpretation: Perspectives on the Philosophy of Donald Davidson*, ed. Ernest LePore. Oxford, UK: Blackwell.

Dewey, John. (2003 [1920]). *Reconstruction in Philosophy*, enlarged edition. Mineola, NY: Dover.

Dewey, John. (1925). *Experience and Nature*. Chicago: Open Court.

Dewey, John. (1929). *The Quest for Certainty*. New York: Minton, Balch.

Dewey, John. (1930). *Individualism, Old and New*. New York: Minton, Balch.

Feffer, Andrew. (1993). *The Chicago Pragmatists and American Progressivism*. Ithaca, NY: Cornell University Press.

Gale, Richard M. (1999). *The Divided Self of William James*. Cambridge, UK: Cambridge University Press.

Hickman, Larry A. (1990). *John Dewey's Pragmatic Technology*. Bloomington: Indiana University Press.

Hickman, Larry A. (2001). *Philosophical Tools for Technological Culture: Putting Pragmatism to Work*. Bloomington: Indiana University Press.

James, William. (1907). *Pragmatism: A New Name for Some Old Ways of Thinking*. New York: Longmans, Green.

James, William. (1909). *The Meaning of Truth: A Sequel to ''Pragmatism.''* New York: Longmans, Green.

Margolis, Joseph. (2002). *Reinventing Pragmatism: American Philosophy at the End of the Twentieth Century*. Ithaca, NY: Cornell University Press.

McDermott, John, ed. (1967). *The Writings of William James: A Comprehensive Edition*. New York: Random House.

McGee, Glenn. (1997). *The Perfect Baby: A Pragmatic Approach to Genetics*. Lanham, MD: Rowman & Littlefield.

Mead, George Herbert. (1938). *The Philosophy of the Act*. Chicago: University of Chicago Press.

Mead, George Herbert. (1964). "Scientific Method and Individual Thinker." In *Selected Writings*, ed. Andrew J. Reck. Chicago: University of Chicago Press.

Mead, George Herbert. (1964). "Scientific Method and the Moral Sciences." In *Selected Writings*, ed. Andrew J. Reck. Chicago: University of Chicago Press.

Menand, Louis. (2001). *The Metaphysical Club*. New York: Farrar, Straus and Giroux.

Morris, Charles W. (1938). *Foundations of the Theory of Signs*. Chicago: University of Chicago Press.

Palmer, L. M. (2002). "Vico and Pragmatism: New Variations on Vichian Themes." *Transactions of the Charles S. Peirce Society* XXXVIII(3): 433–440.

Papini, Giovanni. (1913). *Pragmatismo*. Milan.

Peirce, Charles Sanders. (1903). "Lectures on Pragmatism." In *Collected Papers of Charles Sanders Peirce*, ed. C. Hartshorne and P. Weiss. Cambridge, MA: Harvard University Press.

Putnam, Hilary. (1980). *Reason, Truth, and History*. Cambridge, UK: Cambridge University Press.

Putnam, Hilary. (1994). "Sense, Nonsense, and the Senses: An Inquiry into the Powers of the Human Mind." *Journal of Philosophy* 91(9): 445–517.

Quine, W. V. (1969). "Epistemology Naturalized." In *Ontological Relativity, and Other Essays*. New York: Columbia University Press.

Rorty, Richard. (1998). *Achieving Our Country: Leftist Thought in Twentieth-Century America*. Cambridge, MA: Harvard University Press.

Rorty, Richard. 1986. "Pragmatism, Davidson, and Truth." In *Truth and Interpretation: Perspectives on the Philosophy of Donald Davidson*, ed. Ernest LePore. Oxford, UK: Blackwell.

Stebbing, L. Susan. (1914). *Pragmatism and French Voluntarism*. Cambridge, UK: Cambridge University Press.

Stuhr, John J., ed. (2000). *Pragmatism and Classical American Philosophy: Essential Readings and Interpretive Essays*, 2nd edition. New York: Oxford University Press.

West, Cornel. (1989). *The American Evasion of Philosophy: A Genealogy of Pragmatism*. Madison: University of Wisconsin Press.

INTERNET RESOURCES

Durbin, Paul T., ed. (2003). *Techne* 7(1). Available from http://spt.org. Special author-meets-critics issue on the Deweyan philosophy of technology of Larry Hickman.

Hickman, Larry A. (2003). "Revisiting Philosophical Tools for Technological Culture." *Techne* 7(1): 74–93. Available from http://spt.org.

PRAXIOLOGY

Praxiology, occasionally *praxeology* and rarely *praxæology*, is from the Greek *praxis* meaning goal-directed action, and *logos* in the sense of *knowledge* or *information*. Apparently having stipulative origins in French, namely, *praxéologie* (Mitcham), the lexical term praxiology was introduced by Tadeuz Kotarbiński (1886–1981) in 1965. Polish philosopher and co-founder, with Jan Łukasiewicz and Stanislaw Leśniewski of the Warsaw Center of Logical Research (Warsaw Circle), Kotarbiński used praxiology to reference an area in the philosophy of action that was distinguished from other such areas by its focus on efficient action. With adaptations to engineering, business, law, and more, and with discussions relating efficient action to mathematics, the natural sciences, technology, and ethics, praxiology has developed along three major lines: Kotarbińskian, analytic, and synthetic.

Kotarbińskian praxiology, also traditional or classical praxiology, begins with a practical situation said to be complex and exigent, and with a wish to change it to some prescribed future situation. The process of changing a practical situation is subjected to nine value foci called the *Es* (Collen): efficiency, effectiveness, efficacy, ethicality, economy, educability, executability, evaluability, and expendability. Inasmuch as some Es are factual in nature, for example, efficiency, praxiological inquiries in such areas have been referred to as sciences. Although some Es are more qualitative in nature than others, for example, ethicality, no evaluative hierarchy among the Es exists. Thus economics can compete with ethics in praxiological decision making. The remaining lines of praxiological development focus on one or another phase in the process of change.

Analytic praxiology including pragmatic praxiology refers to an analysis of a situation, specifically, a prediction—based on knowledge of its component parts and their connections—of its response to prescribed stimuli or service conditions. The name *pragmatic praxiology* derives from the centrality given to the prediction of consequences in the theories of pragmatism crafted by Immanuel Kant and Charles Peirce (Ryan et al. 2002). The main question is epistemological: What do humans know will result from what they do? The task of responding to this question often falls to the sciences. Historically significant contributions to analytic praxiology may well be found in the histories of systems analysis and cybernetics. (Mitcham 1994).

Synthetic praxiology including design praxiology extends the task of analytic praxiology from creating knowledge about consequences of action to the making of plans for action. A design is a choice from a portfolio of possible future situations; it is a choice based on analyses of these situations and the processes required to realize them. The main question is methodological: How do humans change the world to realize their wishes? Historically significant contributions to synthetic praxiology surely lie among the works of Wojciech W. Gasparski on design and Henryk Skolimowski on the ethics of design ends, but they may also be found in the histories of operations research and management science. (Mitcham 1994).

Kotarbińskian, analytic, synthetic, and other praxiologies comprise a general praxiology spawning applications to the professions. Because of its transdisciplinary aspirations, taxonomic issues arise where such applications, or special praxiologies, meet the academic disciplines of professional education. Would a praxiology of law correspond to jurisprudence? Would theology be a praxiology for organized religion? Where does praxiology of education fit into philosophy of education? If management science is rightly called management technology, would praxiology be its philosophical aspect? (Bunge 1999) Is military science a praxiology?

The transdisciplinary mode is but one of four modes by which praxiology might engage another learned discipline. In the cross-disciplinary mode the tools and methods of praxiology are used to inquire into another discipline. For example, instead of attempting to prove that engineering is a case of praxiology, one might demonstrate that engineering possesses praxiological properties or natures. In the multidisciplinary mode, tools and methods of praxiology are brought together with those of other disciplines. Remaining intact and distinct, these disciplines join to produce novel subdisciplines. For example, when Ludwig von Mises made praxiology the method of the Austrian School of Economics, he crafted the subdiscipline that can be called praxiological economics. In the interdisciplinary mode, tools and methods of praxiology may likewise be brought together with those of other disciplines, but they would not remain intact. Rather essentials of each would be organized into coherent wholes or novel disciplines displaying principles that disagree with principles of their parent disciplines. For example, chemical engineering, which possesses nonscientific principles, namely Koen's (2003) heuristics, is to a degree the result of an interdisciplinary engagement of praxiology with chemistry.

At about the same time that Kotarbiński was working out praxiology, John Dewey (1859–1952) was working out his naturalism. Both of their transdisciplinary ideas began with practical situations. Dewey worked within a Cartesian framework developing cognitive abilities to make change, which loosened the grip that classical education had on education. In the cross-disciplinary mode with education, Dewey emphasized the needs of the individual to advance the ideals of a capitalistic democracy, and gave ethics primacy. Kotarbiński worked within a Marxist framework developing the human will to make change. Putting ethics in the Es with economics, Kotarbiński emphasized the needs of the state. In the United States, the technocracy movement of the 1930s, which advocated a dictatorship of engineers (Layton 1971), and the communist scare in the early-1930s, which was followed by McCarthyism in the 1950s, were not favorable to praxiology. In Poland, Nazi oppression and subsequent communistic regimes virtually cut off international scholarly communications. These social factors left the STS movement, which was underway in the United States by the early 1970s, to independently develop many ideas discussed in praxiology. In 1978, Karol Wojtyla became Pope John Paul II, the first Polish Supreme Pontiff, and interest in Polish scholarship increased. By 1978 though, STS gained currency with an attendant lessening of the importance of the theory of praxiology.

TAFT H. BROOME, JR.

SEE ALSO *Efficiency*.

BIBLIOGRAPHY

Alexandre, Victor, and Wojciech W. Gasparski, eds. (2004). "French and Other Perspectives in Praxiology." In *Praxiology: The International Annual of Practical Philosophy and Methodology*, Vol. 12. New Brunswick, NJ: Transaction Publishers. Discusses work by scholars from France, Finland, Great Britain, Poland, Portugal, Spain, and the United States. Topics include cooperative actions; university education, and corporate governance in Central and Eastern Europe; innovation in Spain; information systems; and fuzzy logic.

Bunge, Mario. (1999). "Ethics and Praxiology as Technologies." Virginia Polytechnic and State University. Available from http://scholar.lib.vt.edu/ejournals/SPT/v4n4/bunge.html. Argues that the intersection of ethics and praxiology is of a sufficient technological nature to comprise philosophical technology; modifies Kotarbińskian praxiology by elevating the status of ethics in the Es to primacy.

Collen, Arne, and Wojciech W. Gasparski, eds. (2003). "Systemic Change Through Praxis and Inquiry." In *Praxiology: The International Annual of Practical Philosophy and Methodology*, Vol. 11. New Brunswick, NJ: Transaction Publishers. Topics include change as a systemic idea from a research methodologist's point of view; prevalence of hierarchy and control; praxiology in research; the research process as means of systemic change; the Es of praxiological inquiry; and traditional, pragmatic, and design praxiologies.

Dewey, John. (1958). *Experience and Nature*. New York: Dover. Dewey's 1925 naturalism as a metaphor for praxiology.

Koen, Billy Vaughn. (2003). *Discussion of the Method: Conducting the Engineer's Approach to Problem Solving*. New York: Oxford University Press. The engineering method of change as a universal method of creating utopia; the most innovative aspect is Koen's notion of engineering heuristics.

Kotarbiński, Tadeuz. (1965). *An Introduction to the Sciences of Efficient Action*, trans. Olgierd Wojtasiewicz. New York: Pergamon Press. Work began in Poland in 1920; the seminal work on praxiology.

Layton, Edwin T. (1971). *The Revolt of the Engineers*. Cleveland, OH: Case Western University Press. A historical account of the development of U.S. engineering professionalism from 1900 to 1940.

Mises, Ludwig von. (1996). *Human Action: A Treatise on Economics*, 4th revised edition. San Francisco: Fox & Wilkes. Originally published in 1949, Mises's cross-disciplinary application of praxiology to economics for the Austrian School of Economics.

Mitcham, Carl. (1994). *Thinking Through Technology: The Path Between Engineering and Philosophy*. Chicago: Chicago University Press. A critical introduction to the philosophy of technology offering alternatives to the treatment of technology as magic.

Ryan, Leo V., and Wojciech W. Gasparski, eds. (2002) "Praxiology and Pragmatism." In *Praxiology: The International Annual of Practical Philosophy and Methodology*, Vol. 10. New Brunswick, NJ: Transaction Publishers. Presents a 1972 Kotarbinski study of practicality as well as addresses the relevance of pragmatism to management, business ethics, law, and pragmatic inquiry. Includes a model for teaching pragmatism and a review of pragmatism in Europe.

PRECAUTIONARY PRINCIPLE

The precautionary principle was introduced into environmental politics in response to a perception that existing policies did not provide adequate protection to the environment. The most prominent formulation was adopted as Principle 15 of the Rio Declaration from the 1992 United Nations Conference on Environment and Development: "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation" (United Nations 1992). The principle has important implications to the interpretation of science and the regulation of technology, and is an expression of values in relation to the environment.

Terminology

It is important to distinguish between the precautionary principle, a precautionary approach, and precautionary action. The precautionary principle is a framework for thinking that provides foresight in situations characterized by uncertainty, ignorance, and ambiguity, and where there are potentially large pros and cons for both regulatory action and inaction. As a principle, it may have legal standing with implications for applications in the international arena. In the European Union, precaution is interpreted as such a principle with legal standing, and was officially adopted as such in the Maastricht Treaty of 1992.

A *precautionary approach* is a way of doing things along the same lines of thought, but has no legal standing. In international trade disputes, the United States tends to interpret the precautionary principle as an approach and not a principle with legal standing. A *precautionary action* is simply a measure taken to implement the thought behind the principle, or it may be an isolated action taken for other or related reasons.

History

Histories of the precautionary principle and of precautionary actions are different. Precautionary actions are known from before the term was invented. Examples can be drawn from legislation in both the European Union and the United States. However, precaution as a principle dates back to German legislation on air pollution from 1976, where the principle was called "Vorsorgeprinzip," where the German word *Vorsorge* means "care" as much as "precaution" (Boehmer-Christensen 1994). The difference is subtle but significant, because "care" is a positive expression of responsibility and prudence, while "caution" has a connotation of "not daring" and "risk aversion," frequently used in a derogatory way implying that one is too cautious. The German legislation of 1976 introduced many measures related to duty ethics: BAT (Best Available Technology), ALARA (As Low As Reasonably Achievable), LCA (Life Cycle Analysis), and the concept of cleaner production. The common feature of these approaches is that one has an obligation to do the best from the perspective of reason, prudence, and environmental sustainability.

The precautionary principle was given many interpretations at various international conferences (such as the North Sea conferences in 1984 and 1987, and the Bergen Conference on Sustainable Development in 1990) building up to the Rio conference in 1992. The

European Union adopted the principle at the constitutional level in the Maastricht Treaty (1992) by a simple statement in Article 174: Community policy "shall be based on the precautionary principle... ." A commission communication provided an interpretation of the precautionary principle (European Commission 2000), and at the end of the same year this interpretation was endorsed in the Nice Treaty.

In the United States, Kenneth Foster, Paolo Vecchia, and Michael Repacholi (2000) published in *Science* a policy commentary on the E.U. interpretation. This commentary argued that under the practical interpretations adopted by the European Union, the precautionary principle was not in conflict with the weight of evidence analysis approach more typically employed by scientists and health administrators in the United States. Retrospective historical analyses (Harremoës, Gee, MacGarvin, et al. 2002) and contemporary case studies (Tickner 2003) have tended to support this assessment. Andrea Saltelli and Silvio Funtowicz (2003) and others also have explored options for operationalizing basic intuitions involved in the precautionary principle.

Basic Interpretations

The overall impression is that the precautionary principle is a response to societies strongly influenced by *positivism*, which tends to regard scientific and technological development as a priori beneficial. The background is an increasing awareness of the potentially detrimental effects of scientific and technological development. Accordingly, the precautionary principle may be interpreted in several ways and is subject to intensive debate in scientific, technical, social, legal, and political terms. There are two extreme misinterpretations of the principle.

One misinterpretation considers the precautionary principle a one-sided argument for the elimination of all adverse effects on health and environment. To demand absolute proof of safety before undertaking any action is, of course, not realistic, and this view is derogatorily referred to as the *risk averse* interpretation. Were one to apply the precautionary principle in this sense to the precautionary principle, the principle itself would have to be rejected.

A counter-misinterpretation considers any use of the precautionary principle as an unwarranted, costly, unjustified approach to environmental protection, especially in comparison to existing approaches of risk assessment and management and the effect of tort liability law. The precautionary principle is considered a threat to the foundation of technological progress because it would halt innovation and development.

Both interpretations are typical of the polarized debate. The more common or balanced interpretation is that the precautionary principle may be applied when uncertainties are so great that it is impossible to predict the impact of technological development with any degree of accuracy, there are good grounds to suspect danger, and yet policy decisions need to be made. More specifically, in cases of significant uncertainty, when there are both sufficient scientific grounds for suspecting that a new development may have a potential for causing large scale, serious, or irreversible harms, the precautionary principle simply judges that it is more prudent to err on the side of safety. This is obviously an extension of the Hippocratic principle to avoid doing harm, to minimize risk when attempting to do good.

Of course, possible harms can always be considered from more than one perspective. Where environmentalists may see potential harms to the environment from the introduction of a new technology, economists may envision potential harms to the economy from blocking introduction of the same technology. Indeed, taking economic development as the status quo rather than the natural world, economists and business leaders can easily appeal to the precautionary principle to limit technological regulation, claiming that false alarms cause more harm than failures to identify and act on potential dangers. In the face of arguments to this effect by, for example, Bjørn Lomborg (2001) and others, it has been argued that on balance "the evidence indicates that we are receiving substantial benefits from our response to environmental alarms" (Pascala, Bulte, List et al. 2003, p. 1188).

Normative, Balance of Proof, and Risk Perspectives

Further specification of the balanced or moderate interpretation is nevertheless required and has taken at least three forms. The normative specification calls for a number of concerns to be addressed in all cases where there are reasonable possibilities of large-scale, serious, or irreversible harms. This specification has been developed in response to a tendency to disregard a number of prudent concerns. It is important, for instance, to identify and constructively account for uncertainty and ignorance, to assure interdisciplinary perspectives, to evaluate a range of options, to take full account of the values and perspectives of all stakeholders, to assure regulatory independence, and to act on reasonable grounds for concern. In the case of potentially large-scale, ser-

TABLE 1

Type I and Type II Errors

Experimental Results	Worldly Reality	
	− (not harmful)	+ (harmful)
+ (harmful)	False positive Type I error	True
− (not harmful)	True	False negative Type II error

SOURCE: Courtesy of Poul Harremoës.

ious, or irreversible harms, it is further appropriate to choose robust solutions that are adaptable to changing circumstances, because initial decisions are necessarily going to be taken under significant uncertainty, ignorance, or ambiguity (European Environmental Agency 2001).

The balance of proof specification is based on consideration of the risk of a mistaken decision. It can be assumed that no procedure for identification and documentation of environmental harmlessness is certain. There will always be some degree of uncertainty, because of the statistical uncertainties associated with practical experiments and cognitive uncertainties regarding cause-effect relationships.

The distinction between Type I and Type II errors is relevant here as indicating two possible ways in which laboratory results can differ from real-world phenomena. As they occur in a court of law, the two errors are those of convicting an innocent person (Type I) and failing to convict a guilty person (Type II). In the first instance, laboratory experiments could reject a presumption of environmental safety regarding some new technology (guilty verdict), when in fact it is safe (or innocent). This type of mistake or error is known as a *false positive*. In the second instance, laboratory results could fail to reject a presumption about the environmental safety of a new technology (judge the technology not guilty), when in fact it is unsafe (guilty). This is known as a *false negative*. See Table 1. As Kristin Shrader-Frechette has argued, the dangers of Type I errors are risks to industry (and thus economic risks to the public), whereas the danger of Type II errors pose risks to the environment (and thus health risks to the public).

Insofar as the legal system places its emphasis on avoiding Type I errors (false convictions), it is necessarily subject to Type II errors (false acquittals). In a similar manner, insofar as science is more concerned to avoid false assertions (that *X* causes harm when it does not) than false denials (that *X* is does not cause harm when it does), because it is denials that can be falsified by experiment whereas assertions can never be fully confirmed by experiment, then science may be said to have a bias toward letting guilty technologies go free. From this perspective, the precautionary principle promotes shifting the balance of proof from concern with avoiding false convictions to avoiding false acquittals. In medicine, too, physicians have traditionally been concerned first and foremost with avoiding treatments that might harm.

In the regulation of developments that may be harmful to humans or the environment, the standard with respect to choice of acceptable types and levels of error may be thus reasonably quite different from those acceptable in science or in criminal courts. Levels of proof may be graded as follows: "vague, circumstantial, substantial, beyond reasonable doubt, certain." The required level of proof must be determined in relation to the potential harm and the claimed benefits of the activity in question. Cases of potential large-scale, serious, or irreversible harms may justify setting the level of proof at a lower level than "beyond reasonable doubt." In the European Union, "reasonable grounds for concern" is suggested as level of proof for invocation of the precautionary principle with regard to the regulation of chemicals and technological activities (European Commission 2000, p. 9).

These issues are also important to the question of who shall carry the burden of proof. Should the producer, manufacturer, or importer, on the one side? The government, on another side? Or the public, by means to liability suits, on still another side? In many cases, society has adopted the principle of prior approval (positive lists) before placing on the market certain products, such as drugs, pesticides, and food additives. Accordingly, the precautionary principle incorporates a proposed reversal of the burden of proof from the public to the proponent of any development that has a potential for large-scale, serious, or irreversible harms.

This is highly controversial, because the free market economy tends to be based on the principle that any economic activities are permissible as long as they are legal and subject to tort liability for the recuperation of damages. Opponents to the precautionary principle consider any restriction of this economic liberty as detrimental to technical and economic development. In the case of development of new chemicals and genetically modified organisms (GMOs), industry tends to consider such developments potentially so beneficial to society that industry should not have to bear the costs of a greater burden of proof; instead, liability should be invested in society as a whole.

The risk specification involves a comprehensive risk assessment in accord with the standards established in this field. The normative and balance of proof specifications may be included in the process. But a technical risk assessment is assumed to be more scientific and objective, involving as it does hazard identification, dose-response assessment, exposure assessment, and risk characterization (Environmental Protection Agency 1997, Lewalle 1999).

Social studies of science have, however, provided grounds for questioning the complete objectivity of such procedures, which are always undertaken by human beings with their own interests and perspectives. This is why the normative approach explicitly insists that a wide range of stakeholder values and perspectives be considered from the beginning even in framing the issue.

Subsequent risk management involves risk evaluation, emission and exposure control, and risk monitoring, plus risk communication. Risk evaluation and the regulation of emissions and exposures is where political and ethical choices come most obviously into play. What are the values and perspectives to be considered, and what is an acceptable risk? The European Commission communication on the precautionary principle, for instance, explicitly states that "the protection of public health should undoubtedly be given greater weight than economic considerations" (2000, p. 19).

Supplementary Principles

Invoking the precautionary principle nevertheless requires other principles to be considered. The European Commission has named five of these.

- *Proportionality*. Any decision is required to be proportional—that is, even a preliminary invocation of the precautionary principle must consider the balance between the pros and cons of a precautionary action, accounting for all aspects known at the time. In proportionality all concerns may count, not only consequences, but also deontological concerns, like duties, rights, and considerations of justice.
- *Non-discrimination*. Invocation of the precautionary principle means that comparable situations should not be treated differently, unless there are objective grounds for doing so.
- *Consistency*. Measures should be similar to previously adopted measures in similar circumstances.
- *Pros and cons* of action versus lack of action. Even in a provisional invocation of the precautionary principle, an analysis should be made of the factors pointing in favor versus against action or no-action.
- *Scientific development*. It is an essential part of the invocation of the precautionary principle to initiate research and monitoring in order to reduce the uncertainty and ignorance that cause the invocation.

Precautionary Principle Implementation

The means by which the precautionary principle should be implemented also have been the focus of much debate. Implementation must be related to other significant developments associated with risk assessment and management, and principles of good governance.

The tendency is to employ *participatory, discursive, and adaptable* procedures. The participatory processes require the participation at an early stage of all relevant stakeholders, as well as an ongoing discourse with stakeholders for the duration of the project. Adaptive procedures are the logical consequence of the fact that uncertainty and ignorance prevail in the decision making. Accordingly, it has to be publicly admitted that any decision could be false and susceptible to change in the light of new information obtained from research and monitoring.

Concrete regulatory actions can take many forms, from initiation of research and monitoring in order to decrease uncertainty and ignorance, to outright ban of the activity in question. Consider, for example, the case of endocrine disrupters.

Endocrine disrupters are natural hormones, which may be discharged in large quantities (such as the female hormone, estrogen, large amounts of which are discharged in wastewater, in large part due to increased excretion of residues from use of contraceptive pills), or hormone-like, artificial substances with a similar effect (such as Tributyltin [TBT], which is used in antirust paint on boats).

It has been demonstrated that increased concentrations of endocrine disrupters may cause sexual disturbances called *imposex*in fish and invertebrates in the aquatic environment (European Environment Agency 2001, p. 135–143). The first reaction was to increase research, because the evidence was insufficient to justify regulatory actions. With increasing evidence of serious effects, however, TBT has been banned for use on pleasure boats. Measures aimed at paints on commercial ships are forthcoming.

In the case of release of estrogen with wastewater, the question is whether scientifically-based suspicions of serious harms are sufficient to invoke the precautionary principle and demand either a ban of contraceptive pills or, more likely, to demand that wastewater treatment include the removal of endocrine disrupters before water is discharged into the environment. The key question is whether to invoke the precautionary principle immediately or wait for the results of a larger and more reliable risk assessment, which may be time consuming due to a need for more research.

Legal Status

Ambiguities remain regarding interpretation, application, and implementation. Ultimately such ambiguities will be reduced by case law precedence built up through court decisions. Several judgments already point in this direction.

Internationally, the Agreement on Sanitary and Photosanitary Measures and the Agreement on Technical Barriers to Trade have been brought before the World Trade Organization (1997). In Europe, an influential case is that of antimicrobial growth promoters brought before the European Court of Justice (1999).

A European Commission ban on certain antibiotics as growth promoters in animal production was upheld by the court with reference to the precautionary principle because of scientifically-based indications that widespread use of antibiotics might adversely affect the bacterial resistance to related antibiotics for humans (European Environment Agency 2001). However, the judgment also outlines the severe limitations and formal requirements associated with invoking the precautionary principle.

Ethics

The precautionary principle is not a scientific principle. It is an ethical principle in the sense that it makes a statement regarding values and the proper procedures for governance and due process. It is prudent to take action in spite of lack of complete scientific evidence when there are significant uncertainties, recognized ignorance, and ambiguity, combined with scientifically-based suspicions of large scale, serious, or irreversible harms. This is a deontological principle in the sense that it prescribes an approach to prudent action in response to the awareness of the situation.

However, for the precautionary principle to be invoked there must first have been a preliminary risk assessment combined with a preliminary cost-benefit or cost-effectiveness assessment. In ethical terms, what must happen first is a preliminary utilitarian appraisal, the uncertainty of which may provide the justification for invoking the precautionary principle at the time of decision making. The challenge is to "avoid paralysis by analysis" (European Environmental Agency 2001, p. 181).

POUL HARREMOËS

SEE ALSO *Science Policy; Uncertainty.*

BIBLIOGRAPHY

Boehmer-Christensen, S. (1994). "The Precautionary Principle in Germany: Enabling Government." In *Interpreting the Precautionary Principle,* ed. Tim O'Riordan and James Cameron. London: Earthscan.

Cranor, C. F. (1999). "Asymmetric Information, The Precautionary Principle, and Burdens of Proof." In *Protecting Public Health and the Environment, Implementing the Precautionary Principle,* ed. Carolyn Raffensberger and Joel Tickner. Washington, DC: Island Press.

European Court of Justice. (1999). *Pfizer v. EC* (T 13/99) and *Alpharma v. EC* (T 70/99).

Foster, Kenneth R.; Paolo Vecchia; and Michael H. Repacholi. (2000). "Science and the Precautionary Principle," *Science* 288(5468): 979, 981.

Harremoës, Poul; David Gee; Malcom MacGarvin; et al. (2002). *The Precautionary Principle in the 20th Century: Late Lessons from Early Warnings.* London: Earthscan.

Harremoës, Poul. (2003). "Ethical Aspects of Scientific Incertitude in Environmental Analysis and Decision Making." *Journal of Cleaner Production* 11: 705–712.

Lomborg, Bjørn. (2001). *The Skeptical Environmentalist: Measuring the Real State of the World.* Cambridge, UK: Cambridge University Press.

Lewalle P. (1999). "Risk Assessment Terminology: Methodological Considerations and Provisional Results." *Terminology Standardization and Harmonization* II(1–4): 1–28.

Pascala, S.W.; E. Bulte; J.A. List; and S.A. Levin. (2003). "False Alarm over Environmental False Alarms." *Science* 301: 1187–1188.

Popper, Karl R. (2000). *Conjectures and Refutations: The Growth of Scientific Knowledge,* 5th rev. edition. London: Routledge and Kegan Paul.

Saltelli, Andrea, and Silvio Funtowicz. (2003). "The Precautionary Principle: Implications for Risk Management Strategies." *European Journal of Oncology* 2: 67–80.

Shrader-Frechette, Kristin S. (1991). *Risk and Rationality: Philosophical Foundations for Populist Reforms*. Berkeley: University of California Press.

Tickner, Joel A., ed. (2003). *Precaution, Environmental Science, and Preventive Public Policy*. Washington, DC: Island Press. A collection of 24 analyses, many of them contemporary case studies.

INTERNET RESOURCES

Environmental Protection Agency. (1997). "Risk Assessment and Risk Management in Regulatory Decision-Making." *The Presidential/Congressional Commission on Risk Assessment and Risk Management, Final Report* Volume 2, Glossary. Available from http://www.riskworld.com.

European Commission. (2000). "Communication from the Commission on the Precautionary Principle." Available from http://europa.eu.int/comm/.

European Environment Agency. (2001). "Late Lessons from Early Warnings: The Precautionary Principle 1986–2000." *Environmental Issues Series* 22. Available from http://reports.eea.eu.int.

European Union. (1992). Treaty of the European Union (The Maastricht Treaty). Available from http://www.europa.eu.int.

United Nations. (1992). "Rio Declaration on Environment and Development, United Nations, A/CONF.151/26, vol. I." Available from http://www.un.org/documents.

World Trade Organization. (1997). "Agreement on the Application of Sanitary and Phytosanitary Measures." Available from http://www.wto.org.

PREDICTION

Prediction is a central concept in science and politics, with important ethical implications. Its meanings, however, differ in important if subtle ways in these different realms, which can cause confusion about the appropriate relationship between science and society. Distinguishing clearly between the meanings is crucial for understanding and prescribing an appropriate role for science in political and ethical decision making.

Prediction as Confirmation

One way of looking at science, championed especially by the influential twentieth-century philosopher Karl Popper, is to view knowledge acquisition as a process of first making, and then testing, falsifiable hypotheses (Popper 1992). According to this view, the first of these two activities generates predictions about the consequences of the hypotheses, and the second confirms or refutes the predictions. Perhaps the emblematic example of this type of prediction is how Albert Einstein's general theory of relativity, published in 1916, predicted that the path traveled by light would be bent by the force of gravity, and was later confirmed by Arthur Eddington's 1919 experiment in which this bending was observed during a solar eclipse. From this perspective, science is in its essence a prediction-generating-and-testing activity.

But the notion of prediction as inherent in science itself rests on a particular meaning of the word and a particular notion of what counts as science. Whereas common usage of the word prediction refers to the foretelling of future events, philosophers of science have viewed prediction as the process of deducing consequences from hypotheses independent of any sense of time. Indeed hypotheses that are temporally dependent for their correctness are said to have very little predictive power, because they are only true under limited circumstances.

The power of science, from this perspective, lies in its ability to make highly general, experimentally testable predictions about natural phenomena *independent of time or other contexts external to the phenomena*—light should always be bent by gravity. The temporal or locational power of a prediction (if one drops a paperweight from a particular desk at a particular time, one can predict that it will accelerate toward the center of the earth at thirty-two feet per second per second) is trivial compared to the more general, explanatory power of Isaac Newton's gravitational law (the attraction exerted by gravity between any two bodies is directly proportional to the masses of the bodies and inversely proportional to the square of the distance between them). The power of such generality is especially on display when scientific principles inform technological innovation, because the application of invariant laws ensures the uniform behavior of engineered devices from airplane wings and barometers to electronic circuits and clock pendulums.

Yet this view of science is problematic because it dismisses as nonscientific those disciplines that are not grounded in using experiments to test falsifiable predictions, such as most social sciences, paleontology and geology, system-level biology, ecology, and even some branches of the quantitative physical sciences dealing with complex, non-linear systems. Notably these are also the disciplines of science that most directly seek to understand the complexity of human experience and natural systems. More subtly, but of equal importance, generality in scientific prediction is almost always achieved through careful control of experimental conditions, or stripping away contextual *complications*. Newtonian mechanics, for example, operates as predicted in vacuums, in frictionless environments, and on rigid bodies, conditions that are often not met in the real world. Generality, as Nancy Cartwright (1983) argues, is often achieved at the expense of reality. Thus if science is in its essence a prediction-generating activity, where prediction means *logical inference*, then science can have only a limited capacity to inform about how the real world works.

Prediction as Foretelling

Yet it is in this real world that people make decisions about how to act. Indeed turning now to prediction in its more conventional sense, human decision making can be understood as an inherently predictive activity. Human action at every scale from the most mundane to the most ambitious aims at connecting the actions that one takes to some set of desired or expected outcomes. While such fields as philosophy, psychology, and economics have confronted the problem of how humans can make better decisions in light of existing knowledge and experience, it is only in the past several decades that science and technology have begun to offer the credible promise of actually predicting future events as an aid to decision making. Simultaneous advances in computer power, data acquisition technologies, and mathematical modeling are now being applied to predicting everything from economic trends and election results to the spread of diseases and the behavior of the ocean-climate system. This promise of a scientifically legitimate predictive capability has proven extremely attractive to decision makers interested in problems as diverse as selecting appropriate crops to plant in a specific region, assigning rates to insurance policies, and negotiating international environmental treaties. To serve such interests, each year billions of dollars are spent on science and technology aimed at improving predictive capabilities.

Prediction of future events is most familiar—and successful—in the area of short-term weather. Indeed there is a crucial connection between the familiarity and the success of weather predictions. Weather forecasters, who make upward of 10 million forecasts each year in the United States alone, are able to constantly test and refine their predictive skills because they can compare their predictions to the weather conditions that actually occur (*realizations*). At the same time, decision makers who use weather forecasts (everyone from individuals deciding whether to carry an umbrella to military generals deciding how to deploy their forces) are able to develop judgment about the reliability of weather forecasts based on their own multiple experiences, and integrate this judgment into their decision processes. Moreover the production of weather predictions is linked to their use by a dynamic and sophisticated enterprise, including the mass media and companies that sell weather predictions, whose goal is to communicate the forecasts to those who might benefit from them. Finally many decisions based on weather predictions—for example, whether to evacuate a town, mobilize snow plows, or ground a fleet of airplanes—entail significant costs, and if predictions turn out to be wrong, those issuing them may be held accountable for their mistakes.

One or more of these attributes—the ability to test predictions, gain experience in their use, communicate them effectively, and hold people accountable—are missing from most other areas of scientific prediction. The consequences of this distinction are especially important in public policy, for example, where decision makers turn to scientists to predict future costs of a public program, the health consequences of particular levels of chemicals in the environment, the future prospects of an endangered species, the regional climate impacts that can be expected as a result of greenhouse gas emissions, or the behavior of buried nuclear waste. Such predictive challenges are characterized by the fact that the event or condition to be predicted plays out over decades or even centuries, and may represent a temporally and spatially unique set of conditions within an open system. The learning necessary to improve predictive accuracy in such cases is thus very difficult to acquire, because (a) predictions cannot be compared to actual outcomes; (b) causes of error in predictions are contingent on specific conditions and thus cannot be generalized; or (c) in many cases, both.

Obstacles to Prediction

A well-known example of the first kind of difficulty are predictions of long-term climate change, which are the source of considerable scientific and political debate, yet cannot be confirmed in the time frame within which policy decisions about climate change will have to be made. Representative of the second problem was the inability of economic models to predict the change in the relationship between energy consumption and economic growth in the United States that occurred after the Arab oil embargoes of the 1970s. Economists had understood economic growth to be tightly coupled to rising energy use, and thus predicted that the embargo would cripple the U.S. economy. Actual events showed that existing energy technologies could be mobilized to significantly boost energy efficiency, and thus economic activity, in the absence of increased consumption (Schurr 1984). While this insight is important and revealed why past predictions were wrong, it is unlikely to add much to the ability to predict future economic growth trends, because such trends are influenced by innumerable variables of which energy use is only one.

Moreover it is likely that accurate predictions of the behavior of some types—perhaps most types—of natural and social systems are impossible even in theory, due to their complexity, nonlinearity, and openness. Frequentist approaches to prediction, which rely on probabilistic characterizations of past system behavior to predict future behavior, founder on the fact that, for an open system, there is no reason to think that past behavior (even if it has been correctly characterized) will continue unchanged into the future. Deterministic approaches to prediction seek to avoid the pitfalls of frequentist strategies by using first principles (described mathematically) to ascertain causal relations between past, present, and future conditions. Yet determinism has to confront the practical reality that choices must always be made about which aspects of the system are worth characterizing, and which are not. For an open system, such choices are always made on the basis of incomplete knowledge. For example, long-term behavior of complex systems are often dependent on small variations in initial conditions, which means that knowledge of present conditions would have to be characterized with complete accuracy to insure accurate predictions, while errors in this characterization would tend to compound over time. This is why weather forecasts, which depend on knowing the present state of the atmosphere and then projecting future behavior, are accurate to a maximum of about two weeks.

Alternatives to Prediction

In this light, one may well ask the following: Given the limitations, what good is all this science aimed at predicting complex systems?; and If the ability to predict the future is really so limited, how are people going to be able to make successful decisions? These questions are not unrelated.

In considering the first question, the important point is that insight about how complex systems behave may be valuable for reasons other than an ability to predict the future. Charles Darwin's theory of natural selection is one of the most powerful, influential, and enlightening theories of modern science, yet it is predictive in neither the explanatory sense (in that it is not easily falsifiable) nor the temporal sense (in that it can reveal little about how species will evolve in the future). Yet it offers enormous insight into how the natural world works, insight that can enhance understanding and appreciation of the interconnectedness of all things and inform decision making in light of this awareness. Similarly research on ecosystems, the climate system, social systems, and the connections among such systems can help explain causal relations among various system components, characterize past and present conditions, act as an alert to impending problems, and point toward potential solutions. But it is a very different thing to ask science to elucidate the general relations between greenhouse gas emissions and climate behavior (a difficult enough task), than it is to demand that science accurately predict how these relations will unfold on a regional level through the twenty-first century.

From this perspective it is important to recognize that, while decisions always carry with them some expectation of what the future will look like after the decision is made, good decisions—those that move in the direction desired by the decision makers—do not depend on accurate predictions. Numerous strategies exist for making effective decisions in the presence of scientific insight but the absence of accurate predictions.

One approach is prevention. For example, past experience shows that many areas of California are subject to earthquakes, and this knowledge has been sufficient to guide activities, such as better construction practices, that can reduce loss of life and property from earthquakes, without needing to predict them. Another approach is trial and error informed by understanding and monitoring. For example, the Federal Reserve Board modulates macroeconomic behavior in the United States by making small, incremental changes in interest rates and then seeing how those changes affect economic performance. Similarly, biologists and natural resource managers have increasingly been drawn to an adaptive, incremental approach for managing fragile ecosystems. The role of science here is to assess current conditions, suggest plausible cause-and-effect relations for guiding decisions, and then monitor the effects of actions taken to manage the system. This allows learning both from success and error, and it keeps the costs of errors relatively small, because decisions are incremental.

A third approach is to adopt hedging strategies for addressing future risks whose probabilities cannot be accurately predicted. For example, a *no-regrets* approach to global warming could mandate the adoption of energy efficient technologies whose lifetime costs are about the same as less-efficient technologies, and at the same time introduce reforms in land-use practices and insurance coverage that would reduce exposure to future climate events, whether or not they are caused by global warming. A fourth strategy is to introduce redundancy into the system, for example by combining geologic and engineering containment strategies for isolating nuclear waste, rather than depending on only one approach.

Political and Ethical Implications

Rather than making decisions in anticipation of a particular, predicted future, these sorts of approaches aim at building resilience into a system, a quality that allows for desired outcomes to be attained under a variety of plausible futures. Yet these approaches also demand that political commitments to action be made under conditions of uncertainty. This demand is not inherently problematic—indeed all decisions are made under conditions of uncertainty—but the rising expectation that science can provide accurate predictions may undercut the political motivation to actually take action, especially if such action entails political risk. The short-term benefits for both politicians and scientists of the predictive approach are clear: Politicians can avoid making tough decisions yet point to research as a step in the right direction, while scientists receive more funding to develop more accurate predictions. As a result, however, political discourse can shift from a discussion about the values and ethics that should inform action, to an endless debate about the technical merits of contesting scientific predictions. This dynamic is on stark display in a number of high-profile environmental controversies. The elusive promise of accurate scientific predictions may not only delay necessary action, but undermine the vitality of democratic debate.

DANIEL SAREWITZ

SEE ALSO *Global Climate Change; Incrementalism.*

BIBLIOGRAPHY

Cartwright, Nancy. (1983). *How the Laws of Physics Lie.* Oxford:, UK Oxford University Press.

Popper, Karl. (1992 [1935]). *The Logic of Scientific Discovery.* New York: Routledge. Hugely influential philosophical treatment of how reliable scientific knowledge is created.

Sarewitz, Daniel R.; Roger A. Pielke Jr.; and Radford Byerly Jr., eds. (2000). *Prediction: Science, Decision Making, and the Future of Nature.* Covelo, CA: Island Press. Contains expanded treatment of many of the arguments and examples in this article.

Schurr, Sam H. (1984). "Energy Use, Technological Change, and Productive Efficiency: An Economic-Historical Interpretation." *Annual Review of Energy* 9: 409–425.

PRESERVATION

SEE *Conservation and Preservation.*

PRESIDENT'S COUNCIL ON BIOETHICS

Since the 1970s, many governmentally sponsored advisory committees have been formed to offer advice about the ethical and political issues arising from biomedical research and biotechnology. In the United States, one of the most prominent of these is the President's Council on Bioethics (Council), which was established by President George W. Bush in November 2001. The work of the Council illustrates how hard it is to deliberate about the ethical issues provoked by modern science and technology in a political arena of partisan conflict and moral diversity. This is particularly difficult when the ethical and political discussion is influenced by the controversy over abortion and the moral status of human embryos. And yet despite these difficulties, the Council stands out as an attempt to promote a Socratic discussion in political debates about the ethical implications of science and technology.

Creation of the Council

On August 9, 2001, Bush gave a nationally televised speech on stem cell research. Stem cells are found in embryos, and have the power to grow into all of the specialized cells of the body (liver cells, muscle cells, brain cells, and so on). Some scientists believe that stem cells could be used to repair or replace the damaged cells that cause human diseases and disabilities such as Alzheimer's disease, Parkinson's disease, diabetes, and spinal cord injuries. But extracting stem cells from human embryos destroys the embryos, and Bush and others believe this is unethical because it means killing potential human life. This creates a conflict between the moral good in relieving suffering through medical research and the moral good in respecting potential human life. The political background for this controversy is the debate over abortion. Bush and many of his conservative supporters regard abortion as murder because they think that as soon as a human egg is fertilized, there exists a human being with a right to life.

The key issue in Bush's stem cell speech was whether federal funding should be provided to support human embryonic stem cell research. His decision was to allow such funding only for those stem cell lines that had been extracted before August 9, 2001. This would allow funding to support the research, but it would not promote future destruction of human embryos. He ended his speech by announcing that he would appoint a presidential council under the chairmanship of Leon Kass to study the ethical and political issues surrounding such biomedical research.

Kass received a bachelor's degree in biology and medical degree from the University of Chicago; he received a Ph.D. in biochemistry from Harvard University. After working at the National Institutes of Health (NIH) and the National Academy of Science (NAS), he taught for four years as a tutor at St. John's College (Annapolis, Maryland). Kass then returned to the University of Chicago as a professor in the Committee on Social Thought. At St. John's and the University of Chicago, he taught seminars on classic texts of philosophy, literature, and theology.

Kass was influenced by Leo Strauss, who was also a teacher at the University of Chicago and St. John's. Strauss and his students sought to revive the ancient philosophic wisdom of Socrates, Plato, and Aristotle and the ancient theological wisdom of the Bible. In promoting these traditions, the Straussians were critical of modern traditions of thought beginning with political philosophers such as Niccolò Machiavelli (1469–1527), Francis Bacon (1561–1626), and René Descartes (1596–1650). They were particularly skeptical about the philosophical project of Bacon and Descartes, which promoted a new science that would allow human beings to conquer nature. The Straussians feared that this scientific conquest of nature would become a willful quest for power unconstrained by moral or religious limits. When Kass expressed similar skepticism about modern science and technology in his published writings, he won the respect of U.S. political and religious conservatives who shared his suspicion that science was subverting moral and religious traditions. His writings warning against the dehumanizing effects of biotechnology attracted the attention of Bush's conservative advisors, which led to Kass's appointment as chair of the Council.

In consultation with Kass, Bush appointed seventeen other people to the Council: Elizabeth Blackburn, a professor of biochemistry at the University of California-San Francisco; Stephen Carter, a professor of law at Yale University Law School; Rebecca Dresser, a professor of law at Washington University School of Law; Daniel Foster, a professor of medicine at the Southwestern Medical School of the University of Texas; Francis Fukuyama, a professor of international studies at Johns Hopkins University; Michael Gazzaniga, a professor of neuroscience at Dartmouth College; Robert George, a professor of politics at Princeton University; Mary Ann Glendon, a professor of law at Harvard University Law School; Alfonso Gomez-Lobo, a professor of philosophy at Georgetown University; William Hurlbut, a physician and a professor in the Program in Human Biology at Stanford University; Charles Krauthammer, a syndicated columnist for the *Washington Post;* Paul McHugh, a professor of psychiatry at the Johns Hopkins University Hospital; William May, a professor emeritus of theology at Southern Methodist University; Gilbert Meilaender, a professor of theology at Valparaiso University; Janet Rowley, a professor of medicine at the University of Chicago Medical School; Michael Sandel, a professor of government at Harvard University; and James Q. Wilson, a professor emeritus of management at the University of California–Los Angeles and a former professor of government at Harvard University.

Criticism, Conflict, and the Work Begins

Bush's critics thought the Council was biased because it included so many political and religious conservatives (such as Fukuyama, George, Glendon, Krauthammer, Meilaender, and Wilson), who would generally agree with Kass and Bush. But it soon became clear that there was genuine disagreement on the Council, and that some members of the Council (such as Blackburn, Gazzaniga, and Rowley) were strong proponents of biotechnology who rejected Kass's moral criticisms of science.

Scholars of bioethics complained that the Council had no members who were professional bioethicists. This was a deliberate move by Kass. At the first meeting of the Council, Kass indicated that he would lead the Council away from the methods and topics that dominate bioethics as a professional field of academic expertise. "This is a council on bioethics, not a council of bioethicists," he explained at the January 17, 2002, meeting. "We come to the domain of bioethics not as experts but as thoughtful human beings who recognize the supreme importance of the issues that arise at the many junctions between biology, biotechnology and life as humanly lived." He stated that the Council was not required to reach complete agreement, and he quoted from the president's executive order creating the Council: "The council shall be guided by the need to articulate fully the complex and often competing moral positions on any given issue and may, therefore, choose to proceed by offering a variety of views on a particular issue rather than attempt to reach a single consensus position." Kass doubted that complete agreement was likely in any event, because if the Council engaged in serious discussions of the competing human goods at stake in biomedical research and technology, disagreement would surely arise as different people would weigh those various human goods in different ways. For example, some might give more weight to the human good of respect for potential human life and less weight to the human good of relieving human suffering, while others might do the opposite. What was important, Kass insisted, was that every serious point of view be considered as part of a deliberative debate that would probably not reach consensus.

Kass was guiding the Council towards a tradition of ethical and political inquiry that goes back to Socrates, Plato, and Aristotle in ancient Greece. In it, thoughtful people work through the great questions of human life by debating the meaning of the human good—often using classic texts that illuminate fundamental alternatives—without expecting to reach final agreement on the answers to those questions. Kass had been initiated into that Socratic tradition during his years as a student and a teacher at the University of Chicago and St. John's College.

In the first meeting of the Council, Kass led the members in a discussion of a short story by Nathaniel Hawthorne—"The Birth-Mark" (1844)—about a scientist who unintentionally kills his beautiful wife while trying to surgically remove a slight birthmark on her cheek. The clear lesson of the story was that the scientific quest for perfection and power could be destructive in its lack of respect for human beings with all the imperfections of mortal creatures. Reporters and others at this first meeting remarked on the serious—even philosophic—tone of the Council's discussions. It was clear that Kass would turn the discussions of the Council into something like a college seminar on science, technology, and the meaning of human nature. Transcripts of the Council's meetings were posted on its Internet site along with copies of its formal reports. All of this material was designed by Kass to stimulate interested citizens across the nation into serious reflection on the moral character of modern science and technology.

And yet, as must be the case for any committee appointed by the president, the intellectual discussion of the Council could not be separated from partisan political debate. This became clear when the Council released its first formal report, which was on human cloning. The Council debated both reproductive cloning (or cloning to produce children) and therapeutic cloning (or cloning for biomedical research). Bush had argued vigorously for a legal ban on all forms of human cloning. The Council was unanimous in recommending a total ban on reproductive cloning, but it was divided on therapeutic cloning. Cloning human embryos could have therapeutic value in producing human stem cells that would be genetically identical to those of patients who need such cells for restoring damaged tissue, thus avoiding the problem of immune rejection. Some Council members thought this sufficient reason to approve therapeutic cloning. But others who believed that human life begins at the moment at conception considered the destruction of embryos to be murder, and so rejected therapeutic cloning. Still other members who thought that embryos were less than fully human but still deserved deep respect also rejected therapeutic cloning. Kass feared that a lack of consensus for a complete ban on therapeutic cloning would embarrass the president. To avoid this, he convinced a majority of Council members to recommend a four-year moratorium on the process.

When the Council's report was released, some members who opposed Kass's position complained that he had put pressure on three *swing voters*—Dresser, Fukuyama, and McHugh—to agree to the moratorium recommendation. Four of the members who voted to recommend federal funding for embryonic stem cell research—Blackburn, Gazzaniga, Foster, and Rowley—published a statement criticizing the Council's recommendations.

Early in 2004, the two-year terms for the Council members expired. Bush reappointed fifteen of the eighteen members for another two-year term. Carter and May resigned voluntarily. But Blackburn was dismissed. Bush and Kass filled the three vacancies with people who were like-minded to them—Benjamin Carson, a neurosurgeon at Johns Hopkins University; Peter Lawler, a professor of political science at Berry College in Georgia; and Diana Schaub, a professor of political science at Loyola College in Maryland. Prior to their appointments, Lawler and Schaub publicly stated their agreement with Kass's intellectual stance on biotechnology; Schaub had been a student of Kass's at the University of Chicago. Blackburn wrote articles protesting that her dismissal was politically motivated because she had opposed the positions taken by Kass and Bush. Kass responded that politics was not involved at all. The controversy was widely reported in newspapers and science journals as an indication of Bush's effort to promote his political goals among his science advisers.

Politics and Religion

Many contend that the Council's work is distorted by political pressure. In response, Kass argues that critics have not read the Council's reports carefully enough to see how fair it is in surveying arguments on all sides of every debate. Kass notes that journalists concentrate all their attention on the political implications of the Council's recommendations rather than the intricate reasoning supporting those recommendations. To avoid this criticism, which started with the first report, Kass designed the subsequent reports as surveys of opposing positions on moral issues in biotechnology that offer few specific recommendations. The Council has issued reports on using biotechnology to enhance human life, stem cell research, and regulation of reproductive technologies. These reports clearly favor Kass's position that biotechnology might endanger moral values. Yet the reports always include arguments on the other side of the debate. This is Kass's way of promoting serious and fair-minded discussion of the deep moral questions raised by modern science and technology.

Nevertheless bioethicists such as George Annas criticize Kass for leading a "neoconservative bioethics council" that pursues "a narrow, embryo-centric agenda" (Annas and Elias 2004, p. 19). Although Annas concedes that the moral status of human embryos is an important issue, he cites many other important topics in bioethics such as access to healthcare, dangerous commercialization of science and medicine, pricing of drugs, and bioterrorism. Annas also charges that neoconservatives such as Kass have failed to embrace a global bioethics based on human rights because embryos do not have the same status as human beings in international codes of human rights, such as the "Universal Declaration of Human Rights."

In the presidential campaign of 2004, John Kerry criticized Bush for not funding embryonic stem cell research because of religious beliefs not shared by most people. Bush used this issue to win votes from conservative Christians identified with the "religious right." Although religion is rarely mentioned in the council's meetings and reports, some of the members of the council are motivated by religious objections to biotechnology. Kass has written a book on the Bible in which he interprets the Book of Genesis as condemning science and technology as part of the "humanist dream" of "the city of man," particularly as depicted in the biblical story of the Tower of Babel (Kass 2003, pp. 219, 242–243). For Kass, this is part of the Bible's general warning that all civilization expresses the impious pride of human beings.

Council reports show extraordinary intellectual and moral rigor in probing the political and ethical issues arising in modern biotechnology. This reflects Kass's deep understanding of how science and technology arose in the seventeenth century as a project of modern political philosophers to give human beings power over nature. And yet the reports also show how intractable the ethical debate becomes when it is entangled in abortion politics, and in the controversy over whether embryos should be treated as fully human with the same moral standing as children or adults.

LARRY ARNHART

SEE ALSO *Bioethics; Bioethics Committees and Commissions.*

BIBLIOGRAPHY

Annas, George J., and Sherman Elias. (2004). "Politics, Morals, and Embryos." *Nature* 431: 19–20.

Blackburn, Elizabeth H. (2004). "A 'Full Range' of Bioethical Views Just Got Narrower." *Washington Post*, March 7, p. B02.

Blackburn, Elizabeth H., and Janet Rowley. (2004). "Reason as Our Guide." *PloS Biology* 2(4): 1–3. Criticisms of two reports of the Council from two members.

Hall, Stephen S. (2002). "President's Bioethics Council Delivers." *Science* 297(5580): 322–324. Report on the controversy surrounding the cloning report of the Council.

Kass, Leon. (1985). *Towards a More Natural Science*. New York: Free Press.

Kass, Leon. (2002). *Life, Liberty, and the Defense of Dignity: The Challenge of Bioethics*. San Francisco: Encounter Books.

Kass, Leon. (2003). *The Beginning of Wisdom: Reading Genesis*. New York: Free Press.

Kass, Leon. (2004). "We Don't Play Politics With Science." *Washinton Post*, March 3, p. A27.

Kass, Leon, and James Q. Wilson. (1998). *The Ethics of Human Cloning*. Washington, DC: AEI Press.

Kristol, William, and Eric Cohen, eds. (2002). *The Future Is Now: America Confronts the New Genetics*. Lanham, MD: Rowman and Littlefield. Collection of writings showing the conservative fear of biotechnology.

Lawler, Peter. (2004). "Restless Souls." *New Atlantis* 4(Winter): 42–46.

President's Council on Bioethics. (2002). *Human Cloning and Human Dignity: The Report of the President's Council on Bioethics*. New York: PublicAffairs.

President's Council on Bioethics. (2003). *Beyond Therapy: Biotechnology and the Pursuit of Happiness*. Washington, DC: Dana Press.

President's Council on Bioethics. (2004a). *Monitoring Stem Cell Research*. Washington, DC: Government Printing Office.

President's Council on Bioethics. (2004b). *Reproduction and Responsibility: The Regulation of New Biotechnologies*. Washington, DC: Author.

Rowley, Janet D.; Elizabeth Blackburn; Michael Gazzaniga; and Daniel Foster. (2002). "Harmful Moratorium on Stem Cell Research." *Science* 297 (5589): 1957. Criticisms of the cloning report from four members of the Council.

Schaub, Diana. (2003). "Slavery Plus Abortion." *Public Interest* 150(Winter): 41–46.

Weiss, Rick. (2004). "Bush Ejects Two From Bioethics Council." *Washington Post*, February 28, p. A06.

INTERNET RESOURCE

President's Council on Bioethics. "Transcript of Meeting of January 17, 2002." Available from http://www.bioethics.gov/transcripts/jan02/jan17.html.

PREVENTIVE ENGINEERING

Preventive approaches for the engineering, management, and regulation of modern technology distinguish themselves from their conventional counterparts by using design and decision processes that obtain the desired results while preventing or minimizing undesired effects. The term *preventive engineering* was coined by the author in 1989, and has since become a term of some importance in Canada.

Through the beginning of the twenty-first century, societies tended to direct technological and economic growth by means of a kind of design and decision-making that may be compared to driving a car by concentrating on its performance as indicated by the instruments on the dashboard and only occasionally glancing out to see where it is heading. The result has been many preventable "collisions" with human life, society, and the biosphere. The metaphor is appropriate because engineers, managers, and regulators make decisions whose consequences fall mostly outside of their domains of expertise, where they cannot "see" them. This leaves them little choice but to concentrate on obtaining the maximum possible desired outputs from the requisite inputs and to measure success in terms of performance values (output/input ratios such as efficiency, productivity, profitability, cost-benefit ratios, and gross domestic product [GDP]).

The result of non-preventive engineering is a system in which problems are created in every domain of specialization and left to be dealt with by other specialists in whose domain of competence they fall. In this way, an "end-of-pipe" approach has become institutionalized, making it very difficult to get to the roots of any problem, due to an intellectual and professional division of labor in every contemporary university, corporation, and government. The consequence is a labyrinth of technology: a patchwork of compensations that merely shift problems from one place to another.

It is arguable that the costs of maintaining and expanding this labyrinth are substantially undercutting gross wealth production. According to some calculations, net wealth production has been declining for decades (Daly and Cobb, 1989). It is also estimated that more than 90 percent of what the current (non-preventive) system extracts from the biosphere does not end up in salable products (Allenby and Richards 1994). The primary product would appear to be waste. Similarly, according to socio-epidemiology, workplaces have become one of the primary sources of physical and mental illness (Karasek and Theorell 1990). Unfortunately, many economic, social, and environmental policies address symptoms as opposed to root problems.

Because it has become widely recognized that most of the social and environmental consequences of any engineered product, process, or system are determined during the design phase, the present system helps to design a future society and its relations with the biosphere by omission, paying only peripheral attention to undesired consequences. Preventive approaches can turn this situation around.

Preventive approaches grew out of a study attempting to determine the extent to which the current engineering system is preventive in its orientation (Vandenburg 2000). A typical North American undergraduate engineering curriculum was examined by asking two questions: (1) How much do future practitioners learn about the way technology interacts with human life, society, and the biosphere? (2) To what extent do they learn to use this knowledge in a negative feedback mode to adjust design and decision-making to ensure that the desired results are achieved while simultaneously preventing or greatly minimizing undesired results? These questions were converted into two research instruments to score each component of every course. It was found that in the technical core, little or no reference was made to society and the biosphere, and even when there was, little or no use was made of it in a negative feedback mode. In the complementary studies component of the curriculum, little reference was made to modern science and technology, even though few aspects of modern societies are imaginable without them. Hence, students encounter some disciplines that are full of technology and little else, and others full of everything else and little technology. It is no wonder that successful design courses have been almost non-existent. This non-preventive orientation was also found in the curricula of other professions. The research also showed that the situation changed very little over the last few decades of the twentieth century.

The second phase in the study examined whether the above situation changes significantly after graduation, when practitioners enter specific areas of application (Vandenburg 2000). Using the same research instruments, the latest methods and approaches were scored in the areas of materials and production, energy, work, the urban habitat, and computer-based systems. The results showed that, except for a small cluster of methods and approaches, the same non-preventive situation prevailed. This exceptional cluster was then compared with its conventional counterparts.

The author's study made apparent that conventional approaches separate the economy of technology from the ecology of technology because they generally take the form of a two-stage approach. The economy of technology strips away all contexts (human life, society, and the biosphere), leaving only the requisite inputs and the desired outputs of a technology. From the process of converting requisite inputs into desired outputs, participating specialists abstract those aspects that are coterminous with their domains of competence. Alternatives can no longer be assessed in terms of their meaning and value for human life, society, and the biosphere because these specialists have no such knowledge. Instead, they must be assessed in terms of their contribution to the performance of the process as measured by performance values. Such accounting of outputs and inputs is essential for the effective use of scarce resources. However, it is insufficient to ensure that greater outputs are not partly or wholly achieved at the expense of human life, society, and the biosphere. In a second stage, specialists deal with undesired effects only to ensure that these are within the acceptable limits set out by applicable regulations. The two-stage process assumes that the technical and economic optimum achieved in the first stage is not made sub-optimal by the second stage. The first stage is seen as creating wealth and the second as dealing with unavoidable costs. Conventional approaches are fundamentally non-preventive and non-precautionary in their structure. They are based on the production of *gross* wealth, not on optimizing the creation of *net* wealth by subtracting social and environmental costs. Nor do they ask the question how increased wealth correlates with well-being.

In contrast, the methods and approaches receiving much higher scores in the author's study integrate these two stages by adjusting design and decision-making to obtain the desired results while preventing, as much as possible, the undesired ones. These come closer to the way one normally drives a car, by looking out the windows and occasionally glancing at the dashboard. They are equipped with negative feedback regarding their consequences, while conventional approaches are not.

From this comparative study emerged a prescription based on the concept of preventive approaches. In 2002, the Canada Foundation for Innovation recognized this concept as one of twenty-five important recent innovations.

WILLEM H. VANDERBURG

SEE ALSO *Engineering Ethics.*

BIBLIOGRAPHY

Allenby, Braden R., and Deanna J. Richards. (1994). "Introduction." In *The Greening of Industrial Ecosystems*, eds. Braden R. Allenby and Deanna J. Richards. Washington, DC: National Academy Press.

Daly, Herman E., and John B. Cobb, Jr. (1989). *For the Common Good: Redirecting the Economy Toward Community, the Environment and a Sustainable Future*. Boston: Beacon Press.

Downey, James, and Lois Claxton, eds. (2002). *Inno' Va - Tion: Essays By Leading Canadian Researchers*. Toronto: Key Porter Books.

Karasek, Robert, and ?öres Theorell. (1990). *Healthy Work: Stress, Productivity, and the Reconstruction of Working Life*. New York: Basic Books.

Vanderburg, Willem H. (2000). *The Labyrinth of Technology*. Toronto: University of Toronto Press.

PRISONER'S DILEMMA

The Prisoner's Dilemma is one of the simplest yet most widely applicable situations studied in game theory. The Prisoner's Dilemma was discovered by Melvin Dresher and Merrill Flood at the Rand Corporation in 1950, but its name comes from the following story, which was supplied shortly afterward by the Princeton mathematician

Harold Kuhn. The story and its analysis have been used in different ways to draw forth ethical implications.

The Basic Story

Two men are caught committing an illegal act. If neither one confesses, there is enough evidence to ensure that each man will get one year in jail. If both confess, each one gets five years in jail. However, if one confesses and the other does not, the man who does not confess gets ten years in jail but the confessor who incriminates his partner gets off free. This is a special case of the normal form game illustrated in matrix form in Figure 1.

FIGURE 1

The Normal Form of the Prisoner's Dilemma

	Cooperate	Defect
Cooperate	*R, R*	*S, T*
Defect	*T, S*	*P, P*

SOURCE: Courtesy of Herbert Gintis.

The *normal form* specifies a *strategy set* for each player and a *payoff* for each player as a function of the choice of strategy by each player. In this matrix player 1, the row player, chooses a row, and player 2, the column player, chooses a column. In general the Prisoner's Dilemma requires that $T > R > P > S$. This means that if both players defect, each one receives P, whereas if they both cooperate, each one receives $R > P$. If one player cooperates and the other defects, the defector gets T, which is the largest of the four numbers, and the cooperator gets S, which is the smallest. In Kuhn's example cooperate means "not confess," defect means "confess," and the four payoffs are $T = 0$, $R = -1$, $P = -5$, and $S = -10$. As a mnemonic device one can say that T is the temptation to defect, R is the reward for mutual cooperation, P is the penalty for mutual defections, and S is the sucker's payoff for cooperating when one's partner is defecting.

Note that whatever player 1 does, the best response for player 2 is to confess. This is the case because $T > R$ ($0 > -1$ in our example), and so player 2 does better to confess if player 1 cooperates and $P > S$ ($-5 > -10$ in our example), and so player 2 does better to confess if player 1 confesses. Therefore, if both players are self-interested and rational (i.e., they maximize their payoffs), both players will defect, and so their payoffs will be (P, P), which is $(-5, -5)$ in this example.

The Prisoner's Dilemma also can be described in an *extensive form*, which involves displaying the various moves of the players, as well as the payoffs, using a *game tree*, as is shown in Figure 2.

Perhaps the most important application of the Prisoner's Dilemma is to increase one's understanding of the role of market competition in promoting efficiency, growth, and material wealth. Although traditional economic theory posits the ability of markets to "get the prices right" and thus achieve allocational efficiency, a more important effect of market competition is to subject producers in the same industry to Prisoner's Dilemma–like situations in which mutual defection means that each producer chooses to produce high quality at a low price.

Consider, for instance, an industry with two firms. If they cooperate, they will choose a common price that maximizes total profits (the so-called *monopoly price*) and split total sales. However, each has an incentive to undercut the other's price to increase its own profits by taking sales away from the other. Thus, each producer will "defect" by charging the competitive price no matter what the other producer does (Gintis 2000). In effect, market competition, at least when it is working properly, *disciplines* producers, forcing them to act in the public interest.

The Public Goods Game

When there are n players, the Prisoner's Dilemma is known as the Public Goods Game, which is described as follows. Suppose a team of n players can each contribute an amount b to the group at a cost $c < b$ to each contributor. Each player decides independently of the others whether to cooperate (contribute) or defect (not contribute). Suppose at the end of the game the n players share their proceeds equally. Then if m of the players cooperated, each cooperator will earn mb/n, whereas each defector will earn $mb/n - c$. To see whether it pays to cooperate, consider one of the players, say, player A, and assume that $m - 1$ other players cooperate. By cooperating, player A earns $mb/n - c$, whereas by defecting, player A earns $(m - 1)b/n$. Comparing these two quantities, one can see that cooperating pays off more than defecting does precisely when $b > nc$. That is, a self-interested player A will cooperate only if A's share of the b that A contributes to the group, which is b/n, is greater than A's cost c. If $n = 2$ and $b > c > b/2$, the Public Goods Game becomes a Prisoner's Dilemma in which $T > R > P > S$ becomes $b/2 > b - c > 0 > b/2 - c$.

The Public Goods game was made famous by Garrett Hardin (1915–2003), whose article "The Tragedy of the Commons" (1968) argued that all people have a collective interest in maintaining the natural environment, yet if all people are self-interested, each one will overexploit the environment, even though each one hopes that others will act to preserve the environment. For instance, if ten fishers share a lake, the number of tons of fish that can be harvested season after season (the so-called *sustainable yield* of the lake) may be 1,000, which is 100 tons per fisher. However, each individual fisher may prefer to take 200 tons even if this endangers the yields in future years. In this case, cooperate means "take 100 tons of fish" and defect means "take 200 tons of fish." A fisher who is self-interested will hope others cooperate but will defect no matter what the other fishers do.

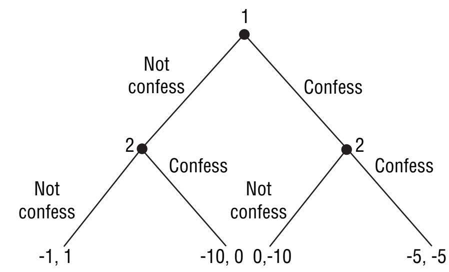
Other examples of social situations that can be couched as *n*-player Prisoner's Dilemmas are (a) pollution, in which each firm hopes the others cooperate (refrain from polluting a river) but defects no matter what the others do; (b) population control, in which each family hopes the other families limit the number of children they bear but bears as many children as it can no matter what the others do; (c) community participation, in which all benefit when all contribute to community projects (schools, roads, public parks, and gardens) but each community member would rather stay home and let the others do the work; and (d) a situation in which a group of farmers share irrigated water; each gains from diverting a large amount of water from their common pool, but all benefit when the water is used in moderation.

Perhaps the most important aspect of the Prisoner's Dilemma is that empirical investigation shows that in real life communities have a variety of resources available to moderate the use of the commons in a reasonable way (Yamagishi 1986, Ostrom 1990). Both state control and privatization of common resources have been advocated, but neither the state nor the market has been uniformly successful in solving common pool resource problems. This is the case because state officials have priorities that often conflict with those of the local resource users and because privatization often concentrates power and wealth in the hands of the individual or group to which the common goods are assigned.

In contrast to the proposition of the tragedy of the commons argument, common pool problems sometimes are solved by voluntary organizations rather than by a coercive state. Among those cases are communal tenure in meadows and forests, irrigation communities and other water rights, and fisheries. These cases often involve local self-organizing regimes that rely on implicit or explicit principles, norms, rules, and procedures rather than the command and control of a central authority.

FIGURE 2

The Extensive Form of the Prisoner's Dilemma



SOURCE: Courtesy of Herbert Gintis.

If agents were truly self-interested, it is not clear how such self-organization could work effectively. However, the fact is that when people play the Prisoner's Dilemma in the laboratory for real money, they very often prefer to cooperate rather than defect as long as their partners cooperate as well (Kiyonari, Tanida, and Yamagishi 2000). Thus, people are generally not well described by the self-interest principle, a fact that has opened up a new research area in human behavior in recent years (Gintis, Bowles, Boyd, and Fehr 2004). This human tendency to cooperate lies at the root of self-organized solutions to common pool resource problems.

Ethical Implications

The Prisoner's Dilemma has important implications for ethical theory. It shows, for instance, that the philosopher Immanuel Kant's (1724–1804) categorical imperative is at best highly ambiguous and at worst fatally flawed. The categorical imperative states that one ought to "act according to that maxim which the actor would at the same time will to become a universal law" (*Critique of Practical Reason,* 1788). In the Prisoner's Dilemma each party would prefer that cooperating were a universal law because in that case the mutually desired outcome would be attained.

However, only in very special cases do players coordinate on the mutual cooperation outcome, and almost never does the duty to cooperate seem to be a defensible ethical commitment. For instance, producers in the same industry who cooperate on Kantian grounds would harm a market economy by colluding to maximize profits at the expense of the public. Similarly, if a person believes that his or her partner will defect, the first person nevertheless is obliged by the categorical imperative to cooperate. Although cooperating in this case may be a nice thing to do ("turn the other cheek"), it would be difficult to defend as a moral duty.

Of course, Kantian ethics is not the only ethical theory that is compromised by game theory in general and by the Prisoner's Dilemma in particular. Utilitarianism also suggests that people act to maximize the sum of utility. In the case of the Prisoner's dilemma this means that each player should cooperate no matter what the other player does. This also lacks plausibility as a general ethical principle.

HERBERT GINTIS

SEE ALSO *Decision Theory; Game Theory; Rational Choice Theory.*

BIBLIOGRAPHY

Gintis, Herbert. (2000). *Game Theory Evolving*. Princeton, NJ: Princeton University Press.

Gintis, Herbert; Samuel Bowles; Robert Boyd; and Ernst Fehr. (2004). *Moral Sentiments and Material Interests: On the Foundations of Cooperation in Economic Life*. Cambridge, MA: MIT Press.

Hardin, Garrett. (1968). "The Tragedy of the Commons." *Science* 162: 1243–1248. Hardin's influential argument is expanded in John A. Baden and Douglas S. Noonan, eds., *Managing the Commons*, 2nd edition. (Bloomington: Indiana University Press, 1998), originally edited by Hardin and Baden (San Francisco, Freeman, 1977).

Kiyonari, Toko; Shigehito Tanida; and Toshio Yamagishi. (2000). "Social Exchange and Reciprocity: Confusion or a Heuristic?" *Evolution and Human Behavior* 21: 411–427.

Ostrom, Elinor. (1990). *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge, UK: Cambridge University Press.

Poundstone,William. (1992). *Prisoner's Dilemma*. New York: Doubleday.

Yamagishi, Toshio. (1986). "The Provision of a Sanctioning System as a Public Good." *Journal of Personality and Social Psychology* 51: 110–116.

PRIVACY

Discussions about privacy are intertwined with the use of technology. The publication that began the debate about privacy in the Western world was occasioned by the introduction of the newspaper printing press and photography. Justices Warren and Brandeis wrote their article on privacy in the *Harvard Law Review* (Warren and Brandeis 1890) partly in protest against the intrusive activities of the journalists of those days. They argued that there is a "right to be left alone" based on a principle of "inviolate personality." Since the publication of that article the debate about privacy has been fueled by claims for the right of individuals to determine the extent to which others have access to them (Westin 1967) and claims for the right of society to know about individuals.

The Nature of Privacy Claims

Inspired by subsequent developments in U.S. law, a distinction can be made between (1) constitutional privacy or decisional privacy and (2) tort privacy or informational privacy (DeCew 1997). The first refers to the freedom to make one's own decisions without interference by others in regard to matters seen as intimate and personal, such as the decision to use contraceptives. The second is concerned with the interest of individuals in exercising control over access to information about themselves.

Statements about privacy can be either descriptive or normative, depending on whether they are used to describe the way people define situations and conditions of privacy and the way they value them or are used to indicate that there ought to be constraints on the use of information or information processing. Informational privacy in a normative sense refers typically to a nonabsolute moral right of persons to have direct or indirect control over access to (1) information about oneself, (2) situations in which others could acquire information about oneself, and (3) technology that can be used to process information about oneself.

Privacy Accounts

Functionalist accounts of privacy argue that privacy serves other values (such as security or autonomy) and that its importance therefore should be explained in terms of those other values. Reductionist accounts argue that privacy claims are really about something else, such as property. Intrinsicalist accounts argue that privacy is valuable in itself (Rössler 2004).

The scarcity account (Fried 1970, Rachels 1984) claims that privacy creates a scarcity of information that allows people to be selective in determining which information they share with whom. In this way one can distinguish between persons with whom one chooses to be close, not so close, or not close at all. On a utilitarian account (Posner 1981) privacy norms are valuable if and insofar as they support valuable social institutions, practices, or actions. Their justification is therefore utilitarian. The moral self-ownership account (Reiman 1984) observes that environments of intensive surveillance and monitoring, such as prisons and mental asylums, convey the message to inmates that they no longer belong to themselves but are owned by the institution. Privacy norms convey the opposite message to individuals: that they own themselves. Autonomy accounts (Benn 1984) emphasize that privacy provides individuals with the autonomy to decide to be unobserved and the discretion to choose to whom to disclose which facts about themselves. Spying and accessing information about persons preempt their autonomous decisions in this respect. A moral autonomy account (Kupfer 1987), in contrast, argues that privacy serves moral autonomy, a second-order autonomy or an autonomy of self-concept. Only when one has a certain amount of control over who has access to oneself can one live a full-fledged moral life in the sense that one feels free to experiment, make mistakes, and criticize oneself. The gaze of others compromises the strong evaluation perspective, which is essential for moral autonomy and for which human beings have a basic capacity. Intimacy accounts (Gerstein 1978, Inness 1992) highlight the importance of intimate relations in human lives. Intimacy seems possible only if information associated with certain types of activities and relations is not widely accessible. A human dignity account (Bloustein 1964) maintains that privacy expresses respect for human dignity and the integrity of a person. According to a property account (Thompson 1975), privacy claims are claims of ownership of personal information and should be rendered as such.

More recently a type of privacy account has been proposed that acknowledges that there is a cluster of related moral claims (cluster accounts) underlying appeals to privacy (DeCew 1997, Van den Hoven 1999, Nissenbaum 2004).

The following types of moral reasons for the protection of personal data and for providing direct or indirect control over access to those data can be distinguished.

1. Prevention of information-based harm. Unrestricted access by others to one's passwords, characteristics, and whereabouts can be used to harm the data subject in a variety of ways.
2. Informational inequality. Personal data have become commodities. Individuals are usually not in a good position to negotiate contracts about the use of their data and do not have the means to check whether partners live up to the terms of the contract. Data protection laws aim at establishing fair conditions for drafting contracts about personal data.
3. Informational injustice and discrimination. Personal information provided in one sphere or context (for example, health care) may change its meaning when used in another sphere or context (such as commercial transactions) and may lead to discrimination and disadvantages for the individual.
4. Encroachment on moral autonomy.

These formulations all provide good moral reasons for limiting and constraining access to personal data and providing individuals with control over their data.

Technology

Information and communication technology has introduced a vast array of possibilities for linking, coupling, and merging databases. Internet searches are logged and can be charted through the use of cookies and spyware. Telecommunications traffic and location data are used to fight crime and global terrorism. Transactional, logistical, and radiofrequency identification data and vehicle registration systems are used to streamline supply chains and improve traffic control. Biometrical data, identification data, and authentication data are used to authorize users and manage access. Profiling and data-mining techniques are used to extract the maximum amount of useful information from what is available (Tavani 2004).

Genetic information constitutes a special type of information about people. It is used not only in health care and health insurance but also in policing and forensics. Genetic information is perceived as constitutive of individual human beings.

Nanotechnology also gives rise to privacy concerns. Miniature recording devices provide almost limitless storage capacity. Ubiquitous software and new recording materials may allow almost anyone to capture data about almost anyone else everywhere and all the time, a state that has been referred to as nano-panopticism (Gutierrez 2004).

Neuroimaging techniques such as computerized axial tomography, positron emission tomography, and functional magnetic resonance imaging make it possible to visualize the inner working and structure of the brain. The images show rational thought, memory activity, and emotional activity in reaction to stimuli and can be used to show a panoply of individual characteristics, defects, malfunctions, and deviancies.

Law, Regulation, and Indirect Control over Access

Data protection laws are in force in almost all countries. The basic moral principle underlying these laws is the requirement of informed consent for processing by the data subject. Furthermore, processing of personal information requires that its purpose be specified, its use be limited, individuals be notified and allowed to correct inaccuracies, and the holder of the data be accountable to oversight authorities (Europa 2004). Because it is impossible to guarantee compliance of all types of data processing in all these areas and applications with these rules and laws in traditional ways, so-called privacy-enhancing technologies and identity management systems are expected to replace human oversight in many cases (Agre and Rotenberg 1997). The challenge with respect to privacy in the twenty-first century is to assure that technology is designed in such a way that it incorporates privacy requirements in the software, architecture, infrastructure, and work processes in a way that makes privacy violations unlikely to occur.

JEROEN VAN DEN HOVEN

SEE ALSO *Genethics; Geographic Information Systems; Information; Information Ethics; Information Society; Internet; Monitoring and Surveillance; Security; Sociological Ethics; Telephone.*

BIBLIOGRAPHY

Agre, Philip E., and Marc Rotenberg, eds. (1997). *Technology and Privacy: The New Landscape*. Cambridge, MA: MIT Press.

Benn, Stanley I. (1984). "Privacy, Freedom and Respect for Persons." In *Philosophical Dimensions of Privacy: An Anthology*, ed. Ferdinand David Schoeman. Cambridge, UK, and New York: Cambridge University Press.

Bloustein, E. (1964). "Privacy as an Aspect of Human Dignity: An Answer to Dean Prosser." *New York University Law Review* 39: 962–1007.

DeCew, Judith Wagner. (1997). *In Pursuit of Privacy: Law, Ethics, and the Rise of Technology*. Ithaca, NY: Cornell University Press.

Fried, Charles. (1970). *An Anatomy of Values*. Cambridge, MA: Harvard University Press.

Gerstein, Robert. (1978). "Intimacy and Privacy." *Ethics* 89: 76–81.

Inness, Julie C. (1992). *Privacy, Intimacy and Isolation*. New York: Oxford University Press.

Kupfer, Joseph. (1987). "Privacy, Autonomy and Self-Concept." *American Philosophical Quarterly* 24: 81–89.

Nissenbaum, Helen. (2004). "Privacy as Contextual Integrity." *Washington Law Review* 79: 101–139.

Posner, Richard A. (1981). *The Economics of Justice*. Cambridge, MA: Harvard University Press.

Rachels, James. (1984). "Why Privacy Is Important." In *Philosophical Dimensions of Privacy: An Anthology*, ed. Ferdinand David Schoeman. Cambridge, UK, and New York: Cambridge University Press.

Reiman, Jeffery H. (1984). "Privacy, Intimacy, and Personhood." In *Philosophical Dimensions of Privacy: An Anthology*, ed. Ferdinand David Schoeman. Cambridge, UK: Cambridge University Press.

Rössler, Beate, ed. (2004). *Privacies. Philosophical Evaluations*. Stanford, CA: Stanford University Press.

Tavani, Herman T. (2004). *Ethics and Technology: Ethical Issues in an Age of Information and Communication Technology*. New York: Wiley.

Thomson, Judith Jarvis. (1975). "The Right to Privacy." *Philosophy and Public Affairs* 4: 295–314.

Van den Hoven, M. Joren. (1999). "Privacy and the Varieties of Informational Wrongdoing." *Australian Journal of Professional and Applied Ethics* 1(1): 30–44.

Westin, Alan F. (1967). *Privacy and Freedom*. New York: Atheneum.

Warren, Samuel D., and Louis D. Brandeis. (1890). "The Right to Privacy." *Harvard Law Review* 4: 193–220.

INTERNET RESOURCES

Europa. (2004). Material on European Union data protection laws is available athttp://europa.eu.int/comm/internal_market/privacy/index_en.htm.

Gutierrez, Eva. (2004). "Privacy Implications of Nanotechnology." Available at http//:www.epic.org.

PROBABILITY

Basic Concepts of Mathematical Probability
History, Interpretation, and Application

BASIC CONCEPTS OF MATHEMATICAL PROBABILITY

Widely used in everyday life, the word *probability* has no simple definition. Probability relates to chance, a notion with deep roots in antiquity, encountered in the works of philosophers and poets, reflected in widespread games of chance and the practice of sortilege, resolving uncertainty by the casting of lots. The mathematical theory of probability, the study of laws that govern random variation, originated in the seventeenth century and has grown into a vigorous branch of modern mathematics. As the foundation of statistical inference it has transformed science and is at the basis of much of modern technology. It has exercised significant influence in ethics and politics, although not always with full appreciation of either its strengths or its limitations.

Thousands of scientists, engineers, economists, and other professionals use the methods of probability and statistics in their work, aided by readily available computer software packages. But there is no strong consensus on the nature of chance in the universe, nor on the best way to make inferences from probability, so the subject continues to be of lively interest to philosophers. It is also part of daily experience—the weather, traffic conditions, sports, the lottery, the stock market, insurance, to name just a few—about which everyone has opinions.

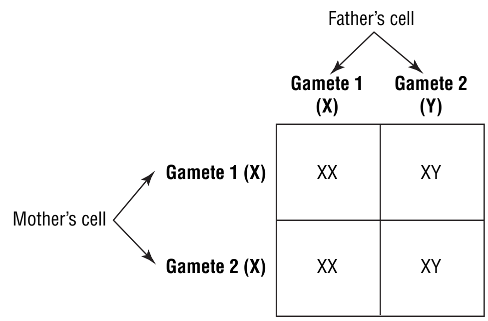
The use of probability in science and technology is often quite technical, involving elaborate models and advanced mathematics that are beyond the understanding of nonspecialists. High-profile controversies may hinge on oversimplification by advocates and the media, unexplored biases, or a lack of appreciation of the extent of uncertainty in scientific results. Yet policy decisions based on such flawed evidence may have far-reaching economic and social consequences. Awareness of the role of probability is thus essential for judging the quality of empirical evidence, and this implies a moral responsibility for citizens of a democratic society.

Although many different techniques of the theory of probability are now in use, they all share a set of basic concepts. It is possible to express these concepts without advanced mathematics, but the concepts themselves are deep, and the results often counterintuitive. Insight may thus require persistent pondering. This entry presents the basic concepts in concise form, using only elementary mathematics. Further details and many applications are found in a wide range of introductory textbooks, written on various levels of mathematical abstraction.

FIGURE 1-2

Figure 1: Probability That Newborn Child Is a Boy

THEORY (MENDELIAN GENETICS)



Probability (male) = 2/4 = 1/2 = 0.5

In a cell division called meiosis the 23 pairs of human chromosomes segregate to form two haploid cells called gametes, each containing 22 autosomes and one sex chromosome (X and Y for males, and X and X for females). In fertilization a male gamete (spermatozoan) fuses with a female gamete (ovum) to form a zygote, a diploid cell with one set of chromosomes from each parent, its sex determined by the father.

SOURCE: Courtesy of Valerie Miké.

Figure 2: Probability That Newborn Child Is a Boy

OBSERVED RELATIVE FREQUENCY

US National Center for Health Statistics
Data for United States 1991–2000

Probability (male) = .5118

Range in annual proportions: .5113–.5123
Average number of births per year: 3.98 million

SOURCE: Courtesy of Valerie Miké. Based on data in *Statistical Abstract of the United States* (1999: Table no. 93, and 2002: Table no. 68). Available from http://www.census.gov.

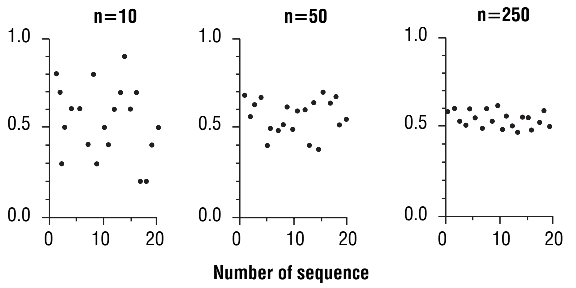
A Simple Example

Consider as a first example the probability that a newborn child is a boy. One approach would be to use the theoretical model shown in Figure 1. According to Mendelian genetics, sex is determined by whether the sperm carries the father's X or Y chromosome; the egg has one of the mother's two X chromosomes. In a cell division called meiosis the twenty-three pairs of human chromosomes segregate to form two haploid (unpaired complement) cells called gametes, each containing twenty-two autosomes and one sex chromosome. In fertilization the male gamete (spermatozoan) fuses with a female gamete (ovum) to form a zygote, a diploid (double complement) cell with one set of chromosomes from each parent, its sex determined by the father. Assuming that the four possible outcomes are equally likely, two of them being XY, the probability that the child is male, written as Probability (male), can be defined as 2/4 = 1/2 = .5.

A second approach would look at the observed relative frequency of boys among the newborn, such as shown in Figure 2. In the ten-year period from 1991 to 2000 there were approximately 39,761,000 registered births in the United States. Of these 20,348,000 were boys, with a relative frequency of .5118. The annual proportions ranged between .5113 and .5123. One could say that the probability of a newborn child being male is .5118, or approximately .51.

FIGURE 3

Empirical Basis of Probability



Proportion of males in 20 sequences of n human births.

SOURCE: Hodges, J.L. and E.L. Lehmann. (1964). *Basic Concepts of Probability and Statistics.* San Francisco: Holden-Day, p. 7.

Which answer then is correct? Most people would agree that the empirical result, based on such a large sample, has to override the model. In fact, the excess of boys among newborns has been observed throughout the world for centuries. The theoretical model is thus not an entirely correct representation of reality.

But what about the sex ratio in smaller samples? Figure 3 presents an experiment based on actual hospital records. The three graphs show the proportion of boys in 20 sequences each of 10, 50, and 250 consecutive births. Note that there is great variation in the sequences of 10, less for 50, and by 250 the proportions settle just above .5. Any one study yields only a single point, and the result from a small sample could be way off. For example, a researcher seeking to establish the proportion of boys among the newborn from a sequence of 10 could come up with a result of .2 or .9! In this example the approximate answer is already known, but in general this is not the case. The use of sample sizes too small to yield meaningful results is a serious problem in practical applications, as is the employment of inadequate theoretical models.

Two Definitions of Probability

Figures 1 and 2 illustrate two ways of defining the notion of probability in a mathematical context.

CLASSICAL DEFINITION. If there is a finite number of possible outcomes of an experiment, all equally likely and mutually exclusive, then the probability of an event is the number of outcomes favorable to the event, divided by the total number of possible outcomes.

This is the case shown in Figure 1, where the probability that a newborn infant is male is given as 2/4 = .5. Customary examples include tossing an unbiased coin or throwing a balanced die. Most situations, however, do not involve equally likely outcomes. Nor does this definition explain what probability is, it just states how to assign a numeric value to this *primitive* idea in certain simple cases.

STATISTICAL DEFINITION. The probability of an event denotes the relative frequency of occurrence of that event in the long run.

In Figure 2, the probability of a newborn infant being male is estimated to be about .51. This is also called the *frequentist* definition and is the one in common use. But it is not a fully satisfactory definition. What does "in the long run" mean? And what about situations in which the experiment cannot be repeated indefinitely under identical conditions, even in principle?

The Axiomatic Approach

A mathematically precise approach is provided by a third definition, the so-called axiomatic definition of probability, which incorporates the other two and is the foundation of the modern theory of probability. It begins with some abstract terms and then defines a few basic axioms on which an elaborate logical structure can be built using the mathematical theories of sets and measure. Probability is a number between zero and one, but nothing is specified about how to assign it. Assignment may be based on a model or on experimental data. Developments are valid if they follow from the axioms, as in other branches of mathematics, independently of any correspondence to phenomena of the physical world.

SAMPLE SPACE AND EVENTS. The framework for any probabilistic study is a *sample space*, often denoted by the letter S, a set whose *elements* represent the possible outcomes of an *experiment*. Subsets of S are called *events*, denoted by A, B, C, and so on. Consider an example of a finite sample space, and let S be the records of 100 consecutive births in a large urban hospital. Events are subsets of these records, defined by some characteristic of the newborn, such as sex, race, or birthweight. Assume further that this sample space of 100 births includes 51 boys, 9 of the infants were of low birthweight (LBW, defined as $\leq$ 2,500 grams), and 20 of the mothers smoked (actually, admitted to smoking) during their pregnancy; 3 of these mothers had LBW babies.

Hospital data of this type can be used, for example, to assess the relationship between smoking and low birthweight, important for the development of public health measures to lower the incidence of LBW. In a formal statistical design called a *case-control study*, a set of LBW babies is closely matched with controls of normal weight, to determine the proportion in each group whose mother smoked. Based on extensive data obtained from hundreds of hospital patients, this was the research method that led to the discovery that smoking is a cause of lung cancer. The case presented here is artificially simple, introduced to illustrate the abstract concepts that form the basis of mathematical probability.

THE ALGEBRA OF EVENTS. The relationships among events in a sample space can be represented by a Venn diagram, such as Figure 4. Let A = LBW babies, and let B = babies whose mother smoked. The event that A does not occur may be denoted by A' ("A prime" or "not A"), consisting of the 91 babies of normal birthweight; A and A' are called *complementary* events. The event that both A and B occur, the *intersection* of A and B, is denoted by $A \cap B$ ("A intersection B"), or simply AB, the set of 3 LBW babies whose mother smoked. The event that either A or B occurs (inclusive or), the *union* of A and B, is denoted by $A \cup B$ ("A union B"), the set of 26 babies who were LBW or their mother smoked, or both. Two events M and F are *mutually exclusive* if the occurrence of one precludes the occurrence of the other. Their intersection MF is the *null set* or *impossible event*, denoted by ϕ (the lower case Greek letter *phi*), where $\phi = S'$, consisting of none of the experimental outcomes. For example, if M and F are the sets of male and female newborns, respectively, then (setting aside the complications of intersexuality) their intersection is an impossible event.

THE AXIOMS OF PROBABILITY. The probability of an event A, denoted $P(A)$, is a number that satisfies the following three axioms:

Axiom 1: $0 \leq P(A) \leq 1$ for all events A in S

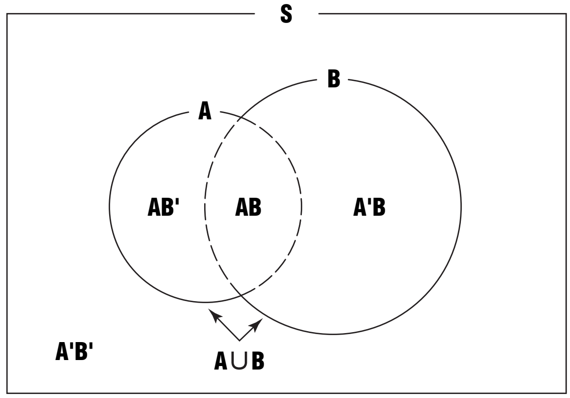
Axiom 2: $P(S) = 1$

Axiom 3: $P(A \cup B) = P(A) + P(B)$, if $AB = \phi$.

Stating the axioms in words, the probability of any event A in the sample space S is a number between zero and one, and the probability of the entire sample space is one (because by definition S contains all events). Furthermore, if two events are mutually exclusive (only one of them can occur), then the probability of their union (one or the other occurs) is the sum of their probabilities. These axioms are sufficient for a theory of finite sample spaces, and Axiom 3 can be generalized to more than two mutually exclusive events. Treatment of infinite sample spaces requires more advanced mathematics.

FIGURE 4-5

Figure 4: Events in a Sample Space



Venn diagram showing events in a sample space, the basis of the axiomatic approach to probability.

SOURCE: Courtesy of Valerie Miké.

Figure 5: Pascal's Triangle

1 1

1 2 1

1 3 3 1

1 4 6 4 1

1 5 10 10 5 1

1 6 15 20 15 6 1

1 7 21 35 35 21 7 1

1 8 28 56 70 56 28 8 1

1 9 36 84 126 126 84 36 9 1

↓ • • • • • • • • • ↓

Each number other than one is the sum of the two directly above it. The nth row represents the binomial coefficients C(n, r).

SOURCE: Courtesy of Valerie Miké.

ELEMENTARY THEOREMS. The following results are immediate consequences of the axioms.

Theorem 1: $P(\phi) = 0$

Theorem 2: $P(A') = 1 - P(A)$

Theorem 3: $P(A \cup B) = P(A) + P(B) - P(AB)$.

The first two theorems state that the probability of the impossible event is zero, and the probability of "not A" is one minus the probability of A. Also called the *addi-*

tion theorem, the third statement means that elements that are in both sets should not be counted twice; the probability of overlapping events must be subtracted. In the hospital example, assuming that individual records are equally likely to be selected, so that the classical definition applies, $P(A) = 9/100 = .09$, $P(B) = 20/100 = .2$, and $P(AB) = 3/100 = .03$. Then the probability that a baby selected at random is either LBW or its mother smoked or both is $P(A \cup B) = .09 + .20 - .03 = .26$.

Conditional Probability and Independence

The two related concepts of conditional probability and independence are among the most important in probability theory as well as its applications. It is often of great interest to know whether the occurrence of an event affects the probability of some other event.

CONDITIONAL PROBABILITY. If $P(B) > 0$, the *conditional* probability of an event A given that an event B has occurred is defined as

$$P(A|B) = \frac{P(AB)}{P(B)}, \qquad (1)$$

that is, the probability of A given B is equal to the probability of AB, divided by the probability of B. For example, consider the conditional probability that a baby selected from the sample of 100 is LBW given that its mother smoked. Then $P(A|B) = .03/.20 = .15$. For nonsmoking mothers, represented by B', the probability of a LBW child is

$$P(A|B') = P(AB')/P(B') = .06/.80 = .075.$$

Rearranging equation (1), and also interchanging the events, assuming $P(A) > 0$, yields the *multiplication theorem* of probability:

$$P(AB) = P(A|B)P(B)$$
$$\text{and } P(AB) = P(A)P(B|A).$$

These relationships, obtained from the definition of conditional probability, lead to the definition of independence.

INDEPENDENCE. Two events A and B are said to be *independent* if the occurrence of one has no effect on the probability of occurrence of the other. More precisely, $P(A|B) = P(A)$ and $P(B|A) = P(B)$, if $P(A) > 0$ and $P(B) > 0$. The events A and B are defined to be independent if

$$P(AB) = P(A)P(B).$$

For example, one would expect a mother's smoking status to have no effect on the sex of her child. So selecting a hospital record at random, the probability of obtaining a boy born to a smoker would be the product of the probabilities, or $(.51)(.20) = .10$.

Assuming the independence of events is a common situation in applications. A prototype model is that of tossing a fair coin, with probability of heads $P(H) = .5$. Then the probability of two heads is $P(HH) = .5 \times .5 = .25$, of three heads is $P(HHH) = .5^3 = .125$, and the probability of n consecutive heads is $(.5)^n$. It follows from Theorem 2 that the probability of at least one tails, or equivalently, the probability of not all heads, is one minus the probability of all heads.

Taking a more real-life (although still oversimplified) example, consider the safety engineering of a space shuttle consisting of 1,000 parts, each of which can fail independently and cause destruction of the shuttle in flight. If each part has reliability of .99999, that is, its chance of failure is one in 100,000 launches, is that a sufficient safety margin for the shuttle? Application of the results above yields

$$P(\text{at least one component failure}) =$$
$$1 - (.99999)^{1,000} = .01,$$

that is, on average one in a hundred shuttle missions will fail, a somewhat counterintuitive result and an unacceptably high risk. With a component failure rate of one in 10,000, the chance of shuttle failure would be one in ten. Achievement of a failure rate of only one in a million per individual parts would be needed to lower the probability of a tragic launch to .001, one in a thousand.

BAYES'S THEOREM. The definition of conditional probability yields formulas that are useful in many applications, and one of these has become known as Bayes's theorem.

Given two sets A and B in a sample space S, with $P(A) > 0$ and $P(B) > 0$, Bayes's theorem can be written in its simplest form as

$$P(A|B) = \frac{P(A)P(B|A)}{P(A)P(B|A) + P(A')P(B|A')}. \qquad (2)$$

Here $P(A)$ is called the *prior probability* of A and $P(A|B)$ the *posterior probability*. Using the definition of conditional probability, the equation shows how to go from the known (or assumed) probability of an event A to estimating its probability given that the event B has occurred. Formula (2) can be generalized to n mutually exclusive events A_k that are *jointly exhaustive* (that is, one of them must occur and their union is S), and $P(A_k) > 0$, for any $k = 1, 2, \ldots, n$,

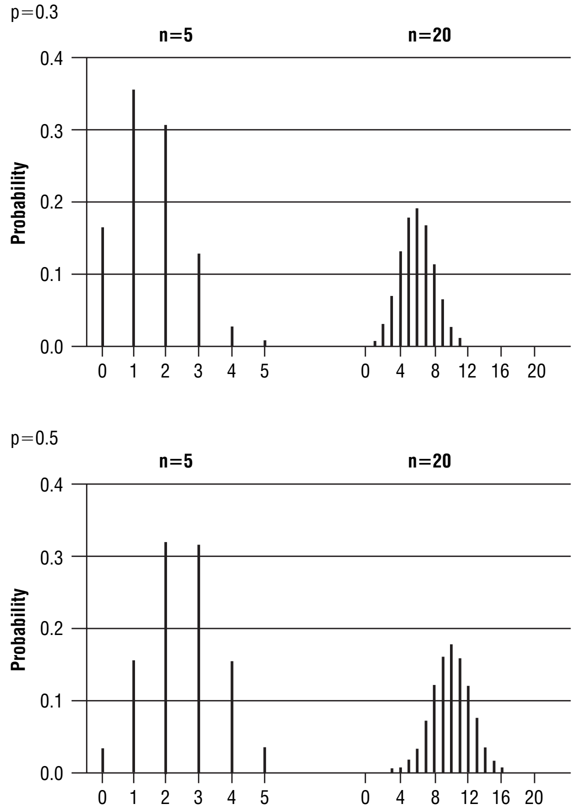
$$P(A_k|B) = \frac{P(A_k)P(B|A_k)}{P(A_1)P(B|A_1) + \ldots + P(A_n)P(B|A_n)}.$$

Bayes's theorem is sometimes referred to as a formula for finding the conditional probabilities of causes. As a somewhat oversimplified example in medicine, it may be used to diagnose (by selecting the highest posterior probability) which of n diseases A_k a patient has, given a particular set of symptoms B, when the prior probability of each disease in the general population is known, as is the probability of this set of symptoms for each of the candidate diseases. The use of conditional probabilities in medical diagnosis has been extensively developed in the field of biostatistics.

Bayes's theorem is also referred to as a formula for revising probabilities as new information becomes available. It is basic to a mode of induction called *Bayesian inference*, where, in contrast to classical or frequentist inference, previous information about a scientific problem is combined with new results to update the evidence. This approach pertains to an alternative, *subjective* interpretation of probability, in which the prior probability may be a *personal* assessment of the truth of the hypothesis of interest.

FIGURE 6

Binomial Distribution



The binomial distribution for two values of p and n. Horizontal scale in each diagram shows values of *r*.

SOURCE: Adapted from Armitage, Peter. (1971). *Statistical Methods in Medical Research*. New York: Wiley, p. 65.

Random Variables and Probability Distributions

Research studies generally seek some quantitative information. In the present mathematical framework, these are numeric values associated with each element of the sample space, and the outcome is determined by the selection of elements in the experiment. The concepts involved are rather abstract. They are needed to connect the intuitive notion of probability with established mathematical entities on which standard operations can be performed to develop a mathematical theory.

RANDOM VARIABLE. The numeric quantity or code associated with each element of a sample space is called a *random variable*, usually denoted by the capital letters X, Y, and so on. Many different random variables can be assigned to the same sample space, depending on the aims of the study. A random variable may be *discrete* or *continuous*. The number of values assumed by a discrete random variable is finite or denumerably infinite (meaning that it can be put in one-to-one correspondence with the positive integers). A special case is the *binary* random variable, which has two outcomes (coded 1 and 0: heads/tails, success/failure, boy/girl). A continuous random variable assumes values along a continuum (e.g., temperature, height, weight). The random variables associated with each baby in the sample space S of 100 hospital records include sex, race, birthweight, and mother's smoking status.

PROBABILITY DISTRIBUTION. The set of probabilities of the possible values of a random variable is called the *probability distribution* of the random variable. The sum of the probabilities is one, because it includes the entire sample space, and $P(S) = 1$. In the simplest case of only two possible outcomes, such as the sex of a newborn child, the distribution consists of $P(\text{male}) = .51$ and $P(\text{female}) = .49$.

PARAMETERS OF A DISTRIBUTION. Parameters are constants that specify the location (central value) and shape of a distribution, often denoted by Greek letters. The most frequently used *location parameter* is the *mean*, also called the *expected value* or *expectation* of X, $E(X)$, denoted by μ (lower case *mu*). Others are the *median* and the *mode*. $E(X)$ is the weighted average of all possible outcomes of a random variable, weighted by the probabilities of the respective outcomes. An important parameter that specifies the *spread* of a distribution is the *variance* of the random variable X, Var(X), defined as $E(X-\mu)^2$ and denoted by σ^2 (lower case *sigma square*). It is the expected value of squared deviations of the outcomes from the mean, always positive because the deviations are squared. The square root of the variance, or σ, is called the *standard deviation* of X, which expresses the spread of the distribution in the same units as the random variable. These concepts are illustrated below for two basic probability distributions, one discrete and the other continuous. When Greek letters are used, it is assumed that the parameters are known. In statistical applications their values are usually estimated from the data. The variance is important as a measure of how widely the observations fluctuate about their mean value, with a small variance providing a more precise estimate of the unknown "true" mean μ.

BINOMIAL DISTRIBUTION. Independent repetition of a *Bernoulli trial*, an experiment with a binary outcome (success/failure) and the same probability p of success, n times yields the *binomial distribution*, specified by the parameters n and p. The random variable X, defined as the number of successes in n trials, can have any value r between 0 and n, with probability

$$P(X = r) = C(n, r)p^r(1 - p)^{n-r}, \quad (3)$$

where $C(n,r)$, the *binomial coefficient*, is the combination of n things taken r at a time, given by the formula

$$C(n, r) = \binom{n}{r} = \frac{n!}{r!(n - r)!}. \quad (4)$$

(The symbol $n!$ is called "n factorial," the product of integers from 1 to n; $0! = 1$. For example, $3! = 1 \times 2 \times 3 = 6$.) Equation (3) is called the *probability function* of the binomial random variable. While random variables are generally denoted by capital letters, the values they assume are shown in lower case letters. (Elementary textbooks, however, do not always make this distinction.) For the binomial distribution $E(X) = np$ and $\text{Var}(X) = np(1-p)$.

Returning to the hospital example, assume that 30 of the 100 infants belong to a minority race, and five records are selected at random. Then X, the number of minority babies selected, could be 0, 1, . . . , 5. The probability that there is no minority baby among the five is

$$P(X = 0) = C(5, 0)(.3)^0(.7)^5 = .17.$$

$C(5, 0) = 1$, because there is only one outcome in which all five babies are white. To obtain the entire distribution, $C(5, r)$ needs to be calculated for the other values of r using formula (4). The binomial coefficients $C(n, r)$ can also be read off *Pascal's triangle*, shown in Figure 5. $C(5, r)$ is the fifth row, yielding the coefficients 1, 5, 10, 10, 5, 1. Applying these to equation (3) for all values of r, with $n = 5$ and $p = .3$, results in the binomial distribution shown in Figure 6, top row, left. The distribution for 20 babies is shown alongside, with expected value

$$E(X) = np = (20)(.3) = 6.$$

This means that on average one can expect 6 babies of a random sample of 20 to belong to a minority group. The second row in Figure 6 shows the binomial distribution for $p = .5$ and $n = 5$ and 20, respectively.

NORMAL DISTRIBUTION. It is seen that for $n = 20$ the distribution looks bell-shaped, and is *symmetric* even for the case $p = .3$, which is *skewed* for $n = 5$. In fact, it can be shown that the binomial distribution is closely approximated by the *normal distribution*, shown in Figure 7. The formula for the normal curve is

$$f(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-(x-\mu)^2/2\sigma^2},$$

the most famous equation of probability theory. To be read as "f of x," the symbol stands for "function of x," its numerical values obtained by computing the expression on the right for different values x of the random variable X. The distribution is completely determined by the parameters μ and σ, but also involves the mathematical constants $\pi = 3.142$ and $e = 2.718$, the base of the natural logarithm. Curves *A* and *B* have different means μ (4 and 8), but the same spread σ (1.0); *B* and *C* have the same mean μ (8), but different spreads σ (1.0 and .5). It can be seen that for each of these normal distributions most of the outcomes (actually about 95 percent) are within 2 standard deviations of the mean.

The normal random variable is continuous and can take on any value between minus and plus infinity. For continuous distributions $f(x)$ is called the *probability density function* of the random variable, which describes the shape of the curve. But for a continuum one can speak of the probability of the random variable X only for an interval of values *x* between two points; it is given by the corresponding area under the curve, obtained by integral calculus. The total area under the curve is one, by definition, as it includes all possible outcomes. The normal distribution plays a central role in statistics, because many variables in nature are normally distributed and also because it provides an excellent approximation to other distributions.

Two Basic Principles of Probability Theory

The most fundamental aspect of mathematical probability can be observed empirically as a fact of nature, and also proved with rigor. This phenomenon can be expressed in the form of two principles. They are given here in their simplest versions, to convey the essential result.

LAW OF LARGE NUMBERS. This laws hold that, in the long run, the relative frequency of occurrence of an event approaches its probability. It is illustrated by the empirical results of Figure 3. Stated more precisely: As the number of observations increases, the relative frequency of an event is within an arbitrarily small interval around the true probability, with a probability that tends to one. The *law of large numbers* connects observed relative frequency with the mathematical concept of probability, and has been proved with increasingly refined bounds on the true probability. A more general formulation pertains to the sample mean approaching the true mean, or expected value. If the occurrence of an event is denoted by 1 and its nonoccurrence by 0, then the relative frequency is the mean of the observations, which approaches the expected value *p*.

CENTRAL LIMIT THEOREM. This theorem states that, in general, for very large values of *n*, the sample mean has an approximate normal distribution. The theorem can be proved with great precision for a variety of conditions, without specifying the shape of the underlying distribution. Figure 6 suggests the result for the binomial distribution. A striking example is given in Figure 8, which shows the distribution of averages of 5 digits, selected at random from the integers between 0 and 9. This discrete random variable has a *uniform distribution*, where each outcome has the same probability .10. Yet the normal approximation is quite good already for this small sample size. The *central limit theorem* is a powerful tool for assessing the state of nature in a wide range of circumstances, with measures of uncertainty provided by the normal distribution.

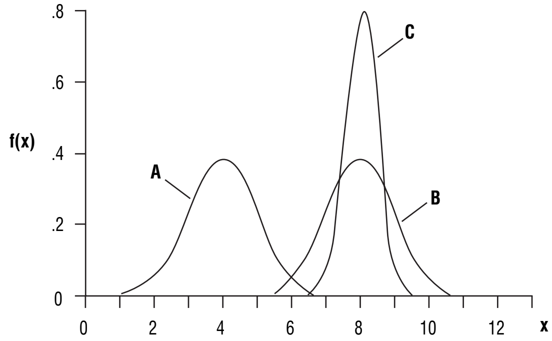
FIGURE 7-8

Figure 7: Normal Distribution

$$f(x) = \frac{1}{\sqrt{2\pi}\,\sigma} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

μ = mean = median = mode

σ^2 = variance; σ = standard deviation



A: $\mu = 4$, $\sigma = 1.0$

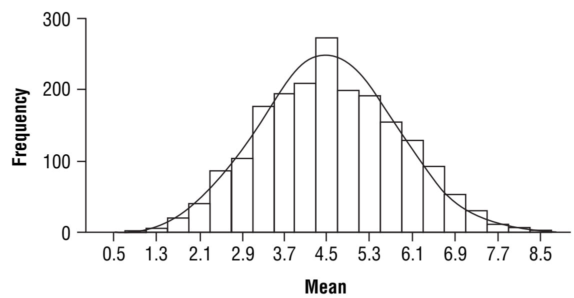
B: $\mu = 8$, $\sigma = 1.0$

C: $\mu = 8$, $\sigma = 0.5$

The normal distribution for different values of μ and σ. The formula includes the constants $\pi = 3.142$ and $e = 2.718$, the base of the natural logarithm.

SOURCE: Courtesy of Valerie Miké.

Figure 8: Central Limit Theorem



Distribution of means from 2,000 samples of 5 random digits with the approximating normal distribution.

SOURCE: Armitage, Peter. (1971). *Statistical Methods in Medical Research*. New York: Wiley, p. 87.

Concluding Remarks

The concepts discussed here form the basis of the mathematical theory of probability, which—unlike the interpretation of probability—is not subject to controversy. The interested newcomer has a wide choice of textbooks as guides in further pursuit of the subject. The main criterion of selection should be comfort with the level of abstraction and the style of presentation: neither too terse nor too wordy. The purpose of symbol in mathematics is the unambiguous and universal expression of concepts. The use of symbol is an indispensable, welcome shorthand for those who understand; it should never be a hindrance to understanding.

Many ethical issues in science and technology require greater insight on the part of the public and call for better education concerning the extent of related uncertainties. But how does one promote understanding of a deep and complex notion such as chance and its myriad manifestations in everyday life? For the mathematical approach a good way is to start early: Encourage the young to play numbers games, to work on puzzles exploring the different ways things can happen, to confront logical paradoxes, and to savor the joy of insight—the aha! experience. Doing mathematics because it is fun enhances intuition and develops the habit of critical thinking, helping the child to grow into a self-confident adult always in search of understanding. But when is it too late? To play mathematical games the only requirement is to be young at heart.

VALERIE MIKÉ

SEE ALSO *Risk: Overview; Statistics; Uncertainty.*

BIBLIOGRAPHY

Anderson, David R., Dennis J. Sweeney, and Thomas A. Williams. (1994). *Introduction to Statistics: Concepts and Applications*, 3rd edition. Minneapolis/St. Paul: West Publishing. Contains several chapters on probability, with many examples; no calculus required.

Armitage, Peter. (1971). *Statistical Methods in Medical Research.* New York: Wiley. Includes a concise summary of the basic concepts of probability theory. Fourth edition, cowritten with Geoffrey Berry and J. N. S. Matthews published in 2001, Malden, MA: Blackwell Science.

Edwards, A. W. F. (2002). *Pascal's Arithmetical Triangle: The Story of a Mathematical Idea.* Baltimore: Johns Hopkins University Press.

Feller, William. (1950, 1966). *An Introduction to Probability Theory and Its Applications.* 2 vols. New York: Wiley. A classic text of probability; Vol. 1 requires only elementary mathematics.

Gardner, Martin. (1978). *Aha! Aha! Insight.* New York: Scientific American. A popular collection of mathematical games, one of a series by this author, illustrated with cartoons; includes a chapter on combinatorics, a basic component of probability.

Gnedenko, Boris V. (1962). *The Theory of Probability,* trans. B. D. Seckler. New York: Chelsea Publishing. Translation of *Kurs teorii veroyatnostei.* A classic text on an advanced level by a leading Russian mathematician of the twentieth century.

Hacking, Ian. (2001). *An Introduction to Probability and Inductive Logic.* Cambridge, UK: Cambridge University Press. Introductory textbook for students of philosophy, with many examples from everyday life.

Hodges, J. L., Jr., and E. L. Lehmann. (1964). *Basic Concepts of Probability and Statistics,* 2nd edition. San Francisco: Holden-Day. Textbook in a more mathematical context, but does not require calculus. Second edition published 1970.

Kolmogorov, Andrei N. (1956). *Foundations of the Theory of Probability,* 2nd English edition, trans. Nathan Morrison. New York: Chelsea Publishing. Translation of *Grundbegriffe der Wahrscheinlichkeitsrechnung* (1933). The original work on the axiomatic basis of probability theory.

Kotz, Samuel; Norman L. Johnson; and Campbell B. Read, eds. (1982–1999). *Encyclopedia of Statistical Sciences.* 9 vols. plus supp. and 3 update vols. New York: Wiley.

Kruskal, William H., and Judith M. Tanur, eds. (1978). *International Encyclopedia of Statistics.* 2 vols. New York: Free Press.

Laplace, Pierre-Simon de. (1812). *Théorie analytique des probabilités* [Analytic theory of probability]. Paris: Courcier. First comprehensive treatment of mathematical probability.

Laplace, Pierre-Simon de. (1951). *A Philosophical Essay on Probabilities,* trans., from the 6th French edition, Frederick Wilson Truscott and Frederick Lincoln Emory. New York: Dover. Translation of *Essaie philosophique sur les probabilités*, 1819. Addressed to the general public, included as the introduction to the third edition (1820) of the work listed above.

Riordan, John. (2002 [1958]). *An Introduction to Combinatorial Analysis.* New York: Dover. A classic of combinatorial analysis, a branch of mathematics basic to probability.

Strait, Peggy Tang. (1989). *A First Course in Probability and Statistics with Applications,* 2nd edition. San Diego, CA: Harcourt Brace Jovanovich. A careful, thorough presentation of mathematical concepts and techniques for the beginner, with hundreds of examples from a wide range of applications.

Weaver, Warren. (1963). *Lady Luck: The Theory of Probability.* Garden City, NY: Anchor Books. A witty, engaging introduction to probability, addressed to the general reader.

HISTORY, INTERPRETATION, AND APPLICATION

It is often said that something is "probably the case" or "probably not the case." The word *probable* comes from the Latin *probabilis*, meaning commendable, which itself derives from *probare,* to prove. Indeed, the English *probable* and *provable* have the same etymologic origin. The scientific study of probability takes the everyday notions of recommending and approving and gives them strict definitions and systematic analysis, something that narrows their focus while enhancing their power to inform. Insight into related matters is essential in advanced technological societies where experts regularly give technical advice to a public that must then decide whether or not to accept it. This may involve the development of new government policies or actions to be taken by individuals, such as submitting to a new medical treatment.

But there are other complex issues to consider. It is generally understood that probability has something to do with chance, a concept of enduring fascination throughout history. While philosophers explore alternative interpretations of probability that lead to different modes of induction in science, there remains the enigma of the role of chance in the world. Given the theories of quantum physics and evolutionary biology proclaiming a universe of chance, how do these impact the fundamental questions of philosophy that sooner or later confront every thinking person: Who am I? Why am I here? How should I live my life?

Reflecting in search of insight, it is important to distinguish between what is science and what is philosophy, and to differentiate between the speculations of philosophers—traditionally fraught with controversy—and the daily activities of practicing scientists. There is a need to understand the role of probability in science and technology, as well as its relation to the perennial questions of human existence. After a brief sketch of the history of probability, the present entry offers some thoughts on this vast and profound subject, concluding with a discussion of the applications of probability at the start of the twenty-first century.

Highlights of History

This quick survey of the history of probability is presented in two sections, beginning with the evolution of mathematical concepts and then turning to their use in philosophical speculation.

THE RISE OF MATHEMATICAL PROBABILITY. There are earlier records of mathematics applied to games of chance, but the beginning of the theory of probability is generally identified with the 1654 correspondence between the two French mathematicians Blaise Pascal (1623–1662) and Pierre de Fermat (1601–1665) concerning the so-called problem of points in gambling. The question was how to divide the stakes between two players who part before completing the game. To arrive at the solution, Pascal introduced the binomial distribution for $p = .5$ and found the coefficients by means of the arithmetical triangle, a curious numeric structure now named after him. In 1657 the Dutch mathematician Christiaan Huygens (1629–1695) published his monograph *De Ratiociniis in Ludo Aleae* (Reasoning on games of chance), the first printed mathematical treatment of games of chance. In these games equally likely outcomes, such as the six faces of a balanced die, were the assumption that led to the classical definition of probability. The first major work devoted to probability theory was *Ars Conjectandi* (The art of conjecturing) by the Swiss mathematician Jakob (Jacques) Bernoulli (1654–1705), published in 1713. It contained the first form of the law of large numbers.

About this time in England, attention focused on the by then established systematic recording of births and deaths and related practical issues of insurance and annuities. Relative frequency was applied to mortality data by the merchant John Graunt (1620–1674), whose *Natural and Political Observations . . . Made upon the Bills of Mortality* (1662) marked the beginning of actuarial science. The stability of observed ratios suggested the second, the statistical or frequentist, definition of probability. William Petty (1623–1687), physician and mathematician, coined the term *political arithmetic* in his quantitative analysis of social phenomena that would become the foundation of modern economics. Also working in England, the French mathematician Abraham de Moivre (1667–1754) wrote *The Doctrine of Chances; or, A Method of Calculating the Probabilities of Events in Play* (1718, 1738, 1756), another landmark in the history of probability. The second and third editions of the book include his discovery of the normal curve as the limit of the binomial distribution.

Important advances were made in the first part of the nineteenth century. The normal distribution, applied to measurement variations in astronomy, was studied by the French mathematician Pierre-Simon de Laplace (1749–1827), author of the first comprehensive work on probability, *Théorie analytique des probabilités* (1812; Analytic theory of probability). Laplace discovered and proved the earliest general form of the central limit theorem. The normal curve is also called the Gaussian distribution, after the German mathematician Carl Friedrich Gauss (1777–1855), who developed it as the law of errors of observations, in conjunction with the principle of least squares, in which it plays a key role. Least squares, a method for combining observations to estimate parameters by minimizing the squared deviations of the observations from expected values involving the parameters, became a basic tool in astronomy, geodesy, and a wide range of other areas.

Probability came to be used for the analysis of variation in itself, not as errors to be eliminated, in the social sciences and in physics and biology. The intense study of heredity triggered by Charles Darwin's (1809–1882) theory of evolution, spearheaded by his cousin Francis Galton (1822–1911), would lead to the new field of mathematical statistics around the turn of the twentieth century. The axiomatic foundation of the modern theory of probability was the work of the Russian mathematician Andrei N. Kolmogorov (1903–1987), published in 1933.

PROBABILITY AND PHILOSOPHY. The notion of probability dates back to antiquity, and beyond games of chance to questions of philosophy, of permanence and change, of truth and uncertainty, of knowledge and belief. The revival of interest in the thought of the ancients during the Renaissance brought about an interplay of intellectual currents with scientific discoveries that energized a renewed search for explanation and meaning. The role of chance was at the core of developments from the start.

Pascal posed a challenge to skeptics of his day in the famous "Wager" of his *Pensées,* published posthumously in 1670, in which the question of God's existence was to be answered as if by the toss of a coin at the end of life. Presenting arguments for betting that God exists, Pascal developed basic elements of decision theory concerning courses of action in the face of uncertainty.

The work of Isaac Newton (1642–1727), his universal law of gravitation and his synthesis of cause and effect explained by laws of physics in a fully determined universe, launched the era of modern science. Since then, reports of scientific advances have been at the forefront of public consciousness, dominant factors to be integrated into any cohesive worldview. Newton's system involved his concept of an omnipresent deity who maintains the motion of heavenly bodies, and this led to a lively natural theology (part of philosophy, as it does not have recourse to Revelation) in the eighteenth century. In contrast to the observed regularity of planetary orbits there was variability in human affairs, but here the stable patterns of long-run frequencies also seemed to imply design and purpose. The constant excess of males among the newborn was a recurring example.

In 1710 John Arbuthnot (1667–1735), physician and scholar, published an influential essay titled "An Argument for Divine Providence, Taken from the Constant Regularity Observed in the Births of Both Sexes." He found that in the eighty-two consecutive years on record more boys than girls had been born in London. He reasoned that because boys were at greater risk of dying young as a result of their duties in the world, there was a need in a monogamous society for more boys to be born, and this was wisely arranged by Providence. His article contained the earliest example of a test of a statistical hypothesis, concluding that the observed result would be highly unlikely if in fact the true probability of a boy was one-half.

De Moivre aimed to show that probability had more consequential objects than the frivolous pastime of gambling, and in the second and third editions of *The Doctrine of Chances* argued for its serious mission in proving the existence of God. While chance produces irregularities, he wrote, it is evident that these are governed by laws according to which events happen, and the laws serve to preserve the order of the universe. We are thus led "to the acknowledgment of the great MAKER and GOVERNOUR of all; *Himself all-wise, all-powerful,* and *good*" (1756, p. 252).

One of the most famous documents in the history of science is "An Essay towards Solving a Problem in the Doctrine of Chances," by Thomas Bayes (1702–1761), an English clergyman also interested in probability. It is the first expression in precise, quantitative terms of one of the chief modes of inductive inference. The essay contains what is now called Bayes's theorem and is central to approaches known as Bayesian inference. The manuscript was published posthumously in 1763, with an introduction by the Reverend Richard Price (1723–1791). In delineating the importance of Bayes's achievement, Price suggested that his method of using the probabilities of observed events to compare the plausibility of hypotheses that could explain them is a stronger argument for an intelligent cause than the appeal to laws obtained from chance events proposed by de Moivre. More generally, as asserted by Price and explored by modern scholarship, Bayes's method in a sense evades the problem of direct induction posed by the Scottish philosopher David Hume (1711–1776), who rejected the very possibility of inductive reasoning. A Bayesian does not claim to justify any set of beliefs as uniquely rational. But having a belief structure that satisfies the axioms of probability, one's earlier *personal probability* (*degree of belief*) can be updated by new evidence in a coherent, reasonable manner. Bayes's method, the argument goes, provides a uniquely rational way to learn from experience.

In Germany, using results from England as well as his own extensive collection of data, Johann Peter

Süssmilch (1707–1767), military chaplain and mathematician, wrote the first analytic theory of population, *Die göttliche Ordnung in den Veränderungen des menschlichen Geschlechts, aus der Geburt, dem Tode, und der Fortpflanzung desselben erwiesen* (1741; The divine order in the fluctuations of the human race, shown by the births, deaths, and propagation of the same). Through his pioneering work in demography Süssmilch sought to discern in the detected patterns of population trends, in this natural order, the eternal laws of God.

As the use of probability expanded in the nineteenth century, so did philosophical concern with the problem of chance in a deterministic universe, with questions of causality, proof, natural law, free will. Speculation entered a new phase with the theory of evolution, when chance assumed a dominant role, to be enhanced by quantum theory in the early twentieth century. The debate continues with renewed vigor, in the light of new developments in cosmology, evolutionary biology, and other related disciplines.

Interpretation: A Commentary

The following discussion of various aspects of probability does not aim to be comprehensive or exhaustive. Rather, it offers some comments to stimulate thought and further exploration of this deep, complex subject.

OBJECTIVE VERSUS SUBJECTIVE PROBABILITY. Probability has a dual nature, recognized since its emergence in the seventeenth century. It may be *aleatory* (frequentist, from "dicing") or *epistemic* (pertaining to knowledge), also called *objective* or *subjective* probability. Objective probability takes a sort of Platonic view, assuming the existence of idealized states, represented by a mathematical model and estimated by observed relative frequency. Subjective probability is degree of belief, and it involves personal judgment.

Both interpretations are common in everyday use. The probability that a newborn child is a boy, which is .5 according to Mendelian genetics and .51 as observed relative frequency, provides two examples of objective or frequency-type probability. The subjective or belief-type may refer to any statements expressing some belief or opinion. It can be illustrated by the high-profile Terri Schiavo case of early 2005. A severely brain-damaged woman, on artificial nutrition and hydration for years, had her feeding tube removed by court order at the request of her husband but against the strong objections of her parents. There were many conflicting reports in the media concerning important aspects of the case, so that no one not directly involved could possibly know the facts for sure. In the absence of a living will, a key factor was the husband's claim, challenged by others, that prior to being stricken fifteen years earlier the young woman had clearly stated her wishes not to be kept alive under these circumstances. The diverse opinions expressed in public and private debates were examples of subjective probability, not determined by objective information, but reflecting the division in American society on a host of related issues.

The precise interpretation of probability in science has been of special concern to philosophers. The theory of subjective probability is the theory of coherence of a body of opinion, guided by its conformance to the axioms of probability that both types must obey, with probability as a number between zero and one. There are several approaches of subjective probability, explained and illustrated with simple examples in Ian Hacking's 2001 textbook *An Introduction to Probability and Inductive Logic*.

The subjective probability of a proposition may be defined as the value to the user of a unit benefit contingent on the truth of the proposition. The concept of personal value or *utility* is central to decision theory in economics and the behavioral sciences. But in general statistical inference, the two interpretations of probability are in direct opposition, with no resolution likely in the foreseeable future. The subjective approach, usually called *Bayesian*, involves combining one's *prior probability*, based on a qualitative assessment of the situation, with new information to obtain the *posterior probability*. A key controversial issue is the subjective choice of the prior probability. Critics of objective probability counter that relative frequency itself is subjective, because it depends on the denominator used, and what about situations in which long-run repeated experimentation under identical conditions is not possible, even in principle? And so it goes. But any approach of logic has its intrinsic limitations. There are no right or wrong answers to the debates of philosophers; probability and chance are among the primitive concepts always open to analysis, such as knowledge, cause, and truth.

Some points to remember: Unless otherwise indicated in the title of a published report, the "default" method of analysis is based on objective probability and the classical (Neyman-Pearson) theory of statistical inference. From the viewpoint of communicating scientific results to the public, often in media sound bites, objective probability seems to be the more suitable method. In any case, under many conditions the results are similar. But discoveries are not made by formula. Creative scientists know what is happening in their own field and entertain ideas in the context of their own views. Out of this may emerge something new after years of search and many blind alleys. Ethical concerns pertain to violation of the codes of research conduct and false reporting of results, whatever the claimed method of confirmation.

CHANCE AT THE HEART OF REALITY? From the great Aristotelian synthesis of antiquity to the late nineteenth century, physical determinism with strict causality was a basic assumption of science and philosophy. Chance was taken as a measure of ignorance, a lack of knowledge of the complex interaction of unknown causes. This changed with the theory of evolution, involving random mutation and natural selection, and was followed in the early twentieth century by the discovery of quantum mechanics and indeterminism at the fundamental level. According to Heisenberg's uncertainty principle, the position and momentum of elementary particles can be considered together only in terms of probabilities. These theories endow chance with a distinct identity, as an explanatory principle of effects without a cause.

Is chance then an intrinsic part of nature, a feature of reality? That was the Copenhagen interpretation of quantum theory, accepted by the majority of physicists, although it never became unanimous. Albert Einstein expressed his opposition in the famous statement: "God does not play dice with the universe." An alternative view is to differentiate between interaction in nature and the level of measurability in physics (Jaki 1986). But the acceptance of chance in quantum mechanics does not imply a lawless universe; the probabilities of the different states can be precisely measured, and on a macroscopic scale nature appears to follow deterministic laws. There is also the concept of contingent order: Events that may be random still obey a larger law; an example would be random mutation in biology, within the structure of Mendelian genetics.

Again, some points to consider: Training in physics at the doctoral level is required to appreciate the implications of quantum mechanics. The subject has no intuitive meaning for nonspecialists, and there is continued disagreement among physicists. Speculation on the nature of reality belongs to philosophy, even if done by physicists. Intrinsic to the intellectual motivation of working scientists is a philosophy of realism, the belief in an external world of order that is accessible to human inquiry. In this context chance remains a measure of uncertainty, and that is the relevant interpretation for the applied sciences and technology.

OBSERVING RANDOMNESS. The word *random* cannot be defined precisely; one can say only what it is not. In textbooks of probability and statistics it is generally an undefined term, like *point* in geometry. The random numbers generated by computer and used in many research applications are in fact produced by given rules and as such are not random; *pseudorandom* is the proper technical term. There is much ongoing research on the concept of randomness. The simplest common example of a random experiment, the flipping of a coin, has been analyzed in terms of Newton's laws of physics, with upward velocity and rate of spin of the coin determining the outcome. Similar analyses hold for dice and roulette wheels.

Chaos theory has found that very little complexity in a deterministic system is needed to bring about highly complex phenomena, often unpredictably "chaotic" behavior. Almost imperceptible differences in the initial conditions can result in widely diverging outcomes. First noted in a computer simulation of a weather system, this has become known as the "butterfly effect," the image of a butterfly flapping its wings causing a hurricane somewhere across the globe. The phenomenon has been observed in a variety of fields, and the theory being developed has application in a wide range of disciplines, including hydrodynamics, biology, physiology, psychology, economics, ecology, and engineering. The important observation is that even many phenomena that are adequately covered by deterministic theories of classical physics prove to be chaotic, suggesting that there are real limitations on what can be learned about physical systems.

Clearly here scientific determinism does not imply epistemological determinism (meaning that results can be established with certainty). The phenomena appear random and need to be addressed in terms of probabilities. These discoveries should teach caution in expectations for the claimed effects of various aggressively promoted economic and social policies for giant systems such as the United States and other nations.

FREE WILL AND THE LAWS OF PROBABILITY. As a simple example, consider a local telephone calling region where the length of a call does not affect its cost. Residents can call anyone in the region they wish, at any time they wish, and talk as long as they wish, for one unit charge per call. Then the probability distribution of call durations for any given time period will be an *exponential distribution*. The number of calls arriving at an exchange during a fixed time interval will follow a *Poisson distribution*, with higher means for busy periods of telephone traffic. These precisely defined laws make possible the efficient design of communications systems.

From the engineering viewpoint the calls, initiated by the free will of large numbers of individuals, are random, following known probability laws with parameters that are estimated from observations.

PURPOSE IN THE UNIVERSE? The evolution controversy is often presented to the public as the conflict between two diametrically opposed fundamentalist views: Strict Darwinism, according to which chance variation and natural selection are sufficient to explain the origin of all life on Earth, and so-called creationism, which accepts a literal interpretation of the Book of Genesis of the Old Testament. In fact the situation is more complex.

Some evolutionary biologists hold that further structures beyond strict Darwinism are needed to account for the complexity of living systems. They are naturalists, whose explorations use the latest scientific advances to seek better explanations in the natural order. Many mainstream believers accept the fact of evolution, and those interested in science also question the mechanism of evolution. They are creationists in the sense that they believe in Creation, but they seek to learn what science has to say about how the world came into being. They believe that there is purpose in the universe, and see no problem with considering intelligent design as one of the explanatory hypotheses. Because the aim is to understand all of life and human experience, they do not think it rational to exclude any viable hypotheses.

Working along these lines are the American researchers Michael J. Behe, William A. Dembski, and Stephen C. Meyer, who argue that the complex specified information found in the universe, including irreducibly complex biochemical systems, cannot be the product of chance mechanisms and thus provides evidence of intelligent design (Behe, Dembski, and Meyer 2000). In cosmology the big bang theory of the origin of the universe and the anthropic principle concerning conditions necessary for the existence of life may be used in speculations of natural theology. Any emerging results that show consistency of science with the tenets of belief should be discussed openly, along with everything else. Submit it all to the test of time.

THE RELEVANCE OF PASCAL. The work of Pascal, of enduring interest for 300 years, was the subject of books by two prominent thinkers of the twentieth century—the Hungarian mathematician Alfréd Rényi (1921–1970) and the Italian-German theologian and philosopher of religion Romano Guardini (1885–1968), who held the philosophy chair "Christliche Weltanschauung" (Christian worldview) at the University of Munich.

Letters on Probability (Rényi 1972) is a series of four fictitious letters by Pascal to Fermat, assumed to be part of the lost correspondence between the two mathematicians. Addressed to the general reader, it is a witty and charming exploration of the notion of chance and probability, in the cultural context of the seventeenth century that shows the timelessness of the subject. In the last letter Pascal reports on a dialogue he had with a friend concerning the merits of objective and subjective probability. They discussed *De rerum natura* (On the nature of things), by the Roman poet-philosopher Lucretius (fl. first century B.C.E.), in which he described the Greek atomistic philosophy of Democritus (c. 460–c. 370 B.C.E.) and Epicurus (341–270 B.C.E.); they wondered what the ancients might have meant by chance and random events. In its images of whirling atoms the poem conveys a striking picture of Brownian motion. Pascal is here an advocate of objective probability, reflecting the views of the author.

Pascal for Our Time (Guardini 1966) is a biography placing an immensely gifted believer at the point in the history of ideas when the scientific consciousness of the modern age had fully emerged, but that of the previous era had not yet faded. Pascal is presented as a human being who—simultaneously endowed with keen insight in science, psychology, and philosophy—seeks with reflection to justify his existence at every moment. Guardini shows Pascal's relevance at the intellectual and cultural watershed reached by the twentieth century.

For Pascal thinking was the basis of morality, and a reasoned search the way to proceed to find meaning. Human longing far surpasses what this life has to offer: "Man infinitely transcends man" (Pascal 1995, #131; the numbering refers to the fragments in this edition of the *Pensées*). A totally committed search is the only option of reason. But the search is feebleminded if it stops before reaching the absolute limits of reason: "Reason's last step is the recognition that there are an infinite number of things which are beyond it. It is merely feeble if it does not go as far as to realize that" (#188). Faith offers more knowledge, but it has to be consistent with the evidence of sense experience: "Faith certainly tells us what the senses do not, but not the contrary of what they see; it is above, not against them" (#185).

The ultimate limits of human reason, perceived by Pascal, were established in the twentieth century with Kurt Gödel's incompleteness theorem in mathematics. The search Pascal so strongly urged was taken up by the natural theologians, among others, and it continues into the twenty-first century. And for thoughtful believers there still cannot be a conflict between faith and science.

THE ETHICS OF EVIDENCE. The comments shared above fit into a proposed framework for dealing with uncertainty, the *Ethics of Evidence* (Miké 2000). The Ethics of Evidence calls for developing and using the best evidence for decision-making in human affairs, while recognizing that there will always be uncertainty—scientific as well as existential uncertainty. It calls for synthesis of the findings of all relevant fields, and taking personal responsibility for committed action. Philosophical questions such as the nature of reality and purpose in the universe cannot be decided by the latest findings of a particular science. The French philosopher Étienne Gilson (1884–1978) argued in his book *The Unity of Philosophical Experience* (1999 [1937]) that this age has been going through the last phase of the current cycle of twenty-five centuries of Western philosophy. A new philosophical synthesis is needed, with a first principle that integrates the accumulating insights of science and other disciplines.

Application of Probability

Since the 1960s much historical scholarship has focused on what Gerd Gigerenzer and colleagues (1989) aptly described as *The Empire of Chance: How Probability Changed Science and Everyday Life*. There are encyclopedias devoted to the subject, with probability as an integral component of the field of statistics. Probability is the basis of theories of *sampling*, *estimation* of parameters, *hypothesis testing*, and other modes of *inference*, in a multitude of complex designs for the simultaneous study of variables of interest.

Reminiscent of the beginnings with games of chance, the Hungarian mathematician John von Neumann (1903–1957) published a seminal essay in 1928 on the theory of games of strategy, opening up entirely new paths for mathematical economics. He collaborated with the Austrian economist Oskar Morgenstern (1902–1977), by then both in the United States, on their classic work *Theory of Games and Economic Behavior* (1944). The theory of games provides models for economic and social phenomena, including political and military contexts, in which participants strive for their own advantage but do not control or know the probability distribution of all the variables on which the outcome of their acts depends. An important extension is noncooperative game theory, which excludes binding agreements and is based on the concept of Nash equilibrium, used to make predictions about the outcome of strategic interaction. It is named after its originator, the American mathematician John F. Nash (b. 1928). Game theory is inference in the form of decision-making.

More generally, there are *stochastic processes*, in what is called the probability theory of movement; these are systems that pass through a succession of states, usually over time, as distinct from deterministic systems in which a constant mechanism generates data that are assumed to be independent. Examples of these include epidemic theory, study of complex networks, finance theory, genetic epidemiology, hydrology, and the foundations of quantum theory.

Ethical aspects of probability pertain to knowing and using the proper techniques to clarify and help resolve problems in science and technology, with close attention to remaining uncertainties. If mechanisms of action are fully understood, as in many engineering systems, careful design and built-in redundancies will result in reliable performance within specified probabilities. But in most areas of interest, such as medical, social, and economic phenomena, the number of variables is large and the mechanisms often unknown or at best poorly understood. Thus only a selection of potentially relevant factors can be studied in any one tentative model, amid vast uncertainties. Misuse of such limited results makes the public vulnerable to manipulation by state, market, and a multitude of interest groups. It seems impossible to overstate the importance of awareness and education concerning these issues.

VALERIE MIKÉ

SEE ALSO *Pascal, Blaise; Risk: Overview; Statistics; Uncertainty.*

BIBLIOGRAPHY

Arbuthnot, John. (1710). "An Argument for Divine Providence, Taken from the Constant Regularity Observed in the Births of Both Sexes." *Philosophical Transactions of the Royal Society of London* 27: 186–190. Reprinted in *Studies in the History of Statistics and Probability*, Vol. 2., ed. Maurice G. Kendall and R. L. Plackett. New York: Macmillan, 1977.

Bayes, Thomas. (1763). "An Essay towards Solving a Problem in the Doctrine of Chances." *Philosophical Transactions of the Royal Society of London* 53: 370–418. Reprinted in *Studies in the History of Statistics and Probability*, Vol. 1, ed. Egon S. Pearson and Maurice G. Kendall. London: Griffin, 1970.

Behe, Michael J.; William A. Dembski; and Stephen C. Meyer. (2000). *Science and Evidence for Design in the Universe*. San Francisco: Ignatius Press. Authors are trained in biochemistry, mathematics, and philosophy.

Bernoulli, Jacques. (1713). *Ars Conjectandi* [The art of conjecturing]. Basel: Impensis Thurnisiorum.

David, Florence N. (1962). *Games, Gods, and Gambling: The Origins and History of Probability and Statistical Ideas from the Earliest Times to the Newtonian Era*. London: Charles Griffin. Illustrated story of the prehistory of probability and its early development. Assessment of Pascal's contribution questioned by other scholars, such as Rényi (1972).

Edwards, A. W. F. (2002). *Pascal's Arithmetical Triangle: The Story of a Mathematical Idea*. Baltimore: Johns Hopkins University Press.

Eisenhart, Churchill, and Allan Birnbaum. (1967). "Tercentennials of Arbuthnot and de Moivre." *American Statistician* 21(3): 22–29.

Gigerenzer, Gerd; Zeno Swijtink; Theodore Porter; et al. (1989). *The Empire of Chance: How Probability Changed Science and Everyday Life*. Cambridge, UK: Cambridge University Press. Summary of a two-volume work by a team of historians and philosophers of science, written for a general audience.

Gilson, Étienne. (1999 [1937]). *The Unity of Philosophical Experience*. San Francisco: Ignatius Press. Analysis of the history of Western philosophy with a proposed new philosophical synthesis.

Graunt, John. (1662). *Natural and Political Observations Mentioned in a Following Index, and Made upon the Bills of Mortality*. London. Reprinted in *Natural and Political Observations Made upon the Bills of Mortality*, ed. Walter F. Willcox. Baltimore: Johns Hopkins University Press, 1939.

Guardini, Romano. (1966). *Pascal for Our Time*, trans. Brian Thompson. New York: Herder and Herder. Translation of *Christliches Bewußtsein: Versuche über Pascal*, 1935.

Hacking, Ian. (1975). *The Emergence of Probability: A Philosophical Study of Early Ideas about Probability, Induction, and Statistical Inference*. London: Cambridge University Press. Includes speculation on the dual nature of probability.

Hacking, Ian. (1990). *The Taming of Chance*. Cambridge, UK: Cambridge University Press. Continuation of 1975 work (see above), exploring the development of probability to the beginning of the twentieth century.

Hacking, Ian. (2001). *An Introduction to Probability and Inductive Logic*. Cambridge, UK: Cambridge University Press. Introductory textbook for students of philosophy, with many examples.

Huygens, Christiaan. (1657). *De Ratiociniis in Ludo Aleae* [Reasoning on games of chance]. In *Exercitationum Mathematicarum Libri Quinque* [Five books of mathematical exercises], ed. Frans van Schooten. Leiden, Netherlands: Johannis Elsevirii.

Jaki, Stanley L. (1986). "Chance or Reality: Interaction in Nature versus Measurement in Physics." In his *Chance or Reality and Other Essays*. Lanham, MD: University Press of America. Analysis of the controversy over the interpretation of quantum mechanics by a noted historian of science.

Kolmogorov, Andrei N. (1956). *Foundations of the Theory of Probability*, 2nd English edition, trans. Nathan Morrison. New York: Chelsea Publishing. Translation of *Grundbegriffe der Wahrscheinlichkeitsrechnung*, 1933. The original work on the axiomatic basis of probability theory.

Kotz, Samuel; Norman L. Johnson; and Campbell B. Read, eds. (1982–1999). *Encyclopedia of Statistical Sciences*. 9 vols. plus supp. and 3 update vols. New York: Wiley.

Kruskal, William H., and Judith M. Tanur, eds. (1978). *International Encyclopedia of Statistics*. 2 vols. New York: Free Press.

Laplace, Pierre-Simon de. (1812). *Théorie analytique des probabilités* [Analytic theory of probability]. Paris: Courcier. First systematic treatment of probability theory.

Laplace, Pierre-Simon de. (1951). *A Philosophical Essay on Probabilities*, trans., from the 6th French edition, Frederick Wilson Truscott and Frederick Lincoln Emory. New York: Dover. Translation of *Essaie philosophique sur les probabilités*, 1819. Addressed to the general public, included as the introduction to the third edition (1820) of the work listed above.

Miké, Valerie. (2000). "Seeking the Truth in a World of Chance." *Technology in Society* 22(3): 353–360. Discusses the work of Pascal in a contemporary cultural context.

Moivre, Abraham de. (1718). *The Doctrine of Chances; or, A Method of Calculating the Probabilities of Events in Play*. London: W. Pearson. 2nd edition, London: Woodfall, 1738. 3rd edition, London: Millar, 1756. Reprinted: New York: Chelsea Publishing, 1967; Providence, RI: American Mathematical Society, 2000.

Pascal, Blaise. (1995). *Pensées* [Thoughts], trans. A. J. Krailsheimer. London: Penguin. Originally published in French, 1670. Fine modern English translation, with an introduction by the translator.

Peterson, Ivars. (1990). *Islands of Truth: A Mathematical Mystery Cruise*. New York: Freeman. One in a series of richly illustrated books by a science writer on new ideas in mathematics, addressed to the lay reader; includes chaos theory.

Rényi, Alfréd. (1972). *Letters on Probability*, trans. László Vekerdi. Detroit, MI: Wayne State University Press. Translation of *Levelek a valószínűségről*, 1969. Incisive and witty exploration of the notion of probability, in the form of fictitious letters assumed to be part of a lost correspondence between Pascal and Fermat. Written for the general reader.

Stigler, Stephen M. (1990). *The History of Statistics: The Measurement of Uncertainty before 1900*. Cambridge, MA: Harvard University Press, Belknap Press. A comprehensive history, tracing the interplay of mathematical concepts with the needs of several applied sciences that gave rise to the field of statistics.

Süssmilch, Johann Peter. (1741). *Die göttliche Ordnung in den Veränderungen des menschlichen Geschlechts, aus der Geburt, dem Tode, und der Fortpflanzung desselben erwiesen*. [The divine order in the fluctuations of the human race . . .]. Later enlarged ed. reprinted, Augsburg, Germany: Verlag-Cromm, 1988. First analytic theory of population by a founder of modern demography.

von Neumann, John, and Oskar Morgenstern. (1944). *Theory of Games and Economic Behavior*. Princeton, NJ: Princeton University Press.

PRODUCT SAFETY AND LIABILITY

As people become increasingly dependent on the use of engineered products, product safety and liability become issues of worldwide importance. In many countries, however, there are no strong traditions promoting safety standards in the technical design and testing of consumer products, nor are there methods of legal redress when such standards are not met. The ethics of product safety and liability is thus reasonably addressed by treating the United States as a leading case study, with the inclusion of some supplementary references to related developments in other countries. It is also necessary to acknowledge the role of product safety standards in relation to global trade practices.

U.S. Perspective

According to figures from the Internet site of the U.S. Consumer Product Safety Commission (CPSC), consumer products are annually responsible for more than 22,000 deaths and 29 million injuries (more than two deaths and 3,000 injuries per hour) at a total annual cost (including property damage) of more than $700 billion. Although the magnitude of these numbers may be subject to argument, they support the contention that product-related injuries were the primary factor in deaths of people from ages one to thirty-six, exceeding deaths from cancer and heart disease (Andre and Velasquez 1991). Staggering as such numbers are, product safety has significantly *increased* over the past three decades: "The CPSC's work to ensure the safety of consumer products—such as toys, cribs, power tools, cigarette lighters, and household chemicals—contributed significantly to the 30 percent decline in the rate of deaths and injuries associated with consumer products over the past 30 years" (CPSC).

Just as Rachel Carson's *Silent Spring* (1962) marked the beginning of the modern popular environmental movement, the publication of Ralph Nader's *Unsafe at Any Speed* (1965), which documented the neglect of safety features in the design of the Chevrolet Corvair and other U.S. automobiles, launched the contemporary consumer product safety movement. Nader influenced a number of federal laws concerned with public health and safety, including the National Traffic and Motor Vehicle Safety Act (1966), the Consumer Product Safety Act (1972), and the Freedom of Information Act (1966), as well as numerous not for profit consumer rights organizations.

In the intervening years, a succession of highly publicized product safety cases has fueled public interest in the topic including those concerning the Ford Pinto (1970s), the Dalkon Shield Intrauterine Device (1970s–1980s), the Bjork/Shiley heart valve (1979–1986), the Therac-25 radiation therapy machine (1985–1987), the Ford/Firestone tire recalls (2000), the health risks attributed to smoking, numerous airline crashes, and, perhaps the most spectacular product failure of all, the space shuttle *Challenger (1986)*. Product safety is now promoted by many governmental and nongovernmental organizations including national product safety testing and certification organizations such as the Underwriters Laboratories (founded 1894) in the United States; the International Organization for Standardization (ISO, founded 1946); consumer groups such as the Consumers Union (founded 1936), publishers of the popular magazine *Consumer Reports;* and socially conscious investment groups such as the Calvert Fund (created 1990). The Worldwide System for Conformity Testing and Certification of Electrical Equipment (IECEE), maintained by The International Electrotechnical Commission (IEC) (founded 1906), includes a code of ethics for product safety certification programs.

Product Safety, Liability, and Engineering Ethics

During the same period as the Carson and Nader books, professional engineering societies began to take more seriously the role of engineers and the engineering profession as stewards of product safety. All contemporary codes of engineering ethics state that engineers have a responsibility to protect *the public safety, health, and welfare,* and most codes state that this duty should be held *paramount*.

The notion that safety is of primary importance in engineering is also fundamental to nearly all academic treatments of engineering ethics (Herkert 2000). A key concept is the notion of *professional responsibility*, which many ethicists characterize as a type of moral responsibility arising from special knowledge possessed by an individual (Whitbeck 1998). Philosopher Mike Martin and engineer Roland Schinzinger argue that professional responsibility in engineering involves "the creation of useful and safe technological products while respecting the autonomy of clients and the public, especially in matters of risk-taking" (Martin and Schinzinger 1996, p. 42).

Yet while product safety is central to discussions of engineering ethics, the closely related legal concept of product liability is often ignored, or even attacked by engineering professionals and others. "Developing from the Industrial Revolution, U.S. product liability law is derived from case law and restatements of law anchored in contract and tort. It is based on the belief that consumers need protection from business and that business should bear the costs of harms inflicted on consumers" (Product Liability Lawyer Resource Center Internet site). Over time, the legal standard regarding product liability has evolved from the doctrine of *let the buyer beware,* to a legal theory requiring a determination of negligence on the part of the manufacturer, to the modern legal standard of strict liability (liability imposed without fault). Product liability claims can be based on manufacturing defects, design defects, and information defects (lack of appropriate warnings).

Judgments in product liability cases can include both compensatory (reimbursement for costs) and punitive damages; large judgments have often been the focus of attention in the controversy over product liability, especially in cases when the judgment may seem out of proportion to the harm. In one notorious case, a jury awarded a woman nearly $3 million for burns she received when she spilled coffee purchased at a McDonald's drive-up window.

Critics of current product liability law, including many professional engineering societies, call for rollbacks often approaching the old *let the buyer beware* policies. For example, in 1996 Congress passed legislation that would have severely limited the effect of product liability litigation by placing a cap on punitive damages and enacting stricter requirements for holding manufacturers liable. President Bill Clinton vetoed the bill; however, the debate over product liability reform continued.

The proponents of product liability reform argue that the current system unjustly rewards plaintiffs and stifles technological innovation, resulting in a lack of competitiveness on the part of U.S. manufacturers and decreased product safety. Supporters of the current system counter that it generally works as intended in discouraging the manufacture of defective products and compensating people injured by such defects (Hunziker and Jones 1994). To some the debate over product liability reform is a classic business/consumer conflict. A *New York Times* editorial (1996), for example, described proposed legislation as "The Anti-Consumer Act of 1996." Despite the arguments of both sides, the evidence is mixed concerning whether product liability rewards result in improvements in product safety (Hunziker and Jones 1994).

Engineers and engineering societies have tended to side with the proponents of product liability reform (Herkert 2001, 2003). A vice president of engineering of a major U.S. automobile company, for example, has argued that product liability restricts engineering practice by inhibiting innovation, discouraging critical evaluation of safety features, and preventing implementation of new or improved designs (Castaing 1994). The 1998 position statement on product liability of IEEE-USA, a unit of the Institute of Electrical and Electronics Engineers (IEEE) concerned with professional issues in the United States, calls for stringent limits on product liability including holding the manufacturer blameless when existing standards are met, adequate warnings are provided, or the product is misused or altered by the user. Other engineering societies, such as ASME International (formerly the American Society of Mechanical Engineers) have also actively supported product liability reform (ASME International 2001).

Given the primary responsibility of engineers for public safety, health, and welfare stated in the codes of ethics, it is surprising that the product liability issue has not drawn more attention from the perspective of engineering ethics (Herkert 2001, 2003). There is little, if any, evidence, however, to suggest that engineering societies promoting changes in the product liability system have considered the effect that decreasing the impact of product liability would have from the point of view of engineering ethics. On the whole, the engineering community has paid little attention to the ethical implications of product liability. For example, a major study of product liability and innovation by the National Academy of Engineering (Hunziker and Jones 1994), which considered such issues as corporate practice, insurance, regulation, and the role of scientific and technical information in the courtroom, touched only briefly on ethics (in a chapter on the need to address public risk perceptions) (Fischhoff and Merz 1994). Even the ethics literature is equivocal on the issue of product liability. For example, one well-known essay on engineering responsibility in the Ford Pinto case advocated stronger regulation and fines and imprisonment for corporate officials to achieve desired levels of safety, giving only passing notice to the role of product liability litigation (DeGeorge 1981).

One aspect of product liability and calls for its reform that can be readily identified as an ethical issue is the notion of *standard of care* (Kardon 1999). Though usually considered in a legal context, the standard of care in engineering design is also important in considering the ethical responsibilities of engineers. Many discussions of product liability turn on the concept of standard of care. Examples include such classic engineering ethics cases as the Turkish Airlines DC-10 disaster, where some blamed the luggage handlers for failing to secure the poorly designed cargo door, and the McDonald's coffee case, where public (and engineering) opinion generally held the product's *user* responsible for the accident. In such attitudes there is an assumption that the user should be held to a standard of care in use of a product equivalent to the standard of care applied to designers and manufacturers in its creation.

The McDonald's Coffee Case

Observers often tend to blame the victim in accidents of this kind. Such cases, however, are rarely that clear cut, as Howard Twiggs notes when commenting on the McDonald's case:

> That case demonstrates how well our system works. Unfortunately, headlines and misrepresentations by civil justice's opponents misshaped public opinion about [the] case against McDonald's. The public was led to believe that a woman driving a car was holding a cup of McDonald's coffee between her knees, spilled it, burned herself, and hired a trial lawyer who conned a jury into awarding her $2.86 million. (Twiggs 1997, p. 9)

Included among the facts of the case as cited by Twiggs to buttress his point were the following:

- The accident occurred in a parked car.
- The coffee was served scalding hot (180°–190° F), which can cause third-degree burns in seven seconds; this is 40–50 degrees hotter than normal coffee service. The victim suffered third-degree burns over 6 percent of her body.
- McDonald's had earlier reports of more than 700 people, including infants, being burned by its coffee.
- The victim attempted to settle out of court for $20,000 in medical bills.
- The jury awarded $200,000 for actual damages, which they reduced to $160,000 because they found the victim partly at fault.
- The jury based its award of $2.7 million in punitive damages on two days of coffee sales by McDonald's.
- The trial judge reduced the punitive damages to three times actual damages ($480,000) and ordered postverdict mediation where the case was settled.
- Despite telling the jury at trial that they would not do so, McDonald's immediately stopped selling coffee at this temperature.

Lessons for Engineering Design

On the face of it, the assumption that the victim is to blame in such instances undermines the notion that professionals have ethical responsibilities that go beyond those of nonprofessionals. A counter example more in tune with notions of professional responsibility would be an engineering designer who attempts to foresee preventable harm to users by anticipating common forms of product misuse, a doctrine sometimes applied in legal rulings concerning standard of care (Kardon 1999).

Roger Boisjoly (1998), the renowned whistle-blowing engineer in the *Challenger* case, argues that design engineers do have the obligation to anticipate product safety problems, even in so-called instances of product misuse. Following his blacklisting in the aerospace industry, Boisjoly became a consultant specializing in forensic engineering. As a forensic engineer, he became involved with product safety cases that included defective trigger lock switches on handheld drills, unstable step stools, and tipping problems in common household stoves; in most cases the products had met applicable regulatory standards. Boisjoly testified in two cases involving stove-tipping accidents; in one an adult and in the other a child leaned on open oven doors and were scalded with hot food being prepared on the stove's burners. Similar to the McDonald's case, the manufacturers had been provided ample evidence of the defect by prior complaints and litigation. As part of his investigation, Boisjoly, in about two weeks, designed an inexpensive collapsible door hinge that solved the problem. As Boisjoly demonstrates, ensuring product safety involves more than meeting engineering standards and avoiding liability—an engineer's professional obligation to protect public safety includes anticipating safety hazards and where possible designing the hazards out of the system.

International Issues

While political concerns over product safety and liability in the United States continue to focus on the relative responsibility of manufacturers and consumers, additional issues are prevalent in the rest of the world. In Europe debate is centered on needed harmonization of product safety standards both within the European Community and with respect to other nations, most notably the United States. Such concerns are primarily motivated by a desire to lower trade barriers but they also have important product safety implications because safety issues and standards can vary from country to country (Mader and Krøigaard 1999). In the developing world, as in so many other aspects of technological development, the outlook for product safety is much worse. An article calling for establishment of a consumer product safety commission of India points out safety and health problems with the entire range of consumer products, including unprocessed or improperly packaged food, unsafe rail transport, and dangerous toys and other hazards that lack child-proofing (Desikan 1999). Such inequities will continue in the absence of enforcement of national product safety standards and until fair and effective international standards are developed and recognized.

JOSEPH R. HERKERT

SEE ALSO *Engineering Ethics; Ford Pinto Case.*

BIBLIOGRAPHY

Carson, Rachel. (1962). *Silent Spring.* Boston: Houghton Mifflin. Biologist's celebrated and controversial account of the ecological impacts of pesticides.

Castaing, François J. (1994). "The Effects of Product Liability on Automotive Engineering Practice." In *Product Liability and Innovation,* ed. Janet R. Hunziker and Trevor O. Jones. Washington, DC: National Academy Press.

De George, Richard T. (1981). "Ethical Responsibilities of Engineers in Large Organizations: The Pinto Case." *Business and Professional Ethics Journal* 1: 1–14. Classic essay on moral responsibilities of would-be whistleblowers that uses the Ford Pinto's questionable gas tank design as a case study.

Editorial. (1996). "The Anti-Consumer Act of 1996." *New York Times,* March 21, Section A, p. 24.

Fischhoff, Baruch, and Jon F. Merz. (1994). "The Inconvenient Public: Behavioral Research Approaches to Reducing Product Liability Risks." In *Product Liability and Innovation,* ed. Janet. R. Hunziker and Trevor. O. Jones. Washington, DC: National Academy Press.

Herkert, Joseph R. (2000). "Engineering Ethics Education in the USA: Content, Pedagogy, and Curriculum." *European Journal of Engineering Education* 25(4): 303–313.

Herkert, Joseph R. (2001). "Future Directions in Engineering Ethics Research: Microethics, Macroethics and the Role of Professional Societies." *Science and Engineering Ethics* 7(3): 403–414.

Herkert, Joseph R. (2003). "Professional Societies, Microethics, and Macroethics: Product Liability as an Ethical Issue in Engineering Design." *International Journal of Engineering Education* 19(1): 163–167.

Hunziker, Janet R., and Trevor O. Jones, eds. (1994). *Product Liability and Innovation.* Washington, DC: National Academy Press. Report of a committee of the National Academy of Engineering on the impact of the U.S. product liability system on technological innovation.

Martin, Mike W., and Roland Schinzinger. (1996). *Ethics in Engineering,* 3rd edition. New York: McGraw-Hill. Classic text on engineering ethics co-authored by an engineer and a philosopher.

Nader, Ralph. (1965). *Unsafe at Any Speed: The Designed-in Dangers of the American Automobile.* New York: Grossman. The consumer advocate's expose of unsafe automobile designs, especially General Motors' Corvair.

Twiggs, Howard. (1997). "How Civil Justice Saved Me From Getting Burned." *Trial Magazine* June: 9. Also available from http://www.atla.org/secrecy/data/twiggs.aspx.

Whitbeck, Caroline. (1998). *Ethics in Engineering Practice and Research.* Cambridge, England: Cambridge University Press. Engineering ethics text unique in its attention to both professional ethics and research ethics.

INTERNET RESOURCES

American Society of Mechanical Engineers International. "Public Policy Agenda: 2003-2004." Available from http://www.asme.org/gric/Agenda/PPA2003-2004StateIssues.html.

Andre, Claire, and Manuel Velasquez. (1991). "Who Should Pay? The Product Liability Debate." *Issues in Ethics* 4(1). Available from http://www.scu.edu/ethics/publications/iie/v4n1/pay.html.

Boisjoly, Roger. (1998) "Professionalism." IEEE-USA. Available from http://www.ieeeusa.org/PACE/LIBRARY/boisjoily.html. The noted whistleblower from the space-shuttle Challenger case discusses professionalism in engineering design drawing on his experiences as a design engineer and as a forensic engineer.

Desikan, R. (1999) "Product Safety: A Long Way to Go." *The Hindu.* Available from http://www.hinduonnet.com/folio/fo9910/99100180.htm. Special *Consumer* issue, October 31, 1999.

IEEE-USA. "Tort Law And Product Liability Reform." Available from http://www.ieeeusa.org/forum/POSITIONS/liability.html.

Kardon, Joshua B. (1999). "The Structural Engineer's Standard of Care." Online Ethics Center for Engineering and Science. Available from http://onlineethics.org/cases/kardon.html.

Mader, Donald A., and Søren Krøigaard. (1999). "Achieving Harmonization of Product Safety Standards." Compliance Engineering. Available from http://www.ce-mag.com/archive/1999/novdec/guesteditorial.html.

Product Liability Lawyer Resource Center. "Product Liability Laws Evolution." Product Liability Lawyer.com. Available from http://www.productliabilitylawyer.com/evolutionOfProductLiability.cfm.

U.S. Consumer Product Safety Commission (CPSC). "CPSC Overview." Available from http://www.cpsc.gov/about/about.html.

Virginia Department of Public Health. "Product Safety." Available from http://www.vahealth.org/civp/product/.

Worldwide System for Conformity Testing and Certification of Electrical Equipment (IECEE). "Code of Ethics Applicable to a Product Safety Certification Organization." Available from http://www.iecee.org/cbscheme/html/cbcode.htm.

PROFESSIONAL ENGINEERING ORGANIZATIONS

Professional engineering organizations are the primary channels by which engineers working in particular technical disciplines, or otherwise possessing common interests, share technical knowledge, regulate professional practice, influence public policy, and maintain the traditions and reputation of the profession. These organizations, as well as the profession of engineering itself, are of relatively recent origin, arising during the Industrial Revolution. In contrast, the primary object with which engineering is concerned—technology—is of ancient origin.

Historical Background

Throughout the history of civilization, humans have been engaged in developing and adjusting to changed circumstances for technological development. Construction, shipbuilding, irrigation, mining, metallurgy, and military fortification are prominent examples of technologies with extensive histories. Prior to the eighteenth century, the bulk of knowledge and practices in these areas was largely uncodified, slow to spread between geographic regions, and passed from one generation to another mainly through apprenticeship.

During certain periods, the artisans and tradespeople who plied these skills organized themselves for mutual benefit. In the late Roman and Byzantine periods, such organizations were called *collegia*, and in medieval times, *guilds*. Among the purposes these organizations served, were the regulation of prices, product quality, and entry into the craft. But with the coming of the Scientific and Industrial Revolutions, the status of guilds diminished as the pace of technological development accelerated and the expansion of trade routes increased the availability of imported goods.

By the late-eighteenth century, developments such as the advent of steam power, the increased complexity of military ordnance, the rise of canal building, and the genesis of mechanized production had begun to cause significant changes in society, and the need for a more formal means of acquiring and transmitting technical training began to grow. One leader in the creation of technical schools was France, first for military engineers, and then for engineers engaged in civilian projects. This model for technical education, which relied heavily upon mathematics, spread to other parts of continental Europe by the early-nineteenth century, and to England and the United States in the following decades.

Although England lagged France in developing technical schools, it was at the forefront of the Industrial Revolution by virtue of industrious, self-made engineers such as John Smeaton (1724–1792), who is widely considered to be the founder of the civil engineering profession. In 1771 he formed the Society of Civil Engineers, which was later renamed the Smeatonian Society. The meetings of this society were generally informal, and membership was not necessarily restricted to engineers; rather it also included those who had business or political interests in the engineering of public works.

In 1818 the Institution of Civil Engineers (ICE) was founded in England and is considered to be the earliest of the modern professional engineering societies. Its membership was restricted to practicing engineers and meetings were expressly for the purpose of exchanging technical information. Although the ICE grew slowly during its first couple of decades, these two characteristics formed the basic blueprint for subsequent societies, the next one of which was the Institution of Civil Engineers of Ireland formed in 1835. The Swiss Society of Engineers and Architects, followed in 1837, and then in 1847 the British Institution of Mechanical Engineers and the Royal Institution of Engineers in the Netherlands were formed. Between 1850 and 1900, no fewer than thirty additional professional engineering societies began operating in Europe, Scandinavia, North America, South America, South Africa, and Japan. Subsequently the number and types of professional engineering societies grew rapidly such that by the start of the twenty-first century hundreds of organizations existed worldwide.

Diversity of Technical Disciplines

The first main differentiation among types of professional engineering societies occurred along disciplinary lines. The original term civil engineering was meant to distinguish engineers engaged in the building of public works from military engineers. By the mid-nineteenth century, the rise of steam power, railroads, and mechanized production led to a divergence between mechanical engineering and civil engineering. By the latter part of the 1800s, societies had formed for mining engineering, electrical engineering, marine engineering, and sanitary engineering. In the United States, five organizations have become known as the *founder societies*. These are the American Society of Civil Engineers (ASCE, formed in 1852), the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME, formed in 1871), the American Society of Mechanical Engineers (ASME, formed in 1880), the Institute of Electrical and Electronics Engineers (IEEE, formed in 1963 from the merger of the American Institute of Electrical Engineers [AIEE, formed in 1884] with the Institute of Radio Engineers [IRE, formed in 1912]), and the American Institute of Chemical Engineers (AIChE, formed in1908). In 1904 the then existing four ancestor organizations formed a meta-organization known as the United Engineering Society (UES) in an effort to unify the engineering profession, but it failed to thrive. In 1979 the American Association of Engineering Societies (AAES) was founded with a similar goal. However the continued emergence of new and dissimilar engineering disciplines (e.g., automotive, aerospace, industrial, nuclear, computer, and biomedical), along with the increasing diversity of knowledge within each discipline, has proved to be a powerfully fragmenting force within the profession, and has generally thwarted attempts at unification. Thus the proliferation of professional engineering organizations accelerated through the twentieth century, paralleling the expanding scope of science and technology.

For this type of society, one organized around a particular technical discipline, the primary purposes are typically (a) to foster the presentation, discussion, and dissemination of the latest technical information and practices relevant to the discipline and its associated industry; (b) to provide a mechanism for overseeing the development of technical codes and standards relating to safety and uniformity in that industry; and (c) to promote the reputation and welfare of both the profession and the industry. In support of these main functions, societies frequently take on additional roles, such as supporting educational programs, lobbying political bodies, establishing professional ethics codes, documenting the history of the discipline, and offering various career development and continuing education benefits to members.

The technical engineering societies span a broad spectrum with respect to size, scope of activities, and focus of mission. Some tend to have close ties with particular industries, and engage in very practical activities that serve to promote and support those industries. Others maintain more independence, and pursue a broader agenda of technical and professional development activities. Overall these technically-oriented engineering societies, via research journals, conference proceedings, and trade magazines, are responsible for the bulk of engineering technical publication worldwide.

The technical societies are also instrumental for the development of technical codes and standards, which either serve to facilitate the compatibility of products and services across an industry, or which become incorporated in laws prescribing safe engineering practices. For example since its inception ASME has been engaged in the work of standardizing the specifications for such items as screw threads and pipe fittings, and in developing safety codes for the design of boilers and pressure vessels, explosions of which had been a serious safety hazard throughout the 1800s. The IEEE has been responsible for developing codes and standards on topics ranging from electrical insulation to digital communications protocols. What in the United States have been the purview of non-governmental organizations have in Europe, however, often been the responsibility of a government ministry.

Regulation of Professional Practice

The traditional focus of the discipline-specific engineering societies—developing a particular body of technical knowledge and overseeing its application in related industries—has proved to be a powerful organizing principle that is relatively loose and inclusive, largely transcending geographic boundaries, employment status, and political climate. In contrast there is another organizing principle that is more parochial, more exclusive, and more entwined with political and legal affairs. This organizing principle, which has given rise to a different type of professional engineering organization, is the idea that the title *engineer*, and *the practice* of engineering, ought to be controlled, either through a legislated process for *licensure*, or otherwise formalized procedures for *registration*. The organizations that have developed around this idea are the various state, provincial, and national societies and boards that oversee and promote professional licensure or registration.

In the United States the first law regarding the licensing of engineers was enacted in Wyoming in 1907 in response to disputes over property and water rights caused by incompetent surveyors. Other states also enacted engineering licensure laws following negative events, such as the St. Francis Dam collapse in California in 1928 and a school boiler explosion in Texas in 1937, both of which resulted in hundreds of lives lost. By 1950 all states had licensing laws. In 1934 the National Society of Professional Engineers (NSPE) was founded in the United States with the mission of promoting "the competent, ethical, and professional practice of engineering," mainly through the endorsement of licensure, which is a requirement for NSPE membership. In addition each state has its own NSPE affiliate organization, many of which, such as the Ohio Society for Professional Engineers (formed in 1878), pre-date the NSPE itself. Because licensing laws are enacted at the state level, these state-level organizations lobby state legislatures to maintain and improve the laws, and work with the state boards that oversee their enforcement. Licensure generally requires an education from an accredited institution, passage of qualifying examinations, and a specified number of years of probationary engineering experience.

Notwithstanding these developments, in the United States licensure has remained a difficult issue for the engineering profession. Most state licensing laws restrict the use of the *Professional Engineer* title and the offering of *engineering services* to the public. These requirements for licensure have had the biggest effects on civil engineers engaged in the design and construction of public works, and on consulting engineers. However the majority of engineers are employed by companies to do internal product design and development, product testing, technical sales, or project management. These engineers are exempt from licensure, with the result that less than 20 percent of engineers are licensed in the United States. NSPE and its state affiliates have struggled to convince more engineers of the benefits of licensure to both the individual and the profession.

While licensing laws affect only a small minority of engineers in the United States, legal constraints on engineering practice are even less strict in many other countries. In the United Kingdom, for example, neither the title of engineer nor the practice of engineering are restricted. There is, however, a voluntary engineering registration system that confers the title *Chartered Engineer* upon qualified applicants. This registration process is governed by the Engineering Council (UK), which is an independent, royal-chartered organization comprising most of the discipline-specific engineering societies in Great Britain as corporate members. In continental Europe, a few countries, notably Germany, Italy, Austria, and Luxembourg, place a significant degree of legal restriction on engineering practice, while in most other countries the constraints are more lax, or else nonexistent. The *European Federation of National Engineering Associations* (FEANI) serves to coordinate engineering registration qualifications between European nations to allow engineers the freedom to practice across international borders. FEANI confers the title EUR ING (European Engineer) to qualified applicants. In a related international effort, the Engineers Mobility Forum (EMF), together with the Engineer Coordinating Committee of the Asia-Pacific Economic Cooperation (APEC), comprising national engineering organizations from many countries in Oceania, Asia, Africa, North America, and Europe, have created the *International Registry of Professional Engineers* to facilitate comity in engineering qualifications between countries.

The overriding concern of these engineering professional organizations is to protect the reputation, professional status, and economic interests of the engineering profession by ensuring that engineers, regardless of technical specialty, are certified competent in their practice. In addition these organizations seek to influence political bodies to generate legislation and international agreements protective of the professional status of engineering and conducive to profitable engineering practice. One hallmark of this category of professional organization is the emphasis on the promulgation of codes of ethical conduct for engineers. Though details of the ethical codes vary from organization to organization, the codes generally emanate from a few central canons that are somewhat universal. These include holding public safety and welfare of paramount importance, performing work only in areas of competence, making public statements in an objective and truthful manner, and maintaining the interests and confidentiality of clients and employers. In areas where engineering practice is restricted by licensure laws, elements of these ethical codes are generally incorporated into the legal code. Most of the discipline-specific professional organizations have also adopted their own similar codes of ethics that members are expected to uphold.

Other Engineering Organizations

In addition to organizations devoted to technical interests or professional status, there are various other types of special purpose engineering professional organizations. Some of these are aimed at developing a supportive community of interest with respect to race, culture, or gender, such as the Society of Women Engineers, the National Society of Black Engineers, and the Society of Hispanic Professional Engineers. Engineers Without

Borders is an international humanitarian network that seeks to assist disadvantaged communities worldwide and to promote responsible and sustainable engineering. Other organizations are devoted to promoting quality and innovation in engineering education. These include the American Society for Engineering Education, the International Network for Engineering Education and Research, and the European Society for Engineering Education. Many countries have established national advisory organizations, comprising some of the most highly respected engineers, for the purpose of assisting government on matters of public policy related to technology. Examples include the Royal Academy of Engineering in Great Britain, the National Academy of Technologies of France, and the National Academy of Engineering in the United States.

Conclusion

The engineering profession is broad in scope, encompassing topics from nuts and bolts to satellite communications, and from deep-sea oil exploration to medical implants. It is heterogeneous in constitution, with practitioners running the gamut from independent consultants to employees of large, multinational corporations, and performing job functions from detailed component design to company CEO. Perhaps because of the diverse nature of the profession, there is a corresponding profusion in the number and types of engineering professional organizations, each seeking to meet the professional needs of some portion of the engineering community.

BYRON P. NEWBERRY

SEE ALSO *Association for Computing Machinery; Engineering Ethics; Federation of American Scientists; Institute of Electrical and Electronics Engineers; Institute of Professional Engineers New Zealand; Nongovernmental Organizations; Research Integrity; Union of Concerned Scientists.*

BIBLIOGRAPHY

Armytage, W. H. G. (1966). *A Social History of Engineering*. Cambridge, MA: MIT Press. A look at the relationship of engineering and society from antiquity to the twentieth century

Buchanan, Robert A. (1989). *The Engineers: A History of the Engineering Profession in Britain, 1750–1914*. London: Jessica Kingsley Publishers.

Layton, Edwin T. 1986 (1971). *The Revolt of the Engineers: Social Responsibility and the American Engineering Profession*. Cleveland, OH: Case Western Reserve University Press. The best single history of U.S. engineering to 1940.

Reader, William J. (1987).*A History of the Institution of Electrical Engineers, 1871–1971*. London: Peregrinus. A company history, not very critical.

Sinclair, Bruce. (1980). *A Centennial History of the American Society of Mechanical Engineers*. Toronto: University of Toronto Press. A history of the organization and a look at some of the tensions arising from the dual professional-employee roles of engineers.

Watson, Garth. (1988). *The Civils: The Story of the Institution of Civil Engineers*. London: Thomas Telford.

Watson, Garth. (1989). *The Smeatonians: The Society of Civil Engineers*. London: Thomas Telford.

PROFESSIONAL ETHICS

SEE *Profession and Professionalism.*

PROFESSION AND PROFESSIONALISM

• • •

Engineering is generally considered a profession, but science, or at least some of the sciences, are sometimes counted as professions and sometimes distinguished from them. Often, a dispute about the professional status of a science begins when someone proposes it have a code of ethics. What is a profession? What has professional status to do with ethics? What distinction, if any, exists between the professional status of engineering and science? Why should the professional status of either matter?

Four Senses of "Profession"

In ordinary usage, *profession* has at least four senses. First, *profession* can be a mere synonym for *vocation* (or *calling*), that is, any *useful* activity to which one devotes (and perhaps feels called to devote) much of one's life. (If the activity were not useful, it would be a hobby rather than a vocation.) *Profession* in this sense has no necessary relation to income. Even a *gentleman*—in the now outdated sense describing someone rich enough to live comfortably without working—might have such a profession. Max Weber's "Science as a Vocation" (1901) explains how a now-bureaucratized professoriate can still be a vocation in this sense. Weber never uses the term *profession*.

Second, *profession* can be a synonym for *occupation*, that is, any typically full-time activity (defined by function or discipline) by which practitioners generally earn a living. In this sense, one may, without irony, speak of a professional thief or professional athlete. The opposite of *professional* (in this sense) is *amateur* (one who engages in the activity for love rather than money) or *dilettante* (one who lacks the seriousness of those who must live by such work). This is the sense of *profession* from which *professionalism* derives. To exhibit professionalism is to exhibit the knowledge, skill, or judgment characteristic of someone who makes a good living in the occupation. Both engineers and scientists are now generally professionals in this sense, though science still seems to have more room than engineering for amateurs and dilettantes.

Third, *profession* can refer to any occupation one may openly admit to or profess, that is, an honest occupation: While athletics can be a profession in this sense, neither thieving nor being a gentleman can. Thieving cannot because it is not honest; being a gentleman (in its outdated sense) cannot because, though an honest way of life, it is not an occupation. Occupation seems to be the (primary) sense of *profession* in Émile Durkheim's seminal work on professions (written about the same time as Weber's work on vocation).

These three senses of *profession* are alike in having obvious synonyms. If *profession* had only these senses, it would, being redundant, seem destined to disappear from use. Its increasing popularity suggests that these three senses derive from a fourth, the primary sense and the source of the term's popularity. *Profession* in this fourth sense is a special kind of honest occupation. There are at least two competing approaches to defining it: the sociological and the philosophical.

Sociological Definitions

The sociological approach to defining *profession* has its origin in the social sciences. Its language tends to be statistical; the definition does not purport to state necessary or sufficient conditions for an occupation to be a profession, but merely what is true of "*most* professions," "the *most* important professions," or the like. Generally, sociological definitions understand a profession to be any honest occupation whose practitioners have high social status, high income, advanced education, important social function, or some combination of these or other features easy for the social sciences to measure.

Sociological definitions differ a good deal. Some emphasize public service, (individual) autonomy, (group) self-regulation, dangerous knowledge, having a code of ethics, or the like, while others do not. What explains the great variety of sociological definitions? Part of the explanation is that, being statistical, such definitions are not threatened by a few counter-examples. But that is only part of the explanation. Another factor is that when the counter-examples grow more numerous than the professions fitting the definition, defenders can distinguish between *true professions*, *fully developed professions*, or *paradigms* and those not fitting the definition (*pseudo-professions*, *less well developed professions*, or *quasi-professions*). The only professions that appear on every sociological list of true, fully developed, paradigmatic professions are law and medicine. When evidence suggests that even these do not fit the definition, sociologists can retreat again, claiming that their definition states an *ideal type* that actual professions only approximate. When asked why this ideal type is chosen over another, sociologists generally explain the choice in terms of a theory of society they accept (Marxist, Weberian, Durkheimian, or the like). Sociological definitions seem to derive from theory, not evidence. The way professions understand themselves plays a surprisingly small part in the sociological approach.

For most sociological definitions, little distinguishes contemporary professions from what used to be called the *liberal professions* (those few honest *vocations* requiring a university degree in most of early modern Europe). Carpentry cannot be a profession (in the sociological sense) because both the social status and education of carpenters are too low. Science is a profession in this sense because scientists have relatively high status, high income, advanced education, and important social functions. Technical managers also form a profession in this sense because they too tend to have high income, high status, advanced education, and an important social function. According to most sociological definitions, Europe and the Americas have had professions for many centuries.

Philosophical Definitions

The philosophical approach to defining *profession* attempts to state necessary and sufficient conditions. A philosophical definition is therefore much more sensitive to counter-example than sociological definitions are. Philosophical definitions may be developed in one of (at least) two ways: the Cartesian or the Socratic.

The Cartesian way tries to make sense of the contents of one person's mind. One develops a definition by asking oneself what one means by a certain term, setting out that meaning in a definition, testing the definition by counter-examples and other considerations, revising whenever a counter-example or other consideration seems to reveal a flaw, and continuing that process until one has put one's beliefs in good order.

In contrast, the Socratic way seeks common ground between one or more philosophers and *practitioners* (those who normally use the term in question and are therefore expert in its use). A Socratic definition begins with the definition a practitioner offers. A philosopher responds with counter-examples or other criticism, inviting practitioners to revise. Often the philosopher will help by suggesting possible revisions. Once the practitioners seem satisfied with the revised definition, the philosopher again responds with counter-examples or other criticism. And so the process continues until everyone is satisfied with the result. Instead of the private monologue of the Cartesian, there is a public conversation. But neither the Cartesian nor the Socratic approach is empirical (in the way the sociological approach at least claims to be). They are equally analyses of concepts. They differ primarily in how they understand concepts. For the Cartesian, concepts are more or less private; for the Socratic, they are a public practice.

What follows is a Socratic definition: "A profession is a number of individuals in the same occupation voluntarily organized to earn a living by openly serving a certain moral ideal in a morally permissible way beyond what law, market, and morality would otherwise require."

According to this definition, the members of a would-be profession must have an occupation. Mere gentlemen cannot form a profession. Hence, members of the traditional liberal professions (clergy, physicians, and lawyers) could not form a profession until quite recently—until, that is, they ceased to be gentlemen, began to work for a living, and recognized that change in circumstance. That seems to be well after 1800. Most professions are much younger than the function they perform or the discipline they exploit.

The members of the would-be profession must not only have an occupation, they must *share* it. So, for example, chemists and chemical engineers cannot form one profession because they are trained in different academic departments, learn different skills, and generally do different work. They belong to different occupations.

Ethics and Professions

According to the Socratic definition above, each profession is designed to serve a certain moral ideal, that is, to contribute to a state of affairs everyone (all rational persons at their rational best) can recognize as good. So, physicians have organized to cure the sick, comfort the dying, and protect the healthy from disease; engineers, to help produce and maintain safe and useful objects; and so on. But a profession does not just organize to serve a certain moral ideal; it organizes to serve it *in a certain way*, that is, according to standards beyond what law, market, and morality would otherwise require. A would-be profession, then, must set *special* (morally permissible) standards. Otherwise it would remain nothing more than an honest occupation. Among its special standards may be a certain minimum of education, character, or skill, but inevitably some of the standards will concern conduct. These standards of conduct will be ethical (as distinct from moral): they will govern the conduct of all members of the *group* simply because they are members of that group (and not, as ordinary moral standards do, just because they are moral agents).

These special standards will, if effective, be ethical in another sense as well. They will be *morally* binding on members of the profession (and only them). The members of a profession must pursue their profession openly; that is, engineers must declare themselves to be engineers, chemists must declare themselves to be chemists, and so on. The members of a (would-be) profession must declare themselves to be members of that profession in order to earn their living by that profession. They cannot be hired as such-and-such (say, an engineer) unless they let people know that is what they are. If their profession has a good reputation for what it does, the declaration of membership will aid them in earning a living. People will seek their help. If, however, the profession has a bad reputation, their declaration of membership ("I am a tinker") will be a disadvantage. People will shun their help. The profession's special way of pursuing its moral ideal is what distinguishes its members from others in the same occupation, and from what the members would be but for their profession.

Of course, the declaration of membership must be true. Those who declare membership in a profession to which they do not belong are mere charlatans, quacks, impostors, or the like. How membership is determined may vary a good deal from one profession to another. Some professions have only a set curriculum to assure minimum knowledge. (Graduate with the appropriate degree and one is a chemist.) Other professions have only a test. (Pass the examination and, however one learned the discipline, one is an actuary.) And other professions have a more complex standard. (So, for example, to be a physician, one must graduate with a certain degree, work under supervision for a time, and pass certain examinations.) What all professions share are special standards distinguishing members from others. Whatever their origin, these standards, once accepted in practice, constitute the *professional organization*. The professional organization (that is, the profession) is distinct from any technical, scientific, or mutual-aid society members of a profession may form.

The members of a profession, being free to declare membership or not, will generally declare membership if, but only if, the declaration benefits them overall—that is, serves some purpose of their own at what seems reasonable cost. The purpose may be high-minded, self-interested, or even selfish. Whatever the purpose of individuals, their membership in a profession identifies them as engaged in pursuing the profession's moral ideal according to the morally permissible special standards the profession has adopted. *Occupations* can be "value free" (that is, have no special commitments); *professions* cannot.

Where members of a profession declare their membership voluntarily ("I am an architect"), they are part of a voluntary, morally permissible, cooperative practice. They are in position to have the benefits of the practice, employment as members of that profession, because the employer sought such-and-such and they (truthfully) declared their membership. They will also be in position to take advantage of the practice by doing less than the standards of practice require, even though the expectation that they would do what the standards require as declared members of the profession is part of what won them employment. If cheating consists in violating the rules of a voluntary, morally permissible, cooperative practice (that is, taking unfair advantage of the practice), then every member of a profession is in a position to cheat. Because cheating is morally wrong, every member of a profession has a moral obligation, all else equal, to do as the profession's special standards require.

A profession's ethics imposes moral obligations on members of that profession. These obligations may, and generally do, vary from profession to profession (and, within a single profession, may also vary over time). These obligations appear in a range of documents, including standards of education, admission, practice, and discipline. A code of ethics is the most general of these documents, the one concerned with the practice of the profession as such.

Status and Profession

According to the Socratic definition above, an occupation's status as a profession is (more or less) independent of license, state-imposed monopoly, and other special legal intervention. Such special legal interventions are characteristic of bureaucracy rather than profession. In principle, professions are not the creatures of law; and, even in practice, some professions (such as Certified Computer Professionals) do without license, monopoly, and other legal protection against market pressures, except for protection of their designation (such as "CCP") analogous to that the law gives to trademarks to protect the consumer from counterfeits.

An occupation's status as a profession is, according to this definition, also more or less independent of its social status, income, and other social indexes of profession. There is, for example, no profession of technical managers, even though technical managers have relatively high social status, income, and education and important social functions. What technical managers lack is a common moral ideal beyond law, market, and ordinary morality—and common standards, including a code of ethics, settling how that ideal should be pursued. There is, in contrast, certainly a profession of nursing, though nurses typically earn much less than technical managers and have much lower social status. The only high status a profession entitles one to is being regarded as more reliable or trustworthy in what one does for a living than one would (probably) be if that way of earning a living were not organized as a profession. This high status is deserved only insofar as the profession continues to meet the special standards it has set for itself. An occupation should become a profession in this fourth sense if, but only if, it is willing to assume the burdens that generate that high status. The current popularity of the terms *professional* and *professionalism* is evidence that, on the whole, the professions have been handling that burden pretty well.

MICHAEL DAVIS

SEE ALSO *Codes of Ethics; Durkheim, Émile; Professional Engineering Organizations.*

BIBLIOGRAPHY

Abbot, Andrew. (1988). *The System of Professions: An Essay on the Division of Expert Labor*. Chicago: Chicago University Press. An important example of a sociological approach to professions.

Bayles, Michael. (1981). *Professional Ethics*. Belmont, CA: Wadsworth. A widely used text.

Camenisch, Paul. (1983). *Grounding Professional Ethics in a Pluralistic Society*. New York: Haven Publishing. Eclectic approach to explaining the moral status of professional obligations. Contrasts nicely with Bayles' consequentialism.

Chalk, Rosemary. (1980). *AAAS Professional Ethics Project: Professional Ethics Activities in the Scientific and Engineering Societies*. Washington, DC: American Association for the Advancement of Science. A collection and analysis of codes.

Davis, Michael. (1998). *Thinking Like an Engineer*. New York: Oxford University Press. A detailed argument for understanding engineering as a profession and understanding that status as central to how engineers actually work.

Davis, Michael. (2002). *Profession, Code, and Ethics*. Aldershot, UK: Ashgate. A defense of the Socratic definition of profession. Includes a chapter on whether scientists have any professional obligations (and several chapters on engineering).

Durkheim, Émile. (1957). *Professional Ethics and Civic Morals*, trans. Cornelia Brookfield. London: Routledge. Lectures given in the 1890s but not published until 1947. Seminal work in sociology of professions although it is actually only about occupations.

Freidson, Eliot. (2001). *Professionalism: The Third Logic*. Chicago: University of Chicago Press. A sociologist arguing that professions are "third logic," distinct both from free market and bureaucratic regulation. Full of interesting examples and important insights.

Gewirth, Alan. (1986). "Professional Ethics: The Separatist Thesis." *Ethics* 96: 282–300. Classic refutation of the claim that professional status to some degree frees professionals from the constraints of ordinary morality.

Goldman, Alan. (1980). *The Moral Foundations of Professional Responsibility*. Totowa, NJ: Littlefield Adams. The classic defense of the claim that some professions are to some degree free of ordinary morality.

Koehn, Daryl. (1994). *The Ground of Professional Ethics*. London: Routledge. An attempt to understand professions as founded on a "covenant"; a worthy example of the Cartesian approach.

Kultgen, John. (1988). *Ethics and Professionalism*. Philadelphia: University of Pennsylvania Press. A philosopher attempting to understand professions using the sociological approach.

Larson, Magali Sarfatti. (1977). *The Rise of Professionalism: A Sociological Analysis*. Berkeley: University of California Press. A good example of the Marxist approach to professions. Dated but still important.

Weber, Max. (1958 [1901]). "Science as a Vocation." *From Max Weber: Essays in Sociology*, ed. H. H. Gerth and C. Wright Mills. New York: Oxford University Press. First published in 1901. A seminal work in the sociology of professions (though it is about vocations, not professions).

PROGRESS

The idea of progress is unique to the cultural tradition of Western Europe and from its birth has had a strong association with ethical issues raised by new knowledge and technological innovation. Although there are allusions to it in the twelfth and thirteenth centuries, the concept first appeared in its modern sense in the transition from the Middle Ages to the Renaissance. The idea was introduced by the early humanists in the context of their invention of the division of history into three periods: a classical age, encompassing the cultures of Greece and Rome from about 600 B.C.E. to 400 C.E.; a culturally dark "middle age" from about 400 to 1300; and their own age, self-proclaimed as a renaissance, or rebirth, of cultural excellence that began in the fourteenth century. In the seventeenth and eighteenth centuries, progress was explicitly coupled to the primacy of objective reason in human affairs and the promise of technological progress became an explicit dogma of the eighteenth century Enlightenment. In the nineteenth and twentieth centuries, progress became the mantra of industrial capitalism, proclaiming the blessing it conferred on society even as the reality of progress came under attack, first by the Romantics, then by philosophers and intellectuals more broadly, and finally by social and political activists.

Defining Progress

What the word *progress* means has thus changed significantly since the mid-fourteenth century. Common to all definitions, however, is the claim that *something* is better than it had been and promises to get better still in the future. What that something is, is what has changed over time. For the humanists, the something was *high culture*—literature, poetry, painting, sculpture, and architecture—and, perhaps surprisingly for humanists to be proud of, technology. All of these, they argued, were better in the fifteenth and sixteenth centuries than they had been and they promised to keep getting better. In the seventeenth and eighteenth centuries, the definition of progress, though it looked to the growing power of modern science as evidence, widened to an identification of progress with intellectual and social reform, and thus with the claim that the subject of progress was the human condition itself, which not only could be, but in fact was being improved by the efforts of human beings themselves. Through initiative, courage, reason, and inventiveness, it was argued, individuals were improving the world in which they found themselves and in the process making people better as people.

In the nineteenth and twentieth centuries, the idea of progress became increasingly complex and controversial. For one thing, the claim that art and literature were progressing fell out of favor. They changed, of course, but many dismissed any judgment that impressionism was better than Renaissance painting or that Yeats was a better poet than Milton. Cultural forms change but do not move toward an ultimate perfection, nor do there exist objective criteria for judging across these forms. Meanwhile contemporary science and technology in effect co-opted the idea of progress, claiming improvement as self-evident. And even as the ideal of human progress shaped nineteenth- and twentieth-century social and political reform movements—liberalism, socialism, and communism—increasingly strident challenges were raised against the claim that the human condition and human beings had improved in any essential way.

The bitterness of the criticism of progress in the late-twentieth century was in part the legacy of two murderous world wars, in part the failure of many social and political reform movements to effect lasting improvements in the quality of life when they achieved power, and in part a response to the emergence of environmental, social, and personal problems linked to applications of increasingly powerful scientific theories and technological innovations. Relevant, too, was the historicism and relativism of much twentieth-century social science and philosophy, according to which there were no universal, objective, and hence value-neutral criteria for judging whether a change of any sort was an unqualified improvement. In the realm of technology, there are objective criteria for comparing and evaluating changes because artifacts are means to ends defined by their makers. Given the intended purpose of a camera, for example, one model can be said to be better or worse than another. But because the notion of purpose or end in relation to nature was abandoned in modern science, there is no basis in science or in technology for judging the value of the ends to be served by technologies and therefore no basis for judging that changes to natural entities are improvements. This isolation of ends from means creates an ethical gulf between technical knowledge and its applications that was only fully appreciated in the second half of the twentieth century, a gulf that further undermined claims of progress even in science and technology.

Progress as Threat and Ideal

From its introduction by the humanists, progress was a profoundly new and a profoundly secular idea, and the claim of real and promised improvement that it made was extraordinarily bold. The idea of progress challenged what had been a deeply rooted belief in pre-modern Western culture, inherited from antiquity, that the golden age of humankind lay in the past and that the aging of the Earth entailed decay for it and its inhabitants, analogous to the aging of individual living organisms. Furthermore the idea of progress implies a directionality to history and to time that contrasts sharply with the cyclical conceptions of time and of history dominant in antiquity. Finally the idea of progress implies an activist role for humans in defining their well-being and in causing it, in the present and for the future.

Judaism and Christianity, through their respective messianic and salvational doctrines, had already introduced an anticlassical directionality to history and time, but this directionality was the culmination of a divine plan and in the hands of God; it was not open to calculated, self-interested human intervention. Attributing value to improving the human cultural or material condition in a Christian context posed a direct challenge to transcendent religious values, and the claim that humans could by their own efforts make themselves better posed an even greater threat. The broad public appeal of and occasional resistance to the ideology of progress, first in Europe and then globally, thus reveals a great deal about these societies and their deepest values.

In the fourteenth century, long before the first hints of modern science or modern philosophy, the idea of progress had already emerged in Western Europe, tentatively in the context of the twelfth- and thirteenth-century university movement, but clearly in the writings of the poet Petrarch, heir to Dante and father of humanism. The humanists are inaccurately depicted as worshipping Greek and Roman literary culture and seeking to reconstruct it imitatively. Petrarch's conception of a Renaissance was not the rebirth of antique ways of living and writing in the manner of a Williamsburg, Virginia. It was a rebirth of the style standard set in antiquity, after a long *dark age* during which this standard, especially in literature, art, and manners, was debased. As a start, then, but only as a start, the humanists sought by emulation first to recover, then to master, and ultimately to improve upon, what the Ancients had achieved—to use ancient texts as stepping-stones to still greater accomplishment. Bees, Petrarch noted, take pollen from flowers but transform it into honey, which is better than pollen. This is the humanist conception of progress: to take the pollen of stylistic excellence from ancient art and transform it into the honey of still greater art.

The idea of progress is expressed clearly enough here for it to have become an issue by the end of the fifteenth century. With the invention of increasingly powerful gunpowder-based weaponry; of printing by movable metal type followed by the rapid growth of a vigorous international printed book industry; of central vanishing point perspective and the flowering of Renaissance art and sculpture; of new, more complex forms of musical harmony and composition; of new, more powerful types of machinery; and with the voyages of discovery east to India and west to the Americas, culminating in Magellan's circumnavigation of the globe in 1525, all enabled by new techniques of mapmaking and navigation, defenders of progress argued that the ancients had been far surpassed by the *moderns*. There followed, throughout the sixteenth century and into the seventeenth, set piece entertainments, popular in courts across Western Europe and in many books and essays, called the Battle of the Ancients and the Moderns in which the claim that *we* were superior to ancient predecessors was defended against the argument that the ancients were superior in quality, as human beings, in spite of subsequent superficial technological superiority.

By the 1660s, the idea of progress was no longer open for debate. Joseph Glanville's *Plus Ultra* (1668) was a paean to the new experimental philosophy, enabling humankind to *go further*, to exceed all limitations previously set by ignorance and superstition (and religion!) on what people can know and achieve. While the engine of progress in the fifteenth and sixteenth centuries had been identified with inventiveness or creativity, especially in art and technology, with the seventeenth-century rise of modern science and philosophy, the engine of progress became reason, especially as exemplified in science and mathematics. This identification of progress with reason became a central dogma of modernism: that through the exercise of reason human beings can improve life on Earth without limit. In both modern philosophy, whether rationalist or empiricist, and in modern science, reason subsumes inventiveness and shifts the focus of progress from art and technology to understanding, with technological innovation merely a fruit or byproduct of understanding.

It is this version of the idea of progress that is at the heart of the eighteenth-century Enlightenment and expressed in Thomas Paine's *Age of Reason* (1795). It is the justification for the republican *experiment* that created the United States and inspired the French revolution; that without kings, history, or God, the exercise of reason alone can create better societies than have ever existed, societies in which people will be happier, healthier, more prosperous, longer-lived, and more productive, for themselves and for others. The clear expectation that basing action on reason would produce better people is articulated in the Marquis de Condorcet's 1793 "Sketch for a Historical Depiction of the Progress of the Human Mind" (*L'esprit humaine*), written, ironically and tragically, on the eve of Condorcet's imprisonment by agents of the very Revolution whose ideals he proclaimed.

Progress Under Attack

The case for the rationalist interpretation of progress was based on the manifest superiority of modern science over ancient, medieval, and Renaissance science, of modern philosophy—René Descartes, Benedict de Spinoza, Gottfried Wilhelm Leibniz, John Locke, and Immanuel Kant—over ancient, medieval, and Renaissance philosophy, and on the continually increasing power of technology, especially after the invention in the late-eighteenth century of mass production machinery and the steam engine. But the Romantic poets, novelists, and playwrights—among them Samuel Taylor Coleridge, William Blake, and William Wordsworth in England, and Novalis and Heinrich Wilhelm Kleist in Germany—rejected the hegemony of reason in human affairs, the capacity of reason to serve as an engine of truly human progress, and even the possibility of a happy ending to human history by creating an earthly, secular version of Paradise. With the spread of the Industrial Revolution and the *dark Satanic mills* (as Blake called them) that were its progeny, of the railroads with their noise and pollution, with the growing, poverty-ridden urban proletariat, the case for social progress weakened.

Progress within science and in technology, however, could hardly be gainsaid. Scientific theories clearly kept getting better in terms of explanatory power, prediction, control, and revelation of hitherto unknown aspects of reality. New inventions—steam-powered factories, ships, and railroads; the telegraph; synthetic dyes; electricity; the telephone; the automobile; and flight—gave people unprecedented capabilities and poured out in seemingly endless profusion. But the note that had been sounded in the sixteenth-century Battle of the Ancient and the Moderns was sounded again: Does any of this scientific and technological progress mean social or human progress? Does it make people better? Is the human condition in fact better than it was before, or is it merely different? Again every improvement entails a change, but not every change entails an improvement!

On what grounds can people judge which changes are improvements? How can they tell which capabilities provided by technological innovations are worth adopting? To whom or to what do people turn to learn how to apply knowledge or implement innovations and set goals, for which particular technologies can provide helpful means? In the absence of goals, means become ends in themselves. Neither technology nor science can help to identify which ends to pursue with their aid: technology because it is purely a means, and science because value-neutrality is central to the methodology of modern science.

The equation of progress with the application of value-neutral reason became increasingly problematic in the course of the nineteenth century. Echoing the earlier Romantic poets, philosophers from Arthur Schopenhauer and Søren Kierkegaard to Friedrich Nietzsche and Henri-Louis Bergson formulated criticisms of reason that undermined its capacity to serve as the engine of human or social progress. By the end of World War I, the claim that through science and reason Western societies and their inhabitants had improved rang hollow. This feeling was intensified by the global slaughter of World War II, a war in which the most advanced forms of value-neutral rationality, science, and technology were proudly allied to the value-laden nonrationality of politics.

The Price of Progress

In the course of the twentieth century, then, it became clear that the price of modern science and science-based technology was that the ties between knowledge and action were sundered. Even as the rate of development of theories in the sciences and the pace of technological innovation accelerated, driven by massive public and corporate funding and by the creation of reinforcing social institutions, even as science and technology became the dominant agents of social change and became inextricably entangled with personal and social life and values, the ethical divide separating knowledge and action widened. It seemed that progress could be defined unequivocally with respect to scientific theory change and technological innovation, but claims that social and personal life style changes were progressive were highly equivocal. Suddenly the ethical implications of science and technology became central issues for society, but there existed no conceptual tools, comparable in power to those available to scientists and engineers, for grappling with these issues, nor did the average person have the political and economic power to challenge the institutions that exploited science and technology.

In fact even the confidence that progress could be defined objectively with respect to scientific theory change and technological action was severely shaken in the 1960s. Technological change can be evaluated objectively but only with respect to parameters that incorporate arbitrary value judgments: A high speed Internet connection is better than a slower speed connection if the values of speed and of being connected to the Internet at all are accepted as givens. These values, of course, cannot be judged objectively. An analogous challenge was raised with respect to science, because from its beginning modern science had as its primary objectives discovering the nature of things, revealing the hidden causes of why things happen, and disclosing reality. In the nineteenth century, questions were raised about the relation between increasingly abstract mathematical physical models of nature and what was *really* out there, but the prevailing view remained that scientific theories changed because newer theories were truer to reality than older ones. To be sure, quantum theory raised more serious questions about the relation between physics and reality than had been asked in the nineteenth century; and the Copenhagen Interpretation of quantum mechanics invented by Niels Bohr and Werner Heisenberg argued that physics could not provide a picture of reality, only an empirically satisfactory account of experience.

It was only in the 1960s, however, that a broad consensus grew among intellectuals, challenging the progressive and objective character of scientific knowledge. People had no real access to the new realities that scientists claimed to be encountering and thus no way to know whether such advances truly constituted progress. This consensus was precipitated by the debate over Thomas Kuhn's *The Structure of Scientific Revolutions* (1962), which led to a broad historical, philosophical, and social scientific critique of the concept of objectivity and for many scholars a rejection of the possibility of objective knowledge. This in turn triggered the so-called *Science Wars* of the 1980s and 1990s in which the objectivity of scientific knowledge and the progressive character of scientific theory change were defended by physical and life scientists. But even if the objectivity of scientific knowledge were conceded, bridging the ethical gulf between value-neutral knowledge and its applications remains an issue in the early-twenty-first century.

STEVEN L. GOLDMAN

SEE ALSO *Change and Development; Development Ethics; Theodicy; Wells, H. G.; Wittgenstein, Ludwig.*

BIBLIOGRAPHY

Becker, Carl. (1993). *The Heavenly City of the Eighteenth Century Philosophers*. New Haven, CT: Yale. An important early twentieth century historian's analysis of the goals of enlightenment social and political reformers. Very well written.

Burtt, Edwin A. (2003). *The Metaphysical Foundations of Modern Science*. New York: Dover. A classic pre-1960s study of the ideas and values underlying the seventeenth century scientific revolution.

Goldman, Steven L., ed. (1989). *Science, Technology and Social Progress*. Bethlehem, PA: Lehigh University Press. A collection of thought-provoking essays by scientists, historians and philosophers on the question of whether modern science and technology have improved the quality of human life.

Hacking, Ian. (2000). *The Social Construction of What?* Cambridge, MA: Harvard University Press. A clearly written, balanced, and insightful account of the "science wars" of the late twentieth century.

Kelly, Donald R. (1991). *Renaissance Humanism*. Boston: Twayne. Excellent introduction to the distinctive ideas and values of key humanist thinkers and why they are important to understanding the riser of modernity.

Kitcher, Philip. (2001). *Science, Truth and Democracy*. Oxford: Oxford University Press. Excellent, deeply thought-provoking discussion of bridging the gap between technical knowledge and its applications in a democratic society.

Kuhn, Thomas. (1962). *The Structure of Scientific Revolutions*. Chicago: University Of Chicago Press. This is the book—short, sharply focused and clear—that precipitated the challenge to the claims that scientific knowledge was truly objective.

PROMETHEUS

In ancient Greek mythology the hero Prometheus (meaning forethought) rose up to the heavens to light a torch from the Sun's fire, then brought it back to Earth for humankind. This fire, stolen from the sun god Helios, transformed humankind into something superior to other living beings. As retribution, Zeus sentenced Prometheus to be chained to a rock while an eagle forever gnawed at his liver; Hercules killed the eagle and freed him. Zeus's divine justice included a ruse for Prometheus's brother Epimetheus (meaning afterthought). He received the gift of an all-good, incomparably beautiful wife, Pandora, who came accompanied by a box that was never to be opened. Pandora could not resist the temptation and opened the box, releasing upon humankind a manifold of miseries and evils—along with hope.

In Greek literature the story of Prometheus can be found in three sources: Hesiod's *Theogony* and *Works and Days* (eighth century B.C.E.) and Aeschylus's *Prometheus Bound* (fifth century B.C.E.). (Aeschylus's drama is the only extant part of a trilogy that began with *Prometheus Fire-Carrier* and concluded with *Prometheus Unbound*.) Plato's *Protagoras* also provides a version of the myth in which Prometheus steals *technai* (technics) from Hephaestus and Athena, after which Zeus commands Hermes to give human beings a sense of justice and shame so that they might live with their new abilities (*Protagoras* 320d-322d). Plato further has Prometheus mentioned as a giver of problematic gifts in the *Gorgias* (523d-e), the *Politicus* (also known as *Statesman* (274a), and the *Philebus* (16e). After Plato, however, it is significant that Prometheus does not have a prominent place in Greek or Roman or even medieval European literature.

The Punishment of Prometheus, as depicted on a Laconian cup, c. 555 B.C.E. *(© Scala/Art Resource, NY.)*

In modern culture, however, Prometheus plays a more significant and somewhat altered role. As Karl Kerényi (1963), among others, notes, he often represents a creative rebellion against the limitations of the human condition, for which he is unjustly punished. Although humanity pays for its productive creations, Prometheus is to be admired for his courage and the heroic self-sacrifice that accompanies technological progress. At the same time, new discoveries, driven by hope springing eternal, repeatedly bring forth negative unintended consequences. In counterpoint to such a Promethean fate, Ivan Illich (1972) presented the image of *Epimethean Man,* who in retrospect learns to practice what, in the early-twenty-first century, is called the "precautionary principle."

Among the many modern reflections on the Prometheus story are the short lyric poem of the same name by Johann Wolfgang von Goethe (1774) and the poetic play, *Prometheus Unbound,* by Percy Bysshe Shelley (1819). The Dirck van Baburen painting *Prometheus Being*

Chained by Vulcan (1623) is representative of a novel visual interest. Ludwig van Beethoven's *Geschöpfe des Prometheus* (ballet, opus 43, 1801) and *Erocia* (third symphony, opus 55, 1801) both reveal the composer's personal sense of confrontation with Promethean struggles. The best-known modern adaptation is, however, Mary Shelley's *Frankenstein, or The Modern Prometheus* (1816).

More recently Carl Orff's opera *Prometheus* (1968), Richard Schechner's performance work *The Prometheus Project* (1985), and Tony Harrison's film *Prometheus* (1998) all link the story to technology, although in different ways. Orff's music has been described as anticipating technomusic. Schechner's performance employs projected images to connect Hiroshima and pornography. In Harrison's film, miners from a closed colliery pit are melted down and made into a golden statue of Prometheus, which is then trucked by Hermes across Europe from Dresden to Auschwitz and eventually to Greece. Allegorically, Hermes, the messenger god in mythology, returns the current age to the immortality of ancient Greece; so too each epoch age revives the original impulse of the promethean myth and this recurrent hope: Carrying the human torch back to its source, like an Olympian returning home, connotes carrying on with humanity, its eternal re-emergence rising from human ashes and senseless destruction to rebirth, with glories restored and horrors transcended.

Finally the extent to which the Prometheus story may serve as a continuing vehicle for reflections on issues related to science, technology, and ethics is indicated by simply noting the titles of the following books: John M. Ziman's *Prometheus Bound: Science in a Dynamic Steady State* (1994); Thomas Parke Hughes's *Rescuing Prometheus: Four Monumental Projects that Changed the Modern World* (1998); Norman Levitt's *Prometheus Bedeviled: Science and the Contradictions of Contemporary Culture* (1999); Darin Barney's *Prometheus Wired: The Hope for Democracy in the Age of Network Technology* (2000); Arthur Mitzman's *Prometheus Revisited: The Quest for Global Justice in the Twenty-first Century* (2003); and William Newman's *Promethean Ambitions: Alchemy and the Quest to Perfect Nature* (2004).

MARY LENZI
CARL MITCHAM

SEE ALSO *Faust; Frankenstein; Playing God.*

BIBLIOGRAPHY

Illich, Ivan. (1972). *Deschooling Society*. New York: Harper and Row.

Kerényi, Karl. (1963). *Prometheus: Archetypal Image of Human Existence*, trans. Ralph Manheim. New York: Pantheon. First German publication, 1946. A Jungian commentary that references Goethe's poetry more than Aeschylus's drama.

PROPERTY

Property is defined as that which is owned, including both tangible things and the right to engage in certain actions. In the physical and social sciences one can speak of a property of a thing or an object in describing a characteristic of that thing. Here property is restricted to the right or authority to determine how a resource is used. Society designates who holds a resource and how it is used through governmental enforcement of laws or through social custom and tradition. Property rights determine not only who is allowed to use a resource but how exclusive the use is, who has the ability to preclude use, and how property may or may not be acquired and exchanged. Property therefore helps define the relationship between individuals and between groups of individuals.

Property and property rights depend on the answers to two fundamental questions: In a just society, what criteria should be used to distribute resources? and What types of property rights structures should be recognized? The philosopher John Locke's (1632–1704) concept of natural rights provides a starting point: Individuals have property rights to themselves and their labor a priori. In other words, independent of institutional, legal, cultural, or social constraints imposed by others, persons have rights to themselves and the products of their labor as long as they do not impede others from exercising the same rights. The idea of natural rights is both intuitive and morally appealing yet is insufficient because in the course of human interactions people tend to impede others from realizing their natural rights.

Property, Technology, and Science

Technology plays a central role in the use and protection of property, and in many instances property rights depend on access to and control of technology. In the extreme case wilderness real estate may be accessed only with a helicopter, but even a computer cannot be used without electricity. Not only the effectiveness but also the security and transferability of property rest on the ability to monitor and enforce property rights. Technologies for monitoring and securing physical property can take the form of locks, fences, security cameras, tamperproof devices, and alarms. In the absence of monitoring

TABLE 1

Property: Compatibility and Exclusivity

	Exclusive	Non-exclusive
Incompatible	Pure private goods: apples, TVs, automobiles	Common property resources: fisheries, roads, groundwater
Compatible	Public goods: concerts, internet access	Pure public goods: national defense, clean air

SOURCE: Adapted from Perloff (2001), p. 628.

or enforcement technologies even well-defined property rights lack meaning.

The control of technology not only determines who has access to property but also may influence capital flows to support research and development. A communications network may facilitate connections between some inventors and venture capitalists and exclude others. At the same time, when research and development are funded primarily by private interests, this can create a risk of subordinating scientific inquiry to profit making. Similarly, easy technological access to venture capital or other types of investments can distort scientific interests.

Scientific research and technological development themselves depend on secure property rights. Without secure intellectual property rights incentives to engage in research and development are lowered because the rewards may not accrue to those who produce those goods.

Characteristics of Property

Property has two main characteristics that determine how well it functions, that is, how easily it can be transferred and how well related rights can be monitored or enforced. The two characteristics are incompatibility and exclusiveness. A good or service is incompatible if consumption by one person precludes consumption by another person. If one person eats an apple, another person cannot eat it. Exclusivity means that the owner of a good should receive all of the benefits and costs of ownership including the ability to exclude consumption of the good for those who do not pay. Owners of a movie theater can exclude customers who do not pay. Owners of a drive-in are less able to exclude non-paying customers. The degree to which something is incompatible and exclusive determines the degree to which a good is private or public. The matrix (Table 1), which is adapted from the work of Jeffrey Perloff (2001, p. 628), summarizes the possible combinations of incompatibility and exclusiveness.

A pure private good is one that is both incompatible and exclusive, such as many consumer goods. With pure private goods there are no restrictions on the property right to use or exchange the good. The value of the good is determined by the ability to exchange the good with others on mutually agreeable terms. With private goods the market price reflects the value of the property right to the good or service in its best use. However, the table does not convey the extent to which most goods and services are hybrids somewhere in the middle. Most goods have degrees of compatibility (that is, they are nonrival) or exclusivity.

Private Goods

The basis of neoclassical economics is private property. In fact, the economic historian Donald McCloskey (1985) defines modern economics as the science of property such that property itself is defined not merely as a thing but as a social relation. If everything owned and exchanged is costless, the property right to the thing being exchanged belongs to the person who values it the most. If the thing has no value, no one will bother with it, and hence there is no need to define the relationship between the thing and anyone who would possess it. The value of property depends on its scarcity. If more than one person desires a thing, property rights to that thing define the relation not only of the owner to the thing but of the owner to anyone else who may value the thing and of nonowners to the thing. The effectiveness of property as a social relation therefore depends on the definition of this social relation and its transferability. For economists well-functioning markets for pure private goods depend on clearly defined property rights.

In regard to the question of how property historically has been defined or how it can be clearly defined economists resort to the tautological argument that rights become well defined when it is in someone's interest to do so. This answer leads to inequitable income distributions. To understand this one can use Allan Schmid's argument about capitalization and the role of property (Schmid 1987). Schmid contends that the property right to exchange facilitates capitalization, or the conversion of future values into present values. In other words one person can consume today by trading his or her future production for someone else's current consumption. The ability to exchange the present for the future provides incentives to innovate and to invest in scientific research and technological development. If property is not transferable over time, the individual producer will have to wait until production is finished in order to consume. In this case there is neither borrowing nor lending.

The problem here is that the way property rights are defined affects the rewards given to innovators. If markets are competitive, the benefits of transferable property rights and their concomitant technological advances will be shared by everyone in society over time. However, perfectly competitive markets rarely exist outside economic theory textbooks. Market power in imperfect markets, which are the norm, means that some individuals have easier access to credit and capital. This typically results in capital markets that provide instant wealth to innovators and an astounding degree of income inequality. The stock market magnifies this inequality and has not always produced capital for new investment; instead it often provides power, both political and economic, that strengthens property holders' interests at the expense of those who do not have access to capital.

Public Goods

At the other end of the spectrum a pure public good such as clean air is both compatible (nonrival) and nonexclusive. The less exclusive a good is, the more difficult it is to monitor and enforce property rights to that good. In the case of a pure public good property belongs to everyone. Because the benefits of ownership accrue to everyone but the costs accrue to no one in particular, the provision of a pure public good depends on someone bearing the cost of production. In many cases with high costs of provision, such as national defense, the government must step in and pay by collecting tax dollars from those who benefit. The share of benefits may not reflect the proportional tax share borne by each taxpayer accurately.

When property is publicly owned or when the acquisition and exchange of property is not well defined, determining a just distribution of resources and deciding who controls access become an ethical minefield. The decision about who gets to decide and how questions of allocation and distribution are decided is complex. Locke's idea of natural rights to oneself and one's labor is difficult if not impossible to extend to communal property. The political philosopher Karl Marx's (1818–1883) version of socialism was an attempt to make collective decisions about the production and distribution of both common and private property. For Marx property could not be appropriated (literally "made one's own"). If profits were realized from collective production, they would be shared equally among all people according to each person's needs. However, Kenneth Arrow's impossibility theorem challenges the possibility of a common social choice.

Between Pure Public and Pure Private Goods

Between pure public goods and pure private goods lies the murky continuum of fuzzy property rights. Some resources are rival but nonexclusive. Groundwater can be accessed by anyone with a pump, but once removed from the ground, it is typically the property of the person who owns the pump. The classic example of a common property resource is the commons, or town pasture, where individuals were allowed to graze their animals without cost. In this case each individual can graze additional animals on the commons without any additional cost to the individual but with a cumulative detrimental cost to the commons. The net effect of each individual's rational actions when property rights are absent and individuals are free to use the resource without cost or at a cost that does not reflect the true value of use is complete degradation of the resource, or what Garrett Hardin (1968) called the tragedy of the commons.

Intellectual property, or ideas, innovations, and inventions, also lies between pure private and pure public goods. Intellectual property rights such as patents and copyrights are some of the most difficult rights to qualify. Intellectual property is both intangible and compatible (nonrival). Once intellectual property is produced, anyone can enjoy it at zero or very low additional cost. Thus, the cost of developing the first unit is often great and the incentive to produce it does not exist unless the producer can charge more than one person for use of the property and recoup the cost of research, development, and normal operating costs. Without the incentive to innovate, new ideas and consequently new technology are slow to develop, especially if other individuals can duplicate the intellectual property easily.

The response of societies to this quandary is to grant patents or copyrights, which are property rights and as such allow individuals to earn an economic profit. Without property rights innovators and entrepreneurs are not willing or able to invest in research and development because they do not have the requisite capital for the endeavor or because they will not reap rewards commensurate with their efforts.

This raises the question of whether science itself is a public or a private good. By granting patents the government essentially places science in the private realm and grants corporations monopoly power over goods that may have a public nature. With scientific research an alternative to patents would be to make all scientific research and development publicly funded. That might allow science to remain independent of corporate power and better serve the public interest. Detractors of this idea believe that without incentives individuals will not develop new ideas. They also believe that without property rights ideas will not be secure. However, less cynical thinkers maintain that the pursuit of science is not necessarily motivated by financial reward. Creativity does not follow a schedule and does not answer to the auditor.

The way property is defined, appropriated, and exchanged is one of the most frequently discussed topics in economic and political philosophy. The challenge to society is to define property rights clearly and in a manner that allows transparent monitoring and enforcement of those rights and to recognize that property rights to some types of entities can lead to gross inequality. Meeting this challenge may lead to greater investment in technology and better-informed choices for individuals and society. Sometimes, however, the nature of the way people interact interferes with clear and effective property rights.

WILLARD DELAVAN

SEE ALSO *Intellectual Property.*

BIBLIOGRAPHY

Christman, John. (1994). *The Myth of Property.* New York: Oxford University Press. A contrarian view of the capitalist idea of property.

Demsetz, Harold. (1967). "Toward a Theory of Property Rights." *American Economic Review* 57(2): 347–359. A classic early article with a formal neoclassical approach to property.

Hardin, Garrett. (1968). "The Tragedy of the Commons." *Science* 162: 1243–1248. The defining article on common property resources.

McCloskey, Donald. (1985). *The Applied Theory of Price.* New York: Macmillan. One of the best-written and most provocative intermediate microeconomic theory textbooks; by a prolific, enigmatic economic historian.

Perloff, Jeffrey M. (2001). *Microeconomics,* 2nd edition. Boston: Addison Wesley Longman.

Schmid, Allan A. (1987). *Property, Power, and Public Choice,* 2nd edition. Westport, CT: Praeger. A profound look at the institution of property.

PROSTHETICS

In a narrow sense, prosthetics is a branch of medicine, specifically of surgery, concerned with the replacement of missing body parts (upper and lower limbs, and parts thereof) after amputation. It is related to orthotics, a branch of medicine that deals with the support of weak or ineffective joints or muscles using supportive braces and splints. In dentistry, prosthetics or prosthodontics is that branch concerned with the replacement of missing teeth and other oral structures. In this narrow sense, a prosthesis is a replacement artificial limb or tooth. In a broader sense, *prosthesis* is the name for any artifact used to restore bodily functions, and *prosthetics* is the field concerned with the development and fitting of artificial body parts, which is the sense at issue here.

Approaches to Prosthetics

Prostheses in this broad sense are an important focus of the relatively new field of bioengineering, or biomedical engineering, which is concerned with the application of engineering techniques to medicine and the biomedical sciences. Bioengineering is itself a broad field, with applications ranging from molecular imaging tools to medical radiation devices. The development of prosthetic techniques and devices is only one of its interests.

Several areas in bioengineering have special relevance to prosthetics. Rehabilitation engineering is an area concerned with ameliorating the impairments of individuals with disabilities. It includes prosthetics and orthotics as defined at the beginning of this entry, but also addresses other disabilities, specifically sensory and speech impairments. It does not address functional impairments in internal organs, however. Other relevant areas include tissue engineering, which involves the repair or replacement of organic cells, tissues, or organs with laboratory-grown biological substitutes; biomaterials engineering, which aims to develop synthetic or natural materials that can replace or augment tissues, organs, or bodily functions; biomechanics, which studies the human musculoskeletal system and its mechanical aspects and includes artificial limb and joint design; cardiovascular engineering, which studies the cardiovascular and blood system and develops techniques and systems for diagnosis, intervention, therapy, and replacement; and neural engineering, which studies the nervous system and develops means to repair or replace damaged and nonfunctioning nerves and sensory systems. Neuroprosthetics is a rapidly growing subfield of neural engineering that aims to develop devices or systems that communicate with nerves to restore functionality of the nervous system.

Although research in prosthetics and bioengineering is primarily aimed at restoring damaged human functions, there has been a growing interest in the augmentation of human functions. Human augmentation or enhancement is a relatively new field in bioengineering directed at developing prosthetic devices that augment normal function or prevent injury to function.

Together with artificial intelligence and robotics, bioengineering is the successor of bionics (a conflation of *biological electronics*), which emerged in the 1950s with the aim of using biological design principles to create novel technological devices and mechanical substitutes for the extension of biological organs. Bionics is specifically concerned with the development of bionic devices or bionic implants, which are electromechanical devices that do not merely replace a body part but also closely mimic or surpass the behavior of a replaced organ, and that are often able to communicate with the nervous system. To attain its aims, bionics relied on a feedback-control framework that was provided by cybernetics, the science of communication and control in animal and machine. Cybernetics has been partially superseded by systems theory, a field that studies the general principles underlying the organization of systems of any kind. Cybernetics has yielded the term *cyborg,* a conflation of *cybernetic organism,* meaning an organism that is part human, part machine. A cyborg is an individual whose biological functions are aided or controlled by technological devices, particularly by bionic implants.

A large number of human biological functions can be restored or improved with the aid of prostheses. The list of implants and related devices is extensive:

- artificial limbs, including robotic ones and ones with sensory feedback to the body
- artificial joints, hips, and vertebrae
- artificial muscles made of polymer
- artificial skin used to promote healing
- artificial bone used to help heal fractures and replace diseased bone
- bracing systems, cervical implants, and spinal cages to support the spine
- silicone or plastic implants to build bony structures of the face
- breast implants
- penile implants
- dental implants and false teeth
- speech synthesizers and artificial larynxes to restore speech
- retinal implants (experimental), intraocular lenses, and artificial corneas to restore vision
- cochlear implants that replace the inner ear and involve a microphone, speech processor, and wiring to the nervous system
- artificial nerves (experimental)
- cardiac pacemakers, defibrillators, artificial heart valves, and heart-assist pumps
- artificial hearts (experimental)
- artificial blood vessels and urological systems
- artificial blood (experimental)
- implanted drug-delivery systems (experimental)
- electrodes implanted in the brain to control seizures or tremor
- implanted chips to locate persons or to regulate devices in "intelligent environments"
- orgasmatrons (implants for women that produce orgasms; experimental)
- spinal neuroimplants with handheld remote control to block pain signals
- motor neural prostheses based on functional electrical stimulation systems, which stimulate motor nerves for movement, respiration, and bladder function
- artificial hippocampi in the brain (experimental)

Research is underway on bioartificial livers, kidneys, pancreases, lungs, and other organs, as well as on more advanced neural prostheses to restore functions of the brain and nervous system.

Anthropological Theories

Most philosophical and anthropological theories that refer to the notion of prosthesis are not so much concerned with understanding prosthetic technologies as normally defined but with an understanding of technology in general by means of the concept of prosthesis. Prosthesis is used as a metaphor to understand technology and its relation to human beings. In prosthetic theories of technology, which have been proposed since at least the late nineteenth century by a variety of different authors, it is claimed that there is no essential distinction between prosthetic and other technologies, because all technologies in some way aim to replace or augment aspects of human functioning. This view has been proposed by, among others, Marshall McLuhan (1911–1980), Henri Bergson (1859–1941), Arnold Gehlen (1904–1976), Ernst Kapp (1808–1896), and Lewis Mumford (1895–1990).

According to the prosthetic view of technology, every technological artifact or system extends the human organism in that it takes human faculties outside the body, thus amplifying already present abilities. The body is itself a toolbox that its owner uses to do things in the world. Technical artifacts serve to replace, extend, or augment tools in this organic toolbox. Weapons and tools such as bows, knives, and saws are extensions of human hands, nails, and teeth; clothing extends the heat control and protection functions of the skin; the wheel extends the mobility functions of the legs; bags extend the ability of the hands and arms to carry things; the radio and telephone extend hearing; television and photography extend the visual function; writing and print media extend human language and memory functions; and the computer extends a large variety of human cognitive functions. Prosthesis, in the narrow sense, is therefore only an instance of the general ability of technology to extend or replace functions of the human organism, and all technologies should be understood in terms of their relation to human functioning.

Even if this view is correct, it is recognized by many authors that all artifacts do not extend the human organism in the same way. Some technological artifacts have a symbiotic relation to the body, whereas others function independently. A relevant distinction seems to exist between artifacts that serve as direct extensions of human functioning by engaging in a symbiotic relationship with human limbs, senses, or other body parts, such as telescopes, glasses, hammers, and canes, and those artifacts that operate separately from the body and are themselves the object of interaction or perception, such as dinner plates, stereo systems, and computer screens. Phenomenologist Don Ihde (1990), drawing on the work of Maurice Merleau-Ponty (1908–1961), argues that humans are able to engage in embodiment relations with some artifacts, which are incorporated into the body schema or body image, meaning that they are integrated with the image that human beings have of their own sensorimotor abilities—an image that defines them as agents and separates them from a world that is to be engaged. (Other artifacts remain separate and subject to interpretative or hermeneutic relations.) Embodiment relations have found support in psychological studies of body schemas.

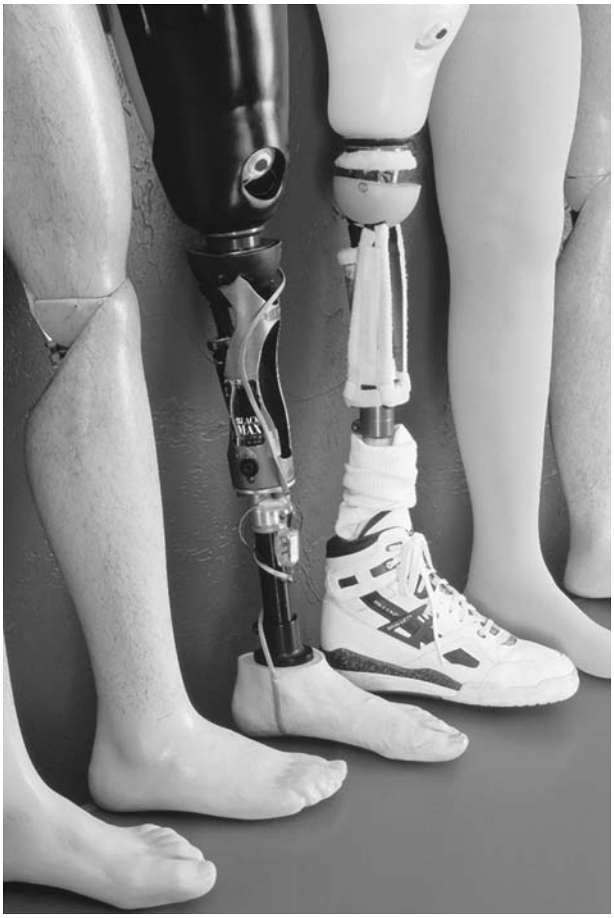
Cyborg Theories

Cyborg theory or cyborgology—the multidisciplinary study of cyborgs and their representation in popular culture—provides another perspective on prosthetics. Studies in cyborg theory tend to use the notion of the cyborg as a metaphor to understand aspects of contemporary—late modern or postmodern—relationships of technology to society, as well as to the human body and the self. In cyborg theory, the notion of cyborg refers to hybrid organisms in science fiction (e.g., *The Six Million Dollar Man, RoboCop, X-Men, Star Trek*'s The Borg), contemporary human beings with prostheses or implants, as well as (contemporary) human beings in general, who are all conceived as cyborgs in the sense of being inherently dependent on technology.

The advance of cyborg theory as an area of academic interest has been credited to Donna Haraway, in particular to her 1985 "Manifesto for Cyborgs." In this essay, Haraway presents the cyborg as a hybrid organism that disrupts essentialist presuppositions of modern thinking, with its black-and-white dichotomies of nature–culture, human–animal, organism–technology, man–woman, physical–nonphysical, and fact–fiction. Cyborgs have no preexisting nature or stable identity, and cut through oppositions because of their thoroughly hybrid character. Haraway holds that modernity is characterized by essentialism and binary ways of thinking that have the political effect of trapping beings into supposedly fixed identities and oppressing those beings (animals, women, blacks, etc.) who are on the wrong, inferior side of a binary opposition. She argues that the hybridization of humans and human societies, through the notion of the cyborg, can free those who are oppressed by blurring boundaries and constructing hybrid identities that are less vulnerable to the trappings of modernistic thinking.

According to Haraway and other authors such as N. Katherine Hayles (1999) and Chris Hables Gray (1995), this hybridization is already occurring on a large scale. Such hybridization is a consequence of the transition since World War II from an industrial to an information society, as a result of technological advances in biotechnology, information technology, and cybernetics. In the new world order that is ensuing, boundaries are constantly blurring, and linguistic categories and symbols increasingly reflect this fact. Many basic concepts, such as those of human nature, the body, consciousness, and reality, are shifting and taking on hybrid, informationalized meanings. In this postmodern, posthuman age, power relations morph, and new forms of freedom and resistance are made possible.

Sharing the positive outlook of cyborg theorists on the technological transformation of human nature, but otherwise quite distinct from it both politically and phi-



Various prosthetic legs. *(© Roger Ressmeyer/Corbis.)*

losophically, transhumanism is a recent school of thought or movement that advocates the progressive transformation of the human condition through technological means. Its early inspirational source was FM-2030 (formerly, F. M. Esfandiary) (1989), a futurist who wrote on the notion of the transhuman in the 1970s and 1980s, while its current main organizing body is the World Transhumanist Association, cofounded in 1998 by Nick Bostrom and David Pearce. Transhumanists want to move beyond humanism, which they commend for many of its values, such as its orientation toward reason and science, its commitment to and belief in progress, and its rejection of faith and worship, but which they fault for a belief in some fixed human nature. Transhumanists want to use modern technology to alter human nature in order to augment human bodily and cognitive abilities and extend human life. They see converging developments in genetic engineering, biomedical engineering, artificial intelligence, nanotechnology, and cognitive science as transcending human nature, thus leading humanity to a transhuman or posthuman condition. They argue that this development should receive full support, because of its potential to enhance human autonomy and happiness and eliminate suffering and pain, and possibly even death.

Ethical Issues

The research, development, application, and use of prostheses and implants raise a number of ethical issues relating to health and safety, distributive justice, identity, privacy, autonomy, and accountability. Special ethical issues are raised by human augmentation or enhancement research.

HEALTH AND SAFETY. The functioning of a prosthesis for the remainder of someone's life cannot be predicted reliably on the basis of a few clinical trials with human subjects or tests with animals. There is a real risk, therefore, that people will be fitted with prostheses or implants that malfunction, have harmful side effects, or are even rejected by the autoimmune system. Negative experiences with silicone breast implants and artificial hearts have already shown the body's resistance to technological interventions. Ideally, prostheses would be tested over many years, decades even, and involve a large number of human subjects. But such extensive clinical trials and experimental uses are often considered too lengthy and costly and raise ethical issues by making guinea pigs out of human beings. Tests on animals often cannot serve as a substitute, while raising ethical issues of their own.

JUSTICE. The development of increasingly sophisticated prostheses and implants presents issues of distributive justice: Will there be a division between biological haves and have-nots? Will there be a division between those who receive no prosthesis or a low-quality or high-risk one and those who receive the best medical care? Do people have a moral right to a replacement part for a malfunctioning organ, when such parts exist? And will all be able to obtain implants that are attuned to their biological characteristics and lifestyle? In a 2003 incident in the United Kingdom, a black woman with an amputated foot was told that she would have to be fitted with a white prosthetic limb unless she paid an additional £3,000 (U.S.$ 5,500) for a black one. Although this is an obvious instance of discrimination, the situation is not always so clear. Who, for example, should pay the extra costs when a person has mild allergic reactions to a prosthesis and demands a much more expensive version that will not cause such reactions? Do producers have a duty to develop special prostheses for people whose biological features do not fit the norm, and should they be able to charge extra for those?

IDENTITY. Acquiring a prosthesis requires people to come to terms with the fact that a part of their body is artificial, and that they are dependent on a piece of technology for their biological functioning. This may be even more of an issue with bionic and neuroprosthetic implants, which may display or induce behaviors only partially controllable, with which one may thus find it hard to identify. Even more so, cognitive prostheses, which are neuroprostheses that aid cognitive function, may be developed in the future, and these may undermine identity even more directly as they directly interface with the mind. Some critics of prostheses have argued for the integrity of the human body, with all its defects and flaws, and worry that as humans increasingly become cyborgs, the essence of humanity will be lost. Social identity may be at issue as well. A particular controversy has arisen over cochlear implants; deaf advocates have argued that they may place children in between the deaf world and the hearing world, and that they may end up destroying the deaf community with its rich history and culture.

PRIVACY. Privacy issues are at stake when implants process or store information or emit identifying signals that can be registered from a distance. Implantable chips for tracking, already common in pets and livestock, are also being considered for children and adults, and they make it possible to trace individuals over long distances. Sensory and neuroprosthetic devices and prostheses equipped with biosensors process and sometimes store information about people's biological states, behaviors, and perceptions that may be accessed by third parties.

AUTONOMY. Prostheses can clearly enhance individual autonomy by restoring functions, but it has been argued that they can also reduce it. Having a prosthesis means being intrinsically dependent on technology. A prosthesis also creates dependence on others for maintenance, diagnosis, and testing. Bionic and neuroprosthetic implants may not even leave their wearer in complete control of their actions or thoughts.

ACCOUNTABILITY. Bionic and neuroprosthetic implants may raise issues of accountability, because the behavior or cognitive processes of their wearers will be determined in part by the workings of machines. If such individuals cause accidents or make bad decisions, who is to blame: they or their implants?

ETHICAL ASPECTS OF HUMAN AUGMENTATION. The field of human augmentation or enhancement raises a number of special ethical issues in addition to the ones already mentioned. Is it ever morally permissible to destroy or impair healthy human tissue or organs to fit an augmentation, considering that this destruction may be irreversible? Can an employer require an employee to have enhanced functions, or put a premium on the possession of such functions? Human augmentations is still a young field, and questions of this sort have mainly been raised in relation to cosmetic surgery, which can be understood as a special type of human augmentation with the purpose of enhancing aesthetic rather than functional qualities. Specifically, breast implants intended to create bigger breasts—as opposed to restoring breasts after a radical masectomy—have created controversy because they have been argued to be "unnatural" and to involve health and safety risks that cannot be justified by reference to their subjective aesthetic value. If certain augmentations become popular, there is also a risk that they will become accepted as the norm and people without them will be seen as cripples. To an extent, this is already happening with breast implants and other cosmetic surgery in some communities, but it may also happen with prostheses that enhance perceptual, motor or cognitive functions.

A large part of the debate on human augmentation, finally, has focused on military applications, specifically the possibility of creating supersoldiers. But should military research be devoted to the creation of a supersoldier, involving implants, steroids, amphetamines, genetically altered muscles, integrated weaponry, and lightning-fast artificial nerves?

Many parts of the human body can already be replaced by prosthetic devices, and revolutionary developments in bioengineering are rapidly expanding the reach of prosthetics. Biomedical engineers and medical specialists have a special, professional responsibility in dealing with the ethical issues that arise as a result, as they are primarily responsible for the development and fitting of prostheses. Many ethical issues also need to be addressed at the level of legislation and public policy. Special moral concerns are raised in the areas of human augmentation or enhancement and neuroprosthetics.

PHILIP BREY

SEE ALSO *Androids; Bioengineering Ethics; Cyborgs; Disability; Posthumanism; Therapy and Enhancement.*

BIBLIOGRAPHY

Brey, Philip. (2000). "Technology as Extension of Human Faculties." In *Metaphysics, Epistemology, and Technology*, ed. Carl Mitcham. London: Elsevier/JAI Press. A study of prosthetic theories of technology from Kapp to McLuhan and beyond.

FM-2030. (1989). *Are You a Transhuman? Monitoring and Stimulating Your Personal Rate of Growth in a Rapidly Changing World*. New York: Warner Books. Culminative statement of the transhumanist project by this transhumanist pioneer.

Gray, Chris Hables, ed. (1995). *The Cyborg Handbook*. New York: Routledge. Reader with important papers in cyborg theory as well as some historic papers in cybernetics, with a foreword by Gray.

Hayles, N. Katherine. (1999). *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*. Chicago: University of Chicago Press. A broad-ranging study of how cybernetics and computer science have fostered a disembodied, posthuman conception of human beings as information constructs.

Ihde, Don. (1990). *Technology and the Lifeworld: From Garden to Earth*. Bloomington: Indiana University Press. A phenomenological study of the relation between human beings and technology, including embodiment relations.

PSEUDOSCIENCE

The distinction between ideas and activities that represent science and those that represent nonscience is usually clear; no one confuses physics with art or chemistry with poetry. Nevertheless, there are ideas and activities related to bodies of knowledge that are not characterized clearly as science or nonscience and sometimes are claimed by their proponents to be science but are considered by most scientists to be pseudoscience. For example, the National Science Foundation (2002) conducted a poll on the different forms of pseudoscience accepted by Americans:

- Thirty percent believe that unidentified flying objects (UFOs) are space vehicles from other civilizations.
- Sixty percent believe in extrasensory perception (ESP).
- Forty percent think astrology is scientific.
- Thirty-two percent believe in lucky numbers.
- Seventy percent accept magnetic therapy as scientific.
- Eighty-eight percent agree that alternative medicine is a viable means of treating illness.

Most scientists reject these beliefs, which are variously called pseudoscience, voodoo science, junk science, crackpot science, or plain nonsense. However, from the perspective of those making the claims, what is being presented is more like a new aspect of science, an alternative science, prescience, or revolutionary science. In a culture in which science is given high status—indeed, this is said to be an age of science—one would expect political theories (scientific socialism), religions (Christian science, scientology, creation science), and even literature (science fiction) to try to associate themselves with science. Precisely for this reason attempts to define the boundaries of science and pseudoscience and to distinguish pseudoscience from mistaken science or not fully accepted science raise ethical as well as epistemological issues.

The Boundary Issues

Here one is faced with a "boundary problem": Where does one draw the boundary between science and pseudoscience and between science and nonscience? The problem is that it is not always or even usually clear where one should draw the line. Whether a claim should be put into the set labeled science or the one labeled pseudoscience depends on both the claim and the definition of the set. In this regard it is useful to expand the heuristic into three categories: normal science, pseudoscience, and borderlands science. The following are examples of claims that might best be classified in one of those three categories:

Normal science: heliocentrism, evolution, quantum mechanics, big bang cosmology, plate tectonics, neurophysiology of brain functions, punctuated equilibrium, sociobiology/evolutionary psychology, chaos and complexity theory, intelligence and intelligence testing

Pseudoscience: creationism, Holocaust revisionism, remote viewing, astrology, Bible code, alien abductions, Bigfoot, UFOs, Freudian psychoanalytic theory, recovered memories

Borderlands science: superstring theory, inflationary cosmology, theories of consciousness, grand theories of economics (objectivism, socialism, etc.), SETI, hypnosis, chiropractic, acupuncture, cryonics, omega point theory

Because these categories are provisional it is possible for them to be moved and reevaluated with changing evidence. Indeed, many normal science claims at one time were pseudoscience or borderlands science. SETI (the search for extraterrestrial intelligence), for example, is not pseudoscience because it does not claim to have found anything (or anyone) yet, is conducted by professional scientists who publish their findings in peer-reviewed journals, polices its own claims and does not hesitate to debunk the occasional signals found in the data, and fits well within the general understanding of the history and structure of the cosmos and the evolution of life. However, SETI is not normal science because its central theme has not surfaced as reality. UFOlogy, by contrast, is pseudoscience. Its proponents do not play by the rules of science, do not publish in peer-reviewed journals, ignore the 90 to 95 percent of sightings that are fully explicable, focus on anomalies, are not self-policing, and depend heavily on theorizing about government conspiracies and cover-ups, hidden spacecraft, and aliens holed up in secret caves in Nevada.

Similarly, superstring theory and inflationary cosmology are at the top of borderlands science, soon to be elevated into full-scale normal science or abandoned altogether, depending on the evidence that is starting to come in for these previously untested ideas. What makes them borderlands science instead of pseudoscience (or nonscience) is the fact that their practitioners are professional scientists who publish in peer-reviewed journals and are trying to devise ways to test their theories. By contrast, creationists who devise cosmologies that they think will fit biblical myths are typically not professional scientists, do not publish in peer-reviewed journals, and have no interest in testing their theories except against what they believe to be the divine words of God.

Theories of consciousness are borderlands science and psychoanalytic theories are pseudoscience because the former are being tested and are grounded in sound facts of neurophysiology whereas the latter have been tested, have failed the tests repeatedly, and are grounded in discredited nineteenth-century theories of the mind. Similarly, recovered memory theory is pseudoscience because it now is understood that memory is not like a videotape that one can rewind and play back and that the very process of "recovering" a memory contaminates that memory. Hypnosis, by contrast, is tapping into something else in the brain, and there may very well be sound scientific evidence in support of some of its claims; therefore, it remains in the borderlands of science.

Signs of the Zodiac. Astrology is one of the most popular forms of pseudoscience. (*© Historical Picture Archive/Corbis.*)

Eliminating Pseudoscience

When one encounters a claim, there is no simple set of rules by which one can determine whether it is science and pseudoscience. However, there are a number of questions that can help illuminate its validity.

1. How reliable is the source of the claim? All scientists make mistakes, but are the mistakes random, as one might expect from a normally reliable source, or are they directed toward supporting the claimant's preferred belief? Scientists' mistakes tend to be random; pseudoscientists' mistakes tend to be directional.
2. Does this source often make similar claims? Pseudoscientists have a habit of going well beyond the facts, and so when individuals make many extraordinary claims, they may be more than iconoclasts. What one is looking for here is a pattern of fringe thinking that consistently ignores or distorts data.
3. Have the claims been verified by another source? Typically pseudoscientists make statements that are unverified, or are verified by a source within their own belief circle. One must ask who is checking the claims and even who is checking the checkers.
4. How does the claim fit with what is known about how the world works? An extraordinary claim must be placed in a larger context to see how it fits.

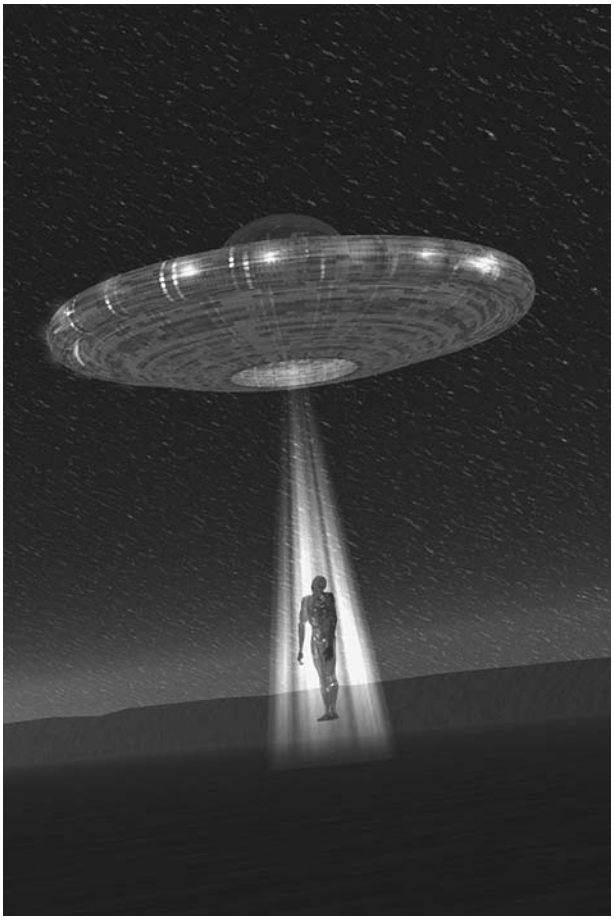


Illustration depicting an alien abduction. Television shows like "The X-Files" have dramatized this pseudoscientific phenomenon. *(© Corbis.)*

When people claim that the pyramids and the Sphinx were built more than 10,000 years ago by an advanced race of humans, they are not presenting any context for that earlier civilization. Where are its works of art, weapons, clothing, tools, trash?

5. Has anyone made an effort to disprove the claim, or has only confirmatory evidence been sought? This is the confirmation bias, or the tendency to seek confirmatory evidence and reject or ignore disconfirmatory evidence. The confirmation bias is powerful and pervasive. This is why the scientific method, which emphasizes checking and rechecking, verification and replication, and especially attempts to falsify a claim, is critical.
6. Does the preponderance of evidence converge on the claimant's conclusion or a different one? The theory of evolution, for example, is proved through a convergence of evidence from a number of independent lines of inquiry. No single fossil or piece of biological or paleontological evidence has the word *evolution* written on it; instead there is a convergence from tens of thousands of evidentiary bits that adds up to a story of the evolution of life. Creationists conveniently ignore this convergence, focusing instead on trivial anomalies or currently unexplained phenomena in the history of life.
7. Is the claimant employing the accepted rules of reason and tools of research, or have those rules and tools been abandoned in favor of others that lead to the desired conclusion? UFOlogists exhibit this fallacy in their continued focus on a handful of unexplained atmospheric anomalies and visual misperceptions by eyewitnesses while ignoring the fact that the vast majority of UFO sightings are fully explicable.
8. Has the claimant provided a different explanation for the observed phenomena, or is it strictly a matter of denying the existing explanation? This is a classic debate strategy: Criticize one's opponent and never affirm what one believes in order to avoid criticism. This strategy is unacceptable in science.
9. If the claimant has proffered a new explanation, does it account for as many phenomena as does the old explanation? For a new theory to displace an old theory it must explain what the old theory did and then some.
10. Do the claimants' personal beliefs and biases drive the conclusions or vice versa? All scientists have social, political, and ideological beliefs that potentially could slant their interpretations of the data, but at some point, usually during the peer-review system, those biases and beliefs are rooted out or the paper or book is rejected for publication.

This final point reveals the ethical nature of science and the way it differs from pseudoscience. Whether the ethics comes from within the individual scientists or from the system of science is irrelevant. The point is that the system works to weed out error, bias, and fraud. Ethical issues arise when pseudoscience masquerades as science for political purposes, as occurs when biblical fundamentalists attempt to legislate their religious beliefs by calling them creation science and have them taught in public school science classes. Serious ethical concerns arise when quasi-scientific claims have health consequences, as do many of the claims of alternative and complementary medicine. The application of nonscientific or pseudoscientific treatments in place of scientifically proven medicine can be dangerous and even deadly.

Here too may be seen how the market, commercialism, and politics can also promote pseudoscience. The tobacco industry maintained that smoking does not cause cancer, for many years beyond when it was reasonable to do so because the evidence for the link between smoking and cancer was overwhelming. The Bush administration's insistence on more data on global warming before preventative measures should be taken is another example of politics overriding science, because virtually all environmental scientists agree that global warming is real.

Science may be flawed, but as Albert Einstein once observed: "One thing I have learned in a long life: that all our science, measured against reality, is primitive and childlike—and yet it is the most precious thing we have."

MICHAEL SHERMER

SEE ALSO *Misconduct in Science; Skepticism.*

BIBLIOGRAPHY

Gardner, Martin. (1996). *The New Age: Notes of a Fringe Watcher*. Buffalo, NY: Prometheus. A collection of essays from the most prolific skeptical author of the modern period, covering dozens of paranormal and pseudoscience claims made on the fringes of the New Age.

Gould, Stephen Jay. (1981). *The Mismeasure of Man*. New York: Norton. Debunks theories of racial differences in intelligence and shows how science can be influenced by cultural forces and also how it can be self-correcting.

Park, Robert L. (2000). *Voodoo Science: The Road from Foolishness to Fraud*. New York: Oxford University Press. The author, a physicist, analyzes cold fusion, perpetual motion machines, free energy, and how well-meaning scientists can go down the road to self-deception.

Sagan, Carl. (1995). *The Demon-Haunted World: Science as a Candle in the Dark*. New York: Random House. A collection of the astronomer's most powerful writings on UFOs, alien abductions, and all manner of pseudoscience and paranormal experiences.

Schick, Theodore, and Lewis Vaughn. (1996.) *How to Think about Weird Things: Critical Thinking for a New Age*. Mountain View, CA: Mayfield. The best textbook on pseudoscience, well organized for both teachers and students and widely adopted in colleges and universities.

Shermer, Michael, general ed. (2002). *The Skeptic Encyclopedia of Pseudoscience*. Santa Barbara, CA: ABC-CLIO. A two-volume compendium that includes various levels of analysis, from short encyclopedic entries to lengthy evaluations, as well as full-fledged investigations and pro-and-con debates.

Williams, William F., ed. (2000). *Encyclopedia of Pseudoscience*. New York: Facts on File. Includes introductions dealing with "Ethical Issues in Pseudoscience" (by Carl Mitcham) and the boundary problem (by William F. Williams) as well as two others on the phenomenon of anomalies.

INTERNET RESOURCES

National Science Foundation. (2002). *Science Indicators Biennial Report*. The section on pseudoscience, "Science Fiction and Pseudoscience," is in Chapter 7, "Science and Technology: Public Attitudes and Public Understanding." Available fromhttp://www.nsf.gov/sbe/srs/seind02/c7/c7h.htm.

PSYCHOLOGY

OVERVIEW

Psychology, defined broadly, is the study of individual behavior. *Individual* can refer to a human or an animal, and *behavior* can encompass anything an individual does, thinks, or feels. Because there are so many things that individuals do, think, and feel, psychology is divided into many subareas that each study a different aspect of individual behavior. For example, some psychologists study how individual behavior is affected by those with whom the individual interacts, others investigate how the brain works to produce thoughts and feelings, and still others study the causes of feeling and thought disorders such as depression and schizophrenia.

Historical Emergence

Psychology is a relatively new scientific field. Wilhelm Wundt (1832–1920) founded the first official psychology laboratory in 1879 at the University of Leipzig, Germany. Psychology has roots, however, in ancient philosophy. Many of its concerns—such as personality development, rationality, language acquisition and use, the structure of consciousness, and the mind–body connection have been addressed by philosophers. Plato (c. 428–347 B.C.E.) stressed the distinction between body and mind, and argued that knowledge depended on the rational soul. Aristotle (384–322 B.C.E.) argued for a unity of body and mind, and that knowledge has a base in sensory perception.

What makes psychology different from philosophy is its efforts to adapt the scientific method to the investigation of individual behavior. To some extent psychology constitutes an effort to place traditional ethics, which may also be defined as the study of human behavior, on scientific foundations. Historically these efforts have taken place in two different settings, the laboratory and the clinic. Early on, these settings gave rise to largely separate approaches that progressed in relative isolation from one another.

From the beginning experimental and clinical psychology expressed different ideals. The experimental division worked from the ideal of scientific curiosity. Its goal was to understand the normal or everyday, for example, attention or memory. In contrast, the clinical division worked from the ideal of helping people and understanding problems. Its goal was to understand the unusual or problematic, for example, depression or antisocial behavior.

Experimental Psychology

The first school of experimental psychology was structuralism, which emerged in Germany in the late nineteenth century. The pioneers of structuralism were physicists and physiologists who attempted to study sensations and perceptions as they would chemistry or biology, by measuring variables and examining how they interacted. Wundt, the founder of structuralism, had the goal of understanding and describing the contents of mind, that is, the basic elements of a person's immediate experience. The technique he developed, which his student Edward Tichener (1867–1927) championed in the United States, was called introspection. In introspection, trained scientists report their mental experience during rigorously controlled conditions. The structuralists were not interested in individual differences, and they did not believe in observing external things, only internal, mental events, so they did not come to much agreement.

In the United States, a second school of experimental psychology, called functionalism, emerged. American psychologists trained in Germany reinterpreted structuralism by emphasizing mental processes and their functions and applications. This approach, led by William James (1842–1910), was much more pragmatic, stressing the utility of mental functions such as attention or memory. The functionalists also argued that both the mental and physical (external) aspects of experience should be studied. Functionalism, however, lacked the scientific rigor of structuralism and instead was a more philosophical approach.

A third experimental movement, Gestalt psychology, emerged in Germany as another reaction to structuralism. The underlying principle was that the whole is different from the sum of the parts, that in breaking things apart into their components one loses the unified whole, or gestalt. Max Wertheimer (1880–1943), the founder of this movement, began with research on how humans can see movement in a series of static images. Although the Gestalt psychologists began with questions such as this based on sensation and perception, they broadened their perspective to ask how people interact with their environments and how this interaction organizes mental activity.

Clinical Psychology

Early clinical psychology was founded by Sigmund Freud (1856–1939), an Austrian physician who chose to study the mind rather than the body. He argued that unconscious processes could explain much of human behavior, including the development of personality and a variety of psychological disorders. Freud's theories dominated the clinical psychology landscape, as he was one of the first people to view mental illness as something to be treated and understood. Although his name is widely recognized, his theories are not well understood by the general public, and his approach had little in common with the experimental psychology of the same period. His technique, called psychoanalysis, was based on observation of individual patients, not on generating and testing predictions using the scientific method. With his practice and theories, however, Freud built a foundation for clinical psychology.

Becoming Scientific

Around 1900, a shift occurred in experimental psychology, namely, the behaviorist movement. Behaviorism arose as a reaction to the subjective nature of both early experimental and clinical psychology. An important early influence on behaviorism was Ivan Pavlov (1849–1936), a Russian physiologist who studied learning and relationships between a stimulus and a response. In a famous experiment, he trained dogs to associate a bell with food, so that they salivated in response to the bell even when the food was not present.

The behaviorist movement was largely defined by the work of John B. Watson (1878–1958). Watson criticized existing psychology research methods for being too subjective and not rigorous enough. He argued that psychology should focus on observable behavior rather than internal mental events. Behaviorism focused on the relationships between stimuli in the environment and behavioral responses. B. F. Skinner (1904–1990), a later but influential figure, extended early behaviorist principles to operant conditioning, or learning from rewards and punishments. Skinner also claimed that development could be explained in terms of behaviorist principles. For example, he argued that development of language was based on simple conditioning rules.

Behaviorism rejected many questions that were ethically relevant, for example, the nature of consciousness or how humans think and reason, because it claimed that these were not things open to scientific investigation. It created its own ethical dilemmas, however. Because behaviorists claimed that learning and conditioning rules could explain everything, people could be viewed as blank slates—anyone could become anything given the right circumstances. But this could portend a darker future in which the behavior of individuals could easily be shaped and controlled through conditioning.

Advances also occurred in clinical psychology because there remained a need for understanding and changing behavior in order to help individuals. Through a series of rejections and adaptations of Freud's theories, the humanist approach to clinical practice emerged. Important figures who modified Freud's work include Alfred Adler (1870–1937) and Carl Jung (1875–1961). Adler's theories were still considered psychoanalytic, but for him, social forces and creativity played an important role. He claimed that the individual tried to compensate for an inferiority felt in childhood, striving for perfection while moving through life. Neither Adler nor Jung were empirical psychologists; they were practitioners and theorists.

Further evolution of Freud's ideas, combined with influences from the existential movement in philosophy, which emphasized personal responsibility, led to the emergence of the humanist movement in clinical psychology. Important figures in this movement were Abraham H. Maslow (1908–1970) and Carl Rogers (1902–1987). Maslow described a hierarchy of needs: Individuals need to first meet their basic needs, such as those for food and safety, before they can meet higher human needs, such as those for belonging, knowledge, or beauty. Rogers advocated a new practice called client-centered therapy, in which the therapist and client (the person seeking help) have a personal relationship based on empathy. In practice, this focused on the process of better knowing one's self.

Ethics played a role in this shift from Freud's psychoanalysis to humanism. For humanists, it was important to recognize personal autonomy and potential, rather than to see individuals as victims of circumstances, unconscious powers, and unconscious thoughts or feelings.

Contemporary Psychology

In the early twenty-first century, experimental and clinical psychology translate into two types of professionals: research psychologists and practice psychologists. Research psychologists conduct experiments to study individual behavior in order to better understand it. Practice psychologists (who include counselors and therapists) use what is known about individual behavior to help individuals understand or change their behavior. In mainstream psychology, the distinction between research and practice is purely a functional distinction between the primary activities of the psychologists in each group. It is important to note that both groups work on and from the same body of knowledge. There still exist some approaches to practice that are based on philosophical or theological systems as opposed to empirical findings, but to the extent that there is no empirical evidence of their treatment efficacy they are not considered part of scientific psychology.

Modern psychology is a product of interactions between the clinical and experimental divisions. While the two divisions are not fully integrated, experimental data informs the practice of psychology, and insights from practice lead to new research in experimental psychology. In addition, psychology has been informed by other fields, including neuroscience, computer science, linguistics, and education. While many areas of specialization have formed, particularly within the academic research community, psychology is still interdisciplinary in that these specializations frequently interact. For example, neuroscientific research on how thoughts can affect mood can be used to develop methods for treating depression.

Ethics for Psychology

Psychologists face many ethical issues in their roles as research scientists and as clinical professionals. Many of these issues stem from the use of human and animal subjects in research, and the need to assure the safety and privacy of individuals seeking treatment. There are a variety of professional organizations for psychologists in each subspecialty area, and many of these organizations have developed codes of ethics. The primary code of ethics for professional psychologists, however, belongs to the American Psychological Association (APA), which is the largest professional association of psychologists worldwide, with 150,000 members as of 2005.

The APA has published ten revisions of its ethics code since it was first formulated in 1953. Unlike most professional codes of ethics, the APA code was developed pragmatically, based on a survey of ethical dilemmas encountered by APA members. The ninth revision, published in 1992, was the first time it included specific standards for academic scientists addressing teaching, training, supervision, research, and publishing. The tenth revision, published in 2002, eliminated language that appeared to allow use of the code to punish psychologists unfairly, increased protections for disempowered groups, and eliminated redundancy and vagueness. This tenth revision contains five general principles to guide the goals of research and practice, and ten standards for the conduct of psychologists.

The general principles included in the code are beneficence and nonmaleficence, fidelity and responsibility, integrity, justice, and respect for people's rights and dignity. The code has been criticized for not specifying an underlying ethical theory (e.g., utilitarianism, deontological ethics) to guide the evaluation of options and assist ethical decision-making. Further, the code lacks guidelines for valuing ethical principles in situations where conflicts arise. The ethics code of the Canadian Psychological Association has addressed this issue by providing a hierarchy that explicitly ranks the general principles it sets forth. The APA code also uses nontraditional ethical language, stating the principles and standards in terms of what psychologists "do" and "do not do," rather than in terms of what they "ought" or "should" do.

The ethical standards put forth in the APA code cover issues relevant to psychologists in their roles as scientists, teachers, and service providers of various types, and are enforced by the Ethics Committee of the APA according to its published rules and procedures. Detection of ethical violations are collected passively, in response to complaints, rather than actively (e.g., by auditing). Punishments for ethical violations can include expulsion from the APA and directives for corrective actions such as supervision, education, treatment, or probation. Other agencies and associations may also use the APA ethics code for assessing the behavior of psychologists.

Psychology for Ethics

In addition to following ethical principles in their professional work, psychologists can also use their expertise to contribute to ethical discussions in a number of ways. For instance, psychological research on moral development has investigated topics such as the development of moral reasoning over the lifespan, the nature of psychological components that are required for moral behavior to take place, and the contributions of social factors (e.g., persuasion, conformity, expectations) to moral discernment. The findings from these studies can be used to help understand and assess culpability for moral infractions, and perhaps also provide direction for helping individuals decrease moral infractions. In a related vein, the emerging field of positive psychology is researching the causes and consequences of individual strengths and happiness, in order to help people develop positive traits such as resiliency and self-efficacy.

The results of research in psychology can also be used to inform specific ethical issues. Although research does not provide a basis for establishing standards for ethical behavior (called the "naturalistic fallacy"), it can provide information about the efficacy of certain means for bringing about desired ends. In many situations, psychology can provide information about the psychological consequences of various social policy alternatives, so that decisions can be based on available evidence. For example, in 2004 the APA filed amicus briefs on issues such as the juvenile death penalty and same-sex marriage, conveying research findings about brain development and decision-making ability in adolescents in the former, and research on relationship characteristics, parenting ability, and psychological benefits of marriage for both same-sex and heterosexual couples in the latter.

AMY SANTAMARIA
ELIZABETH J. MULLIGAN

SEE ALSO *Aristotle and Aristotelianism; Choice Behavior; Freud, Sigmund; Jung, Carl Gustav; Plato; Skinner, B. F.*

BIBLIOGRAPHY

American Psychological Association (APA). (2002). "Ethical Principles of Psychologists and Code of Conduct." *American Psychologist* 57(12): 1060–1073. The tenth revision of the code of ethics put forth by the APA, the primary professional organization for psychologists in the United States.

Bersoff, Donald N., ed. (2003). *Ethical Conflicts in Psychology*, 3rd edition. Washington, DC: American Psychological Association. Discusses the ethics codes of both the American and Canadian Psychological Associations and includes sections on specific ethical issues, as well as more general chapters on applying ethics and teaching ethics.

Brennan, James F. (2003). *History and Systems of Psychology*, 6th edition. Upper Saddle River, NJ: Prentice Hall.

DuBois, James M., ed. (1997). *Moral Issues in Psychology: Personalist Contributions to Selected Problems*. Lanham, MD: University Press of America. Discusses the relation of psychology to philosophy, including how psychology can contribute to moral issues.

O'Donohue, William T., and Kyle E. Ferguson, eds. (2003). *Handbook of Professional Ethics for Psychologists: Issues, Questions, and Controversies*. Thousand Oaks, CA: Sage.

Part I in particular provides an overview of the philosophical systems that might underlie an ethics code (by Andrew Lloyd and John Hansen), a discussion of the APA ethics code in the context of critical thinking about moral and ethical questions (Michael Lavin), and an overview of studies on the development of moral reasoning across the lifespan (Karl H. Hennig and Lawrence J. Walker).

HUMANISTIC APPROACHES

The history of psychology in the twentieth century is the history of a discipline struggling to balance values that seemed, more often than not, to exist in mutual tension. Some psychologists emphasized the necessity of empirical rigor in research, others promoted the development of individual emotional health and maturity, while still other mid-century thinkers would advance larger social and ethical concerns. Psychology's quest to establish itself as a science, combined with its historical emphasis on the connections between the human self and human well-being, produced a discipline of broad application and intense vitality, one uniquely suited to address the problems and opportunities of humankind in a technological age. Nowhere is this better illustrated than in the rise of what has become known as humanistic psychology.

Background

Efforts to limit psychological research to observable phenomena or behavior along began with reactions against the introspective psychological research program of Wilhelm Wundt (1832–1920). In the form of behaviorism, these efforts dominated psychological theory and practice between the two world wars. As conceived by such founders as Ivan Pavlov (1849–1936), John B. Watson (1878–1958), and B. F. Skinner (1904–1990), behaviorism aspired to be wholly objective. Watson insisted upon leaving consciousness and other metaphysical concerns aside for an experimental precision that could not be attained using "internal perception" or any other introspective methods. He articulated his fundamental complaint about previous psychological thought when he wrote, "Behaviorism claims that consciousness is neither a definite nor a usable concept. The behaviorist, who has been trained always as an experimentalist, hold, further, that belief in the existence of consciousness goes back to the ancient days of superstition and magic" (Watson 1924, p. 2). Behaviorism attempted to show that phenomena previously studied using introspective methodologies could be examined much more effectively from a perspective of stimulus and response; only those observations verifiable in more than one instance by more than one observer would be allowed to qualify as scientific.

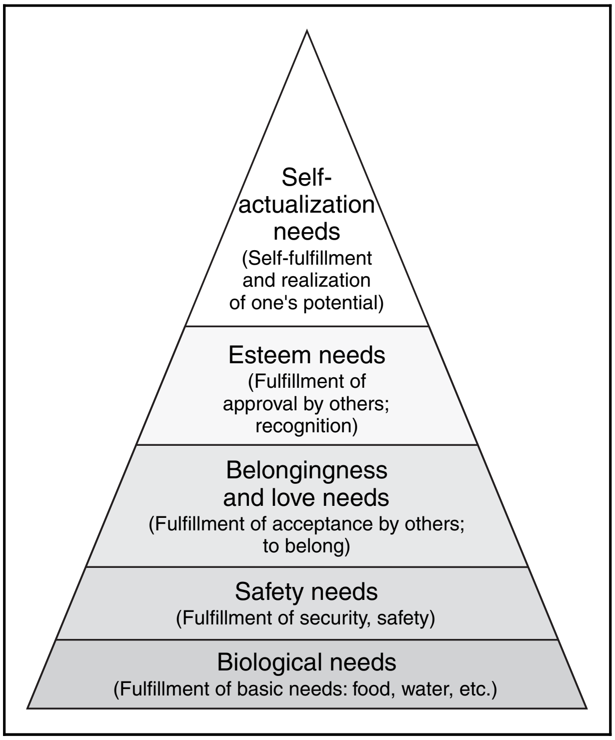
Behaviorism has had lasting effects on the discipline and practice of psychology, including the development of highly objective experimental standards, new statistical methods, and behavior therapies. During the middle decades of the twentieth century, Skinner took Watson's ideas to their ultimate objective extreme, concentrating on the larger goal of predicting and controlling a broad range of human behavior. Much of this work was understandably focused on education and pedagogy, and Skinner and his colleagues often articulated an idealistic quest for positive techniques to solve human problems and improve society.

As psychology honed its experimental methods and techniques, its expanding scientific powers nevertheless brought ethical concerns to the foreground. Some of the most famous and influential studies in the field of behaviorist psychology, while revealing new insights into human consciousness and behavior, also highlighted the need for ethical standards in research practices. For instance, Watson and Rosalie Rayner's 1920 "Little Albert" study conditioned an eleven-month-old child to fear a white rat by pairing its presentation with a loud and startling noise—a fear that the young child generalized to similar animals and objects, and from which he was never deconditioned. Stanley Milgram's elaborate 1965 obedience experiments led subjects to falsely believe that they were carrying out orders to administer extremely severe electric shocks to another person. In the Stanford prison experiment in 1971, Philip Zimbardo assigned subjects to either a prisoner or guard role for a two-week simulation; the growing intensity of the situation and the subjects' increasing absorption into their roles, however, forced Zimbardo to halt the experiment after six days.

While each of these studies provided new discoveries in conditioning, obedience, roles, and attitudes, their effects on human subjects also provided strong arguments for reforms in experimental ethics. Over time, psychology established stringent ethical guidelines for informed consent, debriefing practices, and weighing potential deceptions or risks to subjects (including risks to animals as well as humans) against potential research benefits.

In contrast to the behaviorist attempt to eliminate consciousness by means of a methodological focus on overt behavior, Sigmund Freud (1856–1939) sought to downgrade consciousness through investigations into the power of the unconscious and its influence on behavior. Freud's psychoanalysis, however, developed

FIGURE 1



Pyramid of Abraham Maslow's hierarchy of needs.

primarily in a medical-clinical setting, drawing on clinical experience to formulate theories of human emotional abnormality and irrationality. Psychoanalysis thus developed a theory of human nature that highlighted the hidden complexities of the human psyche. But in the tradition of such thinkers as Plato, Augustine, or Jean-Jacques Rousseau, Freud was also concerned with human capability for self-understanding, the freedom that self-awareness can bring, and, more specifically, capacities to cope with life in more rational ways.

In psychoanalytic practice, too, ethical questions were brought to the fore. Like behaviorism, psychoanalytic theory challenged common conceptions of moral responsibility. Close relations between patient and psychoanalyst sometimes led to behaviors such as sexual relations that clearly violated social and traditional professional norms.

The Humanistic Movement

It was in reaction to both behaviorism and psychoanalysis that humanistic psychology began in the 1950s to develop its special approach to the study and treatment of human behavior—with a new ethical commitment. Among the precursors was Alfred Adler (1870–1937), who criticized Freud's emphasis on sexuality. Humanistic psychology was also influenced by existentialist philosophy, with its focus on human struggles for meaning in a world characterized by scientific and technological dehumanization in such blatant forms as death camps and atomic bombs as well as in what existentialist philosophers from Søren Kierkegaard to Albert Camus saw as the more subtle forms of bourgeois culture.

Holocaust survivor Viktor Frankl (1905–1997), for example, in his book *Man's Search for Meaning* (1959), drew on his unique experiences to argue the power of human decision in the face of the most dehumanizing circumstances. But it was Carl Rogers (1902–1987), Abraham H. Maslow (1908–1970), and Rollo May (1909–1994) who most typified what Maslow himself termed the "third force" in psychology (the first force being behaviorism and the second, psychotherapy). Maslow in particular played a significant role in the development of the humanistic psychology movement, turning from his training in behaviorism to argue for a broader, more holistic version of human health. Maslow believed that no psychological theory could be truly complete unless it took into account complex human factors and motivations such as love and connection (Figure 1). Maslow's "self-actualization" theory of personality and his development of a human "hierarchy of needs" both stressed the universal human potential for achievement.

Even more representative, insofar as humanistic psychology brings its perspective to bear on science and technology, is the work of Erich Fromm (1900–1980). Like other third-force humanistic psychologists, Fromm sought to refocus the central ideas of Freudian psychoanalytic theory to address the moral, emotional, and spiritual crises of an increasingly violent and technology-oriented global society. He was less interested in simple human adaptability, techniques for the control of behavior, or strategies of coping than in nurturing humanity's basic ability to meet the challenges of a difficult transition into modernity, with its changing political systems and assumptions; various physical and spiritual displacements; astounding technological innovations in health, industry, and war; and, later in the century, the long Soviet–American nuclear standoff.

Forced to flee Germany after Adolf Hitler's election in 1933, Fromm was particularly concerned with the development of a "technetronic" society and its dehumanizing implications. He reserved his most incisive critiques for behaviorist strivings for absolute objectivity, arguing that behavioristic theories merely served the cerebral and technical prejudices of industrial society. Understanding, Fromm believed, should be different than "scientific" description. His criticism was often less than subtle: "[George] Orwell's *1984* will need much assistance from testing, conditioning, and smoothing-out psychologists in order to come true. It is of vital importance to distinguish between a psychology that understands and aims at the well-being of man and a psychology that studies man as an object, with the aim of making him more useful for the technological society" (Fromm 1968, p. 46).

Writing from a position similar to that of the existentialist thinkers, Fromm recognized that humankind had lost its traditional religious-ethical moorings, and he worried that the powerful attraction of technology and machinery was evidence that technological society had simply exchanged its religious faith (and humanistic values) for material and technical values: If something is *possible* (build the atom bomb, go to the moon), we should do it; production of *more* is preferred to production of better. People had lost, in that exchange of values, their capacity for deep emotional experiences, and with them their capacity to engage life with any sense of meaning. "Today," Fromm wrote in 1968,

> a widespread hopelessness exists with regard to the possibility of changing the course we have taken. This hopelessness is mainly unconscious, while consciously people are 'optimistic' and hope for further 'progress.' . . . [People] see that we have more and better machines than man had fifty years ago. . . . They believe that lack of direct political oppression is a manifestation of the achievement of personal freedom. (p. 5)

Aside from arguing for a reevaluation of technical values, Fromm advocated a reemergence of practical humanist perspectives, including altered forms of material consumption; an emphasis on social activity against what he perceived as a new and cancerous cultural passivity; changed attitudes about the place and capabilities of the worker in large organizations; more person-oriented, responsible, and imaginative bureaucratic systems; and spiritual renewal focused on faithful practices involving compassion instead of allegiance to ideology or code. Despite the existence of good reasons for pessimism, Fromm displayed the same hopefulness in his own attitudes that he argued would be necessary for the renewal of individuals and society: "The history of man shows precisely what you can do to man and at the same time what you *cannot* do. If man were infinitely malleable, there would have been no revolutions; there would have been no change because a culture would have succeeded in making man submit to its patterns without his resistance" (Fromm 1968, p. 62). One of Fromm's primary goals was to help initiate a resistance against the unimpeded development of a technological culture he believed had come to threaten humanity's connections to broader social and environmental contexts.

Ethics

Despite its inherently ethical orientation, humanistic psychology seldom explicitly couched its concerns in terms of "ethics." No doubt one reason is that both behaviorist and psychoanalytic thought had become over the course of decades extremely skeptical of ethical and moral language, so often used in order to advance destructive or manipulative ideologies, or simply to mask people from themselves. Humanistic psychologists nevertheless believed that to the extent that the inner life of human beings is taken seriously, and human nature conceived of as capable of freedom, people will be better equipped to examine the relationships that have been put at risk.

This fundamental commitment is clearly expressed in the Code of Ethical Principles of the UK Association of Humanistic Psychology Practitioners (UKAHPP). According to its first fundamental principle, "UKAHPP Members respect the dignity, worth and uniqueness of all individuals. They are committed to the promotion and protection of basic human rights, the integrity of the individual and the promotion of human growth, development and welfare. They affirm the self-determination, personal power and self-responsibility of the client." Note, in the last sentence, how the language of "patient" is rejected in favor of "client." More than any other group of psychologists, humanistic psychologists see themselves as working with and for others rather than as being superior to them. In this respect humanistic psychology presents a challenge for all scientists to reconsider the ways in which they conceive themselves as distinct or separate from the larger nonscientific public.

GLENN R. WILLIS
MARGARET M. BRACE

SEE ALSO *Choice Behavior; Freud, Sigmund; Jung, Carl Gustav; Skinner, B. F.*

BIBLIOGRAPHY

Becker, Ernest. (1973). *The Denial of Death*. New York: Free Press.

Blass, Thomas. (2004). *The Man Who Shocked the World: The Life and Legacy of Stanley Milgram*. New York: Basic.

Fromm, Erich. (1968). *The Revolution of Hope: Toward a Humanized Technology*. New York: Harper and Row.

Fromm, Erich. (1973). *The Anatomy of Human Destructiveness*. New York: Holt, Rinehart and Winston.

Homans, Peter. (1989). *The Ability to Mourn: Disillusionment and the Social Origins of Psychoanalysis*. Chicago: University of Chicago Press.

Watson, John B. (1998 [1924]). *Behaviorism*. New Brunswick, NJ: Transaction Publishers.

INTERNET RESOURCE

UK Association of Humanistic Psychology Practitioners (UKAHPP). "UKAHPP Code of Ethical Principles." Available from http://www.ahpp.org/ethical/code_of_ethics.htm.

PSYCHOPHARMACOLOGY

Psychopharmacology is defined as the use of drugs to modify mental or behavioral performance. In general, psychopharmacology is used in the treatment of biologically based mental illnesses, although there has been increased interest in using drugs to enhance performance in healthy individuals.

Psychopharmacology assumes a strong mind-brain connection, if not a complete reduction of mind to brain. However, early theories about the relationship of brain chemistry to behavior were weak and post hoc. Most drugs were discovered accidentally and adopted because of their effects on symptoms (Valenstein 1998). Only later were theories of the ways drugs act on the brain developed, followed by theories of how mental states are related to brain chemistry. Although the mechanism of action on neuronal receptors has been elucidated for many drugs, the mechanisms by which drugs influence behavior at the whole-brain level are poorly understood. There are no definitive biological markers for diagnosing mental illness, and thus diagnosis relies on a clinical judgment of whether symptoms are present.

Although theories that mental illnesses result from a specific underlying chemical imbalance are not well substantiated, they have encouraged afflicted persons to seek treatment by reducing some of the stigma associated with psychological theories of mental illness. The discovery of drugs that alleviate some of the most debilitating symptoms of mental illness also allowed deinstitutionalization to occur, resulting in much more effective, community-based treatment programs

Psychopharmacologic Agents

The major classes of psychopharmacologic agents (Schatzberg and Nemeroff 1998) are antipsychotics (also known as neuroleptics), antidepressants, anxiolytics (antianxiety agents), and mood stabilizers. In addition, cognitive enhancing drugs are receiving increasing interest and use.

ANTIPSYCHOTICS. Antipsychotics, which are used primarily for the treatment of schizophrenia, reduce symptoms such as paranoia, visual and auditory hallucinations, and delusions. The first drugs of this type—phenothiazines— initially were produced as synthetic dyes. Later research in the 1940s showed that they act on the central nervous system as antihistamines. When administered to patients with allergies, they produced side effects that included decreased muscle tone, reduced nausea, and mild elation. That led to their use to relax patients before surgery, treat Parkinson's disease, and calm agitated and manic patients. In manic patients these drugs were also found to reduce the psychotic symptoms associated with the disorder. Antipsychotics are the most successful variety of psychopharmaceutical agents, reducing symptoms in 90 percent of patients in the acute phase of the disorder. Long-term use, however, may result in negative side effects that include tardive dyskinesia, which is characterized by involuntary motor movements such as those seen in Parksinson's patients, and neuroleptic malignant syndrome, which is a potentially fatal side effect. In contrast to the typical antipsychotics, the development of atypical antipsychotics has focused on not only reducing psychotic symptoms but also on improving negative symptoms (for example, loss of motivation, social withdrawal, and affective flattening) associated with schizophrenia and reducing adverse side effects.

ANTIDEPRESSANTS. Antidepressant pharmaceuticals also were discovered fortuitously. After World War II chemical companies had a surplus of the rocket fuel hydrazine, which they began modifying in an attempt to find new compounds with properties that might be useful for medical purposes. In the course of testing one of the new compounds against tuberculosis it was found to cause euphoria as a side effect. A derivative of hydrazine was synthesized as iproniazid, and after animal testing showed that the drug increased alertness, it became a treatment for depression.

There are three primary classes of antidepressants: selective serotonin reuptake inhibitors (SSRIs), monoamine oxidase inhibitors (MAOIs), and tricyclics. Common SSRIs include fluoxitine (Prozac) and paroxitine

(Paxil), MAOIs are exemplified by phenylzine (Nardil) and isocarboxazid (Marplan), and tricyclics include amitriptyline (Elavil) and imipramine hydrochloride (Tofranil).

All these drugs are considered equally effective in reducing depressive symptoms. The typical response rate of patients with uncomplicated unipolar depression to antidepressants is about 65 percent, compared with a 30 percent response rate on placebo. In addition to reducing current symptoms of depression these drugs appear to reduce the 50 percent relapse rate of major depressive episodes by 50 percent over the course of one year. The observed response rate with pharmacologic agents has been found to be identical to that of cognitive-behavioral psychotherapy. Treatment for depression that combines pharmacologic treatment and psychotherapy is more effective than is either modality alone (Burns 1980).

Side effect profiles or counterindications usually influence which drugs are prescribed more frequently. Side effects of SSRIs include headache, tremor, nausea, diarrhea, insomnia, agitation, nervousness, and sexual dysfunction. More important, SSRIs were found to increase suicidal behavior among adolescents, prompting the U.S. Food and Drug Administration (FDA) to mandate "black box" warnings to that effect on prescription bottles. Side effects of MAOIs include weight gain, orthostatic hypotension (drop in blood pressure when standing up quickly), delayed ejaculation, insomnia, and cholinergic side effects such as blurred vision, constipation, dry mouth, speeded heart rate, and urinary retention; MAOIs also require a diet that avoids foods with tyramine as hypertension and cerebral hemorrhage or death (rare) may occur. Side effects of tricyclics include weight gain, sexual dysfunction, cholinergic side effects, and sedation.

ANXIOLYTICS. The first drugs for treating anxiety were discovered in 1945 during testing of drugs designed to combat infectious bacteria. Those early drugs were found to be extremely habit-forming and to produce drowsiness, and ultimately were replaced by a class of antianxiety drugs called benzodiazepines (for example, alprazolam [Xanax] and diazepam [Valium]) that were discovered after an unexpected chemical reaction occurred in a compound that originally had been developed for use as a dye.

Benzodiazepines are very effective in reducing anxiety. In fact, since their introduction in the 1960s anxiolytics have been referred to as "happy pills." Eighty-two percent of patients on alprazolam show improvement compared with 42 percent on placebo. These drugs are also effective in reducing the occurrence of panic attacks. Benzodiazepines are among the most frequently prescribed drugs; however, they are habit-forming, and many of the 7 million prescriptions written yearly in the United States are in response to simple stresses of everyday life rather than debilitating conditions.

MOOD STABILIZERS. Mood-stabilizing drugs are used in the treatment of bipolar (manic-depressive) illnesses, in which patients suffer from recurrent cycles of depressive moods followed by manic periods. Lithium is the primary treatment for manic-depressive illness. Its effectiveness was discovered in the course of testing the hypothesis that uric acid would increase mania. Uric acid was difficult to work with because it was not easily soluble, and so lithium urate was used instead and surprisingly reduced mania. The FDA approved lithium treatment for mania in 1970 after a double-blind study showed that all the manic patients on lithium remained well, whereas half the patients who were switched from lithium to a placebo relapsed.

Additional double-blind, placebo-controlled studies have found that 70 to 80 percent of patients show improvement on lithium. Lithium reduces the intensity of manic and depressive episodes and decreases the overall number of episodes. Major side effects include excessive thirst and volume of urine, memory problems, tremor, and weight gain. In addition, high doses can lead to endocrine and renal complications.

COGNITIVE ENHANCERS. Cognitive-enhancing drugs are designed to improve cognitive functions such as memory and attention. Pharmacological agents to improve memory function are particularly important in slowing the memory loss observed in patients with Alzheimer's disease. The focus of this research has been on drugs that influence the brain systems involved in learning and memory. More specifically, agents are being developed to help patients retain memories that may be lost as individuals age. In clinical trials, donepezil (Aricept), rivastigimine tartrate (Exelon), and galantamine (Reminyl) all have been shown to reduce cognitive decline in the early stages of Alzheimer's. However, the measures of performance used have been very general tests of cognitive functioning, and so the exact cognitive function that is affected by these drugs is unclear. Side effects of these medications usually occur at higher doses and include gastrointestinal problems, dizziness, and headaches.

Drugs that enhance attentional functioning have been developed for the treatment of attention deficit hyperactivity disorder (ADHD). These drugs help patients maintain attention on a task over an extended period and reduce impulsive motor behaviors. Treatment for ADHD has consisted primarily of psychostimulants, including methylphenidate (Ritalin), *d*-amphetamine (Dexedrin), and a mixture of amphetamine salts (Adderall). Although the idea of giving stimulants to reduce hyperactivity is counterintuitive, these drugs have been shown to reduce symptoms in 70 to 80 percent of children with ADHD and are much more effective than are psychological treatments. These drugs reduce psychomotor activity and restlessness and increase a patient's ability to pay attention. Some of the more frequently reported side effects of psychostimulants include weight loss, social withdrawal, irritability, and insomnia.

With the development of these drugs interest has increased in the possibility of creating cognitive enhancers for healthy adults. Early research investigating the effects of Alzheimer's drugs on memory in healthy adults showed little to no improvement in memory function. As a result of that failure pharmaceutical companies began to focus on drugs that influence the formation of new memories and the retention of memories. However, data showing clinical effectiveness of these drugs were not available in the first years of the twenty-first century. In contrast to memory enhancement, much research suggests that healthy individuals who take methylphenidate and other psychostimulants show improvements in working memory and sustained attention. Conflicting research not only failed to replicate those improvements but found impairments in other cognitive functions. Before these drugs are prescribed for cognitive enhancement, their effects on healthy adults must be confirmed in controlled clinical trials.

Ethical Considerations

The ethical issues surrounding psychopharmacology can be grouped into four categories: research on psychopharmacologic agents, use in clinical treatment of illness, use for performance enhancement, and prophylactic or preventive use.

RESEARCH. Ethical issues in psychopharmacological research are largely the same as those in research in general and include issues related to the ethical treatment of animals, the informed consent of participants, and the appropriate use of placebos in control groups (Roberts and Krystal 2003). Because of the high commercial value of these products conflicts of interest among scientists are also important.

CLINICAL TREATMENT. Ethical issues that arise in the treatment of mental illness include informed consent (whether treatment is taking place inside or outside a research study), weighing the risks of side effects against the benefits of treatment (particularly the increased risk of suicide among adolescents taking certain antidepressants and the risks to the fetus or child of a pregnant or nursing mother receiving treatment), and access to treatment (for example, whether financial ability should determine which patients get access to newer, more expensive antipsychotics and which get cheaper, older, and less effective generic medications).

However, there are also "big picture" issues concerning what is viewed as an illness and when treatment should be directed at the individual rather than the environment. With most prescriptions for antidepressants and anxiolytics being written by general physicians rather than mental health professionals, drugs often are prescribed for dispositional characteristics or problems that are not biological in nature (for example, for persons dealing with stressful life events, grieving from a loss, or pessimistic by nature) even though psychological interventions designed to enhance coping skills could be more effective. Further, environmental change may be more effective than individual interventions in reducing the prevalence of some mental illnesses.

For example, with suicide as a leading cause of death among college students, perhaps it would be more efficacious to think about rampant depression as a problem stemming from the environment rather than from the individual. This changes the focus of treatment to modifications of the environment, (such as transition programs, peer support resources, and so on) as opposed to treating the many individuals who are suffering as a result of that environment. This amounts to taking a human factors approach to society and asking how to take what is known about cognitive strengths and limitations and use it to redesign cultural institutions to maximize productivity and benefit the individual while minimizing stress.

COGNITIVE ENHANCEMENT AND PROPHYLAXIS. Ethical questions concerning cognitive performance enhancement and prophylactic use have begun to be addressed. (President's Council on Bioethics 2003). The use of enhancing drugs when deficits are present (for example, for patients with Alzheimer's or ADHD) is subject to the same ethical questions as is the use of other psychopharmaceuticals for the treatment of illness. New ethical concerns arise when drugs are used to enhance performance in patients in whom no deficits are present (Farah, Illes, Cook-Deegan, et al. 2004) or to prevent illness when no signs of illness are present. For example, the potential risks of taking a drug are much more important in risk-benefit calculations when the patient's quality of life is high in the absence of the drug.

Questions of access and coercion also arise: With the use of Ritalin as a study aid reportedly on the rise among high school and college students, does this constitute an unfair advantage to the users? Will nonusers feel pressured to use the drugs in order to compete with users? Will those who cannot afford the drugs be left behind? In addition, general questions of what it means to be a person have been asked: To what extent is character built by coping with the limitations and imperfections present in oneself and others? Should individuals be free to experiment on themselves with such drugs? Will achieving human perfection make people happier?

Finally, with the contemporary emphasis on genetic contributions to psychiatric disorders, individuals eventually may be able to take drugs prophylactically based on genetic tests that assign an increased probability of developing a disorder. This raises concerns about whether this information should be supplied to individuals and how they will interpret the risks. It also prompts questions about how likely an outcome should be before information is given or action is taken. In light of the relative lack of understanding of brain system dysfunctioning in disorders, prophylactic use of drugs likely will become an increasingly serious issue.

ELIZABETH J. MULLIGAN
ERIC D. CLAUS

SEE ALSO *Emotion; Neuroethics; Psychology.*

BIBLIOGRAPHY

Burns, David D. (1980). *Feeling Good: The New Mood Therapy*. New York: Avon. Provides a comprehensive overview of pharmacologic and cognitive-behavioral treatments for depression.

Farah, Martha J.; Judy Illes; Robert Cook-Deegan; et al. (2004). "Neurocognitive Enhancement: What Can We Do and What Should We Do?" *Nature Reviews Neuroscience* 5: 421–425. A response to the President's Council on Bioethics (2003). Presents an argument in support of the development and use of cognitive enhancing drugs.

President's Council on Bioethics. (2003). *Beyond Therapy: Biotechnology and the Pursuit of Happiness*. Washington, DC: Author.

Roberts, Laura Weiss, and John Krystal, eds. (2003). Special issue on psychopharmacology and ethics. *Psychopharmacology* 171(1): 1–119.

Schatzberg, Alan F., and Charles B. Nemeroff, eds. (1998). *The American Psychiatric Press Textbook of Psychopharmacology*, 2nd edition. Washington, DC: American Psychiatric Press.

Valenstein, Elliot S. (1998). *Blaming the Brain: The Truth about Drugs and Mental Health*. New York: Free Press. Presents the historical development of drugs used to treat mental illness and critically analyzes the role of the pharmaceutical industry in promoting biological theories of mental illness.

PUBLIC POLICY CENTERS

Policy centers or *think tanks* (as they are often called) are an influential, diverse part of the U.S. not-for-profit sector. Those that contribute to discussions of science, technology, and ethics include organizations such as the liberal progressive Institute for Philosophy and Public Policy at the University of Maryland and the culturally conservative Ethics and Public Policy Center in Washington, DC. (Bioethics centers, which also contribute to these discussions, constitute a special category of policy centers and are considered in a separate article.)

Historical Background

Policy centers have grown in number and significance since the foundation of the Carnegie Endowment for International Peace in 1910 and the Institute for Government Research (IGR) in 1916, the first private organizations dedicated to analyzing public policy issues at the international and national levels, respectively. Subsequently IGR founder Robert Somers Brookings (1850–1932) established two supporting organizations: the Institute of Economics and a graduate school bearing his name. The Brookings Institution was formed when these three groups merged in 1927.

Both the Carnegie Endowment (with a staff of 100 and operating expenses of more than $19 million) and the Brookings Institution (with a staff of 275 and expenses of about $40 million) are still going strong, and have been joined by roughly 100 active think tanks in the Washington, DC, area. These include a number of additional policy centers that have expanded since their rather humble beginnings—among them, the Heritage Foundation (with more than 200 staff and more than $34 million in revenue); American Enterprise Institute (with 60 resident scholars, more than 100 adjunct scholars, and more than $18 million in revenues); the Urban Institute (including ten major policy centers with large staffs and operating expenses of more than $77 million); the Cato Institute (with 90 full-time staff, 60 adjunct scholars, 16 fellows, and revenues of roughly $13 million); and the Institute for Policy Studies (with a staff of 30 and expenses of roughly $1.5 million). (Staff and budgetary information is available from the Internet site of each organization, except Cato, obtained from an annual report.)

The expansion in both the numbers and influence of these organizations provides testament to the increasing complexity in government policy making and the growing demand for specialized knowledge and advice. Politicians and bureaucrats who make and implement policy often rely on outside experts to translate academic research and dialogue into predigested, understandable information and recommendations.

The term *think tank* originated in the United States during World War II to describe the secure environment where military and civilian experts developed military strategy. Subsequently the term was applied to contractors (such as the Rand Corporation) that worked closely with the military on both long-term strategy and short-term consulting. During the 1960s and 1970s, the use of the term was further expanded—first to include organizations focusing on international affairs, and then more broadly to cover organizations working on domestic political, economic, or social issues (McGann 2002).

The Role of Policy Centers in the United States

Think tanks inhabit the world of *nongovernmental organizations*—the third sector—and their success is primarily evaluated in terms of influence on the political process and the media. Think tanks operating in Washington, DC, at the beginning of the twenty-first century represent divergent points of view (for example, liberal, conservative, or libertarian) and cover a wide range of subject matter (from international relations to the environment, bioethics to economics) (Ricci 1994). Some specialize in one issue or field—for instance, the Pew Center on Global Climate Change, the Ethics and Public Policy Center. They are also diverse in their activities, roles, and sources of funding. As a result, neatly defining and categorizing think tanks is not an easy task. Nonetheless think tanks generally conduct policy research and analysis, and provide advice. In the United States, think tanks do any or all of the following:

- Serve as incubators for ideas that may later inform policy making;
- Provide a public forum for the exchange of ideas and debate;
- Provide advice to policymakers and offer expertise to the media;
- Advocate for particular positions—often crossing the line from think tanks to *do tanks*. (McGann 2002)

The influence of think tanks in Washington is considerable. While modern-day politicians often publicly eschew the *policy elite*, the variety and complexity of issues public officials confront often results in their reliance on such experts—if not directly, then indirectly (Smith 1991). Policymakers' staffs and outside stakeholders to whom they turn for advice routinely rely on publications and briefings by policy center staffs. Recent offerings by well-established think tanks such as Brookings and AEI include seminars on topics as diverse as ocean policy, Chinese labor issues, post-election Iraq, global warming, and the science of happiness.

In addition to being ubiquitous as *pundits* on television news programs and roundtables, think tank fellows and researchers often rank high in surveys and journal articles as individuals with the greatest influence on Washington, DC, policymakers (Ricci 1994). Over the years, think tanks have provided an important forum for independent research and strategic thinking that has informed important public policy debates.

Policy Centers with a Purpose

Ethical issues flow from the influence of policy centers on the process of governing. While campaign finance receives a great deal of public scrutiny, the influence of special interests on policy centers, which in turn influence elected officials, is often ignored. In addition to think tanks that may have a certain thrust (some would say bias) in approaching a wide sweep of policy issues, or that develop deep expertise in a specific subject area, a number of think tanks have been established to promote or attack certain policy proposals. Corporate interests financially support some of these and a central mission of such policy centers is to promote their sponsors' agenda. While financial support is sometimes acknowledged, such information is often not provided on the web sites of these centers, in their meeting materials, or in their publications. However most think tanks are established as not-for-profits. In order to maintain 501(c)(3) nonprofit status, lobbying must represent only a fraction of total expenditures for the organization and financial records must be disclosed (although not necessarily in a widely accessible manner).

The creation of for-profit ventures that merge lobbying, think tank, and journalism functions has further complicated the scene. Staff in some Washington, DC, area think tanks are as likely to come from Capitol Hill offices or the field of journalism as they are from the halls of academia. They use their skills and contacts to actively lobby for policy positions espoused by their clients. Such *journo-lobbying* has been called "an attempt to dominate the entire intellectual environment in which officials make policy decisions . . . funding everything from think tanks to issue ads to phony grassroots pressure groups" (Confessore 2003, from Internet site). Blurring the spectrum of journalism and think tanks and lobbying raises obvious concerns about real or apparent conflicts of interests.

Analytical work published by various policy centers can range from rigorously researched, documented, and peer-reviewed books that serve an important role in elevating the policy debate to brief issue papers or even just press releases or short articles with little or no supporting analysis. With the advent of the Internet and email, centers can develop and widely disseminate *fact sheets* in minutes. Questions regarding the expertise of researchers, rigor and review of work product, and independence of analysis cast doubt upon the intellectual integrity of some think tanks. Because early twenty-first century think tanks weigh in on so many issues of scientific, social, and economic significance, the danger of an independent-sounding think tank fronting for specific private-sector interests under the guise of objective research and analysis provides reason to be concerned. Some articles in the popular press have revealed strategies to do just that (Confessore 2003, Cushman 1998).

Benefits of Policy Centers

In spite of concerns about think tanks with a specific corporate agenda, many play a valuable role where they conduct genuinely objective research and provide analyses critical to informing government policy making. Their publications and workshops often provide a rich resource for those wanting to understand complex technical, economic, and scientific issues and how they relate to questions of policy. Whether affiliated with universities (for example, the Institute for Philosophy and Public Policy at the University of Maryland) or independent, they provide a rich research environment for scholars. They allow research staffs the luxury of delving deeply into important topics regardless of the current political climate or government sponsorship, thus providing important and stable intellectual capital.

VICKI ARROYO

SEE ALSO *Bioethics Centers; Science Policy.*

BIBLIOGRAPHY

Cushman, John H., Jr. (1998). "Industrial Group Plans to Battle Climate Treaty." *New York Times* April 26, sec. 1, p. 1.

McGann, James G., and R. Kent Weaver, eds. (2002). *Think Tanks and Civil Societies: Catalysts for Ideas and Action.* New Brunswick, NJ: Transaction Publishers.

Ricci, David M. (1994). *The Transformation of American Politics: The New Washington and the Rise of Think Tanks.* New Haven, CT: Yale University Press.

Smith, James A. (1991). *Idea Brokers: Think Tanks and the Rise of the New Policy Elite.* New York: Free Press.

INTERNET RESOURCES

American Enterprise Institute. Available from www.aei.org.

Brookings Institution. Available from www.brookings.org.

Carnegie Endowment for International Peace. Available from www.carnegieendowment.org.

Cato Institute. Available from www.cato.org.

Confessore, Nicholas. (2003). "How James Glassman Reinvented Journalism—As Lobbying." *Washington Monthly,* December. Available from http://www.washingtonmonthly.com/features/2003/0312.confessore.html

Heritage Foundation. Available from www.heritage.org.

Institute for Policy Studies. Available from www.ips-dc.org.

Urban Institute. Available from www.urban.org.

PUBLIC RELATIONS

SEE *Advertising, Marketing, and Public Relations.*

PUBLIC UNDERSTANDING OF SCIENCE

Concern for the public understanding of science constitutes a field of teaching and research focused on the communication of science and technology to the nonscientific public. As science, technology, and society become increasingly intertwined, public communication concerning science and technology is of ever more obvious importance to relations between science, technology, and ethics.

Basic Issues

Strong belief in the social importance of scientific and technological knowledge is part of the professional heritage of scientists and engineers. But to a significant portion of the general population, regardless of educational level, many scientific and technological developments remain mysterious. Such mysteriousness arose originally both from the unique powers of science as well as the specialization of scientific knowledge. It easily degenerates into either excessive faith in or mistrust of scientific-technological developments, attitudes that in turn become a challenge for relations between scientific-technological knowledge and the public. This is especially true because even in the presence of irrational and easily manipulated faith and fears, the enormous powers of science and technology call for control by democratic decisions, the ultimate intelligence of which sometimes depends on a measure of scientific and technological literacy. The public understanding and communication of science have become topics of increasing concern since the 1960s as public attitudes to science became more ambivalent than the overweening optimism that reigned immediately after World War II.

For a variety of reasons, increased public understanding of science has been seen as preferable to a strict separation between science and the public. These reasons include: benefits to science, economic growth, national power and influence, participation by individuals in democratic societies, increased work skills, skills for public policymakers faced with issues that have scientific and technological dimensions, and intellectual, aesthetic, and moral benefits (Thomas and Durant 1987). There is mild consensus that the front-end loaded approach to science education needs supplemental adult education. But contention remains on such factors as how to conceive of "the public" (Miller 1983), how to measure "understanding," and what specific responsibilities are apportioned to scientists, engineers, and members of the public. A few even contend that increased public understanding may damage science and technology policy decisions (Trachtman 1981). Others fear the movement will foster a flattening scientism, or that it is solely motivated by scientists' wish for more public money.

The public communication of science and technology includes, in its widest sense, all of the means, manners, and sites that promote an interaction among science, technology, and the public. The media play an important role in the diffusion of scientific-technological information and in the analysis of the results, limits, benefits, and risks of technoscience. Popularization opens science and technology communication to new voices, to new information generators, and to new critics. But despite a growing acceptance of such activities by the scientific community since the 1980s, popularization is still rarely encouraged or rewarded by academic institutions. But simple linear, one-way, hierarchical models of communication processes are slowly being replaced with more nuanced representations of complex interchanges between scientists and various publics (Gregory and Miller 1998).

Scientists and engineers have been transformed, intentionally or not, into communicators, active participants in public debates, and spokespersons of scientific-technological knowledge. Some professional codes of ethics reflect the nature of new responsibilities brought on by these roles. In some senses there is a clear distinction between the roles of researcher and communicator. Technoscientific communicators must be able to set their knowledge in novel contexts, using different jargon, and often on short timescales, and be more aware of ethical, legal, and societal implications. But in another sense, both roles require respect for others, awareness of personal biases, and the formation of reasonable arguments. Programs for training technoscientists to communicate about their work in a clear and effective way are growing.

Increasingly researchers contend that the communication of scientific-technological knowledge should not be an attempt to achieve the exclusive goal of gaining the *confidence* of the public in scientific-technological matters. Rather, the main goal should be to make the public *participants* in these matters. David Layton and others (1993) argue that the lack of public understanding of science is often conceptualized in terms of a paternalist "deficit model" in which passive lay consumers of knowledge have cognitive gaps (i.e., ignorance) that need to be filled by the producers of expert objective knowledge. They propose an "interactive model" that rejects the objectivity of expert knowledge, the passivity of nonexpert consumers, and the homogeneity of the public. Science is interpreted as an interactive partner that should be responsive to diverse, context-dependent societal demands—where credibility is more important than objectivity. Many agree that this contextual and interactive approach is an improvement over the deficit model, but it is important to recognize and accommodate the knowledge asymmetries that necessarily remain between experts and the public (Miller 2000).

These newer models capture the continuous process of mutual and reciprocal construction between various technoscientific and societal communities. The process is a dynamic one of negotiating the meaning and worth of scientific-technological knowledge involving different actors. The social context and networks of people influence, in turn, the manners of perceiving this knowledge.

Most policy issues in complex, modern societies reveal the attributes of "post-normal science" (Funtowicz and Ravetz 1993) characterized by uncertainty, because there is no consensus concerning values, there are many conflicts even about the facts of the matter, and it is necessary to make urgent decisions. Post-normal science provides, in this sense, a fairly coherent explication of the necessity for greater participation in political-scientific processes. This also means that, in order for the public to gain a clear understanding of the potential and limitations of science, an inclusive dialogue will move much of the backstage scientific disagreements into the forefront (Miller 2000). Clearly the resultant understanding will not be a noncritical appreciation or acceptance.

Research Programs

The first public understanding of science research program emerged in the United States in the wake of the Soviet launch of *Sputnik I* (1957) and fears that U.S. students were not learning sufficient science. The Physical Science Study Committee (PSSC) at Harvard University, headed by Gerald Holton, F. James Rutherford, and Fletcher Watson, spearheaded development of new, more engaging physics curricula for both high schools and colleges that focused on the practice of science and included a measure of the history and philosophy of science. The National Science Board followed this work with the commencement in 1972 of the biennial "Science Indicators" surveys to gauge knowledge of and attitudes about science. In the 1980s, broader science education reforms were initiated. One example is the American Association for the Advancement of Science (AAAS) Project 2061, which began in 1985 (the most recent year in which Halley's comet appeared) and constitutes a long-term initiative to advance literacy in science, mathematics, and technology so that by 2061 (when Halley's comet makes its next appearance) fundamental change will have been achieved. By the 1990s the term *public understanding of science* had largely been replaced in the United States by concerns for *scientific literacy* and to some extent *technological literacy*. It was also argued that science, technology, and society (STS) education had an important role to play in developing such literacy in the non-scientific public.

Other public understanding of science research programs appeared in Europe. In the United Kingdom, especially, promoting the public understanding of science has been a major activity that traces its lineage back to the creations of the Royal Institution (1799) and the British Association for the Advancement of Science (1831). For instance, according to its charter, the Royal Institution—which is not to be confused with the Royal Society—was founded for "diffusing the knowledge, and facilitating the general introduction, of useful mechanical inventions and improvements; and for teaching, by courses of philosophical lectures and experiments, the application of science to the common purposes of life." It was at the Royal Institution that Michael Faraday in 1826 initiated the Friday Evening Discourses (for adults) and his famous Christmas Lectures on science (for young people).

The more proximate origin, however, was a decision of the Royal Society in 1985 to establish a working party to examine the extent and nature of the public understanding of science and its adequacy for an advanced democracy. The resulting Bodmer Report (1985) led to establishment of the standing Committee on the Public Understanding of Science (COPUS) and a continuing series of reports and initiatives. A 1993 white paper titled "Realising Our Potential" further confirmed the commitment of the United Kingdom to the public understanding and communication of science.

In February 2000 a select committee of the House of Lords published a report titled *Science and Society* that reflected recent changes in the "deficit model" interpretation of the science communication problem and the associated belief this could be remedied by more scientific-technological knowledge. This report reconceptualized the relationship between science and society in a way that emphasized contextual and interactive approaches. It led to proposals to replace "Public Understanding of Science" with "Public Engagement with Science and Technology" (PEST)—and in 2003 to a reorganization of COPUS as a national umbrella organization. A similar contextual and audience-centered approach arose slightly earlier from research performed in the United States (Lewenstein 1992).

The European Union has conducted two major studies that centered on determining the level of knowledge and attitudes of the population. Is the public knowledge of science increasing? Not much, to judge from the Eurobarometer 1992 and 2001 surveys in which interviewers used comparable tests. Although nearly half of all Europeans (45.3%) declared in the 2001 survey (European Commission 2002), "I am interested in science and technology," one in two of them also believe that they are not well informed. In 2001 the European Commission established a "Science and Society" program to promote scientific education and culture structured in thirty-eight actions. It underlined the importance of improving the channels of communication. These efforts are also bolstered by the European Collaborative for Science, Industry, and Technology Exhibitions, which include 300 member institutions and attract over 30 million visitors annually.

NICANOR URSUA
TRANSLATED BY JAMES A. LYNCH

BIBLIOGRAPHY

Bodmer, Walter. (1985). *The Public Understanding of Science*. London: Royal Society. Known as the Bodmer Report.

Cope, Edward Meredith. (1970 [1877]). *The Rhetoric of Aristotle, with a Commentary*. Vol. II. Revised and edited by John Edwin Sandys. Dubuque, IA: William C. Brown.

Dickson, David. (2000). "Science and Its Public: The Need for a 'Third Way.'" *Social Studies of Science* 30(6): 917–923.

European Commission. (2002). "Europeans, Science, and Technology: Survey Findings." *RTD Info: Magazine for European Research*, Special Issue, March 2002. Also available from http://europa.eu.int/comm/research/rtdinfo/previous_en.html.

European Commission. (2002). "Talking Science." *RTD Info: Magazine for European Research*, no. 34. Special Issue, September 2002. Also available from http://europa.eu.int/comm/research/rtdinfo/previous_en.html.

Funtowicz, Silvio, and Jerome R. Ravetz. (1993). "Science for the Post-normal Age." *Futures* 25(7): 739–755.

Gregory, Jane, and Steve Miller. (1998). *Science in Public: Communication, Culture, and Credibility*. New York: Plenum Press.

Hilgartner, Stephen. (1990). "The Dominant View of Popularization: Conceptual Problems, Political Uses." *Social Studies of Sciences* 20(3): 519–539.

House of Lords. Select Committee on Science and Technology. (2000). *Science and Society*. London: Her Majesty's Stationery Office.

Irwin, Alan. (1994). "Science and Its Publics: Continuity and Change in the Risk Society." *Social Studies of Science* 24: 168–184.

Irwin, Alan, and Brian Wynne, eds. (1996). *Misunderstanding Science? The Public Reconstruction of Science and Technology*. Cambridge, UK: Cambridge University Press.

Layton, David; Edgar Jenkins; Sally Macgill; and Angela Davey. (1993). *Inarticulate Science? Perspectives on the Public Understanding of Science and Some Implications for Science Education*. Driffield, East Yorkshire, UK: Studies in Education.

Lewenstein, Bruce V., ed. (1992). *When Science Meets the Public*. Washington, DC: American Association for the Advancement of Science. Fourteen papers derived from a conference of the AAAS Committee on Public Understanding of Science and Technology.

Miller, Jon D. (1983). *The American People and Science Policy*. New York: Pergamon Press.

Montgomery, Scott L. (2003). *The Chicago Guide to Communicating Science*. Chicago: University of Chicago Press.

Thomas, Geoffrey, and John Durant. (1987). "Why Should We Promote the Public Understanding of Science?" *Scientific Literacy Papers* 1: 1–14.

Trachtman, L. E. (1981). "The Public Understanding of Science Effort: A Critique." *Science, Technology, and Human Values* 6(36): 10–15.

Wynne, Brian. (1992). "Misunderstood Misunderstandings: Social Identities and Public Uptake of Science." *Public Understanding of Science* 1(3): 281–304.

Wynne, Brian. (1992). "Public Understanding of Science Research: New Horizons or Hall of Mirrors?" *Public Understanding of Science* 1(1): 37–43.

Wynne, Brian. (1995). "The Public Understanding of Science." In *Handbook of Science and Technology Studies*, ed. Sheila Jasanoff, Gerald E. Markle, James C. Petersen, and Trevor Pinch. Thousand Oaks, CA: Sage.

INTERNET RESOURCES

European Commission. (2001). "Science and Society: An Action Plan." Available from http://europa.eu.int/comm/research/science-society/action-plan/action-plan_en.html.

Miller, Steve. (2000). "Public Understanding of Science at the Crossroads." Available from http://www.bshs.org.uk/conf/2000sciencecommpapers/miller.doc.

Rademakers, Lisa. (2000). "Discovering a Code of Ethics for Science Journalism." Available from http://www1.stpt.usf.edu/peec/Rademakers.pdf.

PUGWASH CONFERENCES

In 1995 the Pugwash Conferences and one of its cofounders, the physicist Sir Joseph Rotblat, shared the Nobel Peace Prize in recognition of their decades-long work to reduce the threat of nuclear war and seek the abolition of nuclear weapons. As announced by the Norwegian Nobel Committee, Pugwash and its then president, Joseph Rotblat, were being recognized "for their efforts to diminish the part played by nuclear arms in international politics and in the longer run to eliminate such arms. It is the Committee's hope that the award of the Nobel Peace Prize for 1995 to Rotblat and to Pugwash will encourage world leaders to intensify their efforts to rid the world of nuclear weapons" (Norwegian Nobel Committee Communique, 13 October 1995).

The purpose of the Pugwash Conferences is to bring together, from around the world, influential scientists, scholars, and public figures concerned with reducing the danger of armed conflict and seeking cooperative solutions for global problems, especially those at the intersection of science, technology, and security. Meeting in private as individuals, rather than as representatives of governments or institutions, Pugwash participants exchange views and explore alternative approaches to arms control and tension reduction with a combination of candor, continuity, and flexibility not often possible in official diplomatic meetings. Because of the stature of many of the Pugwash participants in their own countries, insights from Pugwash discussions tend to penetrate quickly to the appropriate levels of official policymaking.

Origins and Organization

The Pugwash Conferences take their name from the small fishing village of Pugwash, Nova Scotia, Canada, site of the first meeting in 1957, which was attended by twenty-two eminent scientists from the United States, Soviet Union, Europe, Japan, Canada, and Australia. The stimulus for this first Pugwash meeting was the "Manifesto" issued in 1955 by Bertrand Russell and Albert Einstein, and also signed by Max Born, Percy Bridgman, Leopold Infeld, Frederic Joliot-Curie, Herman Muller, Linus Pauling, Cecil Powell, Joseph Rotblat, and Hideki Yukawa, which called upon scientists of all political persuasions to assemble to discuss the threat posed to civilization by the advent of thermonuclear weapons. American philanthropist Cyrus Eaton hosted the 1957 meeting at Thinkers' Lodge in Pugwash, his birthplace, and Mr. Eaton continued to provide crucial support for Pugwash in its early years.

From that beginning evolved both a continuing series of meetings at locations all over the world—with a growing number and diversity of participants—and a decentralized organizational structure to coordinate and finance this activity. Pugwash convenes between eight and twelve meetings per year, consisting of the large annual conference, attended by 150 to 250 people, and the more frequent workshops and study group meetings, which focus on specific issues and typically involve twenty to fifty participants.

Although very loosely structured—anyone who attends a Pugwash Conference becomes a member—the organization has been presided over since its inception by a series of distinguished scientists. Among the presidents, besides Rotblat, have been Nobel Laureate in chemistry Dorothy Hodgkin and Sir Michael Atiya, both from the United Kingdom, and Professor M. S. Swaminathan of India. Since 2002 the Secretary General has been Professor Paolo Cotta-Ramusino, who is a professor of mathematical physics at the University of Milan, and the executive director has been Dr. Jeffrey Boutwell of the United States (former associate executive officer at the American Academy of Arts and Sciences). A twenty-eight-member council, which generally meets once per year, and a six-member executive committee provide formal governance for Pugwash. Council members are elected every five years at the Quinquennial Conferences, held since 1962, which approve the long-term goals and bylaws of Pugwash. Marie Muller, professor of international politics at the University of Pretoria, is chair of the Pugwash Council. Pugwash has four small permanent offices, in Rome, London, Geneva, and Washington, DC, which help coordinate activities with more than fifty national Pugwash Groups around the world.

Evolution of the Pugwash Agenda

During the height of the Cold War, when few official channels existed between the Soviet Union/Eastern Europe, and the United States and Western Europe, Pugwash helped create unofficial lines of communication among scientists and policy makers, which in turn contributed to laying the groundwork for some of the most important arms control treaties of the period, including the Partial Test Ban Treaty of 1963, the Non-Proliferation Treaty of 1968, the Anti-Ballistic Missile Treaty of 1972 and SALT I accords, the Biological Weapons Convention of 1972, and the Chemical Weapons Convention of 1993. Despite subsequent trends of generally improving international relations and the emergence of a much wider array of unofficial channels of communication, Pugwash meetings play an important role in bringing together key scientists, analysts, and policy advisers for sustained, in-depth discussions of crucial arms-control issues, particularly in the areas of nuclear, chemical, and biological weapons.

In the early-twenty-first century, the Pugwash Workshops on Nuclear Weapons focused on bringing together scientists and policy makers from areas of regional tension such as South Asia, the Korean Peninsula, and the Middle East to discuss ways of reducing the threat posed by nuclear and other weapons of mass destruction in those regions.

The Pugwash Chemical and Biological Warfare Workshops, which began in 1959, meet twice per year, involving scientists and other technical experts, official negotiators, and industry representatives to explore means of strengthening the international prohibitions on the development and deployment of chemical and biological weapons (CBW) as well as possible CBW terrorist threats.

The Pugwash Workshops on Energy, the Environment, and the Social Responsibility of Scientists capitalize on the global network of Pugwash scientists to hold meetings and consultations on the major scientific and technological issues facing the international community. The workshops cover issues such as global climate change and future world energy needs as well as more specific topics, such as two workshops held in Cuba on public health and medical research. The Pugwash Conferences also have as one of its major goals the promulgation of ethical norms for the scientific community, which was the subject of a workshop in Paris, France, in June 2003.

While Pugwash findings reach the policy community most directly through the participation of members of that community in Pugwash meetings and through the personal contacts of other participants with policy makers, additional means of disseminating policy analysis include the *Pugwash Newsletter* (published twice per year), *Pugwash Occasional Papers* and *Issue Briefs*, and the Pugwash website. Some Pugwash publications include *Nuclear Terrorism: The Danger of Highly Enriched Uranium* (2002) and *U.S.-Cuban Medical Cooperation: Effects of the U.S. Embargo* (2001), and others more generally focused on global perspectives regarding issues of humanitarian intervention and the ramifications of missile defenses for nuclear stability.

Complementing Pugwash is an international Student/Young Pugwash movement, inaugurated in 1979. This is a global network of national groups with their own agendas and goals. Although organizationally separate from the Pugwash Conferences, International Student/Young Pugwash helps introduce students and younger scientists and scholars to the principles and objectives of Pugwash.

Founded on the principle of the individual responsibility of scientists for their work, the Pugwash Conferences have worked toward the twin goals of abolishing nuclear weapons and the peaceful settlement of international disputes since 1957. Emerging challenges in science, technology, and international politics of the twenty-first century make those principles and goals more relevant than ever.

JEFFREY BOUTWELL

SEE ALSO *International Relations; Rotblat, Joseph.*

BIBLIOGRAPHY

INTERNET RESOURCES

Pugwash Conferences on Science and World Affairs. Available from www.pugwash.org. Website for the Pugwash Conferences.

International Student/Young Pugwash. Available from www.student-pugwash.org. Website for the ISYP.

PURE AND APPLIED

The terms *pure science* and *applied science* began to appear in British usage some time after 1840, and were regularly used by American scientists from about 1880 through the 1930s, when pure science began to be replaced by *basic* or *fundamental science* (Kline 1995). While there is no firm consensus on how applied science differs from either pure science on the one hand, or engineering and technology on the other, distinctions made between pure and applied science are relevant to ethics because of the presence of widely held beliefs that pure science is more or less ethically innocent or neutral, and that any ethically troubling matters arise only when science is applied to practical matters.

Motives and Content

One generally recognized basis for distinguishing pure from applied science is the motives or aims of scientists: If one is engaged in science in order to increase one's understanding of the world, one is doing pure science, whereas if one is doing science in order to solve problems regarding human activity, one is doing applied science. A similar approach, more sociological, is to distinguish pure and applied science according to the setting and source of the aims directing scientific activity: Pure science is academic science, and applied science is science in commercial firms or on government projects. Scientists in academia have the freedom, within broad limits, to pursue their own aims, investigating whatever matters strike their curiosity, for however long it might take. Traditionally, their findings are their own property. Scientists working for industry or government are not at liberty to choose their own aims. They work on projects of others' choosing, and face strict limits of time and resources. Their findings belong to their employers.

So science is pure to the extent that its aims are internal to scientific practice (truth, demonstration), with minimal intrusion of external aims (money, status, social welfare). In contrast, applied science refers to science *applied* to external aims, typically in commercial or governmental projects.

While most scholars recognize that applied and pure science have different motives or aims, some maintain that practical motives of control and use cannot be the defining feature of applied science, because on this conception science conducted with a practical aim, engineering, and technology are all applied science. Yet the consensus from recent scholarship is that neither engineering nor technology is accurately characterized simply as applied science, because both involve forms of knowledge and skill that are not derivable from scientific theory or experiment. While engineering and technology employ science among their elements, they are distinguished from applied science by their cognitive content.

Considering cognitive content suggests that there is a second sense of the term applied science. There exist what are called *the applied sciences,* as the term is used, for example, in descriptions of university schools or programs. Here applied science is distinguished from basic science, a distinction based on content. Science is basic if it enhances human understanding of the class of entities with which it is concerned. Applied science refers to the sciences that start from the theories, models, and methods of basic science and use them to understand those material properties and processes that show promise of enabling the synthesis of new materials or creation of new energy-generating or transforming processes. For example, optoelectronics and electroceramics are applied sciences based particularly on the physical theories of thermodynamics and kinetics.

There is considerable overlap between these distinctions between applied science (content) and science applied (motive), because the applied sciences are ultimately motivated by practical aims of control and use. Yet making this distinction allows one to more accurately represent cases of, on the one hand, pure applied science (for example, physicists, typically in academic settings, studying the electrical properties of ceramic materials, having as their primary motive the production of knowledge) and, on the other, basic science done with a practical intent (for example, scientists employed by biotech firms who work on characterizing fundamental molecular mechanisms).

Ethical Implications

The difference in aims of pure science and science applied to practical matters suggests an important difference in the norms appropriate to these practices, specifically a difference in norms regarding proper procedure under conditions of uncertainty, when one does not know or cannot predict the outcome of some course of action.

In pure science, it is considered preferable to limit false positives (claims of an effect when none is present—also known as Type I errors) rather than false negatives (claims of no effect when an effect is present—Type II errors). That is, it is seen as worse to accept a falsehood (Type I error) than to reject a truth (Type II error). An epistemological value judgment of this sort is usually seen as healthy, cautious skepticism, a virtue when doing science.

Kristin Shrader-Frechette (1990) argues, however, that this approach is not the most rational one when applying science, at least in situations of uncertainty. In the applications of science in situations of uncertain outcomes, two types of errors are relevant: one may accept and develop an application that proves to be on balance harmful, or one may reject the development of an application that is on balance beneficial. When scientific rationality is used to evaluate situations with these kinds of possible outcomes, the result is a preference for erring in accepting developments that might be harmful, rather than for erring in rejecting developments that might prove harmless. If science is seen as seeking to maximize truth, it would seem to be most rational to push forward with the development of knowledge, or its applications, on the grounds that error, whether conceptual or practical, will be more likely discovered and then dealt with, thus further maximizing truth, whereas failure to go forward with an investigation means that the truth in that domain will not come out.

But the aim of science applied to practical matters is not the maximization of truth. If it is to be seen as the maximization of something, it is the maximization of welfare, and once welfare is a concern then rationality demands a consideration of values other than purely epistemological ones.

If one takes a consequentialist utilitarian perspective, concern focuses not only on the probability of a hypothesis being true but also on the likely consequences following from a hypothesis. Practical errors arising in the application of science can adversely affect large numbers of people. If the situation is one of genuine uncertainty, meaning that it is not possible to assign probabilities to various outcomes, and some outcomes are worse than others, it can be argued that the most rational strategy is to act as if the worst consequence that could happen will happen, and thus seek to minimize the possibility of the worst-case scenario. That is, in a situation in which it is not possible to assign probabilities to either possible beneficial consequences or possible disastrous consequences, then it is better to forego possible benefits, if doing so prevents possible disasters.

If one takes a deontological perspective such as that of Immanuel Kant (1724–1804), matters of the social and legal obligation, informed consent, and the voluntariness of risk become relevant in deciding whether to apply some scientific knowledge. Shrader-Frechete concludes that, while the proper procedural norms in pure science are strictly epistemological, the proper procedural norms for applying science to practical matters are both epistemological and ethical.

Apart from consideration of the different procedural norms of pure science and science applied, some conclusions can be drawn about the general relevance to ethics of the distinctions between pure science and science applied, and basic science and applied science.

For duty-based ethical perspectives such as Kant's, and virtue-based moral perspectives with their focus on character, the distinction of pure science versus its applications, based as it is on motives for action, will have moral significance. For example, respect for the autonomy of persons would support the moral permissibility of all basic science, regardless of what might be done with the resulting knowledge. In contrast, utilitarian and other consequentialist approaches focus on foreseeable consequences rather than motives, and the pure/applied distinction will have little importance. If it can be foreseen that the knowledge gained from some basic science will most likely produce more harm than good, the motives of the scientists are beside the point: Such knowledge should not be gained, at least not in the referenced context. Those doing pure science have an obligation to consider not only *how* they should proceed but also *whether* they should proceed.

With respect to the basic/applied distinction regarding content, those for whom consequences determine the rightness of actions will not concern themselves with whether those consequences result from basic or applied science. For nonconsequentialists, pure applied science, like basic science, would always seem to be permissible, while the morality of the practical application of applied science will depend on whether those involved act upon their obligations toward others.

Beyond Science

It remains to be considered whether the previous analysis might be relevant in other areas in which the pure/applied distinction is used. Certainly it is common to speak of pure and applied ethics, pure and applied art—and, on rare occasions, distinctions may even be drawn between pure and applied engineering or technology.

With regard to ethics the pure/applied distinction can, as in science, be drawn on the basis of motives or content. With reference to motives, people pursue ethical reflection in the pure sense simply as a topic of interest in its own right, or in the applied sense when they do so in order to lead better lives. As with science, the sociological context of the former would probably be the university, of the latter a clinical or other practical setting. (In some interpretations, pursuit of the former itself leads to a better life.) With reference to content, ethics can be basic in the sense of engaged with fundamental insight into theories and principles or applied in the sense of making particular decisions. Whether and to what extent the further analysis of the different epistemological and ethical assessments of Type I and Type II errors applies remains an open question. Nevertheless, with regard to pure/applied art, it can be suggested that parallel reflections would be relevant.

With regard to engineering and technology and the pure/applied distinction, issues become more problematic. In part this is because of the application factor that is already built into these disciplines. As one observer has described it, "Pure technology is the building of machines for their own sake and for the pride or pleasure of accomplishment" (Daedalus 1970, p. 38). Samuel C. Florman (1976) refers to something similar when he analyzes "the existential pleasures of engineering." Any pure engineering or pure technology, pursued for its own sake, is nevertheless something more closely engaged with the world, and thus more directly subject to ethical assessment, than pure or basic science. It is difficult to imagine engineering or technology ever being as pure or basic in an ethically relevant sense as pure or basic science.

RUSSELL J. WOODRUFF

SEE ALSO *Neutrality in Science and Technology.*

BIBLIOGRAPHY

Bunge, Mario. (1966). "Technology as Applied Science." *Technology and Culture* 7(3): 329–347.

Daedalus of New Scientist [pseud.]. (1970). "Pure Technology." *Technology Review* 72(8): 38–45.

Feibleman, James K. (1972). "Pure Science, Applied Science, Technology: An Attempt at Definitions." In *Philosophy and Technology: Readings in the Philosophical Problems of Technology*, ed. Carl Mitcham and Robert Mackey. New York: Free Press.

Florman, Samuel C. (1976). *The Existential Pleasures of Engineering*. New York: St. Martin's Press. 2nd edition, 1994.

Kline, Ronald. (1995). "Construing Technology as Applied Science: Public Rhetoric of Scientists and Engineers in the United States, 1880–1945." *Isis* 86(2): 194–221.

Niiniluoto, Ilkka. (1993). "The Aim and Structure of Applied Research." *Erkenntnis* 38(1): 1–21.

Ravetz, Jerome R. (1971). *Scientific Knowledge and Its Social Problems*. Oxford: Clarendon Press.

Shrader-Frechette, Kristin. (1990). "Island Biogeography, Species-Area Curves, and Statistical Errors: Applied Biology and Scientific Rationality." *Proceedings of the Biennial Meeting of the Philosophy of Science Association* 1990, vol. 1: 447–456.

Q

QUALITATIVE RESEARCH

Since the seventeenth century modern science has emphasized the strengths of quantitatively based experimentation and research. The success of quantitative research in the so-called hard sciences, especially physics and chemistry, stimulated attempts to extend quantitative work into the social or human sciences, where its application was somewhat problematic. A countermovement with ethical dimensions developed during the nineteenth century as increased attempts at exploration and colonization resulted in efforts to document "native" cultures in qualitative ways; that countermovement contributed to the formalization of methods in anthropology. In the twentieth century qualitative methods were adopted in sociology; many of the applied disciplines, such as nursing, education, and business; and human and rural ecology, geography, and engineering. By the 1970s qualitative research and qualitative inquiry had become the rubrics of a reformist movement in the social sciences, with professional associations, journals, and basic reference works appearing into the twenty-first century.

Basics

Many distinct qualitative research methods were developed and formalized, including ethnography, phenomenology (as a method), conversational or discourse analysis, narrative inquiry, grounded theory, participant observation, and ethology. Those methods were complemented by research designs and analytic strategies that allowed data of different levels and types to be accessed, such as focus groups, case studies, and action research. Qualitative research is used in micro and macro descriptions, concept and theory development, and evaluation, all of which often combine or overlap and add to the complexity of methods. There are also different perspectives or schools of thought on qualitative research, such as Marxism, phenomenology, ethnomethodology, cultural theory, symbolic interactionism, feminism, critical theory, and structuralism. These theoretical underpinnings provide a lens that focuses an inquiry on particular purposes, agendas, and goals so that a researcher may choose to conduct, for example, a critical ethnography or formulate a feminist-grounded theory.

Transcending such differences among schools of qualitative inquiry, all qualitative research exhibits seven basic characteristics. The most important are (1) thick description, or rich and relevant descriptions of the social, cultural, linguistic, and material contexts in which people live; (2) the presentation of the perspective of the people being studied (the emic, or natives', point of view); and (3) the use of relatively small and purposefully selected (rather than large and randomly selected) samples. Qualitative inquiry also involves (4) the inductive development of explanation, concepts, and theory; (5) reliance on observational and interview data; (6) the use of textual data involving content and thematic analysis (rather than numerical data and statistical analysis); and (7) techniques of verification that assess the trustworthiness of data, replication, and saturation.

Contributions

What does qualitative inquiry contribute to knowledge? Using microanalytic inquiry, qualitative researchers explore, document, evaluate, and diagnose mechanisms and individual, group, or organizational behavior for purposes such as investigating problems (e.g., drug errors); processes of teaching, learning, or care giving; naturally occurring interactions between individuals and groups; and behavioral indexes (e.g., expressions of pain) and situations (e.g., drug trafficking).

Qualitative researchers also explore the subjective subjectively. They are concerned with perceptions, beliefs, and values and with the responses and experiences of people. Qualitative researchers look for norms and for exceptions to both obvious and less recognized patterns of behaviors. That research illuminates, explicates, and interprets to provide understanding. This knowledge allows the recognition of humanity in oneself and in others, leading to the ability to care for and teach people, run organizations and programs, and identify practices and develop policy. Qualitative inquiry provides the information, substance, rationale, and interventions needed for the optimal funding of social programs.

Qualitative researchers develop pertinent and useful concepts and valid theories. "Knowing what is actually happening" essentially removes subjectivity and enables action, providing organizing systems and paradigms and thus facilitating efficient, effective, and cohesive approaches to, for instance, health care and education.

Issues and Ethics

Qualitative research arose in the nineteenth century as a form of ethical resistance to what was seen as an unwarranted extension of quantitative methods. That challenge has been revived by attempts by what is known as the Cochrane Collaboration (a group that supports and publishes meta analysis of research, usually clinical drug trials, and evaluates the research using criteria recommended by Archie Cochrane, that support experimental design). Qualitative data is dismissed as "anecdotal" and is valued least to promote quantitative criteria for evidence in the assessment of healthcare interventions, in which efficacy, evaluation, and certainty are valued above context-based and applied knowledge. That approach devalues the contribution of qualitative inquiry. Moreover, the valuation of science for objective knowledge, experimental design, and hard data and measurement has devalued qualitative inquiry in universities and funding agencies, making qualitative inquiry a lower priority in curricula and in the agendas of funding agencies.

Recent efforts to strengthen qualitative inquiry, along with an increasing awareness of the limits of quantitative inquiry and its complementary relationship with quantitative inquiry, have led to increasing interest in mixed-method design, especially research designs that combine qualitative and quantitative inquiry. However, the underlying debate about the rigor of qualitative inquiry continues to constitute an ongoing challenge to qualitative researchers. Are qualitative findings rigorous enough to stand on their own, or should qualitative theories be tested quantitatively? Can qualitative results be generalized?

Despite criticisms, qualitative research is considered a powerful tool for eliciting the meaning of situations and for making sense of the complexity of life as it is lived and communicating that complexity. In the 1990s the art-based qualitative movement used techniques from the theater, the presentation and dissemination of qualitative findings, and the elicitation of qualitative data that reveals the implicit. Qualitative results also may be represented in the form of poetics and even as art installations in efforts to facilitate understanding of the worldview of the other.

In qualitative research ethics also comes into play. Issues of consent are paramount, dealing with subjects not only agreeing to participate in a qualitative study but to remain in that study over time. Such consent is considered ongoing, and the onus is on the researcher to ensure that participants are fully cognizant of the nature of a project. Because the quality of the data is dependent on the relationship with the participant (the establishment of trust) and because of the intimate nature of the topics qualitative researchers study protection of a participant's privacy by providing anonymity and confidentiality is important. The paradox here is that in the process of concealing identities the altering and/or removal of identifiers changes the data and creates the risk of impairing validity. However, this protection of the rights of the individual is one of the hallmarks of qualitative inquiry. It is this, along with its interest in patterns of human behavior, that distinguishes qualitative inquiry from journalism.

JANICE M. MORSE

BIBLIOGRAPHY

Denzin, Norman K., and Yvonna S. Lincoln, eds. (2000). *Handbook of Qualitative Research,* 2nd edition. Thousand Oaks, CA: Sage. A manual describing the strategies for conducting most of the qualitative methods.

Denzin, Norman K., and Yvonna S. Lincoln, eds. (2002). *The Qualitative Inquiry Reader*. Thousand Oaks, CA: Sage. Reprints of seminal articles in qualitative inquiry.

Morse, Janice M., ed. (1994). *Critical Issues in Qualitative Research Methods*. Thousand Oaks, CA: Sage. Addresses important issues in qualitative research, with authors' discussion of each chapter.

Morse, J. M. and Richards, L. (2002). *Readme First for a User's Guide to Qualitative Methods*. Thousand Oaks, CA: Sage. A basic text and guide to the qualitative methods literature.

Strauss, Anselm, and Juliet M. Corbin. (1998). *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*, 2nd edition. Thousand Oaks, CA: Sage. A text describing the method of grounded theory.

INTERNET RESOURCES

International Journals of Qualitative Methods. Available at http://www.ualberta.ca/~ijqm/. An open access journal that specializes in qualitative methods.

The Qualitative Report. Available at www.nova.edu/ssss/QR/practice.html. An online journal that also provides links to web pages, papers and other texts, other journals, and course syllabuses.

R

RACE

Race, at a most basic level, is a system for classifying people by various forms of similarity and difference. Race is a culturally, socially, and scientifically defined concept whose meaning—depending on the period in history, geographic location, and the scientific or technological context—has changed over time. Race is a fluid concept. The meaning of race has evolved from a term describing livestock lineage to a tool used in medical diagnoses. The ethical implications of race in relation to science and technology depend on the ways in which it is deployed and by whom. In this regard, race can be used to make informed scientific and technological decisions, or it can be used to reinforce cultural stereotypes and regimes of discrimination.

Origins of Race

Prior to the sixteenth century, the current connotations of race did not exist. The most common use of the term *race* was in reference to the domestication of livestock. A "racial stock" was a group of animals bred for a specific purpose. In the sixteenth century, this animal husbandry term migrated and began to be used to describe peoples. Race became a way to explain differentiations within "human stock." Europeans were the first to use the terms *race* and *stock* to delineate between different human groups. Customs and regional origins, as well as religious values and beliefs, determined the degree of difference. The characteristics attributed to races and stocks were similar to those now attributed to culture. Race did not carry powerful biological overtones. Soon, however, it became a way of evaluating and differentiating between those considered to be civilized and those deemed to be uncivilized.

Indeed, for the Enlightenment philosophes and scientists of the seventeenth and eighteenth centuries, what was most important was the human race as a whole and the prospects for its progressive advancement. Enlightenment science advocated at least two propositions that severely limited the use of race as a justification for social discrimination. First, Enlightenment anthropologists were monogenists rather than polygenists; that is, they believed that human beings were created only once. As confirmed by the ability of all human beings to interbreed, all human beings were one species, and variations were the results of varieties within the species, not differences between species. Second, for the Enlightenment, environment and education were considered much more important than heredity. When the Baron de Montesquieu in his *Spirit of the Laws* (1748) argued that human differentiation was caused by environmental and historical factors, the corollary was that such differentiations were of secondary importance and could be overcome by means of education. On the basis of such views, France's Constituent Assembly abolished slavery in 1791 shortly after the beginning of the French Revolution, and the British abolished the slave trade in 1821.

Over the course of the eighteenth century, however, the understanding of race changed from a difference based on geographic boundaries and cultural heritage to one based on physical differences that could be easily categorized into human "types." This perception of race had its roots in the tenth edition of Carolus Linnaeus's *Systema Naturae* (1758). In this volume

Linnaeus brought together perceptions of cultural and physical characteristics to describe race, a formulation that marked the emergence of a racialized discourse within Western science. Linnaeus argued that four "races" existed with specific physical features, emotional temperaments, and intellectual abilities: Homo americanus—reddish, choleric, erect, tenacious, content, free, and ruled by custom; Homo europaeus—white, ruddy, muscular, stern, haughty, stingy, and ruled by opinion; Home asiaticus—yellow, melancholic, inflexible, light, inventive, and ruled by rites; Homo afer—black, phlegmatic, indulgent, cunning, slow, negligent, and ruled by caprice. In differentiating species into subspecies based on elements that are common to the entire species, Linnaeus linked elements such as skin color directly to perceived behavioral propensities and eventually to biological variation.

Such a system of classification became increasingly used to distinguish not human variation but different species. Distinctions made at the subspecies level enabled value judgments to be made about superiority, inferiority, domination, and subserviency, based on physical attributes. As the Enlightenment commitment to the primacy of environment over heredity faded, this solidified perceptions that the characteristics displayed by each subspecies were immutable. Based on common characteristics, race evolved, from an indicator of similarity and difference, to a system of classification, and finally to a concept that imbedded cultural and physical characteristics into individual biological makeup. By the nineteenth century race as a biological and scientific concept had been firmly instantiated within scientific studies undertaken by natural philosophers Georges Cuvier (1812) and Charles Darwin (1859).

Racialization of Science

The nineteenth century also saw the racialization of science. Racialization is a social process by which beliefs about race become instruments of social categorization, cultural classification, political judgments, and economic decisions. New scientific work emerged to validate the underlying implications within Linnaeus's system of classification. Louis Agassiz (1850), Pierre Paul Broca (1861), and Samuel George Morton (1839), as well as others, endeavored to produce scientific evidence confirming their beliefs that white Europeans were at the top of the racial hierarchy. Researchers used the now discredited sciences of *polygeny,* that racial groups had different origins and were different species; *phrenology,* the study of the shape and protuberances of the skull to reveal character and mental capacity; and *craniometry,* the measurement of the skull to determine its characteristics as related to sex, race, or body type, to separate and differentiate races. According to Audrey Smedley, author of the 1993 book *Race in North America,* the reconceptualization of race in the nineteenth century created "a social mechanism for concretizing and rigidifying a universal ranking system that gave Europeans what they thought was a perpetual dominance over indigenous people of the New World, Africa, and Asia" (pp. 303–304). The hierarchy soon became understood as the natural order of things.

The scientifically supported perceived difference in races produced a Western ideological position of global superiority. The racialization process created an environment in which nonwhite peoples were viewed as socially, culturally, and intellectually inferior. It produced a scientific rationality that sustained this belief structure. The ways in which political and racial ideologies influenced science is well illustrated in the work of the French scientist Paul Broca (1824–1880). When Broca's craniometric studies produced results suggesting that Germans possessed larger brains than the French, he adjusted his data for body size, in order to show that German brains constituted a smaller percentage of overall body mass than French brains did. In like manner, when Broca found that people of African heritage had larger cranial nerves than Europeans, this clearly meant that cranial nerves did not contribute to intellectual activity of the brain. It is these processes of racialization in science that justified beliefs in racial superiority and inferiority, which in turn enabled racism to flourish. The racism was masked by religious authorities, and the racialized scientific truths of eugenics and Social Darwinism further reinforced the misperception of racial difference that reverberates to the present day.

By the late nineteenth century, racial difference became the dominant lens through which the Western world perceived racial and ethnic otherness. This perspective directly influenced the scientific and technical opportunities for those who were not white. In the United States, science codified the social attitudes about black inferiority and became the dominant obstacle inhibiting blacks, as well as other nonwhite persons, from engaging in scientific and technical work. Those who were able to partially overcome the barriers created by a tradition of racialization and contribute to science and engineering were regularly dismissed as exceptions or marginalized for what was assumed to be substandard work by substandard humans. By the beginning of the twentieth century, it was widely held in scientific and technical communities that people of African descent had contributed nothing worthwhile to the scientific and technical development of the modern world.

At the 1913 annual meeting of the American Association for the Advancement of Science, James McKeen Cattell, at the time the owner and editor of the journal *Science*, confirmed this opinion. In a speech titled "Science, Education, and Democracy," he argued that while there was a need for more educational opportunities for Negroes, it was clearly understood that "[t]here is not a single mulatto who has done creditable scientific work" (Cattell 1914, p. 154). This statement—which repeats equally negative judgments found in both David Hume's essay "Of National Characters" (1753) and Immanuel Kant's "On the Different Races of Man" (1775)—overlooks the highly regarded work by the agricultural chemist George Washington Carver (c. 1864–1943), the physician Rebecca Cole (1846–1922), the developmental biologist Ernest Everett Just (1883–1941), and the inventor Granville T. Woods (1856–1910). Nevertheless, their racial identification made their scientific and technical careers difficult at best.

Scientific Criticism of Race

During the early twentieth century scientists also began to challenge the conceptions of race developed in nineteenth-century science. For many it became an ethical issue when research began to reveal that many scientists altered their data to fit the valued racial hierarchy of the day. The foremost critic of scientific racism was the eminent anthropologist Franz Boas (1940). Boas applied a scientific rigor to counteract the social and racialized rigor of the nineteenth-century racial science. He recalculated data, exposed the inaccuracies, and provided evidence that would argue strongly against the racialization of science. His work indicated that many scientists molded their data to fit a worldview that aimed to maintain and strengthen a racial hierarchy that located Europeans at the top. By deploying the power of genetics and biology, he was able to begin breaking the hold that racialized assumptions about human variation had in science. But the perception had been so deeply imbedded in scientific practice that it would take decades to destabilize it. It is in this regard that the U.S. Public Health Service could conduct a forty-year experiment, known as the Tuskegee Syphilis Study (1932–1972), on 399 black men in the late stages of syphilis (Jones 1993).

The rise of Nazism represented a new wrinkle in the tradition of racialized science. What distinguishes the Nazi agenda from other historical genocidal efforts was its reliance on science. For instance, in 1934 the Nazi deputy party leader, Rudolph Hess, spoke of National Socialism as applied biology. Nazi racial purification, based on a racialized biomedical vision, escalated from forced sterilization to holocaust (Lifton 1986).

The claims of inherent racial inferiority during the reign of Nazism and the subsequent Holocaust provided an important impetus for the United Nations to produce a public statement challenging the scientific basis of race. The United Nations contended that such wholesale disregard for human life was made possible by the continued propagation of racial inequality. To reconstitute the ways in which race had been constructed, the United Nations Educational, Scientific and Cultural Organization (UNESCO) convened a panel of social and natural scientists and charged them with producing a definitive statement on racial difference. The panel produced two statements: Statement on Race (1950) and Statement on the Nature of Race and Race Differences (1951). Primarily written by Ashley Montagu, a student of Boas, the statements declared that race had no scientific basis and called for an end to racial thinking in scientific and political thought. Within the next two decades UNESCO would release two more statements: Statement on the Biological Aspects of Race (1964) and Statement on Race and Racial Prejudice (1967). Although important, these statements did not immediately influence social policy and the public attitudes that had been ingrained about race.

Continuing Issues

Scientifically the importance of race diminished over the latter part on the twentieth century. Race reemerged, however, with the organization of an international research project to determine the DNA sequence of the human genome. The Human Genome Project (HGP) began in 1990, and researchers produced a complete map in 2003. One of the major goals of the HGP was to find and elucidate the function of human genes. Some of the most promising and troubling outcomes of the HGP in the context of race have to do with genetic therapy. Genetic researchers contend that the human genome consists of chromosome units or haplotype blocks. Haplotype maps (HapMaps) can possibly provide a simple way for genetic researchers to quickly and efficiently search for genetic variations related to common diseases and drug responses.

The danger is that this research might re-ensconce the biological concept of race within scientific practice and knowledge production. It is already common practice for physicians to base clinical decisions on a patient's perceived race. The positive potential of HapMaps could be overshadowed by the manipulation of genetic data to support racialized stereotypes, renew claims of genetic differentiation between races, and add biological authority to ethnic stereotypes. These pitfalls arise when genetic data become the basis on which racially specific drugs or treatments are designed. In 2003 the U.S. Food and Drug Administration proposed guidelines that would require all new drugs be evaluated for their effects on different racial groups. In the contemporary world, the genetic origins of race reappear much more quickly than they are eliminated.

The connections between biology and race are far from settled. In thinking about the future ethical implications of this relationship, it is necessary to consider what function the multiple manifestations of race will serve within social, cultural, scientific, medical, and technological practices, as well as the ways in which researchers will deploy race within the conflicting and overlapping realms. As a result, race will continue to be one of multiple issues and concepts that will determine on what terms we as a society will engage each other humanely.

RAYVON FOUCHÉ

SEE ALSO *Class; Eugenics; Feminist Ethics; Genocide; Holocaust; Human Rights; IQ Debate; Nazi Medicine; Social Darwinism; Tuskegee Experiment.*

BIBLIOGRAPHY

Agassiz, Louis. (1850). "The Diversity of Origin of the Human Races." *Christian Examiner* 49: 110–145. A statement on polygeny and the disparate origins of human races.

Boaz, Franz. (1940). *Race, Language, and Culture*. New York: Macmillan. A collection of the most important essays written by Franz Boas on the science of anthropology.

Broca, Paul. (1861). "Sur le volume et la forme du cerveau suivant les individus et suivant les races" [On the volume and form of the brains of individuals and races]. *Bulletin de la Société d'anthropologie de Paris* 2: 139–207, 301–321, 441–446. Argues that intelligence can be related to anthropometic differences.

Cattell, J. McKeen. (1914). "Science, Education, and Democracy." *Science* 39(996): 154. Speech presented to the American Association for the Advancement of Science (AAAS) stating minorities have not contributed to science.

Cuvier, Georges. (1812). *Recherches sur les ossemens fossiles de quadrupèdes* [Research on the fossil bones of quadrupeds], Vol. 1. Paris: Deterville. A collection of anatomical studies that is one of the early works of vertebrate paleontology.

Darwin, Charles. (1859). *On the Origin of Species by Means of Natural Selection*. London: John Murray. Contends that species change though an evolutionary process of natural selection.

De Montesquieu, Baron. (2002 [1748]). *Spirit of the Laws*. Amherst, NY: Prometheus Books. A comparative study of three types of government: republic, monarchy, and despotism.

Dubow, Saul. (1995). *Scientific Racism in Modern South Africa*. Cambridge, UK: Cambridge University Press. Examines the relationship between science and colonial power in south Africa, Zimbabwe, Mozambique, and Mauritius.

Duster, Troy. (2003). *Backdoor to Eugenics*, 2nd edition. New York: Routledge. Discusses the ethical struggles and social implications of new genetic technologies.

Fouché, Rayvon. (2003). *Black Inventors in the Age of Segregation: Granville T. Woods, Lewis H. Latimer, and Shelby J. Davidson*. Baltimore: Johns Hopkins University Press. Reconeptualizes what it means to be an African American inventor.

Gould, Stephen J. (1996). *The Mismeasure of Man*, rev. edition. New York: Norton. Examines the history, politics, and power of science and the way biology has been deployed to construction racial difference.

Graves, Joseph L., Jr. (2001). *The Emperor's New Clothes: Biological Theories of Race at the Millennium*. New Brunswick, NJ: Rutgers University Press. Uses the scientific method to argue that races do not exist as a biological category.

Harding, Sandra, ed. (1993). *The "Racial" Economy of Science: Toward a Democratic Future*. Bloomington: Indiana University Press. A series of essay that address the ways that aspects of science are racially constructed.

Jones, James H. (1993). *Bad Blood: The Tuskegee Syphilis Experiment*, rev. edition. New York: Free Press. Details the history and affects of a government sponsored experiment on African American syphilitics.

King, James C. (1981). *The Biology of Race*, rev. edition. Berkeley and Los Angeles: University of California Press. Contends that race is a social, not biological, concept.

Kuttner, Robert E., ed. (1967). *Race and Modern Science: A Collection of Essays by Biologists, Anthropologists, Sociologists, and Psychologists*. New York: Social Science Press.

Lifton, Robert Jay. (1986). *The Nazi Doctors: Medical Killing and the Psychology of Genocide*. New York: Basic. Describes the conflicting roles that German doctors played in Nazi genocide.

Linnaeus, Carolus. (1758). *Systema Naturae* [System of nature], 10th edition. Stockholm: Laurentii Salvii Homiae.

Manning, Kenneth R. (1983). *Black Apollo of Science: The Life of Ernest Everett Just*. New York: Oxford University Press.

McMurry, Linda O. (1981). *George Washington Carver: Scientist and Symbol*. New York: Oxford University Press.

Morton, Samuel George. (1839). *Crania Americana; or, a Comparative View of the Skulls of Various Aboriginal Nations of North and South America*. Philadelphia: Dobson. Claims to find different cranial capacities between races.

Smedley, Audrey. (1993). *Race in North America: Origin and Evolution of a Worldview*. Boulder, CO: Westview Press. Traces the evolution of race over three centuries as it transitions from a folk category to a concept used to define superiority and inferiority.

Stepan, Nancy Leys. (1991). *The Hour of Eugenics: Race, Gender, and Nation in Latin America*. Ithaca, NY: Cornell University Press. A comparative study examining how eugenics was taken up by scientist and social reformers in Mexico, Brazil and Argentina.

RADIATION

Radiation is everywhere. Life would not exist on Earth without radiation from the sun. Additionally, many important technological activities are based on radiation, such as radio and telecommunications. Another type of radiation is used for producing X-ray images in industrial and medical applications. Radiation is also emitted as a side effect from various technological activities. Some types of radiation are known to be harmful to human beings and need to be carefully managed. Other types are not believed to be dangerous, but are a source of worry among the general public. An example is possible radiation risks from power lines, cellular phones, and cellular base stations, which since the 1980s have received considerable media attention.

Protection of humans and the environment from the harmful effects of radiation is called radiation protection. The field of radiation protection evaluates scientific knowledge of adverse health effects from radiation and influences legislation and regulations for protection. The field is complex and involves intricate ethical problems. Lauriston S. Taylor, one of the pioneers of radiation protection during the early 1900s, once said, "Radiation protection is not only a matter for science. It is a problem of philosophy, morality and the utmost wisdom" (1980, p. 854).

It is important to distinguish between ionizing and nonionizing radiation. The biological effects of the two types of radiation are very different, as are therefore the methods of protection. Radiation is ionizing if the energy of the radiation suffices to remove an electron from an atom to create an ion. Conversely, if the energy does not suffice to create ions it is called nonionizing.

Nonionizing Radiation

The most important types of nonionizing radiation are electromagnetic and consist of electric and magnetic waves propagating at the speed of light. Electromagnetic radiation comes from both natural and technological sources and has different properties depending on the frequency of the electromagnetic waves. Low-frequency electromagnetic fields and radio waves come from electric appliances, power lines, radio and television broadcasting, and natural sources such as thunderstorms. Microwaves are used in microwave ovens, radar, and telecommunications. Infrared radiation, visible light, and ultraviolet radiation are emitted from the sun, artificial light, and other technical applications. Electromagnetic radiation with frequencies above visible light has enough energy to change chemical bonds and cause ionizations. Ultraviolet radiation lies on the borderline between nonionizing and ionizing radiation, but is usually considered nonionizing.

The biological effects of nonionizing electromagnetic radiation depend on the frequency and the intensity of the radiation. Low-frequency electromagnetic fields and radio waves pass through human bodies without any apparent effects, but can induce electrical currents and stimulate human nerve cells at high intensities. Microwaves cannot penetrate far into human bodies, but high intensities can cause heating of tissue and burn injuries to the skin. Infrared radiation and visible light can produce surface heating and cause harm to the eye in high intensities. Ultraviolet radiation cannot penetrate the skin, but is known to cause skin cancers.

Claims that low-frequency electromagnetic fields and microwaves can cause cancer are controversial. These types of radiation have insufficient energy to damage the DNA directly, and no other mechanism is known through which they could cause cancer. The prevailing scientific view is that these types of radiation are unlikely to cause cancer. Other effects, such as reduced fertility, memory loss, and fatigue, have been reported, but there is no consistent evidence for these kinds of adverse health effects.

International and national recommendations on exposure limits for nonionizing radiation are based on guidelines from the International Commission on Non-Ionizing Radiation Protection (ICNIRP). The ICNIRP is a nongovernmental organization officially recognized by the World Health Organization (WHO), the International Labour Organization (ILO), and the European Union (EU). The ICNIRP recommends exposure limits for different types of nonionizing radiation. The exposure limits are set with a margin of safety to the level at which health effects occur. The ICNIRP guidelines are based on scientifically verified health effects of nonionizing radiation. Potential, but not proven, hazards are not used as a basis for the limits.

The most important ethical issue regarding nonionizing radiation concerns how to deal with potential health hazards that are scientifically controversial. Examples include the possible risks of radiation from power lines and cellular base stations. Typical exposure levels in these cases are substantially lower than the exposure limits recommended by the ICNIRP, but they do introduce new exposures into society and, in the case of cell phones, such exposures are centered around sensitive parts of the human body. Thus, some countries have, in addition to the recommended exposure limits, adopted precautionary strategies for managing possible hazards from nonionizing radiation. These strategies include the use of prudent avoidance and the precautionary principle.

Prudent avoidance can be defined as a general reduction of needless exposure. This means taking simple, easily achievable, low-cost measures, even in the absence of a demonstrable health hazard. *Prudent* refers to expenditures and does not include any requirement for assessment of the potential health benefits of adopted measures. In practice, this means that the location of new facilities can be influenced by prudent considerations, but need not be modified, because this would involve higher costs. Prudent avoidance can also take the form of voluntary measures, for example, to recommend that manufacturers of mobile phones minimize radiation exposure to the head.

The precautionary principle is not a single, well-defined principle, but the basic idea is that measures against a possible hazard ought to be taken even if evidence for the existence of the hazard does not suffice to be treated as a scientific fact. It is usually thought that the application of the precautionary principle should be science-based and should reference plausible explanations for possible mechanisms for hazards. A common further requirement is that precautionary measures should be temporary and subject to review when further knowledge is gathered. Because scientific evidence and plausible mechanisms are missing for possible risks of low levels of nonionizing electromagnetic radiation, it has been argued that the precautionary principle is inappropriate for these types of radiation.

Adopting precautionary approaches are not unproblematic. What level of precaution should be taken, and what should be the basis for the decision? The WHO has argued that precautionary approaches regarding nonionizing electromagnetic radiation should be adopted with care, and under the condition that scientific assessments of risk and science-based exposure limits are not undermined by arbitrary precautionary approaches.

Ionizing Radiation

Radiation is ionizing if it has enough energy to ionize atoms and molecules. There are two types of ionizing radiation: high-frequency electromagnetic radiation and particle radiation. Examples of ionizing electromagnetic radiation include gamma rays and X rays. Most particle radiation is ionizing. Common types of particle radiation are alpha (helium nuclei), beta (electrons), neutron, and proton radiation.

Ionizing radiation originates from both nonhuman and human sources. Nonhuman or natural sources of ionizing radiation are cosmic rays and naturally occurring radioactive substances in Earth's crust, the human body, air, water, and food. The level of natural exposure varies around the globe, and cosmic radiation is more intense at higher altitudes. The total exposure from all natural sources is called natural background radiation. The natural background radiation is by far the greatest contributor to human exposure to ionizing radiation.

Some human activities can enhance the exposure from natural sources. Examples include radon gas from the soil that concentrates in buildings, mining, and the combustion of fossil fuels that contain radioactive substances. Aircraft passengers and crew are subject to higher levels of cosmic radiation at flight altitudes. Environmental contamination by radioactive residues come from atmospheric nuclear weapons tests (performed between 1945 and 1980), the Chernobyl accident (1986), and the operation of nuclear power plants. These activities contribute only a small fraction of the global average exposure to ionizing radiation.

The largest human-made exposures to ionizing radiation stem from medical procedures. Medical exposures include diagnostic exposures (such as X-ray examinations) and therapeutic exposures (as in tumor treatment). Occupational exposure to ionizing radiation affects workers in industry, medicine, and research. The level of occupational exposure is generally similar to that of the average natural exposure. A few percent of workers are exposed to radiation levels several times greater than the average natural exposure. A comparison between the average exposures from different sources of ionizing radiation is listed in Table 1.

The biological effects of ionizing radiation are generally well known. Ionizing radiation can cause cell death and acute harm to organs if sufficient numbers of cells are damaged. Another type of damage occurs in cells that are modified. This may lead to inheritable genetic changes and the development of cancer, which may manifest itself decades after exposure. Acute effects

TABLE 1

Annual Average per Person Effective Doses of Ionizing Radiation in Year 2000 from Natural and Human-made Sources

Source	Worldwide annual per person effective dose (mSv)	Range or Trend of Exposure
Natural background	2.4	Typically ranges from 1–10 mSv, depending on circumstances at particular locations, with sizeable population also at 10–20 mSv.
Diagnostic medical examinations	0.4	Ranges fron 0.04–1.0 mSv at lowest and highest levels of health care.
Atmospheric nuclear testing	0.005	Has decreased from a maximum of 0.15 mSv in 1963. Higher in northern hemisphere and lower in southern hemiphere.
Chernobyl accident	0.002	Has decreased from a maximum of 0.04 mSv in 1986 (average in northern hemisphere). Higher at locations nearer to accident site.
Nuclear power production	0.0002	Has increased with expansion of program but decreased with improved practice.

SOURCE: UNSCEAR (2000).

Range or trend of exposures from the different sources: Natural background typically ranges from 1–10 mSv, with sizable population also at 10–20 mSv. Diagnostic medical examinations ranges from 0.04–1.0 mSv at lowest and highest levels of health care. Atmospheric nuclear testing has decreased from a maximum of 0.15 mSv in 1963. Chernobyl accident has decreased from a maximum of 0.04 mSv in 1986 (average in northern hemisphere). Higher at locations nearer accident site. Nuclear power production has increased with expansion of programme but decreased with improved practice.

occur if the radiation dose is substantial (as in accidents), while it is believed that cancer and hereditary effects may be caused by the modification of a single cell. As the dose increases, the probability of these effects also increases.

The effects and penetration of ionizing radiation depend on the type of radiation. Exposure from ionizing radiation is therefore quantified by the effective dose, which is a measure that takes the type of radiation into account. The unit for the effective dose is the sievert (Sv). One sievert is a very large dose, and it is common to express the effective dose in millisieverts instead (1 mSv = 0.001 Sv). Sometimes the unit rem is used instead (1 rem = 0.01 Sv).

Epidemiological data argue for a linear relation between the dose and the cancer risk from ionizing radiation for intermediate dose levels. A linear dose–effect relation means that an increase in dose implies a corresponding increase in effect. Because of statistical limitations, the dose–effect relation cannot be determined for low doses. Therefore, the risks of low-dose ionizing radiation must be estimated based on knowledge of biological mechanisms that cause or inhibit cancer and inheritable defects. The dose–effect relation for low doses is important, because the exposure to the public or in normal work situations are in ranges where the risk is uncertain (below 50 mSv).

It is especially important to know if there is a threshold for the dose–effect relation for ionizing radiation. If there is no threshold, there is a (small) risk associated with even very low exposure levels. The prevailing scientific consensus, represented by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), is that a threshold is unlikely and that a linear dose–effect relationship for small doses is consistent with current knowledge about the mechanisms by which ionizing radiation causes harmful effects. This view is challenged by those who believe that there is a threshold (and thus no risk) for very low doses of ionizing radiation. Some even argue for a positive effect called hormesis at very low levels.

Setting Standards

Radiation protection from ionizing radiation is generally the same all over the world, because of the profound influence of the International Commission on Radiological Protection (ICRP), a nongovernmental organization whose recommendations are used by both national radiation protection authorities and international organizations as a basis for more detailed guidelines. The ICRP works under the assumption that the risk of cancer and hereditary effects from low doses of ionizing radiation is without a threshold and that the dose–effect relation is linear—the so-called linear, no threshold assumption. This approach to the risks of low-dose ionizing radiation can be seen as precautionary, although the assumption is supported by scientific knowledge.

The 1990 ICRP recommendations are based on a system of three principles: justification, optimization, and dose limitation. The justification principle states that no additional dose should be tolerated unless there is an associated benefit to the exposed individuals or to society that outweighs the detriment. Though the principle may seem obvious, its application gives rise to complex ethical issues. The concepts of benefit and detriment are difficult to define, and calculations are often associated with great uncertainties and errors. Other ethical issues include how the benefit for society can be weighed against the detriment to individuals, issues of free and informed consent, and who should make the decisions (for example, stakeholders or experts).

According to the optimization principle, total exposure should be kept as low as reasonably achievable (or ALARA), with economic and social factors taken into account. (Based on the acronym, this principle is sometimes called the ALARA principle.) What is reasonable depends on economic considerations, which means that doses need not be lowered further if the economic cost would be too high. The principle is thus a trade-off between economics and protection. Cost–benefit analysis has often been applied for optimization of protection, although the ICRP stresses that it is only one possible method.

The optimization principle does not consider the distribution of doses among individuals. A strict application of the principle may thus, at least in theory, lead to a situation in which a few individuals are exposed to substantially higher doses than others. The optimization principle can be seen as utilitarian or consequentialist, focusing on total rather than individual effects.

The dose-limitation principle requires that individual doses not exceed unacceptable levels. This principle can be seen as deontological, because it implies a duty to protect individuals from undue harm. In many cases, the optimization principle and the dose-limitation principle coincide, but there can be cases in which the two principles conflict. In the ICRP system such conflicts are resolved by first applying the dose-limitation principle and after that the optimization principle, deontology before utility.

Under the common assumption that cancer and hereditary effects do not have a threshold, a dose limit (above zero) cannot yield a completely safe level. The dose limits should, according to the ICRP, be regarded as the boundary to unacceptable doses, and protection should essentially be due to the optimization principle. As a dose limit cannot yield a wholly safe dose, a decision on a dose limit will always involve value judgments and ethical considerations. What is acceptable or not is a complex ethical issue, and judgments are not necessarily the same in all contexts.

The dose limits recommended by the ICRP are 1 mSv per year for the public and 20 mSv per year for occupational exposure. A special question regarding dose limits is why it is acceptable for workers to be exposed to higher risks than the public. This is an ethically problematic issue, not just for radiation protection. Arguments that have been used are that the limit for the general public concerns exposure for the whole life and not just the working life, and that the public includes children and other more susceptible individuals. Workers may also be informed of their exposure levels and thus voluntarily accept them, whereas the public has no alternative.

An important concept in radiation protection from ionizing radiation is the collective dose. The collective dose is defined as the mean dose for each individual in an exposed population multiplied by the number of individuals. There has been considerable controversy over what influence the value of the collective dose should have. Considerable collective doses can arise from exposure to large populations even if the dose to each individual is very low. This may be the case in global contamination from radioactive substances (such as in atmospheric nuclear weapons tests) or in contamination that stretches very far into the future. If the risk of cancer from ionizing radiation is proportional to the dose and without a threshold, it follows that the expected number of cancer cases is proportional to the collective dose. In spite of this, it has been argued that small individual doses should not pose a problem even if the collective dose is great.

Arguments to the effect that "risks ought to be disregarded if they are sufficiently small" are called *de minimis* arguments. Common arguments for calling risks *de minimis* are that they are trivial compared to other risks humans accept, that they are trivial in comparison to natural risks, or that they have to be disregarded in order to avoid the allocation of unreasonably large economic resources to investigate or manage them. It has often been claimed that risks with a probability on the order of magnitude of one in a million or smaller are *de minimis*. Nevertheless, such a general *de minimis* level is ethically problematic because it would allow many small risks that in combination may yield a large risk for an individual. Furthermore, many small risks to many people may also yield a large total effect. For example, exposing each of ten million persons to an independent risk of death of one per million yields ten expected fatalities. Also, the mathematical "law of large numbers" yields that the actual outcome will be around ten fatalities.

Another ethical problem in radiation protection arises from the long-term management of radioactive waste. Radioactive materials may be dangerous for hundreds of thousands of years, and mistakes made now may affect future generations. This problem is not exclusive to radioactive waste, because many other technological activities have consequences reaching far into future; examples include emissions that may lead to global climate change and damage to the ozone layer. The discussion regarding radioactive waste is nevertheless important, because many countries have not made final decisions for long-term management of the radioactive waste from nuclear reactors and/or nuclear weapons. The problem of distant future effects poses intriguing ethical problems. What is the moral status of future, nonexisting individuals and what duties do persons today have toward them? The International Atomic Energy Agency (IAEA) is of the opinion that radioactive waste should be managed in such a way that predicted impacts on the health of future generations will not be greater than today and that no undue burden is imposed on future generations.

PER WIKMAN

SEE ALSO *Chernobyl; Hormesis; International Commission on Radiological Protection; Regulatory Toxicology.*

BIBLIOGRAPHY

International Atomic Energy Agency (IAEA). (1996). *Radiation Protection and the Safety of Radiation Sources.* Vienna: Author. The foundation document of the IAEA system of protection.

International Commission on Non-Ionizing Radiation Protection (ICNIRP). (1998). "Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (Up to 300 GHz)." *Health Physics* 74(4): 494–522. Describes the rationale for the ICNIRP guidelines for limiting exposure to electromagnetic fields.

International Commission on Non-Ionizing Radiation Protection (ICNIRP). (2001). "Review of the Epidemiologic Literature on EMF and Health." *Environmental Health Perspectives* 109(suppl. 6): 911–933. An authoritative overview of the knowledge base for the risks from electromagnetic fields.

International Commission on Non-Ionizing Radiation Protection (ICNIRP). (2002). "General Approach to Protection against Non-Ionizing Radiation." *Health Physics* 82(4): 540–548. The foundation document of the ICNIRP system of protection.

International Commission on Radiological Protection (ICRP). (1992). *1990 Recommendations of the International Commission on Radiological Protection.* Oxford: Pergamon Press. The foundation document of the ICRP 1990 system of protection that has had a profound influence on radiation protection internationally.

Lindell, Bo. (1985). *Concepts of Collective Dose in Radiological Protection: A Review for the Committee on Radiation Protection and Public Health of the OECD Nuclear Energy Agency.* Paris: Organisation for Economic Co-operation and Development, Nuclear Energy Agency. A detailed guide to the concept of collective dose, and related ethical issues.

Silini, Giovanni. (1992). "Ethical Issues in Radiation Protection: The 1992 Sievert Lecture." *Health Physics* 63(2): 139–148. Reviews ethical issues that have been considered in the development of radiation protection from ionizing radiation.

Sowby, David, and Jack Valentin. (2003). "Forty Years On: How Radiological Protection Has Evolved Internationally." *Journal of Radiological Protection* 23(2): 157–171. An overview of international organizations in radiation protection and the development of the ICRP recommendations since 1950.

Taylor, Lauriston S. (1980). "Some Nonscientific Influences on Radiation Protection Standards and Practice: The 1980 Sievert Lecture." *Health Physics* 39(6): 851–874. A classic text on more philosophical aspects of radiation protection by one of the first members of ICRP.

United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). (2000). *Sources and Effects of Ionizing Radiation: UNSCEAR 2000 Report to the General Assembly, with Scientific Annexes.* 2 vols. New York: United Nations. An authoritative overview of the knowledge base for the risks from ionizing radiation.

Wikman, Per. (2004). "Trivial Risks and the New Radiation Protection System." *Journal of Radiological Protection* 24(1): 3–11. Examines ethical and philosophical aspects of a novel way of thinking in radiation protection.

RADIO

Radio includes a broad group of technologies that utilize electromagnetic radiation (also called radio waves) to transmit and/or receive information. Examples of radio technologies can be drawn from numerous industries, applications, and end users. A partial listing would include radio (and television) broadcasting, maritime communications, radio navigation, cellular telephony, satellite communications, numerous military applications, wireless computer networking, noncontact identification systems, military and meteorological radar, global positioning systems, and radio astronomy (see Figure 1).

What all these systems have in common is the conversion of electrical energy from one form into another, specifically, from electrical currents bound in conduc-

Figure 1: Part of the Very Large Array (VLA) radio telescope operated by the National Radio Astronomy Observation in Socorro, New Mexico. The VLA is capable of receiving extremely faint energy from extragalactic sources. *(JLM Visuals.)*

tive materials such as wires and cables into unbounded electromagnetic radiation that is free to propagate through space, the atmosphere, or another nonconducting medium. This is the process of radio transmission. Radio reception is the reverse process, in which incoming electromagnetic radiation is converted into electrical currents in the antennas, wires, and components of a radio receiver.

Historical Developments

The following material is a brief history of the development of radio technology with an emphasis on related ethical, political, and legal issues. This history draws on Christopher Sterling and John Michael Kittross's *Stay Tuned* (2002).

The background of radio was the earlier practical development of wired electronic signal transmission and reception, as in the telegraph (1830s and 1840s) and James Clerk Maxwell's electromagnetic theory (1860s), which was confirmed by Heinrich Hertz's laboratory experiments (1880s). It was his ability to draw on those previous achievements that enabled Guglielmo Marconi (1874–1937) (see Figure 2) to transmit and receive the first wireless telegraph messages in 1895, an experiment that he followed up with wireless transmissions across the English Channel (1899) and the Atlantic (1901).

The rapid development of radio led in 1910 to the Wireless Ship Act in the United States, which required a radio and an operator on all oceangoing passenger vessels. Through World War I the U.S. Navy continued to control radio facilities, while the U.S. Congress debated the future government role in relation to the new technology. Shortly after the war, in 1921, thirty broadcasting stations went on the air, using only two frequencies or channels.

In 1922 President Herbert Hoover hosted the first radio conference, which called for government regulation of radio technology, limited advertising, and classification of radio stations by the services they provided. Two years later the British physicist Sir Edward Victor Appleton conducted the first experiment with radio range-finding equipment, reflecting radio waves off the ionosphere to determine its height. This was an important step in the development of radar.

Later in the 1920s President Calvin Coolidge signed the Radio Act of 1927, establishing the Federal Radio Commission (FRC). In that decade the National Association of Broadcasters issued a code of radio advertising and programming ethics.

In 1932 the engineer Karl Jansky discovered a strong source of radio noise that later was discovered to originate outside the solar system; this marked the beginning of radio astronomy. In 1934 the Federal Communications Commission (FCC) was established to replace the FRC. Later in the decade, in 1937, the first practical mobile radio, the DR38a transmitter-receiver, was developed.

During World War II both Axis and Allied engineers made significant advances in land, mobile, maritime, and airborne radio as well as radar. After the war, in 1948, scientists at Bell Laboratories demonstrated the potential uses of the transistor. Between 1945 and 1960 numerous television stations began broadcasting coast to coast, linked by microwave radios.

The year 1958 marked the invention of the integrated circuit. In the 1960s the concept of a broadband mobile telephone system was outlined. In 1969 the first frequency-resuing commercial cellular system was used on trains running from Washington to New York. By the 1980s analog cellular telephone use had become widespread. Digital cellular systems with increased capacity were introduced in the 1990s. Another significant development was the FCC auction of spectrum for the Personal Communications Services (PCS) band.

The Radio Frequency Spectrum as a Limited Natural Resource

The electromagnetic spectrum contains frequencies from below 1 Hertz (one cycle per second) to above 1025 Hz. However, a much smaller subset of those frequencies lend themselves to terrestrial radio systems. Although there is not universal agreement on the boundaries, the "radio spectrum" is the subset of the electromagnetic spectrum with frequencies from 100,000 Hz to 100 GHz (105 to 1011 Hz).

The lower end of the radio spectrum is less suited for most communications applications. The rate at which information can be transmitted (the data rate) becomes lower as the frequency decreases. This does not mean that low-frequency waves travel through space more slowly because all electromagnetic radiation travels at the speed of light. However, the theoretical rate of information transfer decreases with decreasing frequency. This gives rise to a lower limit to the frequency band that can be used for most radio systems. Additionally, the ionosphere becomes opaque at lower frequencies, limiting some applications, although enhancing others.

At higher frequencies the entire atmosphere (not just the ionosphere) becomes opaque except for a few "windows" in which electromagnetic radiation is free to propagate without being absorbed significantly (see Figure 3). There is an optical window (the atmosphere is transparent to the frequencies human eyes can detect), and there is a radio window. Transmission of signals at frequencies above this window are absorbed or scattered rapidly by the atmosphere, similarly to the way fog limits visible frequencies. The opaque nature of the atmosphere at higher frequencies establishes an upper limit to the radio spectrum; thus, the radio spectrum is capped in its upper and lower ends. This means that the radio spectrum is a limited natural resource. Because of its immense importance and finite nature, the radio spectrum presents significant distributive justice issues.

Ethics, Politics, and Law

The ethical, political, and legal aspects of radio can be arranged in a four-fold taxonomy. Although there is significant overlap amongst the categories, they are useful in conceptualizing the major issues and highlighting the important ethical traditions pertaining to radio development and use.

First, there are issues surrounding the technological development of radio that pertain to topics in engineering ethics. For example, the use of radio for military applications and growing concerns about the health effects of electromagnetic frequencies present ethical challenges to engineers who are responsible for upholding the safety, health, and welfare of the public.

Second, radio content and use issues instantiate several aspects of broadcast journalism ethics as they place responsibilities on program directors, journalists, and radio managers. These obligations are traditionally formalized in codes of ethics such as the NAB code of radio advertising and program ethics and the Radio-Television News Directors Association (RTNDA) code of ethics, which states that electronic journalists ought to serve as trustees of the public reporting the truth with fairness, integrity, and independence.

Third, the broader cultural and societal impacts of radio raise issues explored in the philosophy of technology and the field of Science, Technology, and Society (STS) studies. Radio technologies reciprocally interact with various elements of culture to co-produce societal

Figure 2: Guglielmo Marconi, considered the father of radio. *(Hulton-Deutsch Collection/Corbis.)*

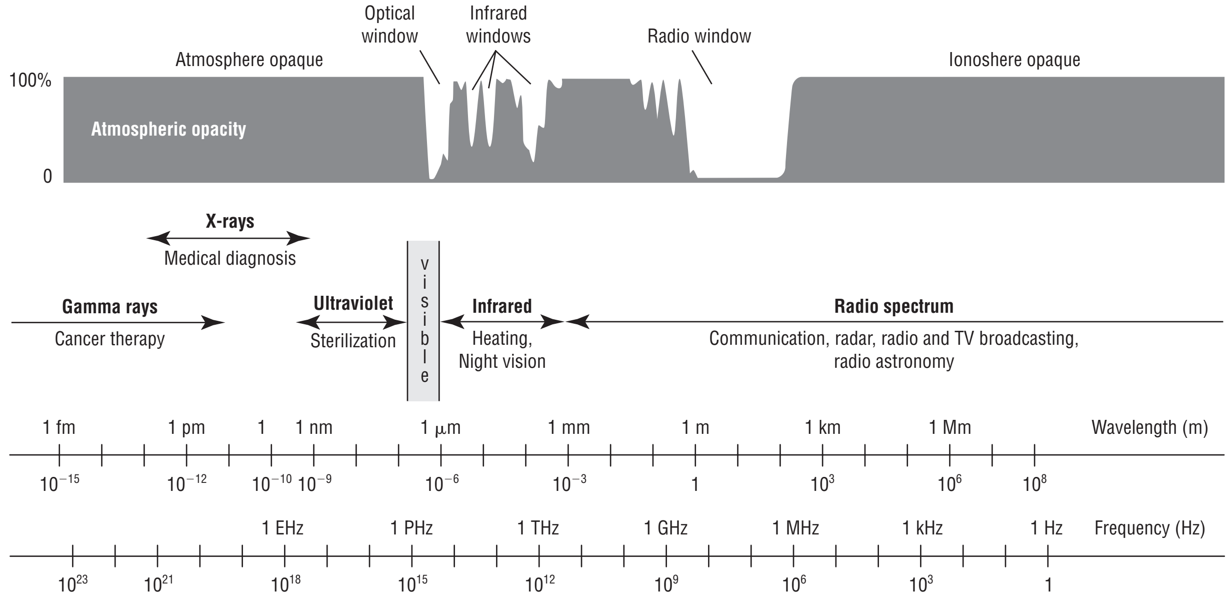
changes and personal life experiences. In the United States, for example, conservative talk radio programs have exerted massive influence over the political landscape and Christian programming has also come to dominate certain markets, which has influenced conceptions about religion in the public sphere. Such developments underscore the idea that radio is not a neutral medium, but rather an active agent that is used to selectively broadcast some voices and messages rather than others. It is a political and cultural force, albeit somewhat eclipsed by television. Interestingly, the rise of opinion and advocacy programs on radio seemed to foreshadow a general shift in media (furthered by the Internet and the "blogosphere") away from trust in a few supposedly neutral broadcast centers to a variegated spectrum of information streams.

Lastly, questions of how radio should be used and regulated raise fundamental issues from political philosophy such as distributive justice, the proper relationship between government and private enterprise, censorship and the proper limits to freedom of speech, and the concentration of corporate control over media.

As a common resource, it has been widely maintained that the radio spectrum must be centrally regulated to insure fairness and efficiency. For example, the International Telecommunication Union (ITU) is a regulatory body within the United Nations system that helps coordinate global telecommunications networks and services. Additionally, each country has its own national frequency allocation plan. In Germany, for example, each state exercises its own authority over radio broadcasting rather than a centralized federal entity. In the United States that plan is administered by the FCC. The FCC is an independent government agency, directly responsible to Congress, which plans, allocates, and monitors the use of the radio spectrum for nongovernment users. FCC rules pertaining to free speech and censorship tend to raise the most public controversy, especially those relating to indecency, obscenity, and profanity. These rules do not apply to satellite and cable broadcasting. The National Telecommunications and Information Administration (NTIA) is responsible for the allocation and assignment of frequencies for use by the federal government The national frequency allocation plan divides the spectrum into a

FIGURE 3

The Electromagnetic Spectrum and the Opacity of the Earth's Atmosphere



SOURCE: Ulaby, Fawwaz T. (2001). *Fundamentals of Applied Electromagnetics*. Upper Saddle River, NJ: Prentice-Hall, p. 20.

The electromagnetic spectrum and the opacity of the earth's atmosphere. The optical and radio windows are frequency bands transparent to electromagnetic radiation.

multitude of frequency bands, reserving bits of spectrum for different types of users and reducing channel interference. It plays a vital role in balancing the often conflicting needs of commercial, military, scientific, and educational uses.

Although some level of government regulation may be necessary, many advocate further deregulation in order to capture the benefits of market competition and avoid inefficiency, corruption, or other unethical practices by centralized bureaucrats. Others, however, fear that deregulation will lead to further corporate monopolization of local markets. In the United States, concerns are developing that the increased corporate consolidation of radio diminishes its locality, threatens the democratizing value of free and independent communication, homogenizes music play lists, and undermines journalistic quality.

Similar debates about the proper roles of private and public or community radio sparked the 1967 creation of the U.S. Public Broadcasting Act, which established the Corporation for Public Broadcasting (CPB). The CPB receives annual appropriations from Congress to support independent local stations and National Public Radio (NPR), which was established in 1970. Although this helps defend the independence, integrity, and diversity of radio journalism, it also raises accountability issues about the use of federal funds.

College and community listener sponsored radio stations also attempt to secure independence and diversity at the fringes of corporate media conglomerations. In 2000, the U.S. government began issuing licenses for low-power (below 100 watts) radio stations partially to provide another avenue for local communities (especially low-income and minority) to obtain diverse, community-oriented information. Most of these licenses have been obtained by rural communities and churches, and they have not had the expected impact on urban areas that are most dominated by commercial radio. Concerns have been raised that Christian stations are monopolizing these markets, thus producing the same drawbacks from consolidation. There is also some concern that these stations interfere with broadcasts from bigger stations. Furthermore, many low-power radio broadcasts still operate illegally as "pirate" stations. Some of these stations are switching to internet broadcasts in attempts to avoid federal lawsuits.

Current Trends

As more uses of radio technologies are conceived, developed, and marketed (e.g., cell phones and wireless internet connections) and as demand for existing uses continues to grow, the radio spectrum will become increasingly crowded. Interference among users will become increasingly difficult to avoid and solve. Modulation schemes that are more tolerant of interference such as spread spectrum–based technologies should see increased use, as should hardware-based solutions such as more sophisticated filtering. Spectral crowding also will result in the continued migration toward higher frequencies despite the greater atmospheric attenuation and other technological obstacles. Finally, both the general public and those involved in the technical industries will be forced to become more aware of the limits of the radio spectrum, the importance of coordination and regulation, issues involving radio interference, and spectral crowding.

J. BRIAN THOMAS

SEE ALSO *Advertising, Marketing, and Public Relations; Communication Ethics; Communication Systems; Entertainment; Networks.*

BIBLIOGRAPHY

Kobb, Bennett. (2001). *Wireless Spectrum Finder: Telecommunications, Government, and Scientific Radio Frequency Allocations in the U.S., 30 MHz–300 GHz,* 6th edition. New York: McGraw-Hill.

Kraus, John D. (1986). *Radio Astronomy*, 2nd edition. Powell, OH: Cygnus-Quasar.

Radio Astronomy: Observing The Invisible Universe. (1999). Video. Produced by Dick Young Productions, New York, NY, for the National Science Foundation, USA.

Reed, Dana George, ed. (2001). *The ARRL Handbook for Radio Amateurs*. Newington, CT: American Radio Relay League.

Sterling, Christopher H., and John Michael Kittross. (2002). *Stay Tuned: A History of American Broadcasting,* 3rd edition. Mahwah, NJ: Lawrence Erlbaum.

RAILROADS

Railroads use flanged wheels rolling over fixed rails for human transportation; the vehicles on these rails are commonly called *trains* because they are usually composed of a train of cars linked together. Trains have distinct characteristics that have called for specialized legal and policy regulation, and to some extent for the application of ethical principles.

Prior to the development of steam locomotion, early horse-drawn trains ran on tracks serving mines, where the ground was otherwise too uneven for wheeled vehicles. The first horse-drawn trains began operating at English coal mines in the 1630s. In 1758, the British Parliament established the Middleton Railway in Leeds; it began to adopt steam locomotives in 1812. The Middleton Railway claims to be the oldest railway in the world; however, at this time it carried only freight, not passengers. The first public steam-operated passenger railway was the Stockton & Darlington in England, which began operations in 1825. Commenting on railroad developments and aspirations at the time, the *English Quarterly Review* wrote: "What can be more palpably absurd and ridiculous than the prospects held out of locomotives traveling *twice as fast* as stagecoaches! We should as soon expect the people . . . to suffer themselves to be fired off on . . . [a] rocket, as to put themselves at the mercy of such a machine, going at such a rate" (Bianculli 2001, vol. I, p. 15).

The Nineteenth Century Experience

Early American railroads competed with canals, packet steamers, stagecoach lines, and turnpike companies for investment. Government did not immediately intervene on the side of the new technology; as late as 1856, the Erie Canal was subsidized by a tax on rail traffic. Local interests did not always want the railroad in the early years. Farmers tended to oppose them because the locomotives set fire to crops, scared livestock, and, most significantly, brought in cheap produce from elsewhere to compete with local products.

In February 1815 the New Jersey legislature passed the first railroad charter in the United States, authorizing a horse-drawn train to connect Trenton and New Brunswick. During the 1820s, almost every state granted railroad charters. John Stevens (1749–1838) built the first successful American steam locomotive in 1825, the same year the Stockton & Darlington began operation in Great Britain.

From the outset, an excitement for the technological possibilities was attached to railroad development that drove an unprecedented rush of development and adoption. Trains were seen as powerful tools and symbols of nation building. Just two years after the opening of the Stockton & Darlington, the Baltimore & Ohio was chartered as the first westward-bound railroad in the United States; and in 1831, President Andrew Jackson (1767–1845) in a message to Congress portrayed railroads as the binding force that would hold the most remote parts of the new nation together. A French

New York, New Haven, and Hartford diesel engine. *(Library of Congress.)*

observer remarked, "The American seems to consider the words democracy, liberalism, and railroads as synonymous terms" (Bianculli 2001, vol. I, p. 17). Jackson later became the first U.S. president to ride a steam-powered train.

In 1830 the Baltimore & Ohio began operations, pulled initially by horses and mules, switching to its steam locomotive, the "Tom Thumb," a few months later. A New York City to Washington line was in place by 1840, and a decade later, the country had 9,000 miles of track in service. Railroads permitted the development of urban centers not on rivers, and most railroad development was east-to-west, connecting rivers to each other instead of running parallel to them. However, most early railroads were short, local, and did not connect to one another.

Railways were the most capital-intensive enterprise the world had ever seen, far exceeding mills. They largely drove the development of the joint-stock company and therefore of modern Wall Street-style finance.

From scarcely twenty-five miles of public railroad worldwide in 1825, the mileage grew to over 160,000 miles in fifty years, with approximately one third of that being in the United States. As American eyes looked to the west, the railroads took on a new importance as the tool by which western lands would be secured to the Union and then controlled. In addition to other financial incentives, the federal government offered railroads ten to twenty square miles of adjoining land for every mile of track built. This resulted in the grant of 338,000 square miles to the railroads, which then realized additional profits developing or selling this land or leasing it out. In some cases, these land grants emboldened the railroads to lay track away from the nearest large towns, confident new towns would develop right alongside. In other cases, the railroads demanded subsidies from towns in order not to bypass them. When San Bernardino refused to pay the Southern Pacific, the railroad created the town of Colton, California, just five miles away.

A race began to finish the transcontinental railroad; the Union Pacific, originating at Omaha, Nebraska, headed west, while the Central Pacific, beginning in Sacramento, laid track east. The two competitors bickered over where the lines would meet; if the Ulysses S. Grant (1822–1885) administration had not intervened to force both roads to accept a meeting place in Utah, they would have ended up running parallel to one another for some 1,500 miles. The transcontinental railroad was completed in 1869.

From 1870 through about 1890, the railroads played a major role in the settlement of the west. In this twenty-year period, the Denver population increased from 5,000 to 107,000, while Minneapolis went from a town of 13,000 people to one of 164,000. But already by 1871, land grants were a fertile source of political scandal, with accusations that the railroads were charging exorbitant fees and foreclosing on tenants who could not pay.

The nineteenth-century railway was a major tool of nation-building and national identity. Canadian technology and media philosopher Harold Innis saw the railway as a bulwark of centralization, territorial expansion, nationalism, and state authority. Like the United States, Canada also was consolidated by the building of a transcontinental road, which reinforced the new nation's extremely tenuous control west of Ontario. "[T]he drive for railways embodied a sense of divine purpose, a mission to conquer the surrounding wilderness, that made the colonists, rather unexpectedly, less British and more American" (den Otter 1997, p. 12). For cultural historian Wolfgang Schivelbusch (1986), by forcing the creation of time zones to help schedule train traffic and turning journeys across great distances into well-ordered experiences, the railroad brought about the industrialization of time and space.

The Twentieth Century

From 1850 to about 1950, trains were the primary means of inland transport, but in the age of automobiles and airplanes there is some question as to whether trains are still needed. Unlike Europe, where the train has deep aesthetic, environmental, and cultural appeal, the United States flagged in its commitment to a national railway system. They are "of marginal utility and relevance to most people . . . more nostalgia than interest" (Perl 2002, p. 1). In the United States, those who defend the perpetuation of rail lines often do so on sentimental and historical grounds, though environmental arguments (that each train obviates the hydrocarbon emissions of a number of automobiles and trucks) are also applicable. Trains were already perceived as a fading technology in the United States as early as the 1940s, as government aggressively supported the automobile by building highways everywhere.

In the face of competition from the car and later from the passenger airline, private American railroads in the 1950s began to close down passenger service while maintaining the more lucrative freight contracts. Although state railroad boards sometimes fought aggressively to preserve passenger service, regulatory responsibility shifted to the federal Interstate Commerce Commission, which agreed that the train was of declining utility. From 1958 to 1971, about 75 percent of passenger train mileage was abandoned by the railroads. But at the same time it became harder for them to compete with trucks and aviation in the freight business, and the railroad share of intercity freight declined from 68 percent in 1944 to 44 percent in 1960.

When automobiles and then airplanes first became prevalent, the railroads struggled to cover their fixed costs (track building and maintenance) out of a declining revenue. By contrast, automobile and aviation interests never became financially responsible for their entire infrastructure: Automobile manufacturers and trucking companies did not own the highways, airlines did not build airports. The infrastructure they require is paid for with public money, while the railroads had long been responsible for their own costs.

The Amtrak Corporation was founded in 1971 with $25.4 billion in federal subsidies and grants, as a response to the frightening bankruptcy of the Penn Central Railroad, which had been losing $375,000 a day on its passenger service. Amtrak took over passenger lines from twenty participating railroads, which were offered a choice of stock in Amtrak or a tax break. Only one tax-paying railroad chose the stock. At the time, the National Association of Railroad Passengers said that Amtrak was "operated by people who don't want it to succeed." Amtrak was also described as a "policy blocker," preventing more radical legislation (Perl 2002, p. 99). Amtrak has been a failure as a commercial entity, losing much more money than anyone anticipated. As of early 2005, the George W. Bush administration was proposing that Amtrak receive no further funding from the federal government.

Aesthetic and environmental considerations aside, trains only make sense if they provide speed and convenience equal to or greater than automobiles, at less cost than airplanes. Japan has succeeded in creating high-speed rail lines that connect directly to airports and travel more rapidly than cars. The trend at Amtrak has been the opposite. After debuting the Metroliner, which went from New York to Washington in under three hours, Amtrak has slowed this train down so that it is barely faster than the regular, less expensive service.

Anthony Perl (2002) notes that passenger railroads suffer from the perception that they should be profit-making entities rather than a national service. No one complains that New York subway fares only cover 71 percent of the cost of operating the system, while Amtrak is considered a failure for recouping 78 percent of its costs.

Public Service or Private Enterprise?

The question of whether trains should be a public service or private enterprise has played out most dramatically in Great Britain, where the nationalization of British Rail during the Thatcher era was based on the premise that "private = good, public = bad" (Murray 2001, p. 2). Andrew Murray describes the nationalization of British Rail as privatization run amok, a solution without a problem, since the entity that was replaced had a very high record of safety and reliability. It has been supplanted by a strange patchwork of several principal players and hundreds of subsidiary ones, with the tracks all owned by one entity, Railtrack, the rolling stock placed in separate leasing companies and leased back to franchisees, and maintenance and repair services sold to thirteen other companies that subcontract much of the work. The piece most visible to the public—the franchisee train operators, which include several of Britain's major bus companies and also Virgin Airways—own nothing except their trademarks.

The result has been a substantial increase in bureaucracy, decline in decisiveness and speed of decision-making, and a general lack of cooperation among the various entities. Examples include the fact that operators will no longer wait for connecting trains to arrive (they pay a fine if they start late, regardless of the reason); tickets on one line are not accepted on competing lines rolling over the same tracks, so if you miss your connection to London you often cannot go out on the next train without buying another ticket; substantial increases in overtime, and therefore in exhausted workers driving trains, as the lines make their declining base of experienced employees work harder, rather than hiring and training additional ones; and a terrible lack of interest in safety measures unless mandated by government. Some train crashes have resulted, with substantial loss of life and stories of safety systems switched off or malfunctioning. Murray is skeptical that these problems can be solved without re-nationalizing the railroads.

The history of trains, like that of dams and other nineteenth-century technologies, describes an arc from symbol of political and economic power to a nostalgia-supported technology left behind in a strictly technological competition with other interests and solutions. The future of trains will depend very much on the practicality of new technological innovations to make them compete effectively with automobiles, at prices that make sense. Without massive federal subsidies and a major change in governmental thinking, trains may not prevail for environmental or sentimental reasons alone.

JONATHAN WALLACE

SEE ALSO *Bay Area Rapid Transit Case; Roads and Highways; Ships.*

BIBLIOGRAPHY

Bianculli, Anthony J. (2001). *Trains and Technology: The American Railroad in the Nineteenth Century*, 3 vols. Newark: University of Delaware Press. A detailed technological history of nineteenth century steam locomotion.

den Otter, A.A. (1997). *The Philosophy of Railways: The Transcontinental Railway Idea in British North America*. Toronto: University of Toronto Press. Describes the social impact of Canadian railway building.

Innis, Harold Adams. (1971). *A History of the Canadian Pacific Railway*. Toronto: University of Toronto Press. Technology philosopher Harold Innis, a predecessor of Marshall McLuhan, analyzes the impact of the railroad on conceptions of nationhood, distance and time.

Murray, Andrew. (2001). *Off the Rails: Britain's Great Rail Crisis—Cause, Consequences, and Cure*. London: Verso. A sarcastic and lively analysis of the effects of railway privatization in Great Britain.

Perl, Anthony. (2002). *New Departures: Rethinking Rail Passenger Policy in the Twenty-first Century*. Lexington: University of Kentucky Press. An analysis of the results of the nationalization of U.S. passenger service via creation of the Amtrak Corporation.

Schivelbusch, Wolfgang. (1986). *The Railway Journey: The Industrialization of Time and Space in the Nineteenth Century*, trans. Anselm Hollo. Berkeley: University of California Press. Original German publication, 1977.

RAIN FOREST

The ethical and policy issues associated with rain forests are doubly related to technology and science: While technology has provided the tools for cutting down rain forests, science has produced knowledge about their importance that leads to the questioning of such practices.

If one compares maps of the world featuring maximum biodiversity, deserts, and desertification (for example, putting side by side Mittermeier et al., *Hotspots* [2000], p. 19; the *Encyclopedia of Deserts* [1999], inside cover; and the *World Atlas of Desertification* [1997], pp. 44–45), the most striking feature is the proximity of maximum and minimum biodiversity in well-defined bands that circle the globe—because of the heat of the sun at the Equator and related atmospheric and climate effects. That is, the areas that contain the highest levels of biological diversity are almost all endangered to a high degree as well.

Kathlyn Gay (2001) introduces her summary of worldwide research and activism on rain forests by describing tropical rain forests as those close to the Equator and characterized by a minimum of 80 to 120 inches of rainfall per year that make up 6 percent of the surface of the Earth. These are found in parts of Central and South America, Africa, Asia, and the United States, with the best-known being in Amazonia. Others are located in Papua New Guinea, the islands of Madagascar, Malaysia, Thailand, Mexico, Colombia, and Ecuador. Gay's book covers temperate rain forests as well, such as those in the Pacific Northwest of the United States and Canada. With respect to either kind, tropical or temperate, the reason for researcher and activist interest is the impact of forests on climate, including precipitation, soil, and the carbon cycle so necessary for terrestrial life. Decimation of the rain forests would have a lasting impact on world climate, and would also affect winds, rainfall, and heat patterns, especially in the rich equatorial band around the globe.

Deforestation as Problem

Deforestation is a particularly difficult issue in certain areas. The best-known problem area is the Amazon rain forest. Susanna Hecht and Alexander Cockburn (1989) claim that Amazon deforestation is based in the policies of post-World War II Brazilian military governments. In 1964 Brazil began a massive interior settlement program that promoted forest clearing for cattle ranching. Much of the clearing also took place near gold strikes, since cattle grazing allows "large amounts of land—and the mineral rights below it—to be claimed with minimal labour" (Gay 2001, p. 46). Clearing also undermined rubber tapping in the forests, stimulating the rubber tapper Chico Mendes (1944–1988) to highlight the manifold social and environmental problems being created by deforestation (Burch 1994). His murder helped stimulate creation of the World Rainforest Movement (founded 1986) that has criticized the UN Food and Agricultural Organization (FAO) and World Bank support for national forest clearing initiatives (World Rainforest Movement 1992).

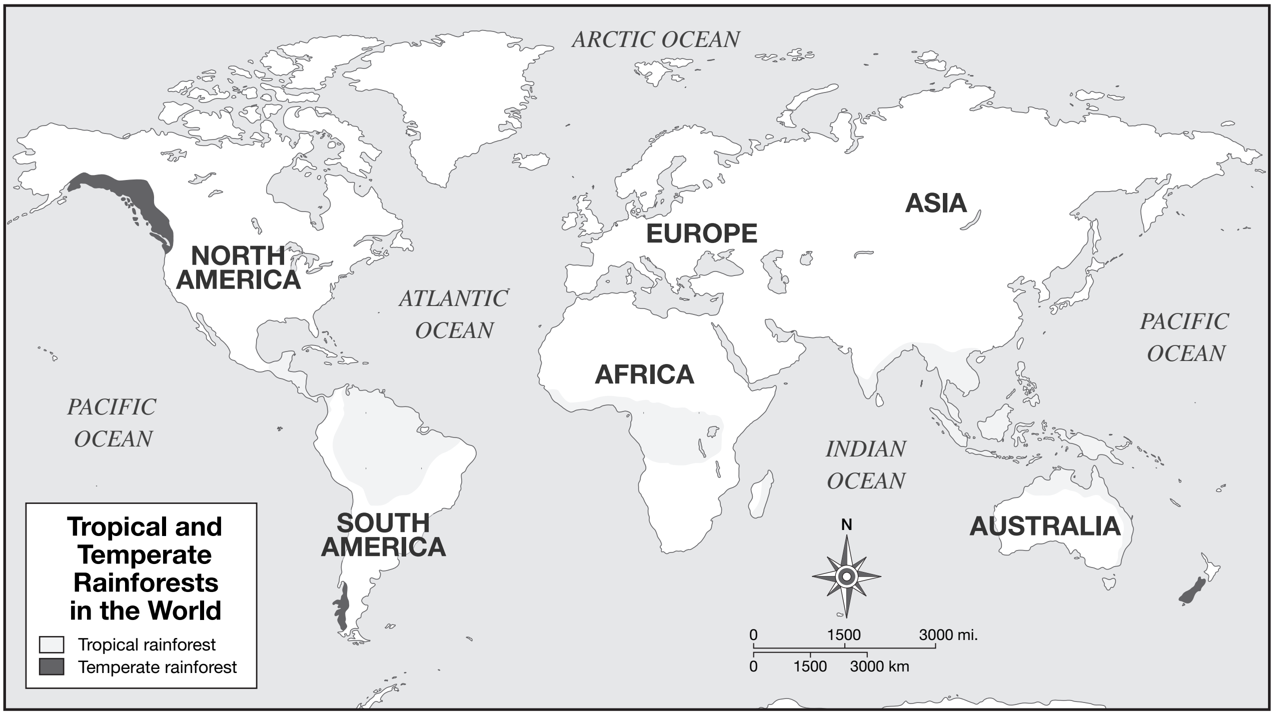
Focus on the human dimension of deforestation is further emphasized in *Tropical Deforestation* (1996), which makes the sweeping claim that "government management of forests often results in deforestation, whereas local community management of forests is usually more likely to contribute to forest conservation" (Sponsel, Headland, and Bailey 1996, p. xx) This broad conclusion is based on anthropological studies that detail work in Mayan Mexico, Polynesia, India, Kenya and other areas of Africa, the Philippines and New Guinea, as well as Madagascar, the Amazon, and other areas of Central and South America.

A more extensive discussion of the problem is provided by Sing Chew (2001), who traces ecological tragedies from 3000 B.C.E. to the year 2000 C.E., under a series of imperial regimes. Chew argues that in every case, from ancient Mesopotamia through Greece and Rome to the Portuguese and Spanish Empires and later European imperialism, deforestation was a constant concomitant of political aggrandizement and empire building—along with the continuing rise in population.

Sustainable Possibilities

Few scholars challenge the link between government policies and deforestation. But some observers such as Bjørn Lomborg, while admitting that overexploitation may be taking place, nevertheless argue that the situation has been exaggerated. For instance, although in 1988 the Brazilian space agency announced that its satellites showed 7,000 fires destroying 2 percent of the Amazonian rain forest per year, subsequent corrections reduced this figure to 0.5 percent, and "in actual fact, overall Amazonian deforestation has only been about 14 percent" since humans arrived (Lomborg 2001, p. 114). Such figures raise important questions of scientific ethics and responsibility on many sides of this important issue.

A number of other scientists, especially environmental economists, argue that tree cutting—even timber harvesting on a large scale—can be managed sustainably. Eberhard Bruening, for example, maintains that it is possible "to mimic nature and utilize inherent ecosystem dynamics and indeterminism to improve self-sustainability and economic viability" (Bruening 1996, p. x). Bruening is not overly optimistic that current managers and their government supporters can do this, but he thinks matters could change if *community-oriented*



forestry were initiated or expanded. (In Bruening's opinion, it has begun in some places including Sarawak in Southeast Asia.) Others emphasize forest-related activities that may prove more profitable than cutting trees in rain forests. For example, Douglas Southgate (1998) discusses ecotourism and its successes in Costa Rica, along with that country's genetic prospecting agreements, debt-for-nature swapping, and offers to serve as a *sink* for other countries in carbon-sequestration trading deals. (Activity in Nicaragua and Guatamala underlie similarly optimistic assessments of profitable alternatives, as described at length by Olman Segura-Bonilla [2000]).

In terms of science, technology, and ethics as related to rain forests (especially tropical rain forests), there is a broad consensus (represented here by Gay) that unethical forest management policies and practices have been implemented by governments since the Bronze Age. The science to support this claim, usually deforestation mapping from satellites, points to continuing tree cutting in spite of environmentalists' outrage—although the precise extent is contested. Indeed others argue that *sustainable management* (of tree cutting) is possible, even in tropical rain forests, provided that scientifically sound forest management practices are employed (Bruening 1996). Proponents of this theory also point to the ever-increasing demand for wood and wood products in the world economy, adding that rain forests can be economically productive in other ways—some even as alternatives to deforestation.

PAUL T. DURBIN

SEE ALSO *Biodiversity; Deforestation and Desertification; Ecological Restoration; Ecology; Environmental Ethics; Environmentalism; Global Climate Change; Sierra Club; United Nations Environmental Program; Water.*

BIBLIOGRAPHY

Bruening, Eberhard F. (1996). *Conservation and Management of Tropical Rainforests: An Integrated Approach to Sustainability*. Wallingford, England: CAB International.

Burch, Joann Johnson. (1994). *Chico Mendes, Defender of the Rainforest*. Brookfield, CT: Millbrook.

Chew, Sing C. (2001). *World Ecological Degradation: Accumulation, Urbanization, and Deforestation 3000 B.C.–A.D. 2000*. Walnut Creek, CA: Alta Mira.

Gay, Kathlyn. (2001). *Rainforests of the World*, 2nd edition. Santa Barbara, CA: ABC-CLIO.

Hecht, Susanna, and Alexander Cockburn. (1989). *The Fate of the Forest: Developers, Destroyers and Defenders of the Amazon*. London: Verso.

Lomborg, Bjørn. (2001) *The Skeptical Environmentalist: Measuring the Real State of the World*. New York: Cambridge University Press.

Mares, Michael A., ed. (1999). *Encyclopedia of Deserts*. Norman: University of Oklahoma Press.

Middleton, Nick, and David Thomas, eds. (1997). *World Atlas of Desertification*, 2nd edition. London: Arnold.

Mittermeier, Russell A.; Norman Myers; Cristina Goettsch Mittermeier; and Patricio Robles Gil. (2000). *Hotspots*, CEMEX, Conservation International; and Chicago: University of Chicago Press.

Segura-Bonilla, Olman. (2000). *Sustainable Systems of Innovation: The Forest Sector in Central America*. Aalborg, Denmark: University of Aalborg.

Southgate, Douglas. (1998). *Tropical Forest Conservation: An Economic Assessment of the Alternatives in Latin America*. New York: Oxford University Press.

Sponsel, Leslie E.; Thomas N. Headland; and Robert C. Bailey. (1996). *Tropical Deforestation: The Human Dimension*. New York: Columbia University Press.

World Rainforest Movement. (1992). *Rainforest Destruction: Causes, Effects and False Solutions*. Penang, Malaysia: Author.

RAMSEY, PAUL

Theologians are often marginalized in public discussions about contemporary social, political, scientific, and technological issues in the United States. (Robert) Paul Ramsey (1913–1988) reminds us of an earlier era when particularly able American theologians were public intellectuals taken seriously by policy makers, the media, and members of the general public.

Life

Born the son of a Methodist minister in Mendenhall, Mississippi, on December 10, Ramsey would always maintain his Methodist connections but follow the path to a public pulpit as one of the leading ethicists of his generation. A 1935 graduate of Millsaps College in Jackson, Mississippi, he published his first essay that same year as a newly appointed teacher of history and social sciences at his alma mater. Departing in 1939 for Yale University, he graduated a year later with a bachelor of divinity degree and continued toward his Ph.D. As he studied under H. Richard Niebuhr (1894–1962), he moved away from the liberal idealistic theology he had acquired at Millsaps and adopted the theological realism of his mentor and the latter's equally well-known brother, Reinhold Niebuhr (1892–1971) at Union Theological Seminary in New York City.

After serving as an assistant professor of Christian ethics at Garrett Biblical Institute in Evanston, Illinois, and completing his Ph.D. at Yale, in 1944 he joined Princeton University where he was eventually (in 1957) appointed as the Harrington Spear Paine Professor of Religion. On retirement from Princeton, he continued work at the independent Center for Theological Inquiry until his death. He was elected a member of the Institute of Medicine (1972) for his pioneering contributions to bioethics, an unusual distinction for a theologian. He died on February 29 in Princeton, New Jersey. His papers reside in the Duke University Library.

Christian Bioethics

The crux of Ramsey's ethics is a focus on the Christian concept of agape as the chief determinant of human and institutional action. Contrary to Roman Catholic teaching, he rejected the relative autonomy of natural law and morality, aligning himself with deontological normative theories. He believed convictions as informed by theology provided the essential basis for all lasting deontological commitments. Ramsey was highly critical, however, of facile pronouncements by ecclesiastical bodies concerning social policy. He maintained throughout his life that theologically informed convictions can and should be expressed in the public arena, a position that, by the end of his professional career, would be strongly challenged on many fronts.

Approaching ethical decision making using the method of complex case studies, Ramsey specifically condemned the dropping of atomic bombs on Hiroshima and Nagasaki and the experiments on mentally disabled children at Willowbrook State School in Staten Island, New York. On the other hand, he upheld just war theory and believed that while any military action should be regretted, such action was often essential to prevent a greater evil. This led Ramsey to be a staunch proponent of the U.S. engagement in Vietnam and yet, consistent with his agape ethic, also to strenuously uphold the rights of persons to engage in sit-ins and other forms of nonviolent protest. He approved of the use of tactical nuclear weapons but did not believe that the mutually assured destruction (MAD) doctrine of U.S. Cold War policy was acceptable since it targeted innocent civilians living in cities for its chief deterrence potency.

A chief protagonist throughout Ramsey's life was Joseph Fletcher (1905–1991) and his *situation ethics*. While both adopted agape as their central frame of reference, they interpreted its import and action quite differently, with Fletcher arguing that one should always act in a situation to maximize happiness for the greatest number, a principle that Ramsey found highly problematic in actual applications—including those employed by Fletcher himself—due to its lack of consistent principles or rules. He believed that Fletcher's focus on individual acts would lead to a weakening of the very principle of love it was intended to realize. Charles Pinches and others have argued that Fletcher and Ramsey, despite their surface differences, are both principle monists.

Assessment

Ramsey's most lasting contributions have been in the arena of medical ethics; a fact signaled by the reissue of many of his works in this area and medical conferences devoted to his ethical approach. He was one of the first ethicists to explore difficult medical cases and use them to frame general policy approaches to such issues as abortion, euthanasia, organ transplants, artificial organs, and emergency room triage. He strongly argued against removal of the term *person* from decisions at the beginning and end of human life, since he recognized that only persons have rights. He maintained that the dying had a right to choose their own death without heroic interventions from medical personnel but rejected any concept of *death with dignity*, consistent with his theological views of death as the last human enemy to be overcome by Jesus Christ.

Despite his disagreements with aspects of it, he drew deeply on Roman Catholic moral tradition so fruitfully that scarcely any Protestant or Catholic ethicist working in the early-twenty-first century neglects the other tradition. At the same time, many of his arguments have been characterized as too focused on Christian theological content and concepts to serve as a useful language for broad public dialogue and not specific enough to be used exclusively by the Christian community to frame its own distinct positions. Many consider Ramsey to be the father of bioethics, although he would be aghast at how that discipline quickly jettisoned from the public sphere the very kind of theologically rich language he was trying to promote.

DENNIS W. CHEEK

SEE ALSO *Bioethics; Medical Ethics.*

BIBLIOGRAPHY

Long, Stephen D. (1993). *Tragedy, Tradition, Transfiguration: The Ethics of Paul Ramsey*. Boulder, CO: Westview Press. Still the most comprehensive study of his work.

McKenzie, Michael C. (2000). *Paul Ramsey's Ethics: The Power of 'Agape' in a Postmodern World*. New York: Praeger. An excellent discussion of the central role of agape in Ramsey's thought.

Ramsey, Paul. (1993 [1953]). *Basic Christian Ethics*. Louisville, KY: Westminster/John Knox Press. Reprint with new introduction of Scribner's original edition.

Ramsey, Paul. (1970). *Fabricated Man: The Ethics of Genetic Control*. New Haven, CT: Yale University Press.

Ramsey, Paul. (1978). *Ethics at the Edge of Life: Medical and Legal Intersections*. New Haven, CT: Yale University Press.

Ramsey, Paul. (2002). *The Patient as Person: Explorations in Medical Ethics*, 2nd edition. New Haven, CT: Yale University Press.

Vaux, Kenneth L., and Mark Stenberg, eds. (2003). *Covenants of Life: Contemporary Medical Ethics in Light of the Thought of Paul Ramsey*. New York: Springer-Verlag. A *festschrift* with eleven contributors and an interview with Ramsey shortly before his death.

Werpehowski, William. (2002). *American Protestant Ethics and the Legacy of H. Richard Niebuhr*. Washington, DC: Georgetown University Press. Explores the writings of Paul Ramsey, Stanley Hauerwas, James Gustafson, and Kathryn Tanner in relation to H. Richard Niebuhr, his brother Reinhold Niebuhr, and to one another.

Werpehowski, William, and Stephen D. Crocco, eds. (1994). *The Essential Paul Ramsey: A Collection*. New Haven, CT: Yale University Press. A superbly edited volume.

RAND, AYN

One of the twentieth century's best known novelists and philosophers, Ayn Rand (1905–1982), who was born in Saint Petersburg, Russia on February 2, and died in New York City on March 6, celebrated the individual in dramatic stories with unconventional characters and plots. The heroes of her four novels are engineers, scientists, architects, and industrialists. Her philosophy, which she called Objectivism, champions the rational productive individual.

In 1936, ten years after her arrival in the United States, Rand published her first novel, *We the Living*. Set in Russia shortly after the communist revolution of 1917, it tells the story of Kira Argounova, a young woman who wants to become an engineer and build bridges, and her struggle to live in a collectivist society at war with the individual.

Rand's second major publication, the novelette *Anthem*, published in 1938, is set in a bleak future in which freedom and individualism have been eliminated in the name of the common good. The achievements of the Industrial Revolution have been lost; people have been reduced to using candles. Against this background of decay one man defies society and rediscovers

Ayn Rand, 1905–1982. Rand began to form her philosophy of rational self-interest, which she called "objectivism," at an early age. This view became the basis for her immensely popular writings, which included *The Fountainhead* and *Atlas Shrugged*. *(AP/Wide World Photos. Reproduced by permission.)*

individual thought, science, and technology, along with the importance of the self.

Rand's third novel, *The Fountainhead,* was published in 1943. Her first major commercial success, *The Fountainhead* is the story of Howard Roark, an innovative young architect who thinks and lives for himself and refuses to copy the designs of the past, and of the opposition he faces from a society that worships tradition and mindless conformity.

Rand's last novel, *Atlas Shrugged,* was published in 1957. Its focus is the heroic individuals who, like the titan of Greek mythology, carry the world on their shoulders: the scientists, inventors, and businesspersons who create the knowledge and technology that sustain human life. *Atlas Shrugged* describes how those "men of the mind," as Rand calls them, liberate themselves from a society that denounces them as evil.

In presenting her vision of the hero, Rand created a new philosophy, Objectivism, on which she elaborated in her later, nonfiction writings. She argued that the subject of philosophy is not a realm of nonsense or mysteries but a science whose purpose is to teach people how to think and live, a science as capable of certainty and proof as is physics or mathematics.

The central idea of Rand's philosophy is that reason is human being's means of survival. Only through a process of reasoning—cold, hard, scientific, logical thought—can an individual understand the world and thus survive and prosper in it. This is why the heroes in her novels are scientists, engineers, and businesspersons; they are rational thinkers.

Rand accordingly defended the power of reason: She argued that the testimony of the senses is unquestionably valid, that human concepts and language con connect one to the facts of reality, and that logic is the only method for reaching truth. She rejected all forms of mysticism and supernaturalism on the grounds that such doctrines defy reason and contradict the fundamental laws of reality.

In regard to ethics Rand advocated rational self-interest. The task of ethics, she argued, is to teach one the principles—the virtues—that one must practice to realize the values that sustain one's life. No outside power, whether society or an alleged god, has the right to demand that one sacrifice one's values and live for its sake. The good is to live one's own life and attain happiness. This is accomplished through a resolute commitment to the virtue of rationality. For Rand the moral and the practical are one.

In regard to political philosophy Rand argued that a proper social system must accord with the individual's nature as a rational being. Individuals in society must be free to live, think, produce and keep the results of their work, and pursue their own goals. They must have the rights to life, liberty, property, and the pursuit of happiness. The social system that results from the protection of individual rights, Rand taught, is laissez-faire capitalism. That system was approached in the freest countries in the nineteenth century, and Rand argued that the thought and productivity that capitalism unleashed made possible the ensuing unprecedented prosperity in those countries.

Rand was one of the twentieth century's champions of science and technology and the rational mind that creates them. She therefore was an opponent of ideological movements that praise more primitive lifestyles, such as the New Left and environmentalism. An increasingly industrialized society, Rand held, is the proper environment for a rational being. Although her thought, which challenged contemporary views, was largely ignored in academic circles during her lifetime, it is receiving growing attention from scholars in the early twenty-first century.

ONKAR GHATE

SEE ALSO *Freedom.*

BIBLIOGRAPHY

Mayhew, Robert, ed. (2004). *Essays on Ayn Rand's We The Living*. Oxford: Lexington Books. This is a collection of sixteen essays by thirteen different contributors on the history as well as literary and philosophical content of Rand's first novel. For the sake of disclosure, please note that I contributed one essay.

Peikoff, Leonard. (1993). *Objectivism: The Philosophy of Ayn Rand*. New York: Meridian. Presents the essentials of Rand's system of philosophy; written by her foremost student.

Rand, Ayn. (1943). *The Fountainhead*. New York: Signet.

Rand Ayn. (1957). *Atlas Shrugged*. New York: Signet.

Rand, Ayn. (1959). *We the Living*. New York: Signet.

Rand, Ayn. (1961). *For the New Intellectual: The Philosophy of Ayn Rand*. New York: Signet. This collection contains the key philosophical passages from Rand's novels as well as a lead essay written by her explaining how philosophy has shaped the course of Western history and why new thinkers are needed.

Rand, Ayn. (1964). *The Virtue of Selfishness: A New Concept of Egoism*. New York: Signet. A collection of essays, by Rand and a colleague, on her ethics of rational self-interest.

Rand, Ayn. (1995). *Anthem*. New York: Signet.

Rand, Ayn. (1999). *Return of the Primitive: The Anti-Industrial Revolution*, ed. Peter Schwartz. New York: Meridian. A collection of essays, by Rand and editor Peter Schwartz, on cultural trends in politics and education.

Smith, Tara. (2000). Viable Values: A Study of Life as the Root and Reward of Morality. Lanham, Maryland: Roman and Littlefield. A critical study of the foundations of Rand's ethics, written by a professor of philosophy at the University of Texas.

RATIONAL CHOICE THEORY

Rational choice theory is a tool for devising a scientific explanation of the way individuals make choices; it is based on the notion that individuals attempt to find the most effective method of attaining their personal goals. Rational choice theory is a fundamental instrument for understanding ethical behavior and is compatible with the idea that such behavior is rooted in the biology of human nature.

An Illuminating Example

Suppose a person has \$10 to spend in a store that has goods X and Y at prices p_x and p_y. To determine how the person will spend the \$10, an economist assumes that the person has a preferences function $u(x, y)$ that he or she maximizes subject to the income constraint $p_x x + p_y y = \$10$, where x is the amount of X purchased and y is the amount of Y purchased. The preference function $u(x, y)$ reflects exactly how the person values different "bundles" of X and Y. For instance, if $u(2, 5) = u(3, 1)$, it is known that if the person has two units of X and five units of Y and if one takes four units of Y from the person, one must give the person an additional unit of X to compensate for the loss.

The assumption that people maximize their preferences subject to the appropriate constraints has proved fruitful in economics. Maximization subject to constraints also is used widely in biology to predict, for instance, how a predator will allocate its time among various prey or how a bumblebee will decide which flower patches to harvest and which ones to ignore (Alcock 1993).

However useful this function is, it may not be true that humans and animals really have utility functions in a meaningful physiological sense. Rather, their choices are the product of extremely complex and poorly understood neurological and hormonal processes. Why, then, is maximization subject to constraints used so successfully? The answer is that a choice process need only satisfy three simple conditions to be represented by a utility function. It is said that an agent is rational when those conditions are satisfied.

Basic Conditions

By a *preference ordering* $\succeq$ on a set A it is meant that a relation such that $x \succeq y$ may be either true or false for various pairs x, y in A. In words one states $x \succeq y$ as "x is weakly preferred to y" (Kreps 1990).

The first condition on $\succeq$ is *completeness*, which means that for any two members of the set, one is weakly preferred to the other (for any x, y in A, either $x \succeq y$ or $y \succeq x$). Note that this implies that any member of A is weakly preferred to itself (for any x in A, $x \succeq x$). Generally, this is a very plausible condition, but it is possible to think of cases in which it will fail to hold. Note that it is necessary to have $x \succeq x$ by the completeness condition. This is why $\succeq$ is referred to as weak preference. One can define strong preference as $x \succ y$, meaning that "it is false that $y \succeq x$." One can use elementary logic to prove that if $\succeq$ satisfies the completeness condition, then $\succeq$ satisfies the following *exclusion condition*: If $x \succeq y$, then it is false that $y \succeq x$.

The second condition is *transitivity*, which states that if x is weakly preferred to y and y is weakly preferred to z, then x is weakly preferred to z. In symbols this is written $x \succeq y$ and $y \succeq z$ implies $x \succeq z$. It is hard to see how this condition could fail for anything one would be likely to call a preference ordering. In terms of strong preference the transitivity condition becomes "if x is strongly preferred to y and y is strongly preferred to z, then x is strongly preferred to z." Again, one can use elementary logic to show that weak preference transitivity implies strong preference transitivity.

The third condition is the *maximization condition*, which states that from any set an agent will choose an element that is weakly preferred to any other member of the set. This condition, which also is called the *independence of irrelevant alternatives*, seems completely unobjectionable, but one can think of cases in which it will fail to hold. For instance, suppose A is a big basket of crumpets of different sizes. When given any pair of crumpets to choose from, the agent chooses the smaller of the two or chooses randomly if they are the same size. This satisfies completeness and transitivity. But suppose that if given a choice among any number of crumpets, the agent always chooses the next to largest, perhaps because he or she does not want to seem greedy. Then the agent will always choose the smaller when choosing among two but will not do this when choosing among more than two.

When these three conditions are satisfied, along with a technical *continuity* condition, there always exists a utility function such that the agent behaves as if maximizing this utility function over the set A from which he or she is constrained to choose. *Rational choice theory* is the study of the behavior of agents who satisfy these conditions, who are called *rational actors*.

Background and Misconceptions

The origins of the rational actor model lie in nineteenth-century utilitarianism and particularly in the works of Jeremy Bentham (1748–1832) and Cesare Beccaria (1738–1794), who interpreted utility as happiness. In *Foundations of Economic Analysis* (1947) the economist Paul Samuelson (born 1915; winner of a Nobel Prize in economics in 1970) removed the hedonistic assumptions of utility maximization by arguing that utility maximization presupposes nothing more than the conditions listed above.

The rational actor model has been misrepresented by those who embrace it and thus has been misunderstood by those who do not. The most prominent misunderstanding is that rational actors are self-interested. For instance, if two rational agents bargain over the division of money they jointly earned, it is thought that rational action requires that each agent try to maximize his or her share. Similarly, it is thought that if a rational actor votes in an election, he or she must be motivated by self-interest and will vote for the candidate most likely to secure his or her personal gain.

Of course, if one considers the term *rational* in the broadest philosophical sense, there is nothing irrational about caring for others, believing in fairness, or making sacrifices for social ideals, and such personal goals do not contradict rational choice theory. For instance, suppose a man with \$100 is considering how much to consume personally and how much to give to charity. Suppose he enjoys a tax break such that for each \$1 he contributes to charity, he is obliged to pay only $p < 1$. Then that person can be treated as maximizing his utility for personal consumption x and contributions to charity y, say, $u(x, y)$, subject to the budget constraint $x + py = 100$. Clearly, it is perfectly rational for him to choose $y > 0$. Indeed, James Andreoni and John H. Miller (2002) have shown that people in fact behave as rational actors in making choices of this type. For instance, when the price p increases, individuals tend to lower the quantity q of contributions to charity.

A second misconception is that the rational choice model assumes that the choices people make are in their own interest, when in fact people often are slaves to passions that are distinctly self-harming. For instance, it often is held that people are deluded or irrational when they choose to smoke cigarettes, engage in unsafe sex, commit crimes in the face of extremely heavy penalties, or sacrifice their health to junk food consumption. It is not clear, however, that these behaviors in any way violate the principles of rational action.

Weakness of Will

Those behaviors have in common a certain *weakness of will*. Smokers may know that their habit will harm them in the long run but cannot bear to sacrifice the present urge to indulge in favor of a far-off reward of a healthful future. Similarly, a couple in the throes of sexual passion may appreciate the fact that they may regret their inadequate precautions in the future, but they cannot control their present urges. This is not irrational but rather time-inconsistent.

A very clear laboratory experiment illustrates this time inconsistency (Ainslie and Haslam 1992). If subjects are offered a choice between $10 today and $11 a week from today, many will take the $10 today. However, if the same subjects are offered $10 to be delivered a year from today or $11 to be delivered a year and a week from today, many of the same subjects who could not wait a week right now for an extra 10 percent prefer to wait a week for an extra 10 percent provided that the agreed on wait is in the future. This finding corresponds to the everyday notion that people are subject to temptation and failure of will, leading them to accept high long-term penalties for small short-term pleasures.

It is instructive to see exactly where the conditions for rational choice are violated in this example. Let x mean "$10 at some time t" and y mean "$11 at time t + 7," where time t is measured in days. Then the present-oriented subjects display x Y when $t = 0$ and Y x when $t = 365$. Thus, the exclusion condition for is violated, and because the completeness condition implies the exclusion condition, the completeness condition must be violated as well.

Despite first appearances time-inconsistent agents can be modeled as rational actors (Ahlbrecht and Weber 1995). To do that one simply insists that the distance between the time of choice and the time of delivery of the object chosen be included explicitly in the analysis. Thus, x_0 means $10 delivered immediately and x_{365} means $10 delivered a year from today, and similarly for y_7 and y_{372}. Then the observation that x_0 Y_7 and Y_{372} x_{365} is not a contradiction.

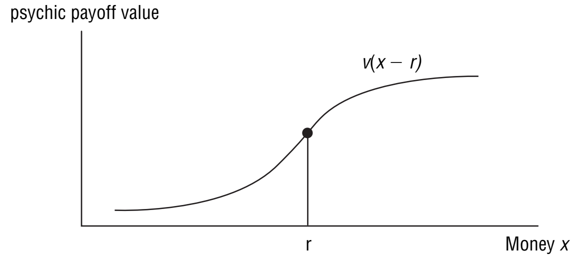
Indeed, here is a simple utility function involving what is called *hyperbolic discounting* (Ainslie 1975). Let zt mean the amount of money delivered t days from today. Then let the utility of zt be $u(z_t) = z/(t + 1)$. The value of x_0 is thus $u(z_t) = u(10_0) = 10/1 = 10$ and the value of y_7 is $u(z_t) = u(11_7) = 11/8 = 1.375$, and so x_0 Y_7. But $u(x_{365}) = 10/366 = 0.027$ whereas $u(Y_{372}) = 11/373 = 0.029$, and so Y_{372} x_{365}.

Prospect Theory

Prospect theory represents a fundamental contribution to rational choice theory that first was proposed by Daniel Kahneman (born 1934; winner of a Nobel Prize in economics in 2003) and Amos Tversky (1937–1996). According to prospect theory, agents value alternatives with respect to a *status quo* position that represents their current situation. This status quo position serves as a reference point with respect to which gains and losses are evaluated.

FIGURE 1

Prospect Theory



SOURCE: Courtesy of Herbert Gintis

Suppose, for instance, an agent has utility function $v(x - r)$, where r is the status quo and x represents a change from the status quo. Prospect theory asserts that there is a "kink" in $v(x - r)$ such that the slope of $v(\cdot)$ is two to three times as great just to the left of $x = r$ as it is to the right, the curvature of $v(\cdot)$ is positive for positive values and negative for negative values, and the curvature goes to zero for large positive and negative values. In other words agents (a) are two to three times more sensitive to small losses than they are to small gains; (b) exhibit declining marginal utility over gains and declining absolute marginal utility over losses; and (c) are very insensitive to either large gains or large losses. This utility function is exhibited in Figure 1.

There are many regularities in experimental data on human behavior that do not fit prospect theory well (Kahneman and Tversky 2000). For instance, returns on equities (stocks) in the United States have exceeded the returns on bonds by about 8 percentage points averaged over the last 100 years. If this were due to risk aversion (concavity of utility function) alone, the average individual would be indifferent between a sure $51,209 and a lottery that paid $50,000 with probability 1/2 and a lottery that paid $100,000 with probability 1/2. This is, of course, implausible, as virtually everyone would choose the risky lottery in this situation. However, a loss aversion coefficient (the ratio of the slope of the utility function over losses at the kink to the slope over gains) of 2.25 is sufficient to explain this phenomenon. This loss aversion coefficient is very plausible from experiments. In a similar vein people tend to sell stocks when they are doing well but hold on to stocks when they are doing poorly. A similar phenomenon holds for housing sales: Homeowners are extremely averse to selling at a loss and will sustain operating, tax, and mortgage costs for long periods in the hope of obtaining a favorable selling price.

One of the earliest recognitions of loss aversion took the form of the so-called *ratchet effect* discovered by James Duesenberry (born 1918). Duesenberry noticed that over the business cycle, when times are good, people spend all their additional income, but when times start to go bad, people incur debt rather than curb their consumption. As a result there is a tendency for the savings ratio to decline over time. For instance, in one study unionized teachers consumed more when the next year's income was going to increase (through wage bargaining) but did not consume less when the next year's income was going to decrease. This behavior can be explained with a simple loss aversion model. A teacher's utility can be written $u(c(t) - r(t))$, where $c(t)$ is consumption in period t and $r(t)$ is the reference point (status quo point) in period t. Suppose the reference point changes as follows: $r(t + 1) = \alpha r(t) + (1 - \alpha)c(t)$, where α [0, 1] is an adjustment parameter ($\alpha = 1$ means no adjustment, and $\alpha = 0$ means complete adjustment to last year's consumption). Note that when consumption in one period rises, the reference point in the next period rises, and vice versa.

One curious implication of prospect theory is the *endowment effect*: By virtue of bhaving something, people tend to value it more than they are willing to pay for it if they do not have it. A common example is the rare wine effect: If a typical consumer wins a $200 bottle of wine in a contest, she will save it for a special occasion and drink it then. However, the consumer would never pay more than $20 for a bottle of wine and could have sold the prize wine if she desired to.

The status quo bias inherent in prospect theory leads to important *framing effects* that can distort effective decision making. In particular, when it is not clear what the appropriate reference point is, decision makers can exhibit inconsistency in their choices. Kahneman and Tversky (2000) give a dramatic example from health care policy. Suppose it is expected that there will be a flu epidemic in which 600 people are expected to die if nothing is done. If program A is adopted, 200 people will be saved, whereas if program B is adopted, there is a $\frac{1}{3}$ probability that 600 will be saved and a $\frac{2}{3}$ probability that no one will be saved. In one experiment, 72 percent of a sample of respondents preferred A to B. Suppose that if program C is adopted, 400 people will die, whereas if program D is adopted, there is a $\frac{1}{3}$ probability that nobody will die and a $\frac{2}{3}$ probability that 600 people will die. It was found that 78 percent of the respondents preferred D to C even though A and C are equivalent and B and D are equivalent. Note that in the choice between A and B the alternatives involve gains whereas in the choice between C and D the alternatives involve losses, and people are loss-averse. The inconsistency stems from the fact that there is no natural reference point for the decision maker because the gains and losses are experienced by others, not by the decision maker himself or herself.

Why Rational Choice Theory Works

One important question remains: Why might one expect the conditions for rational choice to hold? The traditional answer is that humans are rational beings and the conditions for rational choice are the only conditions that satisfy the demands of reason. There are several problems with this justification. The most important is that the rational choice model often applies extremely well to nonhuman species, including insects and plants (Alcock 1993), whose mental apparatus falls far short of the capacity to exercise rational thought. Perhaps equally important, it is clear that humans often make choices that fail the test of right reason (e.g., weaknesses of will, including substance abuse, procrastination, and impulsive behavior), yet their choices do not violate the rational choice conditions.

A more contemporary explanation of the ubiquity of rational choice comes from evolutionary biology. Biologists define the fitness of an organism as its expected number of offspring, and the basic tenet of evolutionary biology is that fitness maximization is a precondition for evolutionary survival. If organisms maximized fitness directly, the conditions of rational choice would be directly satisfied because one could represent the organism's utility function as its fitness.

However, it is known that organisms, including humans, do not maximize fitness directly. For instance, moths fly into flames, few animals are capable of avoiding automobiles in the road, and humans voluntarily limit family size. In fact, biological fitness is a theoretical abstraction that is unknown to virtually every real-life organism. Rather than literally maximizing fitness, organisms have relatively simple preference orderings that are themselves subject to selection in accordance with their ability to promote fitness (Darwin 1872). One can expect preferences to satisfy the completeness condition because an organism must be able to make a choice in any situation it habitually faces or it will be outcompeted by another organism whose preference ordering can be used to make such a choice.

For similar evolutionary reasons one would expect the transitivity condition to hold in regard to choices that have some evolutionary meaning to the rational agent. Of course, unless the current environment of choice is the same as the historical environment in which the individual's preference system evolved, one would not expect an individual's choices to be fitness-maximizing or even welfare-improving. For instance, people in advanced technological societies have a tendency to obesity that can be explained by a weakness of will and a preference for high-calorie foods that may not be fitness-enhancing today but doubtless was at some times in the evolutionary history of the human species, which until about 10,000 years ago reflected the conditions of existence of small hunter-gatherer bands under constant threat of starvation.

Implications

Rational choice theory lies at the foundation of all behavioral science because natural selection strongly tends to select for preferences that satisfy the conditions of the rational actor model. Rational choice does not presuppose "reason," but it does presuppose adaptivity to an evolutionary environment. The fact that some behavioral disciplines, such as sociology, anthropology, and psychology, tend to ignore or reject the rational choice model through misunderstanding it arguably explains their relative immaturity and lack of unified principles in comparison with biology and economics, which tend to accept the principles of rational choice.

The most important implications of rational choice theory for ethics are as follows: (a) Weakness of will is not irrational and probably is an ineluctable dimension of the behavioral repertoire of humans; (b) because rational agents need not be selfish, it is not irrational to act altruistically and to care for others or to hate or act vindictively; and (c) what humans want and what they find ethically satisfying depend on their preference structures, which derive from an interaction between their species history and their personal histories. This argues for a behavioral ethics in which ethical principles are derived not from an appeal to introspection or reason but from the material conditions of the life of the human species.

HERBERT GINTIS

SEE ALSO *Choice Behavior; Decision Theory; Game Theory; Prisoner's Dilemma.*

BIBLIOGRAPHY

Ahlbrecht, Martin, and Martin Weber. (1995). "Hyperbolic Discounting Models in Prescriptive Theory of Intertemporal Choice." *Zeitschrift für Wirtschafts- und Sozialwissenschaften* 115: 535–568.

Ainslie, George. (1975). "Specious Reward: A Behavioral Theory of Impulsiveness and Impulse Control." *Psychological Bulletin* 82: 463–496.

Ainslie, George, and Nick Haslam. (1992). "Hyperbolic Discounting." In *Choice over Time*, eds. George Loewenstein and Jon Elster. New York: Russell Sage.

Alcock, John. (1993). *Animal Behavior: An Evolutionary Approach*. Sunderland, MA: Sinauer.

Andreoni, James, and John H. Miller. (2002). "Giving According to GARP: An Experimental Test of the Consistency of Preferences for Altruism." *Econometrica* 70(2): 737–753.

Darwin, Charles. (1872). *The Origin of Species by Means of Natural Selection*, 6th edition. London: John Murray.

Kahneman, Daniel, and Amos Tversky. (2000). *Choices, Values, and Frames*. Cambridge, UK: Cambridge University Press.

Kreps, David M. (1990). *A Course in Microeconomic Theory*. Princeton, NJ: Princeton University Press.

Samuelson, Paul. (1947). *The Foundations of Economic Analysis*. Cambridge: Harvard University Press.

Tversky, Amos, and Daniel Kanheman. (1990). "Rational Choice and the Framing of Decisions." In *The Limits of Rationality*, eds. Karen Schweers Cook and Margaret Levi. Chicago: University of Chicago Press.

RAWLS, JOHN

Bordley John Rawls (1921–2002) was born in Baltimore, Maryland, on February 21, educated in philosophy at Princeton University, and served in the military in the Pacific theater during World War II. He taught at Cornell University and at the Massachusetts Institute of Technology before becoming a professor at Harvard University where he taught philosophy for almost forty years. His theory of justice transformed twentieth-century political philosophy and has important implications for understanding the ethics of science and technology in terms of political governance and economics of the marketplace. He died in Cambridge, Massachusetts, on November 24.

Major Works

Rawls's major works include *A Theory of Justice* (1971), *The Law of Peoples* (1993), *Political Liberalism* (1993), and *Justice as Fairness: A Restatement* (2001). His writings have been widely distributed and translated into more than twenty languages.

Rawls developed his thought against the background of two existing philosophies: (a) utilitarianism, which employs the principle "the greatest good for the greatest number," and (b) emotivism, which claims moral and political judgments are basically personal or social preferences. Rawls finds both views inadequate, and in *A Theory of Justice* argues at length for a concept of "justice as fairness," which entails the economically "just distribution" of societal benefits and burdens through democratic procedures and institutions. Political procedures for advancing justice must run parallel to those of technological and economic progress.

In effect, Rawls revivifies theories of justice, rights, and international law that have their roots in Immanuel Kant (1724–1804) and social contract theory, as a broad response to totalitarianism and post–World War II inequities. Also, as a World War II veteran, Rawls authored "Fifty Years after Hiroshima," in which he argued against the use of the atomic bomb, and the employment of nuclear technology for nuclear weaponry. The crux of Rawls's argument may be found in a set of hypothetical conditions as follows. Imagine yourself in some "original position" in which you know that you are going to be placed in a complex world among persons with different abilities living in complex social institutional arrangements. At the same time you are prohibited by a "veil of ignorance" from knowing which abilities you might be given or which social institutions you will initially occupy.

In such a situation, Rawls argues, all persons, being both rational and self-interested, would choose to structure their social world around two principles of justice. The first, the "equal liberty principle," would establish equal basic rights and liberties for all. The second, the "difference principle," would defend inequalities on two conditions: (a) equality of opportunity (positions open to all having comparable prospects, talents, and abilities) and (b) economic and social inequalities distributed to benefit those disadvantaged by their social position. Rawls's argument is that when people do not know what abilities or benefits, or deficits and liabilities they might be given, such frame of mind affects the social order they would accept as just or fair. Moreover, such a well-ordered society based upon these principles will justly pair political democracy with economic capitalism.

Since the democratic-inspired revolutions of the eighteenth century, liberal philosophers have argued that rational individualism, republican democracy, and capitalism together could do more than any other systems to increase human rights, opportunities, and goods for more people. Historically, however, philosophers have also noted the recurring divide between rich and poor. In *Political Liberalism,* Rawls thus charges future progress, whether in government or business, in science or technology, with a moral imperative: Use political liberalism to promote justice, to ensure equal rights, and to acquire human rights as well as economic ones.

Rawls's principles of justice remain critical in evaluating these future problems and progress. Reminding his readers, in *The Law of Peoples,* that burdens accompany goods, and responsibilities come with liberties, Rawls analyzed who and what institutions will bear these responsibilities and duties to provide just and more equitable rights in a world in which people are actually situated, and materially advantaged or disadvantaged. Rawls directly formulated definitive tenets for law, rights, and duties that must be publicly instituted to address ongoing concerns and conflicts of minorities, pluralities, or the majority of global peoples. Therein, cosmopolitan individuals, technical experts, scientists, political leaders, and multinational corporations alike could find the principles, laws, and procedures in place to address fairly their worldly operations, disputes, and affairs.

Assessment

Rawls's work has inspired countless commentaries and critical replies in the United States and abroad. For instance, from its first publication in 1971 to its revised edition in 1999, *A Theory of Justice* has been challenged by communitarians and feminists. Both argue that *Theory* is too abstract and individualistic, despite its broad global outreach to diverse peoples, governments, and cultures. Arguably, Rawls draws heavily from Kant's rationalist, individualistic ethics and political philosophy of contractarian government, whereby citizens and their states jointly contract and consent (implicitly and explicitly) to institute and legitimate the just rule of their government.

Rawls has been criticized not only from the left (communitarians and feminists) but also from the right (libertarians and free-market theorists). Most notably, Robert Nozick (1938–2002), Rawls's well-renown Harvard colleague, was also his life-long critic, promulgating a counter theory known as the "entitlement theory" of social justice. In short, Nozick's theory extends another long-standing Western trend, libertarianism, which, like political liberalism, also originated in the eighteenth century, starting with Adam Smith's *The Wealth of Nations* (1776). Nozick wrote *Anarchy, State, and Utopia* (1974) in direct response as a critique of Rawls's *Theory of Justice*. Nozick thereby enlivened visions of justice based upon free-market capitalism and a minimalist state, in which the state serves solely to protect its members from violence and theft, and hence should possess no rights to interfere with one's property acquisition, use, and distribution, nor with any technological innovations and enterprises, unless fraud and unlawful force have been committed or contracts breached.

Rawls's political liberalism provides critical assurance that rational principles of justice and ethical government can control global capitalism, biotechnology, and engineering enterprises, so as to assure more of the world's people that liberties, goods, and opportunities can be more fairly distributed. Because Rawls rejects the premise that the powers and forces of right, possessed by people who are merely empowered and advantaged by circumstance or their societal position, can legitimately constitute justice, his *Theory* can test the progress made, and that still must be made, toward expanding global liberties and economic justice. In demonstrating "justice as fairness," Rawls firmly reestablishes liberal political philosophy: In facing global pluralism—diverse beliefs, values, and bases for differing notions of good—politically just principles and powers for human rights-distribution are morally required to evaluate and improve the actual positions of individuals, states, and global peoples in working toward greater fairness.

MARY LENZI

SEE ALSO *Human Rights; Justice; Liberalism.*

BIBLIOGRAPHY

Freeman, Samuel, ed. (2003). *The Cambridge Companion to Rawls*. New York: Cambridge University Press.

Rawls, John. (1971). *A Theory of Justice*. Cambridge, MA: Harvard University Press, Belknap Press. Rev. edition, 1999.

Rawls, John. (1996). *Political Liberalism and the "Reply to Habermas."* New York: Columbia University Press. *Political Liberalism* originally published in 1993.

Rawls, John. (1999). *The Law of Peoples; with, "The Idea of Public Reason Revisited."* Cambridge, MA: Harvard University Press. Includes a major reworking of the essay "The Law of Peoples," originally published in 1993, along with the essay "The Idea of Public Reason Revisited," originally published in 1997.

Rawls, John. (2000). *Lectures on the History of Moral Philosophy*, ed. Barbara Herman. Cambridge, MA: Harvard University Press.

Rawls, John. (2001). *Justice as Fairness: A Restatement*, ed. Erin Kelly. Cambridge, MA: Harvard University Press.

REGENERATIVE MEDICINE

SEE *Aging and Regenerative Medicine.*

REGULATION AND REGULATORY AGENCIES

Regulation is a concept that is associated intimately with science, technology, and ethics. In the most general sense regulations control or direct human activities in accordance with a rule that has been promulgated. Neither sciences nor technologies could exist without internal processes of professional self-regulation. Biology includes research on the processes that regulate early embryonic development. The larger societies in which science and technology are embedded are dependent on forms of regulation that run the gamut from social to legal and governmental. Ethics is a form of regulation that often is seen as being more conscious or self-critical than social regulation and more broad than legal regulation.

The modern social construction of regulatory agencies as part of government was one attempt to respond to the complexity of advancing technological societies by "delegating legislation" that established appropriate institutional bodies to create and enforce "administrative laws" in specific areas of need such as water treatment, radio wave frequency allocation, and air traffic control. Reactions to the bureaucratic inefficiencies sometimes introduced by such agencies has led to countermovements for deregulation.

Historical Background and Modern Emergence

Regulations existed from the earliest periods of human history. Heads of tribes established rules that enabled closely related groups to live at peace within defined territories; rules of marriage, divorce, compensation for damage, bequests, and the status of slaves were set out in the Code of Hammurabi, which was carved in stone in Babylon in the 1700s B.C.E. Before that time the definitions of key weights and measures were established; for example, the mina (one-sixtieth of a talent) was a unit of payment that was mentioned specifically in the Code of Hammurabi. A talent, which might have been the weight a man could carry with comfort (about sixty pounds), had superseded the ox or cow as the unit of exchange.

In the era that preceded democratic governments the all-powerful prince was able to promulgate regal (regulatory) powers to modulate the behavior of his subjects according to his wishes. After the emergence of liberal democracies in the 1700s C.E. individuals and organizations within a society often were allowed to behave as they wished as long as they did not violate any of the rules and regulations crafted to ensure social order and the well-being of the society.

Those rules and regulations constitute a subset of the ethics of a society that are formulated and promulgated by those elected to a representative assembly. That assembly or body of lawmakers acts in place of the prince and therefore may be seen as an agent that regulates the affairs of the society. This is an example of the first level of the regulatory agency: the parliament or legislature.

In a democracy this type of regulatory agency involves the full complement of the members of the society who are eligible to vote and provides laws that have to be obeyed on pain of penalty when they are flouted. Those laws are upheld by an enforcement authority consisting of the police and if necessary the army that brings people suspected of lawbreaking before a judiciary where argument is presented with or without lawyers before a judge and a body of peers (the jury). If the guilt of the accused is established, punishment is meted out in the form of a fine, imprisonment, or another type of penalty.

The second level consists of religious authorities. In this case regulations or ethics are based on interpretations of sacred texts by clerics who have been given the authority to make such determinations by the head of the order or by the collective will of the congregants. The matters that are dealt with at this level are subject to compliance with laws of the state that override ecclesiastical regulation if there is a conflict. Thus, the way the church conducts its business and the messages the church promotes in helping members establish a workable relationship with the deity are an area of regulation for which this agency is fully responsible.

A third tier of regulation operates through groups of individuals who are selected by governmental departments and given authority by the issuance of specific laws to regulate the behavior of particular industries or service organizations. The first body of this type was set up in 1852 by the U.S. Congress as the Steamboat Inspection Service. That body was required to establish and maintain standards of design and production for the boilers that were used to power the paddles of steamboats plying the Mississippi River. Before that time explosions of those boilers resulted in the deaths of hundreds of passengers. Eventually that situation led to the establishment of a professional society, the American Society of Mechanical Engineers (ASME), that drew up codes of conduct to govern the education and practical training of the engineers involved in boiler design and construction along with specific codes that governed the construction of boilers that then were incorporated into local and state law.

In 1887 in the United States the Interstate Commerce Commission (ICC) was established to, among its other regulatory activities, prevent destabilizing competition in railway fares and set fare rates that would allow investment in new track and facilities as well as provisions for maintenance and safety measures without preventing the delivery of dividends to encourage further investment.

Other countries and international organizations established their own regulatory agencies. The United Nations (1945) and its subagencies, notably the World

Health Organization, the Food and Agricultural Organization, and the World Bank, were set up. In addition to a variety of international laws, those agencies provide regulations that control trade and the sustainable use of resources as well as the financial control of terrorism. The Treaty of Rome in 1957 established the European Union, which may issue directives whose power is binding on its members. There is also an International Organization for Standardization (1947) that has issued 14,000 international standards that enable world trade to proceed with confidence and a World Intellectual Property Organization that deals with regulations involving patents.

U.S. Regulatory Agencies

During the twentieth century some fifty regulatory agencies were established by the U.S. Congress. Some of the tasks undertaken by those bodies can be of major importance, for example, regulation of the quality of food and drugs through U.S. Food and Drug Administration regulations for pharmaceuticals and vaccines that often require manufacturers to test their products for safety, efficacy, and the consistency of their production process over a period of five to fifteen years at a cost of $500 million to $1 billion per product. Other tasks are trivial, including setting the when times a drawbridge may be raised or lowered.

Those agencies regulate financial operations (the Securities and Exchange Commission, established in 1933) and control the way people use their local environments (the Environmental Protection Agency, established in 1970). All aspects of the work environment are covered by the Occupational Safety and Health Administration (1970), and the Nuclear Regulatory Commission was set up in 1977 to supervise the development of civil nuclear installations. The development of the executive department of the Congress devoted to agricultural matters has spawned numerous regulatory agencies that oversee most aspects of agricultural practice. When it can be demonstrated that there is an overarching social need for regulation, members of Congress seem to be willing to provide the legal powers or instruments that give the agencies they create the tools to do their jobs.

Some of the functions that are served by American regulatory agencies include the following.

REGULATION OF COMPETITION. Although the liberal nature of the American democracy provides for the freedom of individuals and corporations to compete in attracting the attention of customers, corporations sometimes have colluded in setting prices or availabilities that have affected prices in ways that benefit corporations disproportionately. Such conglomerates have been disaggregated by law, and competition has to be active between the disaggregated entities that have been formed. For this reason the Standard Oil Company was broken up in 1911 and the Bell System's telephone monopoly was broken down to the AT&T company and the seven "Baby Bells" in 1982.

CONTROL OF COMPANY ACTIVITIES IN RELATION TO THE ENVIRONMENT. Most manufacturing companies acquire raw materials and convert them to final products, in the process producing solid, liquid, and gaseous wastes. At one time the disposal of that waste was a matter for company determination. Because there have been serious examples of wastes contaminating environments and damaging the health of local people (the Love Canal in New York State was so polluted that it took twenty years to clean up), regulations have been used to protect local residents and workers in the polluting factories.

PROVISION OF INFORMATION ABOUT PRODUCTS. The need to provide composition and calorific data on foods has turned supermarket shopping into an exercise in nutritional virtuosity. Additionally, data in advertisements have to comply with the realities of products and financial deals have to be expressed in ways that provide complete and comprehensible information to those about to take out loans or mortgages.

PROTECTION OF THE WEAK (CHILDREN) AND INFIRM. Regulations also may express the more basic virtues that are considered the hallmarks of a proud and independent society. These virtues include equality of opportunity; nondiscrimination on the basis of racial, ethnic, or religious affiliations; and the need to protect privacy on the street on in a column of data.

Criticisms

Any regulatory regimen is established at a cost. There is a burgeoning bureaucracy to deal with and costs in terms of time and trouble whenever a licence is required to make or do something. This may provide a hurdle for those who are innovating, who may be put off by the specifications they will have to meet to manufacture a product. There is also the consideration that regulations depart from the ideals of a liberal democracy that is premised on the least involvement of the state in the day-to-day activities of its citizens. In the United Kingdom the criticism that is leveled at the government as it seeks to advise and regulate the way people live, eat, and use mind-affecting drugs is that the government has become the "nanny" of the state.

A corollary of this situation is that regulations have to be devised to regulate the regulators. In the United States the Office of Management and Budget (OMB) was set up by a presidential executive order to determine the cost-effectiveness of the activities of the regulatory agencies that have been established by Congress.

People may live in a liberal society that purports to promote freedom of the individual and the corporation, yet they are biological organisms that need to have multiple levels of control to enable them to function. There are at least four levels of biochemical control of cellular function—environmental, enzymatic, energetic, and genetic—in addition to hormonal, neuronal, instinctive, subconscious, and conscious control systems. There are also social control systems, among which regulatory agencies are only one. There is little doubt that the application of a multitiered system of controls provides people with enhanced survival chances: Whether survival is always the only value is another issue.

R. E. SPIER

SEE ALSO *Aviation Regulatory Agencies; Environmental Regulatory Agencies; Foucault, Michel; Regulatory Toxicology; Science, Technology, and Law.*

BIBLIOGRAPHY

Unger, Stephen H. (1994). *Controlling Technology: Ethics and the Responsible Engineer*, 2nd edition. New York: Wiley.

INTERNET RESOURCES

Department of the Environment, Heritage, and Local Government. (2004). "Local Agenda 21." Available at http://www.environ.ie/DOEI/DOEIPol.nsf/wvNavView/Local+Agenda+21?OpenDocument&Lang=.

Environmental Protection Agency, Office of Site Remediation Enforcement. (2004). "The Lovel Canal." *Cleanup News*. Available at http://www.epa.gov/compliance/resourcesnewsletter/cleanup/cleanup3.pdf.

European Union. (2004). Available at http://europa.eu.int/index_en.htm.

International Organization for Standardization. (2004). Available at http://www.iso.org/iso/en/aboutiso/introduction/index.html#four.

Morris, Jane Anne. (1998). "Sheep in Wolf's Clothing." *By What Authority* 1(1). Available at http://www.poclad.org/bwa/fall98.htm.

Office of Management and Budget. (2003). "Report to Congress on the Costs and Benefits of Federal Regulations" Available at http://www.whitehouse.gov/omb/ inforeg/2003_cost-ben_final_rpt.pdf.

Office of Management and Budget, Office of Information and Regulatory Affairs. (2004). Available at http://whitehouse.gov/omb/inforeg/Chap1.htm.

United Nations. (2004). Available at http://www.un.org/english/.

United Nations Suppression of Terrorism Regulations. Available at http://www.fin.gc.ca/news01/01-082e.html.

REGULATORY TOXICOLOGY

Regulatory toxicology is the branch of toxicology (the study of adverse effects of chemicals) that uses scientific knowledge to develop regulations and other strategies for reducing and controlling exposure to dangerous chemicals.

The legal framework in this area is promulgated by governmental agencies. Examples of such agencies in the United States are the Food and Drug Administration (FDA), the Environmental Protection Agency (EPA), and the Occupational Safety and Health Administration (OSHA). Corresponding agencies exist in the European Union (EU) at the national or union level. The primary examples of authorizing legislation in the United States are the Food, Drug, and Cosmetic Act (1938), the Occupational Safety and Health Act (1970), the Clean Air Act (1970), the Federal Insecticide, Fungicide, and Rodenticide Act (1972), the Toxic Substances Control Act (1976), and the Clean Water Act (1977). Corresponding laws exist in the EU.

The Society of Toxicology (United States), EUROTOX (Europe), and the International Union of Toxicology (IUTOX) (global) are major professional organizations. The Society of Toxicology has published a code of ethics for toxicologists that requires its members to:

- Strive to conduct their work and themselves with objectivity and integrity.
- Hold as inviolate that credible science is fundamental to all toxicologic research.
- Seek to communicate information concerning health, safety, and toxicity in a timely and responsible manner, with due regard for the significance and credibility of the available data.
- Present their scientific statements or endorsements with full disclosure of whether or not factual supportive data are available.
- Abstain from professional judgments influenced by conflict of interest and, insofar as possible, avoid situations that imply a conflict of interest.

- Observe the spirit, as well as, the letter of law, regulations, and ethical standards with regard to the welfare of humans and animals involved in their experimental procedures.
- Practice high standards of occupational health and safety for the benefit of their co-workers and other personnel. (Society of Toxicology)

Toxicological Data and Assessment

Toxicity or adverse effects data are obtained either from experimental systems using animals or cell cultures, or from epidemiological studies of humans. The legally required testing differs among groups of chemical substances, ranging from no testing for many industrial chemicals to extensive requirements for pharmaceuticals.

A general problem is that the adverse effects of many chemicals, whether alone or in combination, are unknown. This is due to low data requirements, to statistical limitations in the available data, and to the cocktail effect or the interaction of chemicals. As a rough rule of thumb, epidemiological and experimental studies cannot reliably detect excess incidences of adverse effects of about 10 percent or smaller, and in many cases excess incidences of higher than 10 percent may go undetected. For relatively common types of disease, incidences are between 1 percent (leukemia) and 10 percent (breast cancer in Swedish women). Therefore even in the more sensitive studies, the limits of an observable excess lifetime risk are in the order of 1/100 or 1/1000, a level the public often considers unacceptable.

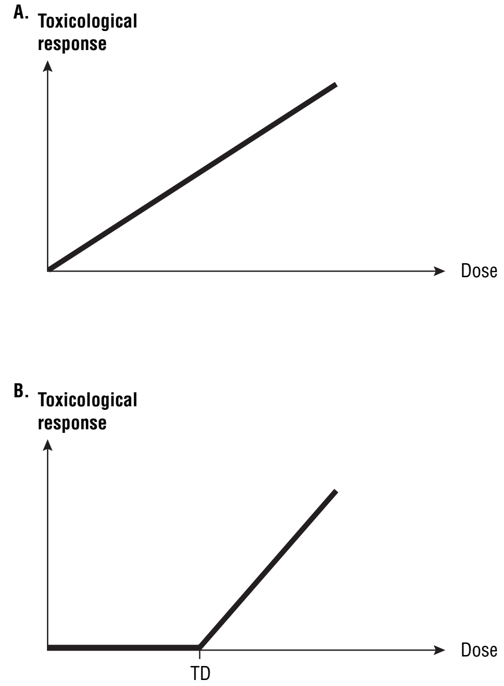
Once data are collected they are used to formulate toxicological assessments. Toxicological *health assessments* aim at identifying the potential adverse effects that a substance may cause in humans. This includes a description of the nature of these effects, their likelihood of occurrence, and their extent or severity.

The process of toxicological assessment is usually divided into four steps (National Research Council 1983, European Commission 2003). The first step of *hazard identification* aims at determining the inherent properties of a substance in order to identify the types of adverse effects to be included in further analysis.

The second step is *dose-response assessment*. The purpose of the dose-response assessment is to describe the relationship between the size of the dose and the response in the exposed. This is essential, because a high dose of a substance with low toxicity can be lethal, while a very low dose of a substance with high toxicity may be harmless. See Figure 1.

FIGURE 1

Dose-Response Relationships



TD = Threshold dose

SOURCE: Courtesy of Christina Rudén.

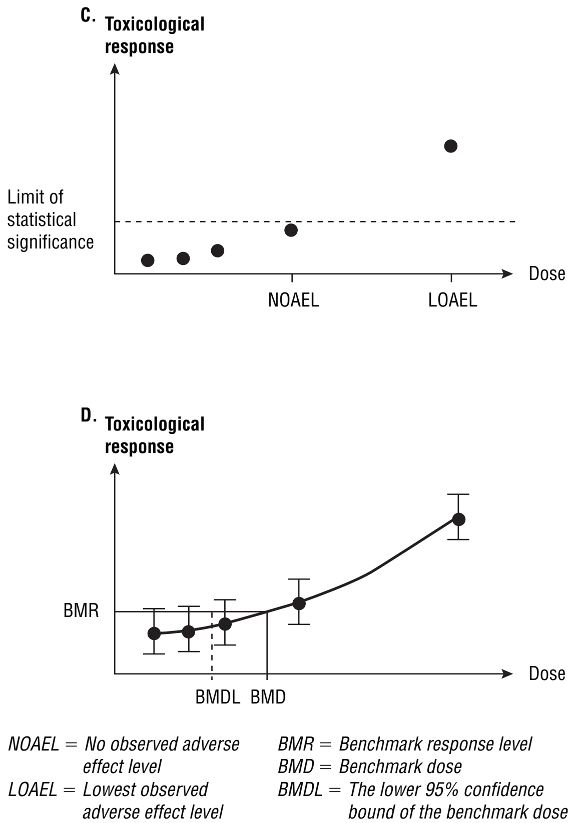
Diagram A shows a linear dose-response relationship increasing from zero exposure. In diagram B a threshold dose is indicated (denoted "TD").

The choice of a toxicological management strategy may depend on whether the dose-response relationship is considered to be linear from zero exposure or if a *threshold dose* is anticipated. A threshold dose is a dose under which no adverse effects are expected.

The lowest dose that has been shown to give rise to a statistically significant adverse effect compared to unexposed controls is the *Lowest Observed Adverse Effect Level* (LOAEL). The highest dose that has been administered without any observed statistically significant adverse effect is the *No Observed Adverse Effect Level* (NOAEL). A *benchmark dose* (BMD) is obtained by fitting a dose-response model to data, and from that model estimating a dose that corresponds to a predetermined change in the toxicological response investigated. The low-level change in response compared to background associated with the BMD is commonly termed the *benchmark response level* (BMR). Continuous dose-response data or incidence data may be used as a basis for these calculations. In the latter case, the BMD is

FIGURE 2

Effect Levels



SOURCE: Courtesy of Christina Rudén.

Diagram C shows the NOAEL/LOAEL approach, and diagram D shows the benchmark dose approach (BMD). The NOAEL/LOAEL is based on effect data for specific dose levels, while the BMD is obtained by curve-fitting of effect data.

generally defined as a 1 percent to 10 percent change in the incidence of the effect compared to background. In any case, the lower 95 percent confidence bound of the benchmark dose (the BMDL) is suggested as an alternative to NOAEL or LOAEL as a starting point for the determination of reference values for estimating acceptable exposure levels. See Figure 2.

The NOAEL, LOAEL, or BMDL should be defined for *critical effect*. Critical effect is the adverse effect that occurs at the lowest dose.

The third step is *exposure assessment*. This aims at determining the likelihood of exposure and estimates the magnitude and duration of the doses, as well as the potential exposure routes. Exposure assessment must be based on monitoring data and/or the use of theoretical exposure models.

The final step is *risk characterization*, which involves comparing the exposure data to the dose-response information in order to characterize the risk in qualitative and (if possible) quantitative terms.

Conclusive dose-response data are rarely available in humans, and therefore risk characterization often involves *extrapolation* from animal data to assess human risk. Absent contrary evidence, it is generally presumed that the effects seen in the test species under experimental conditions are relevant to humans. This presumption is supported by the fact that common test species are physiologically similar to humans.

In *environmental risk assessment* the same basic procedure applies. The outcome of hazard identification and dose-response assessment is the *Predicted No Effect Concentration* (PNEC), and exposure assessment estimates the *Predicted Environmental Concentration* (PEC). In the risk characterization process, the PEC/PNEC ratios are calculated. Extrapolation is made from experimental data (a limited number of single species) to the ecosystem (millions of species and multiple exposures interacting).

Extrapolation of data is hampered by scientific uncertainty. Resolving all uncertainties inherent in extrapolation would require testing on humans and/or an unreasonable number of animals. The presumptions used to overcome gaps of knowledge in assessment involve value judgments.

Toxicological Management

There are a number of possible risk management options in regulatory toxicology, ranging from public education to the banning of toxic substances. Two central systems are classification with labeling and exposure limits.

The *classification and labeling system* is an important part of international chemicals control because the classification process constitutes a background for further regulatory actions. According to the criteria for classification, substances (and preparations) are classified according to their inherent properties. Those fulfilling the criteria have to be provided with a warning label. Agenda 21, adopted at the United Nations Conference on Environment and Development in 1992, provided the international mandate to develop a globally harmonized system (GHS) for the classification and labeling of chemicals. The work was coordinated and managed under the auspices of the Interorganization Programme for the Sound Management of Chemicals (IOMC), administered by the World Health Organization (WHO). The aim is to have the GHS system fully implemented and operational by 2008.

Another major regulatory strategy is the setting of *exposure limits*. In the workplace such limits are called Occupational Exposure Limits (OEL), or Threshold Limit Values (TLV). Limits for exposure via food and drinking water are called Acceptable (or Tolerable) Daily Intake (ADI or TDI).

A health-based exposure limit is usually derived starting with either an experimentally estimated NOAEL/LOAEL, or a BMDL for the effect of concern. To overcome variability and other uncertainties, the experimental dose level is adjusted with an appropriate *uncertainty factor* to reach an exposure level assessed as not associated with adverse effects in humans.. The size of the uncertainty factor may vary from one to several thousands depending on the severity of the effect, the nature of the exposure, the exposed population, data-gaps, and uncertainties in the database.

Toxicological management is based on scientific evidence, but in the decision-making process nonscientific considerations are also taken into account. Examples of such considerations are the technical feasibility of the decision including availability of alternative technical processes, socioeconomic consequences, and value-based judgements of what health effects are acceptable.

CHRISTINA RUDÉN

SEE ALSO *Radiation; Regulation; Risk; Safety Engineering: Practices; Safety Factors.*

BIBLIOGRAPHY

Gad, Shayne C., ed. (2001). *Regulatory Toxicology*, 2nd edition. London: Taylor and Francis. A reference book of the requirements and regulations that both government agencies and non-government organizations promulgate for establishing the safety of a wide spectra of chemical products. It includes information on the United States, the European, and the Japanese systems, and is aimed for the full range of professionals in this field

National Research Council. (1983). *Risk Assessment in the Federal Government—Managing the Process*. Washington DC: National Academy Press. This volume evaluates past efforts to develop and use risk assessment guidelines, reviews the experience of regulatory agencies with different administrative arrangements for risk assessment, and evaluates various proposals to modify procedures. The book's conclusions and recommendations can be applied across the entire field of environmental health.

National Research Council, Committee on Risk Assessment of Hazardous Air Pollutants, Board on Environmental Studies and Toxicology, Commission on Life Sciences. (1994). *Science and Judgement in Risk Assessment*. Washington DC: National Academy Press. This report is aimed at a multidisciplinary audience with different levels of technical understanding. It addresses for instance the background of risk assessment and current practice at EPA, specific concerns in risk assessment, such as extrapolations, and cross-cutting issues that affect all parts of risk assessment. For example, how should uncertainty be handled?

Rudén, Christina. (2003). "Science and Transscience in Carcinogen Risk Assessment—The European Regulatory Process for Trichloroethylene." *Journal of Toxicology and Environmental Health*, part B: Critical Reviews 6(3): 257–277. In this article the European Union regulatory process for classification and labelling is described, it also reports an example of how hazard assessments are performed within this legislation.

Van Leeuwen, Cornelis Johannes: Josephus Ludovicus: and Maria Hermens, eds. (1995). *Risk Assessment of Chemicals: An Introduction*. Dordrecht, The Netherlands: Kluwer Academic Publishers. This book provides an introduction to risk assessment and management of chemicals, including background information on sources and emissions, distribution and fate processes, toxicology and ecotoxicology, and basic principles and methods for hazard and risk assessment within the legislative framework. It is intended for students and professionals within this field.

INTERNET RESOURCES

European Commission (2003). "Technical Guidance Document on Risk Assessment." Available from http://ecb.jrc.it. This is a set of technical guidance is issued by the European Commission as a help to carry out the risk assessments required within the EU legislations. It includes technical details for conducting hazard identification, dose - response assessment, exposure assessment and risk characterisation in relation to human health and the environment.

Society of Toxicology. Code of ethics. Available from http://www.toxicology.org/memberservices/aboutsot/ethics.html.

RELATIVISM

SEE *Pluralism: Social Pluralism.*

RELIABILITY

• • •

The term *reliability* can be used to indicate a virtue in a person, a feature of scientific knowledge, or the quality of a product, process, or system. Personal unreliability makes an individual difficult to trust. Unreliability in science calls the scientific enterprise into question. Lack of reliability in technology or engineering undermines utility and public confidence and perhaps commercial success. In all cases the pursuit of reliability is a conscious goal.

Scientific Reliability as Replication

Reliability in science takes its primary form as replicability. Research experiments and research must be performed and then communicated in such a way that they can be replicated by others or the results cannot become part of the edifice of science. Both replicability in principle and actual replication by diverse members of the scientific community are central to the processes of science that make the knowledge produced by science uniquely reliable and able to be trusted both within the community and by nonscientists.

Replication is easier to achieve in some scientific domains than in others, but when it fails, the science is judged unreliable. Historically replication was established first in physics and chemistry, and so in the physical sciences especially lack of replicability can become newsworthy. For example, the inability of other scientists to replicate the experiments on which Stanley Pons and Martin Fleischmann based their announcement of the discovery of cold fusion in 1989 doomed the credibility of their claims.

As Harry Collins and Trevor Pinch (1998) have shown in case studies, the replication of particular experiments often depends on the phenomenon of "golden hands." Not all experimenters are equally skilled at setting up and performing experiments, and subtle differences can be more relevant than it is possible to articulate clearly in the methods section of a research article.

In science another version of replicability is associated with peer review. Peer review procedures for scientific publication and for decision making about grants in effect depend on two or more persons coming to the same conclusion about the value of a report or proposal. Assessments must be replicated among independent professionals to support reliable decisions. Several evaluations of the peer review process in various disciplines have been performed (Peters and Ceci 1982). Many of those reports suggest that the system is unreliable because reviewers often fail to agree on the quality of a scientific article. Unreliability in this process undermines the internal quality controls of science, thus hampering progress. It also raises epistemological questions about the constitution of truth.

For instance, even if two reviewers judge a paper to be of high quality, both may be mistaken because they failed to spot a statistical error. In this sense reliability (agreement between reviewers) does not constitute validity (internal consistency or the absence of obvious errors of logic) (Wood, Roberts, and Howell 2004). However, on another level the negotiation of scientific claims within the scientific community is an integral part of determining what is true. Thus, in this sense reliability is a way of making or legitimating truth claims. These issues are made more complex by the role of editors in synthesizing disparate claims by reviewers and the question of whether reliability can be assessed by the metric of agreement between reviewers.

Another example of the issue of replicability in science is associated with the development of the *Diagnostic and Statistical Manual of Mental Disorders (DSM)* in psychiatry. Before this compendium of standardized descriptions of mental disorders was published, diagnoses of psychological illnesses lacked reliability. For example, if three physicians independently saw a patient with a psychological illness, it was unlikely that they would make the same diagnosis. Indeed, this remained the case through the publication of the original *DSM* in 1952 and *DSM-II* in 1968. It was only with the increasing detail and sophistication of *DSM-III*, published in 1980, that the psychiatric community began to achieve a significant measure of reliability in its diagnostic practices and psychiatry became more respected as a science.

This case suggests the connection between reliability and professionalization (the formation of a specialized academic discipline) because replicability was made possible only after a community of practitioners developed a shared conceptual language and a methodology that were sufficiently nuanced to communicate and establish likes as likes. Reliability as a way of establishing truth through replication thus is a product of both material reality and the way peers conceptualize the world and are able to replicate that conceptualization among themselves.

Functional Reliability in Engineering

Engineering or technological reliability is the probability that a product, process, or system will perform as intended or expected. Issues include the expected level of reliability, the cost-benefit trade-offs in improving reliability, and the consequences of failure. When these issues involve persons other than those inventing or tinkering with the relevant products, processes, or systems, with consequences for public safety, health, or welfare, ethical issues become prominent. Just as in science, reliability, in this case in the form of functional reliability, is a precondition for the integration of a particular technological device into the accepted or trusted edifice of the built environment.

Any technological product, process, or system is designed to perform one or more specified functions. In principle, the performance of the system can be defined mathematically and the demands placed on the system can be specified. Because uncertainties are associated with all aspects of systems in the real world, these descriptors should be defined in terms of uncertainties and reliability should be computed as the probability of intended performance. Because most systems have effects beyond their stated output (radiation, accidents, behavior modification, etc.), a comprehensive model must include all possible outcomes. Because complicated models all are based on extrapolations of the basic principles, the fundamental concepts are described in this entry.

The demands placed on a system include environmental and operational loads, which for simplicity will be designated here as a single demand, D. The capacity of the system to absorb those loads and perform its function is designated C, for capacity. The satisfactory operation of the system simply entails that the capacity be at least as large as the demand. This is expressed mathematically as $S = C - D \geq 0$ in which S represents satisfactory performance. In probability terms this becomes $P(S) = P(C - D) \geq 0$.

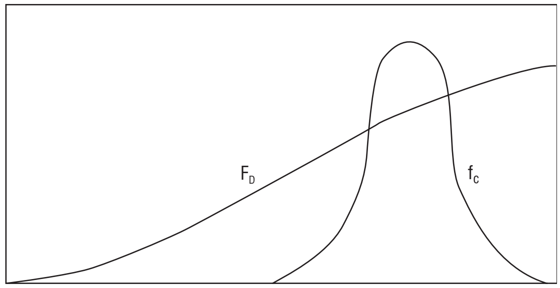
Each of these basic quantities can be described probabilistically by its probability function: $F_D(d)$ for demand and $F_C(c)$ for capacity. It is usually a safe assumption that the capacity (a function of the physical system) and the demand (a function of the operating environment) are statistically independent. In this case the reliability of the system is given by

$$P(S) = \int f_C(x) F_D(x)\, dx$$

in which $f_C(x)$ is the probability density function of the capacity (the derivative of the capacity probability function, $F_C(x)$) if the capacity is a continuous variable and otherwise is the probability mass function of the capacity (analogous to a histogram). In words the preceding equation indicates that one should assign a probability that the capacity is a particular value ($f_C(x)$) and then multiply by the probability that the demand is no greater than that value of capacity ($F_D(x)$). This process then is repeated for all possible values of the demand and the capacity, and the results are added (that is what the integration function does for continuous variables). The integrand of the equation above is shown in the Figure 1.

FIGURE 1

Capacity and Demand



SOURCE: Courtesy of Ross B. Corotis.

The probability function of demand, F_D, is multiplied by the probability density function of capacity, f_C, and the resulting quantity is then integrated over all values to yield the reliability of the system.

TIME DEPENDENCY. Most systems are not designed to be used just once but instead to perform over an intended period. In this case, the demand and the capacity become time-dependent variables and the probability of satisfactory performance is interpreted as being over an intended design lifetime. The formulation of the previous section then is interpreted as being at a single point in time, and the results are integrated over the lifetime.

Most technology displays a characteristic failure curve that is relatively steep at the beginning of the design lifetime, during which time initial defects are discovered. The failure rate then decreases to a steady-state value that exists over most of the design lifetime of the technology. As the technology nears the end of its useful lifetime, the failure rate again rises as parts begin to wear out.

When failure is due to relatively rare events such as environmental hazards, unusual parts wear, and abnormal use, simplified time-dependent models can be developed on the basis of the independent occurrence of these unusual events. These models usually are based on the Poisson process model, which is the simplest among the time-dependent processes that are referred to as stochastic processes. The Poisson model assumes that the occurrence of each event is independent of the past history of performance of the technology.

Systems reliability adds another level to this analysis. A system is a technology that is composed of multiple parts. Usually it is necessary that the parts work together properly for the system as a whole to function as desired. Systems theory builds on the theory described above to consider multiple capacities and demands, and many theories and models have been developed to analyze the risks of systems (Haimes 1998). Because systems analysis can be complicated, formalized approaches such as decision tree analysis (Clemen 1996) and event tree and fault tree analysis have been developed (Page 1989). Approximate analyses use the concepts of systems reaching a discrete number of undesirable states that are referred to as limit states. One then evaluates the probability of reaching those states by using approximate analyses such as the first-order, second-moment (FOSM) method, in which the limit state is approximated by a straight line and the full probability descriptors of the demands and capacities are approximated by the first and second moments of the probability function, which usually are the average and the standard deviation (Melchers 1999).

Software reliability can be used to illustrate some of the issues mentioned here. Newly engineered software is notoriously unreliable. After in-house testing and even after beta (user) testing in the field or market, "patches" regularly have to be introduced as new problems arise. Sometimes those problems arise because of a lack of correctness in the underlying code, and at other times because of a lack of robustness in the overall design. Software engineers also can fail to appreciate the ways users may choose to utilize a particular piece of software, and hackers and others may try to exploit weaknesses in ways that undermine reliability. As software illustrates, the pursuit of functional reliability in engineering and technology is a never-ending quest with ethical implications.

Ethics of Reliability

Despite its ethical importance in science and technology reliability has been subject to little extended ethical analysis. With regard to persons, in which case the virtue of reliability manifests itself as trustworthiness, there has been more discussion. However, the following comments on the ethics of reliability in general are only preliminary observations.

First, as has been suggested in this entry, technological reliability is what makes engineered artifice the basis for improved material well-being. It is for this reason that a few technical professional ethics codes include the promotion of reliability as an explicit obligation. For example, in the Code of Ethics (developed 1948) of the American Society for Quality (founded in 1946), the third fundamental principle commits a member to promote "the safety and reliability of products for public use." However, although in some instances unreliability in products may be attributed to a failure of intention, in other cases it is caused by evolutionary changes in nature (e.g., the evolution of antibiotic-resistant bacteria), economic change (as occurs when parts cease to be available for cars or other vehicles) or unintended consequences. Indeed, unintended consequences are one of the most common ways to conceptualize breakdowns in technological reliability as engineered devices bring about unexpected scenarios. This both raises questions about the degree to which reliability can be an ethical obligation and suggests the need for engineers to consider the wider ramifications of technology in their analyses of reliability and to build flexibility into their designs.

Another instance in which reliability has been adopted explicitly as an ethical concept related to technology occurred at a Poynter Journalism Values and Ethics in New Media Conference in 1997. That conference drafted an ethics code that included the following recommended "Online Reliability Statement":

> This site strives to provide accurate, reliable information to its users. We pledge to:
>
> Ensure information on our Web site has been edited to a standard equal to our print or broadcast standards.
>
> Notify our online users if newsworthy materials are posted from outside our site and may not have been edited or reviewed to meet our standards for reliability.
>
> Update all our databases for timeliness, accuracy and relevance.
>
> Warn users when they are leaving our site that they may be entering a site that has not embraced the content reliability protocol.

The idea here is that professional standards of reliability in the print media need to be transported consciously into a new technological media framework. Similar statements about the need for commitment to reliability in information delivery related in one way or another to technology have been discussed with regard to both medicine and computers.

With regard to science replicability generally is thought of as a self-regulating process that serves both as a method for epistemological quality control and as a way to prevent scientific misconduct, including fabrication, falsification, and plagiarism. Thus, it is a mechanism for nurturing trust within the scientific community. The dominant perception that scientists deal with absolute certainties often undermines public trust in science when scientists openly communicate uncertainties in their research or when a scientific finding of high public concern is disputed and eventually overturned ("In Science We Trust" 2001).

The notion of reliability as replicability also manifests a certain hierarchy of values or axiology in the pursuit of knowledge. Alvin Weinberg (1971) has noted that physics serves as the ideal science (of which other sciences are more or less distorted images) because of the universalizability and replicability of its findings. It most closely approximates deeply entrenched Western beliefs about truth as timeless and noncontextual. However, this ingrained cultural deference to this ideal of science can lead to misunderstandings of science and unrealistic expectations about its contributions to complex political decisions.

Questions also might be raised about the issue of reliability in ethics itself. The human sciences, including ethical inquiry, proceed by means of dialectical and hermeneutical processes that are different from the models of the engineering construction of reliable artifacts or the scientific construction of reliable knowledge claims. In the popular imagination ethical and other value claims often are treated as matters of religious commitment, subjective preference, or legalistic requirements. However, a more nuanced appreciation of the process of ethical argumentation can point to possibilities for reliability.

Substantive agreement and reliability can be found, for instance, in some common documents, such as the Universal Declaration of Human Rights of 1948. Procedural reliability is manifested in the democratic considerations of ethics and other values that also are able to proceed toward common interest solutions through reasonable argumentation, tolerance, compromise, and openness of mind, procedures not dissimilar to those involved in the pursuit of an always provisional scientific truth.

Thus, the test for reliability in ethics may not be replicability, but it also may not be as distant from the actual workings of science as is maintained by many people. Indeed, when it comes to practical affairs, the desirable trait for both science and ethics may not be replicability so much as something more akin to the functional reliability of technology. That is, reliable science and ethics, much like reliable technologies, help human beings navigate toward common goods within complex situations marked by uncertainties and pluralities.

ROSS B. COROTIS
CARL MITCHAM
ADAM BRIGGLE

SEE ALSO *Uncertainty.*

BIBLIOGRAPHY

Clemen, Robert. (1996). *Making Hard Decisions: An Introduction to Decision Analysis*. Pacific Grove, CA: Duxbury Press.

Collins, Harry, and Trevor Pinch. (1998). *The Golem: What You Should Know about Science*, 2nd rev. edition. New York: Cambridge University Press. This controversial book, which argues through a series of seven case studies for the influence of social factors in the assessment of experiments, originally was published in 1993.

Haimes, Yacov. (1998). *Risk Modeling, Assessment, and Management*. New York: Wiley.

"In Science We Trust." (2001). *Nature Medicine* 7(8): 871.

Melchers, Robert. (1999). *Structural Reliability Analysis and Prediction*. New York: Wiley.

Page, Lavon. (1989). *Probability for Engineering*. New York: Computer Science Press.

Peters, Douglas P., and Stephen J. Ceci. (1982). "Peer Review Practices of Psychological Journals: The Fate of Published Articles, Submitted Again." *Behavioral and Brain Sciences* 5: 187–255. Finds that eight of twelve articles resubmitted after they had been published were rejected by the same journal.

Weinberg, Alvin. (1971). "The Axiology of Science." *American Scientist* 58(6): 612–617.

Wood, Michael; Martyn Roberts; and Barbara Howell. (2004). "The Reliability of Peer Reviews of Papers on Information Systems." *Journal of Information Science* 30(1): 2–11.

INTERNET RESOURCES

American Society for Quality. "Code of Ethics." Available from http://www.asq.org. The 1948 code of ethics can be found on their site at http://www.asq.org/join/about/ethics.html

The Poynter Institute. "Online Content Reliability Guidelines." 1997. Includes the "Online Reliability Statement." Available from http://legacy.poynter.org/research/me/nme/me_samprot.htm#relability.

RESEARCH ETHICS: OVERVIEW

Research ethics is typically divided into two categories: those issues inherent in the practice of research, and those that arise in the application or use of research findings. In the United States, ethical practice has come to be known as the responsible conduct of research (RCR); outside the United States another common term is good scientific practice (GSP). Ethical issues associated with the application of research findings deal with their use in the support of legal, social, or economic policy as well as their technological applications (e.g., genetic engineering in therapy and agriculture, bioweapons development, and dam siting and construction).

Many entries in the *Encyclopedia of Science, Technology, and Ethics* cover different aspects of research ethics in more detail. Prime examples include the entries on "Responsible Conduct of Research" and "Scientific Integrity," the composite on "Misconduct in Science," and the series dealing with various aspects of genetics. The focus here is on a more synthetic overview that also highlights some points missing elsewhere.

Background

Both aspects of research ethics came to the forefront of public attention at the end of World War II and have developed more fully over the mid-twentieth century. Leading discussions have often but not always taken place in the United States.

RESEARCH PRACTICE. Initially ethical concerns regarding research practice emphasized the use of humans as research subjects. The revelation of Nazi atrocities at the close of World War II focused international attention on research that subjected individuals to high altitude experiments in low-pressure chambers, freezing due to exposure or submersion in ice water, starvation or seawater as their primary source of fluids, and infection with malaria, typhoid, streptococcus, and tetanus. Judges presiding over the trial of Nazi physicians drafted the Nuremberg Code (1946), which has since been followed by additional ethical codes most prominently the World Medical Association Declaration of Helsinki (1964; most recently revised in 2002). For further depth on these issues see the entries on "Nazi Medicine" and "Human Subjects Research."

In the early 1970s the U.S. Tuskegee Syphilis studies came to light (see "Tuskegee Experiment) and focused national attention on human subjects treatment in the United States. This research, carried out from 1932 to 1972, recruited disadvantaged, rural black males who had contracted syphilis to participate in the study of the course of untreated disease. Although no clearly effective treatment was initially available, when it became apparent that penicillin was effective, participants were not given this medication. When these studies were made known, the U.S. Congress mandated a commission to identify, develop, and articulate the ethical principles that underlie and must guide the acceptable use of human volunteers and subjects in biomedical research. The commission's work resulted in the Belmont Report (National Commission 1978) that serves as the foundational document for research involving humans in the United States.

In the 1980s other egregious examples of scientific misconduct were exposed, including the fabrication and falsification of data, and plagiarism (Broad and Wade 1982, LaFollette 1992). While these were not the first instances of misconduct in science—the Piltdown Man fraud was initiated in 1912—they raised serious concerns not only within but beyond the scientific community. Indeed the U.S. Congress began to demand more consistent oversight of the process of research funding which led to establishment of the Office of Scientific Integrity within the National Institutes of Health that ultimately became the Office of Research Integrity (ORI) in the Department of Health and Human Services.

Moreover, within the scientific community, it became clear that concerns regarding serious scientific misconduct were only the tip of the iceberg in the sense that the professional standards, expectations of colleagues, and ethical values of the research community with regard to many aspects of research practice were not clearly articulated nor widely understood. There was, and is, a wide range of accepted practices without much discussion of the underlying assumptions and wider implications that place those practices along the continuum of preferred, acceptable, discouraged, and prohibited practices. As a result, trainees and even more established researchers are not always clear about the acceptability of established or ongoing practices within the community.

For example, while plagiarism (the misrepresentation of the writings or ideas of another as one's own) is clearly deceptive and unacceptable, other publication practices can also be problematic. The practice of "honorary" authorship—that is, including in the list of authors individuals who have not made a clear and significant intellectual contribution to the published work—became increasingly widespread over the latter part of the twentieth century. The practice of adding names to the list of authors (sometimes without the knowledge or consent of the individual "honored") in exchange for a reagent, a strain of mice, laboratory space, or past tutelage not only tends to "dilute" the apparent contribution of other authors (depending on a reader's assumptions), but also to deny honorary authors any opportunity to make fully informed decisions about their associations with the work.

APPLICATION OF RESEARCH FINDINGS. The end of World War II also brought greater awareness of the ethical implications of the uses of science and technology. The use of the atomic bomb by the United States on Japan raised a host of questions regarding the social responsibility of scientists and engineers for the consequences of their work. The Manhattan Project reflected a national priority to devote all resources, including scientific expertise to winning the war. Yet those working on the project could only speculate on the immediate and long-term health and environmental effects of an atomic explosion. Moreover, as scientist J. Robert Oppenheimer mused, the science was so "technically sweet" that its appeal overrode concerns about the creation of an enormously destructive bomb so unlike the conventional weapons with which people were already familiar.

In the 1960s Rachel Carson and others called attention to the dangers of chemical pollutants in the environment, and reactions took place against some of the kinds of chemicals being used in many agricultural, industrial, and military activities. In the 1970s developments in molecular biology (specifically techniques with recombinant DNA) led researchers to convene a conference in Asilomar, California, to discuss the implications and potential hazards of genetic engineering. This is often identified as the first widespread, proactive effort on the part of the scientific community to acknowledge and address its social responsibility.

The discussion has become more nuanced and complex as the impact of human activity on the environment and on other species as well as other human populations has become more apparent. Whether in the construction of large engineering projects such as dams that dramatically alter the landscape, inundate archaeological treasures, and displace the local population, or in the oftentimes poorly executed use of genetically engineered crops in developing nations, or in many other technological applications, their larger ethical and social implications have become the focus of increasing examination, debate, and institutional reform.

The Responsible Conduct of Research and Good Scientific Practice

Progress in science depends on trust between scientists that results have been honestly presented. It also depends on members of society trusting the honesty and motives of scientists and the integrity of their results (European Science Foundation 2000). Fostering this trust requires clear and strong ethical principles to guide the conduct of scientific research. In the United States, ethical research practice is generally referred to as RCR or the responsible conduct of research. The ORI, the U.S. federal agency primarily concerned with education in RCR, has identified nine core instructional areas in RCR (Office of Research Integrity 2005, Steneck 2004). Areas (1) through (5) deal with the actual conduct of research while areas (6) through (9) are associated with interactions between members of the scientific community.

1. Data Acquisition, Management, Sharing, and Ownership. This area focuses on the ways in which data are recorded, whether in notebooks or in other formats (such as electronic records, photographs, slides, etc.), and how and for how long they should be stored. It explores as well the question of who owns the data, who is responsible for storing them, and who has access to them. Issues of privacy and confidentiality of patient information as well as intellectual property issues and copyright laws are included.
2. Conflict of Interest and Commitments. Discussion of conflicting interests and commitments acknowledges the potential for interference in objective evaluation of research findings as a result of financial interests, obligations to other constituencies, personal and professional relationships, and other potential sources of conflict. It also considers strategies for managing such conflicts in order to prevent or control inappropriate bias in research design, data collection, and interpretation.
3. Human Subjects. Ethical treatment of human research subjects references the requirements of the Office of Human Research Protections (OHRP), which are based on the ethical principles outlined in the Belmont Report (National Commission 1978). These principles include especially (a) respect for persons as expressed in the requirement for informed consent to participate and protection of vulnerable populations such as children and those with limited mental capacity; (b) emphasis on beneficence that maximizes the potential benefits of the research and minimizes risks; and (c) attention to considerations of justice in the form of equitable distribution of the benefits and burdens of the research across populations. Adequate attention to patient privacy and the variety of potential harms including psychological, social, and, economic is essential.
4. Animal Welfare. Research involving animals emphasizes animal welfare in accordance with the regulations of the Office of Laboratory Animal Welfare (OLAW). Principles here emphasize respect for animals used in research (Russell and

Burch 1959) in the form of "the three Rs": reduction of the number of animals used, replacement of the use of animals with tissue or cell culture or computer models or with animals lower on the phylogenetic scale whenever appropriate and possible, and refinement of the research techniques to decrease or eliminate pain and stress.

5. Research Misconduct. Dealing with allegations of research misconduct is essential given its potential for derailing a research career. Definitions of scientific misconduct, including fabrication, falsification, and plagiarism as well as other serious deviations from accepted practice that may qualify as scientific misconduct, as distinguished from error, and protections for whistleblowers are important components of this topic.
6. Publication Practices and Responsible Authorship. Publication practices and responsible authorship examine the purpose of publication and how that is reflected in proper citation practice, criteria for authorship, multiple, duplicate and fragmentary publication, and the pressure to publish. This area also considers allocation of credit, the implications and assumptions reflected in the order of authors, and the responsibility of authorship.
7. Mentor/Trainee Responsibilities. The mentor/trainee relationship encompasses the responsibilities of both the mentor and the trainee, collaboration and competition, possible conflicts and potential challenges. It also covers the hierarchy of power and potential for the abuse of power in the relationship.
8. Peer Review. The tension between collaboration and competition is embodied in the peer review process for both publication and funding. In this area of RCR issues associated with competition, impartiality and confidentiality are explored along with the specifics of the structure and function of editorial and review boards and the *ad hoc* review process.
9. Collaborative Science. Not only does research build on the work of others, but more and more investigators from disparate fields work together. The collaborative nature of science requires that often implicit assumptions about common practices such as authorship and data sharing need to be made explicit in order to avoid disputes.

In Europe, the term of art for discussion of research ethics is GSP or good scientific practice (European Science Foundation 2000). However, unlike RCR, which emphasizes guidelines for positive research behaviors, there is a tendency in other countries to emphasize the avoidance of negative behaviors. This means that despite the name (good scientific practices) discussion focuses on scientific misconduct. For instance, it the pursuit of GSP, the U.K. Office of Science and Technology (OST), the oversight body of the U.K. Research Councils, categorizes scientific misconduct into two broad groups. The first pertains to the fabrication and falsification of research results. The second category pertains to plagiarism, misquoting, or other misappropriation of the work of other researchers. The OST statement "Safeguarding Good Scientific Practice" (1998) stresses the need to avoid misconduct by means of self regulation of and by the research community, arguing that "Integrity cannot be prescribed" (Office of Science and Technology).

With the creation of the Danish Committee on Scientific Dishonesty in 1992, Denmark became the first European country to form a national body to handle cases of scientific dishonesty—again with the aim of promoting GSP. This has prompted similar practices in other Scandinavian countries (Vuckovic-Dekic 2000).

A serious case of scientific misconduct in Germany in 1998 sparked the creation of the international Commission on Professional Self Regulation in Science. This Commission was charged to explore causes of dishonesty in the science system, discuss preventive measures, examine the existing mechanisms of professional self regulation in science, and make recommendations on how to safeguard them. It published a report titled "Proposals for Safeguarding Good Scientific Practice," which advised relevant institutions (universities, research institutes, and funding organizations) to establish guidelines of scientific conduct, policies for handling allegations, and rules and norms of good practice (Commission on the Professional Self Regulation in Science 1998). Fearing over-regulation, the commission recommended that institutions retain authority for establishing misconduct policies (rather than establishing a centralized committee as in the United States and Denmark).

Ethical Issues in the Application of Research

The Enlightenment creed *Sapere aude!* (Dare to know!) symbolized the distinctively modern belief that scientific research is an ethical responsibility, indeed a moral obligation of the highest order. Ancient or premodern thinkers generally maintained that there were limits to the quest for knowledge, beyond which lay spiritual and physical dangers. Although there is a long tradition of critiques of this foundational modern commitment (e.g., Wolfgang von Goethe's *Faust* and Mary Shelly's *Frankenstein*), they have become more refined, extended, and institutionalized in the latter half of the twentieth century as science and technology began to profoundly alter both society and individual lives. The ramifications of various technological developments (e.g., atomic energy, genetic engineering) have demonstrated that unfettered research will not automatically bring unqualified goods to society.

Daniel Callahan (2003) has argued that there is a widespread assumption of the "research imperative," especially in the area of biomedicine and health care. Though a complex concept, it refers to the way in which research creates its own momentum and justification for gaining knowledge and developing technological responses to diverse medical conditions. It can pertain to the ethically dubious rationale of pursuing research goals that are hazardous or of doubtful human value, or the rationale that the ends of research justify the means (no matter how abhorrent). It can also pertain to the seemingly noble goal of relieving pain and suffering. Yet this commitment to medical progress has raised health care costs and distracted attention from the ultimate ends of individual happiness and the common good. Research, no matter how honorable the intent of those performing and supporting it, must be assessed within the context of other goods, rather than elevated as an overriding moral imperative (Jonas 1969, Rescher 1987).

As is considered in entries on "Science Policy" and "Governance of Science," the core assumption of the inherent value of research was operationalized in post-World War II U.S governmental policies for the funding of scientific research. What came to be known as the "linear model" of science-society relations posited that investments in "basic" research would automatically lead to societal benefits (Price 1965). However, the framers of this policy never specified how this "central alchemy" would occur, and they did not adequately address the need to mitigate negative consequences of scientific research (Holton 1979). The economic decline of the late 1970s and 1980s, the end of the cold war in the early 1990s, and the growing federal budget deficits of the same period combined to stimulate doubts about the identity of purpose between the scientific community and society (Mitcham and Frodeman 2004).

The very fact that societal resources are limited for the funding of scientific research has stimulated questions about what kind of science should be pursued. For instance, physicist and science administrator Alvin Weinberg argued in the 1960s that internal assessments of the quality of scientific projects and scientific researchers should be complemented by evaluation of scientific merit as judged by scientists in other disciplines, of technological merit, and of social merit. For Weinberg, because of the limited perspective of those within the community, "the most valid criteria for assessing scientific fields come from without rather than from within the scientific discipline that is being rated" (1967, p. 82).

Put simply, while the internal ethics of research asks: "How should we do science?" the external ethics of research takes up a suite of questions involving participants beyond the immediate scientific community and addressing more fundamental ends. As Daniel Sarewitz (1996) noted the pertinent questions are "What types of scientific knowledge should society choose to pursue? How should such choices be made and by whom? How should society apply this knowledge, once gained? How can "progress" in science and technology be defined and measured in the context of broader social and political goals?" (p. ix).

Myriad attempts have been made to reformulate the relationship between scientific research and political purposes, where the criteria for assessing science derive partially from without rather than from within a particular scientific discipline. Models include Philip Kitcher's ideal of "well-ordered science" (2001) and the concept of "use inspired basic research" put forward by Donald Stokes (1997). Such revised social contracts for science shift the focus from maximizing investments in research to devising mechanisms for directing research toward societal benefits; a shift from "how much?" to "toward what ends and why?" Legislation such as the 1993 U.S. Government Performance and Results Act (GPRA) reflects this focus on the social accountability of publicly funded science, as do technology assessment institutions and ethical, legal, and social implications research performed in conjunction with genome and nanotechnology research.

The prioritization of research projects is another important area in this regard, including the issue of how much money to allocate to the study of different diseases, which often raises ethical concerns about systematic discrimination. The effective use of scientific research and technologies in development policies intended to decrease poverty and improve the health of those in developing countries is a related topic. Diverse experiences with the Green Revolution, for example, show the importance of context in directing research toward common interests and away from negative outcomes such as ecological harms and the exacerbation of wealth disparities. Both of these topics raise the important issue of the role of various publics in guiding and informing scientific research and technological applications.

Although it is still largely true that "more money for more science is the commanding passion of the politics of science" (Greenberg 2001, p. 3), a number of critics and policy makers understand that more is not necessarily better. Scientific progress does not always equate to societal or personal progress in terms of goals such as safety, health, and happiness (Lightman, Sarewitz, and Desser 2003). The potential unintended physical harms that may result from scientific research have long been recognized and debated in terms of the roles of scientists and non-scientists in risk assessment. More recent developments, especially in bio- and nanotechnology research, and the growing specter of catastrophic terrorist attacks have lent a more urgent tone to questions about "subversive truths" and "forbidden knowledge" (e.g., Johnson 1996).

Limiting scientific research raises practical questions such as "Who should establish and administer controls?" and "At what level should the controls be imposed?" (Graham 1979). Some (e.g., McKibben 2003) have advocated the large scale relinquishment of whole sectors of research such as nanotechnology. Others, including the innovator Ray Kurzweil, argue for a more fine-grained relinquishment and the prioritizing of funding for research on defensive technologies to counteract potential misuses of science. This view holds that the optimal response to the potential for bioterrorism, for example, is to lessen restrictions on and increase funding for bioweapons research so that preventive measures and cures can be developed.

Discussion of the ethical implications of the use of scientific research is, at its core, about procedures for democratic decisions and the allocation of authority and voice among competing societal groups. This can be construed in broad terms ranging from criticisms of Western science as a dominant even hegemonic way of knowing that drowns out other voices, to defenses of science as an inherently democratizing force where truth speaks to power. These vague issues take on importance in concrete contexts that concern judgments about the appropriate degree of scientific freedom and autonomy within democratic societies. The most important area in which these issues arise is the use of scientific knowledge in formulating public policies.

Although bureaucratic political decision-making has come to rely heavily on scientific input, it is not obvious how the borders and interstices between science and policy should be managed. On the one hand, it seems appropriate that research undertaken by scientific advisory panels (as distinct from research in general) be somehow connected to the needs of decision makers. On the other hand, sound procedures for generating and assessing knowledge require a degree of independence from political (and corporate) pressures. Failure in the first instance leads to generation of irrelevant information and often delayed or uninformed action. Failure in the second case leads to conflicts of interest or the inappropriate distortion of scientific facts to support preexisting political agendas (Lysenkoism is an extreme example) or corporate policies.

The latter instance is often couched in terms of the "politicization of science," which is a perennial theme in science-society relationships (e.g., Union of Concerned Scientists 2004). Yet in order to attain the democratic ideal of being responsive to the desires and fears of all citizens, the politicization of science in the sense of explicitly integrating it into the larger matrix of goods (and evaluating it from that standpoint) is proper. Scientific research can be "misused" when it is inappropriately mischaracterized (e.g., to over-hype the promise of research to justify funding) or delegitimized (Pielke 2004) and it is important to enforce ethical guidelines against these practices. However, the more common misuse of science that ranges from intentional to unconscious, is the practice of arguing moral or political stands through science (Longino, 1990). This can inhibit the ethical bases of disputes from being fully articulated and adjudicated, which often prevents science from playing an effective role in policy making (Sarewitz 2004).

Teaching Research Ethics

Science educators and researchers have generally believed their responsibility was to teach scientific concepts and laboratory techniques, and it was expected that professional values and ethical standards would be picked up by observing good examples. However, as a result of well-publicized and serious instances of scientific misconduct in the 1980s, the research community has become aware of the need to address the responsible conduct of research explicitly. Thus in 1989 the U.S. National Institutes of Health (NIH) began calling for formal instruction for NIH funded pre- and post-doctoral trainees in the responsible conduct and reporting of research (National Institutes of Health 1989). Moreover, in support of expanding the NIH requirement, both the report of the Commission on Research Integrity, "Integrity and Misconduct in Research" (1995) and the report of the international Commission on Professional Self Regulation in Science, "Proposals for Safeguarding Good Scientific Practice" (1998), highlighted the fact that education in RCR /GSP has been largely neglected worldwide and should be addressed for both trainees and senior scientists. In addition, recognition of the ethical implications of science and technology has led to the incorporation of these topics into many courses and programs aimed at teaching research and engineering ethics. It is widely appreciated that students need to understand that science and technology are not value free and that scientific information can be used for good or ill, misused or abused.

While it is widely believed that "by the time students enter graduate school, their values and ethical standards are so firmly established that they are difficult to change" (Swazey 1993, pp. 237–38) there is a solid body of evidence that supports the view that in fact adults *can* be taught to behave ethically through specific educational programs introduced at the undergraduate and postgraduate level (Rest et al. 1986; Bebeau et al. 1995). This is closely linked to the individual's reconceptualization of his or her professional role and relationship to society. Educational programs can affect awareness of moral problems and moral reasoning and judgment. Moreover, studies show that moral perception and judgment influence behavior.

There is some controversy regarding the emphasis of research ethics education, that is, whether to focus on the rules and regulations, expectations and standards of the research community, or to emphasize moral development. However in reality, teaching research ethics entails both communicating the standards and values of the community and promoting moral development through increased ethical sensitivity and ethical reasoning. Thus the goals of education in research ethics are to:

1. Increase awareness and knowledge of professional standards. Toward this end, professional standards and ethical values of scientific research and conventions are identified and clarified, as is the range of acceptable practices along the continuum of preferred, acceptable, discouraged, and prohibited. In the process, the assumptions that underlie accepted practices are examined and the immediate and long-term implications of these practices are assessed.

2. Increase awareness of ethical dimensions of science. This includes examination of the issues associated with both research practice and the application of research findings.

3. Provide experience in making and defending decisions about ethical issues. Case studies designed to illustrate common research practices and situations are generally used. Discussion of these cases invariably entails in-depth analysis of affected parties, points of conflict, implications of various courses of action, and examination of the expectations, needs and responsibilities of the different characters in the scenario.

4. Promote a sense of professional responsibility to be proactive in recognizing and addressing ethical issues associated with research.

A number of key characteristics of educational programs in research ethics have been identified (Bird 1999, Institute of Medicine 2002). These reflect principles of effective adult education as well as common sense. Programs that are *required* emphasize the view that ethical issues are inherent in research and that awareness of the ethical values and standards of the research community are an essential component of professional education. *Interactive* discussion of ethical issues and concerns raised by a realistic case provides participants with an opportunity to share their experience and solve problems in a context. This approach employs principles of learning science that have been identified through research on how people learn (Bransford et al. 1999). *Broad faculty involvement* in educational programs in research ethics demonstrates that this is valued by professionals across the discipline and incorporates a variety of experience and a range of perspectives with regard to accepted practices. Programs should *begin early* in research education (e.g., undergraduate science laboratory courses) and *continue* throughout college and graduate or other professional education. In so doing, individuals can reflect on their own experience, and their understanding and appreciation of ethical concerns and strategies for problem solving can evolve. When the various components of graduate education (i.e., courses, seminars, laboratory meetings, etc.) address ethical issues they *reinforce and complement* each other.

A variety of formats and strategies have been developed to teach research ethics. The most effective are case-based and integrate discussion of research ethics into all of the various elements of research education: as modules in core courses, stand-alone full semester or short courses on research ethics, departmental seminars, workshops, laboratory and research team meetings, one-on-one interactions between trainees and research supervisors, and computer-based instruction (Swazey and Bird 1997, Institute of Medicine 2002). Each approach has strengths and weaknesses.

Through explicit discussion of ethical issues associated with the practice of research and the application of research findings the research community acknowledges the complexity of the issues and the need to address them. Specifically addressing RCR reaffirms the responsibility of the research community for research integrity, individually and collectively, and the necessity of providing this information to its members. Identifying and examining the ethical issues associated with the application (or misapplication) of research findings emphasizes the responsibility of researchers and of citizens in general to examine and assess the ramifications of science and technology for society.

STEPHANIE J. BIRD
ADAM BRIGGLE

SEE ALSO *Accountability in Research; Animal Welfare; Chinese Perspectives: Research Ethics; Ethics: Overview; Misconduct in Science: Overview; Nazi Medicine; Science: Overview; Sociological Ethics.*

BIBLIOGRAPHY

Bebeau, Muriel J.; Kenneth D. Pimple; Karen M. T. Muskavitch; Sandra L. Borden, and David L. Smith. (1995). *Moral Reasoning in Scientific Research: Cases for Teaching and Assessment*. Bloomington, IN: Indiana University.

Bird, Stephanie J. (1999). "Including Ethics in Graduate Education in Scientific Research." In *Perspectives on Scholarly Misconduct in the Sciences*, John M. Braxton, ed. Columbus: Ohio State University Press.

Bransford, John D., A. L. Brown, and R. R. Cocking. (1999). *How People Learn: Brain, Mind, Experience, and School*. Committee on Developments in Science of Learning and Commission on Behavioral and Social Sciences and Education. Washington DC: National Academies Press.

Broad, W.J., and Nicholas Wade. (1982). *Betrayers of the Truth: Fraud and Deceit in the Halls of Science*. New York: Simon and Schuster.

Callahan, Daniel. (2003). *What Price Better Health?: Hazards of the Research Imperative*. Berkeley, CA: University of California Press.

Commission on Research Integrity (CORI). (1995). *Integrity and Misconduct in Research*. Washington, DC: U.S. Department of Health and Human Services, Public Health Services.

Graham, Loren R. (1979). "Concerns about Science and Attempts to Regulate Inquiry." In *Limits of Scientific Inquiry*, Gerald Holton and Robert S. Morison, eds. New York: W.W. Norton.

Greenberg, Daniel S. (2001). *Science, Money, and Politics: Political Triumph and the Ethical Erosion*. Chicago: University of Chicago Press. Seeks to explain the success of autonomous science embedded in U.S. politics from World War II through the beginning of the twenty-first century and argues that lobbying for money by scientists has corroded their integrity.

Holton, Gerald. (1979). "From the Endless Frontier to the Ideology of Limits." In *Limits of Scientific Inquiry*, Gerald Holton and Robert S. Morison, eds. New York: W.W. Norton.

Institute of Medicine and National Research Council (2002). *Integrity in Scientific Research: Creating and Environment that Promotes Responsible Conduct*. Washington, DC: National Academies Press.

Johnson, Deborah. (1996). "Forbidden Knowledge and Science as Professional Activity," *The Monist*, 79(2): 197–217.

Jonas, Hans. (1969). "Philosophical Reflections on Experimenting with Human Subjects," *Daedalus*, 98: 219–247.

Kitcher, Philip. (2001). *Science, Truth, and Democracy*. Oxford: Oxford University Press. Argues that epistemic values do not stand above or apart from practical social concerns and offers a new model for controlling and directing scientific inquiry.

LaFollette, Marcel C. (1992). *Stealing into Print: Fraud, Plagiarism, and Misconduct in Scientific Publishing*. Berkeley, CA: Oxford University Press.

Lightman, Alan; Daniel Sarewitz, and Christina Desser, eds. (2003). *Living with the Genie: Essays on Technology and the Quest for Human Mastery*. Washington, DC: Island Press. Collects sixteen essays on the central tension between the increasing pace of scientific and technological change and an immutable human core, stressing the importance of individual and public decisions in shaping the outcomes of this tension.

Longino, Helen E. (1990). *Science as Social Knowledge: Values and Objectivity in Scientific Inquiry*. Princeton, NJ: Princeton University Press.

McKibben, Bill. (2003). *Enough: Staying Human in an Engineered Age*. New York: Times Books. Advocates setting limits on the pursuit of knowledge and the quest for greater material wealth as they threaten to undermine the essence of being human.

Mitcham, Carl, and Robert Frodeman. (2004). "New Directions in the Philosophy of Science: Toward a Philosophy of Science Policy," *Philosophy Today*. 48(5 Supplement): 3–15.

National Commission for the Protection of Human Subjects (1978). *The Belmont Report: Ethical Principles and Guidelines for the Protection of Human Subjects of Research*. Washington, DC: Department of Health, Education, and Welfare, Government Printing Office, (OS) 78–0012.

National Institutes of Health. (1989). Reminder and Update: Requirement for Programs on the Responsible Conduct of Research in National Research Service Award Institutional Training Programs. NIH Guide for Grants and Contracts.

Price, Don K. (1965). *The Scientific Estate*. Cambridge, MA: Harvard University Press. Critiques the linear model of science policy that derived from Vannevar Bush's *Science—The Endless Frontier* (1945) and comments on fundamental issues in the relationship between science and politics.

Rescher, Nicholas. (1987). *Forbidden Knowledge and Other Essays on the Philosophy of Cognition*. Boston: D. Reidel. Argues that knowledge is only one good among others. Chapter one is titled "Forbidden Knowledge: Moral Limits of Scientific Research."

Rest, James R.; Muriel Bebeau, and J. Volker. (1986). "An Overview of the Psychology of Morality." In *Moral Development: Advances in Research and Theory*, James R. Rest, ed. New York: Praeger.

Russell, W. M. S. and Burch, R. L. (1959). *The Principles of Humane Animal Experimental Technique*. London: Methuen.

Sarewitz, Daniel. (1996). *Frontiers of Illusion: Science, Technology, and the Politics of Progress*. Philadelphia, PA: Temple University Press. Traces modern myths about science and its relation to society, outlines the problems they raise, and concludes with recommendations to form a new mythology.

Sarewitz, Daniel. (2004). "How Science Makes Environmental Controversies Worse," *Environmental Science and Policy* 7(5): 385–403. Case studies and explanations pertaining to the way in which some environmental conflicts become "scientized."

Steneck, Nicholas H. (2004). *Introduction to the Responsible Conduct of Research*. Washington, DC: Government Printing Office.

Stokes, Donald E. (1997). *Pasteur's Quadrant: Basic Science and Technological Innovation*. Washington, DC: Brookings Institution Press. Analyzes the goals of understanding and use and offers a model of use-inspired basic research to help both science and society.

Swazey, Judith P. (1993). "Teaching Ethics: Needs, Opportunities and Obstacles." In *Ethics, Values, and the Promise of Science*. Forum Proceedings, February 25-26, 1993. Research Triangle Park, NC: Sigma Xi, the Scientific Research Society.

Swazey, Judith P. and Bird, Stephanie J. (1997). "Teaching and Learning Research Ethics" In *Research Ethics: A Reader*, Deni Elliott and Judy E. Stern, eds. Dartmouth, NH: University Press of New England.

Vuckovic-Dekic, Lj. (2000). "Good Scientific Practice." In *Archive of Oncology*, 8 (Suppl. 1): 3–4.

Weinberg, Alvin M. (1967). *Reflections on Big Science*. Cambridge, MA: MIT Press.

INTERNET RESOURCES

Commission on Professional Self Regulation in Science. (1998). "Recommendations of the Commission on Professional Self Regulation in Science." Available from http://www.dfg.de/aktuelles_presse/reden_stellungnahmen/download/self_regulation_98.pdf.

European Science Foundation. (2000). "Good Scientific Practice in Research and Scholarship." Available from http://www.hrb.ie/storage/researchfunding/fundingpolicies/goodscientificpractice.pdf.

Office of Research Integrity. (2005). "Education—Responsible Conduct of Research." Available from http://ori.dhhs.gov/education/ed_rcr.shtml.

Office of Science and Technology. (1998). "Safeguarding Good Scientific Practice." Available from http://www.ost.gov.uk/research/councils/safe.htm#2.1.

Pielke, Roger, ed. (2004). "Report on the Misuse of Science in the Administrations of George H.W. Bush and William J. Clinton," available from http://sciencepolicy.colorado.edu/admin/publication_files/resourse-1429-ENVS%204800%20Report.pdf. Presents a taxonomy of the misuse of science and illustrates it through six case studies.

Union of Concerned Scientists. (2004). "Scientific Integrity in Policy Making: An Investigation into the Bush Administration's Misuse of Science," available from http://www.ucsusa.org/documents/RSI_final_fullreport.pdf. Illustrates through several vignettes the argument that individuals in the administration of President George W. Bush have suppressed or distorted research findings and undermined the quality and integrity of the appointment process.

RESEARCH INTEGRITY

Integrity (from the Latin *integritas*, meaning *whole* or *complete*) refers in ethics to adherence to a code or a usually high standard of conduct. Research integrity thus indicates doing research in accord with standards that properly inform and guide that activity—without deviance under any inappropriate influences. Integrity in this sense has close correlates with authenticity and accountability. Research integrity is also often considered the flip side of research misconduct. Whereas the topic of research misconduct concentrates on the definition, identification, adjudication, and consequences of malfeasance committed by scientists in the course of their research; research integrity concentrates on, as the Institute of Medicine's 2002 report, *Integrity in Scientific Research*, was subtitled: "creating an environment that promotes responsible conduct" of research (Institute of Medicine, p. x). Having received considerable public attention since the 1980s, however, research integrity is a contested issue both within the scientific community and between the community and its patrons.

Public and Professional Tensions

Part of the conflict over research integrity occurs over identifying the appropriate code or standard. Sociologist Robert K. Merton (1973) described four norms of science—communalism (or communism), universalism, disinterestedness, and organized skepticism—that are often cited as antecedent to codes to which scientists are supposed to adhere. But other scholars argue that such norms are not well recognized among all scientists

(Mitroff 1974), or that they are merely self-serving *vocabularies of justification* for scientific autonomy (Mulkay 1975), or that they might have served as guideposts historically but that they are being supplanted by counter-norms that are more bureaucratic and commercially oriented (Ziman 1990).

Many professional societies have written or revised codes of ethics or guidelines for research integrity that encompass normative issues ranging from formal, regulatory definitions of research misconduct (for example fabrication, falsification, and plagiarism) to more subtle professional behavior such as authorship practices and mentorship. In the early-twenty-first century, professional bodies such as the Accrediting Board for Engineering and Technology (ABET) require training in ethics and research integrity for accredited undergraduate engineering programs. Scientific journals have also assumed an active role in defining integrity for their authors around topics such as credit for authorship, conflict of interest, and responsibility for corrections and retractions.

Research integrity is often connected not only with the attempt of the scientific community to encourage ethical behavior within its own ranks, but also with its attempt to maintain professional autonomy from public interference. As such, it is an aspect of the social contract for science in which the scientific community implicitly promised to maintain the integrity of its research in exchange for an unusual lack of oversight—despite public patronage. This tacit agreement was substantially reconfigured during the 1980s and 1990s, as both parties recognized that the promotion and assurance of research integrity must be a collaborative, rather than an autonomous, enterprise (Guston 2000).

The public patrons of research in liberal democracies have a special interest in research integrity not only because of the instrumental use of science and technology for public purposes (for example, only good science can lead to the promises of health, economic advancement, environmental quality, and military security, among others), but also because of the ideological support that good science offers the state by demonstrating its effectiveness and by reifying the concepts of representation and causality upon which representative government is based (Ezrahi 1990). In the United States, research integrity has become a pressing issue to the funding agencies and professional societies that mediate between public patrons and practicing scientists. A driving force for attention to research integrity was the promulgation of rules in 1990 by the National Institutes of Health (NIH) to require institutions participating in training grants to provide training in the responsible conduct of research. Such training often includes discussions not only of misconduct, but also of whistle-blowing, the protection of human and animal research subjects, the mentoring relationship, and the consequences of recently emergent economic relations in research including conflicts of interest and intellectual property rights. In 2000 the Office of Research Integrity (ORI) of the U.S. Public Health Service proposed more specific and broadly applicable rules for training in the responsible conduct of research, but as of 2004 these rules had not been implemented.

Because of the increasing recognition that the effects of research—for good or for ill—go beyond the scientific community, there is increasing attention as well to what some (particularly in engineering ethics) call *macroethics*, or the responsibility that scientists and engineers have to behave with integrity not just toward each other and toward their direct patrons but to society more broadly conceived (Herkert 2001). This agenda includes helping to craft private and public policies that make appropriate use of science and its products, assuring that the knowledge-based innovations to which they contribute are not only technically virtuous but socially benign, and even accepting greater involvement of non-scientists in some aspects of technical decision making. This agenda has historical roots, for example, in the characterization of activism by atomic physicists in nuclear weapons policy or molecular biologists in recombinant DNA policy as *scientific responsibility*.

Unresolved Questions

Despite increasing recognition of the importance of research integrity to both the scientific community and the broader society, and the consequent need for collaboration to assure it, several questions remain. One is whether the primary responsibility for assuring the integrity of research lies with individual researchers; research institutions such as universities, professional societies and the community of science; or public patrons of research. The Institute of Medicine (2002) concludes that research institutions should have the primary role, but that public patrons of research have an important oversight role and that individual integrity is still the backbone of the system.

A second question is, given the importance of some institutional role in research integrity, why so few exist. As one such institution, ORI—initially created to investigate allegations of research misconduct—has, in the early-twenty-first century, been changing its agenda toward encouraging training in research integrity and even sponsoring *research on research integrity*. The National Science Foundation (NSF) has also sponsored projects on research integrity, including the On-Line Ethics Center.

A third question is whether greater collaboration between science and society may legitimate an increasingly malign political interference, rather than a benign influence, on public science. The Waxman report, which issued from the U.S. House of Representatives, and a similar report from the Union of Concerned Scientists in 2004, for example, claim to document dozens of threats to research integrity from the intrusion of political agendas into scientific and technical decision making in the bureaucracy.

A fourth question, which makes the others all the more difficult to manage, is—as the Institute of Medicine (2002) concluded—how to create reliable ways to assess the overall integrity of the research environment, as well as the efficacy of any particular interventions (including educational ones). The lack of empirical evidence means that the scientific community can legitimately call for additional research on research integrity, but it also means that political demands for action may be met with less than satisfactory responses.

DAVID H. GUSTON

SEE ALSO *Accountability in Research; Ecological Integrity; Misconduct in Science: Overview; National Institutes of Health; Office of Research Integrity; Professional Engineering Organizations; Social Contract for Science.*

BIBLIOGRAPHY

Ezrahi, Yaron. (1990). *The Descent of Icarus: Science and the Transformation of Contemporary Democracy*. Cambridge, MA: Harvard University Press. Scholarly account of the co-dependence of scientific and democratic ideologies.

Guston, David H. (2000). *Between Politics and Science: Assuring the Integrity and the Productivity of Research*. New York: Cambridge University Press. Includes detailed political and institutional account of research integrity in U.S. in the 1980s and 1990s.

Herkert, Joseph R. (2001). "Future Directions in Engineering Ethics Research: Microethics, Macroethics and the Role of Professional Societies." *Science and Engineering Ethics* 7: 403–414. Responsible research also includes broader societal responsibilities.

Institute of Medicine. Committee on Assessing Integrity in Research Environments. (2002). *Integrity in Scientific Research: Creating an Environment That Promotes Responsible Conduct*. Washington, DC: National Academy Press. The scientific establishment focuses on the research environment to assure integrity.

Merton, Robert K. (1973). "The Normative Structure of Science." In *The Sociology of Science: Theoretical and Empirical Investigations*, ed. Norman Storer. Chicago: University of Chicago Press. Originally published in 1942. The *locus classicus* for the norms of the scientific community.

Mitroff, Irving I. (1974). *The Subjective Side of Science: A Philosophical Inquiry in the Psychology of the Apollo Moon Scientists*. Amsterdam: Elsevier. A non-Mertonian perspective on scientific norms.

Mulkay, Michael J. (1975). "Norms and Ideology in Science." *Social Science Information* 15: 637–656. Challenges Merton's norms.

Union of Concerned Scientists. (2004). *Scientific Integrity in Policymaking: An Investigation into the Bush Administration's Misuse of Science*. Cambridge, MA: Author. Independent group of scientists alleges that U.S. science has been politicized.

Ziman, John. (1990). "Research As a Career." In *The Research System in Transition*, eds. Susan Cozzens, Peter Healey, Arie Rip, and John Ziman. Boston: Kluwer Academic Publishers. Traditional Mertonian norms have been altered by new practices, including commercial relations, in science.

INTERNET RESOURCE

Waxman, Henry A. (2003). *Politics and Science in the Bush Administration*. Washington, DC: U.S. House of Representatives, Committee on Government Reform, Minority Staff. Available from www.house.gov/reform/min/politicsandscience/pdfs/pdf_politics_and_science_rep.pdf. Politicians allege that U.S. science has been politicized.

RESPONSIBILITY

Overview
Anglo-American Perspectives
German Perspectives

OVERVIEW

Ethical responsibility is one of the most commonly employed concepts in discussing the ethics of science and technology. Scientists have obligations for the "responsible conduct of research." The professional responsibility of engineers calls for attending to the public safety, health, and welfare consequences of their work. Entrepreneurs have responsibilities to commercialize science and technology for public benefit, and the public itself is often called on for the responsible support of science and technology. Consumers are admonished to be responsible users of technology. Yet the abstract noun *responsibility* is no more than 300 years old and has emerged to cultural and ethical prominence in association with modern science and technology from diverse legal, social, professional, religious, and philosophical perspectives.

Legal Responsibility

The legal term for responsibility is *liability*. Law makes explicit certain customary understandings of liability in two areas: criminal law and civil law. Criminal law deals with those offenses prosecuted and punished by the state. Civil law includes breaches of explicit or implicit contract in which injured parties may sue for compensation or damages.

Criminal liability was originally construed to follow simply from a transgression of the external forum of the law—doing something the law proscribes or not doing something it prescribes. But as it developed in Europe under the influence of a Christian theology of sin, which stresses the importance of inner consent, criminal liability was modified to include appreciation of the internal forum of intent. The result is a distinction between unintended transgressions such as accidental homicide and intentional acts such as first-degree murder; punishments for the former are less severe than for the latter.

In contrast to the historical development of restrictions on criminal liability, civil liability has expanded in scope through delimitions on the requirements for intentionality. Civil liability can be incurred by contract or it can be what is called "strict liability." In the case of explicit or implicit contract, intentional fault or negligence (a kind of failure of intention) must be proved. In the case of strict liability there need be no fault or negligence per se.

The concept of strict or no-faulty liability as a special kind of tort for which the civil law provides redress developed in parallel with modern industrial technology. In premodern Roman law, for instance, an individual could sue for damages only when losses resulted from intentional interference with person or property, or negligence. By contrast, in the English common law case of *Rylands v. Fletcher*, decided on appeal by the House of Lords in 1868, Thomas Fletcher was held liable for damages caused by his industrial undertakings despite their unintentional and nonnegligent character. Fletcher, a mill owner, had constructed a water reservoir to support his mills. Water from the reservoir inadvertently leaked through an abandoned mine shaft to flood John Rylands's adjacent mine. Although he admitted Fletcher did not and perhaps could not have known about the abandoned mine shaft, Rylands sued for damages. The eventual ruling in his favor argued that the building of a dam, which raised the water above its "natural condition," in itself posed a hazard for which Fletcher must accept responsibility.

In the early twenty-first century, the most common kinds of civil liability are just such no-fault or prima facie liabilities related to "nonnatural" industrial workplaces and consumer products in which activities or artifacts in themselves, independent of intent, pose special hazards. In the United States one of the key cases establishing this principle was that of *Greenman v. Yuba Power Products, Inc.*, decided on appeal by the California Supreme Court in 1963. In the words of Chief Justice Roger Traynor, in support of the majority:

> A manufacturer is strictly liable in tort when an article he places on the market . . . proves to have a defect that causes injury to a human being. . . . The purpose of such liability is to insure that the costs of injuries resulting from defective products are borne by the manufacturers . . . rather than by the injured persons who are powerless to protect themselves.

Religious Responsibility

The term *responsibility* derives from the Latin *respondēre*, meaning "to promise in return" or "to answer." As such it readily applies to what is perhaps the primordial experience of the Judeo-Christian-Islamic tradition: a call from God that human beings accept or reject. Given this reference—together with its regular embodiment in the "responsorials" of liturgical practice—it is remarkable that the term did not, until the twentieth century, play any serious role in European religious-ethical traditions.

The discovery and development of religious responsibility has again paralleled rising appreciation of the ethical issues emerging from science and technology. It is in opposition, for instance, to notions of secularization and control over nature that the Protestant theologian Karl Barth (1886–1968) distinguished between worldly and transcendent relationships. God is the wholly other, the one who cannot be reached by scientific knowledge. There is thus a radical difference between the human attempt to reach God (which Barth calls religion) and the human response to God's divine revelation (a response Barth identifies as faith). In his *Church Dogmatics* (1932) Barth goes so far as to identify goodness with responsibility in the sense of responding to God.

Catholic theologians have been no less ready to make responsibility central to ethics. For the Canadian Jesuit Bernard Lonergan (1904–1984), "Be responsible" is a transcendental precept coordinate with duties to "Be attentive," "Be intelligent," and "Be reasonable." Responsibility also plays a prominent role in the documents of Vatican II. At one point, after referencing the achievements of science and technology, *Gaudium et Spes* (1965) adds that, "With an increase in human powers comes a broadening of responsibility of the part of individuals and communities" (no. 34). Later, this same document on the church in the modern world suggests that, "We are witnesses of the birth of a new humanism, one in which man is defined first of all by his responsibility toward his brothers and toward history" (no. 55).

The most sustained effort to articulate a Christian ethics of responsibility is, however, that of H. Richard Niebuhr's *The Responsible Self* (1963). In this work Niebuhr contrasts the Christian anthropology of the human-as-answerer to the secular anthropologies of human-as-maker and human-as-citizen. For human-as-maker, moral action is essentially consequentialist and technological. For human-as-citizen, morality takes on a distinctly deontological character. With human-as-answerer, the tension between consequentialism and deontology is bridged by responsiveness to a complex reality, by an interpretation of the nature of this reality—and by an attempt to fit in, to act in harmony with what is already going on. "What is implicit in the idea of responsibility is the image of man-the-answerer, man engaged in dialogue, man acting in response to action upon him" (p. 56). Niebuhr's ethics of responsibility is what might now be called an ecological ethics.

Responsibility in Philosophy

The turn to responsibility in philosophy, like that in theology, exhibits two faces: first, a reaction to the challenge posed by the dominance of scientific and technological ways of thinking; and second, an attempt to take into account the rich and problematic complexity of technological practice. The first is prominent in Anglo-American analysis discourse, the second in European phenomenological traditions of thought.

According to Richard McKeon (1957), interest in the concept of responsibility can be traced to diverse philosophical backgrounds, one of which is the Greek analysis of causality (or imputability) and punishment (or accountability) for actions. As McKeon initially notes: "Whereas the modern formulation of the problem [of responsibility] begins with a conception of cause derived from the natural sciences and raises questions concerning the causality of moral agents, the Greek word for cause, *aitia* (like the Latin word *causa*), began as a legal term and was then extended to include natural motions" (pp. 8–9). But it was in efforts to defend moral agency against threats from various forms of scientific materialism that the term became prevalent in analytic philosophy. For instance, H. L. A. Hart's distinctions between four kinds of responsibility—role, causal, liability, and capacity—(Hart 1968) are all related to issues of accountability as they arise in a legal framework, where they can help articulate a theory of punishment to meet the challenges posed by modern psychology.

McKeon's general thesis is that the term *responsibility* appeared in late-eighteenth and early-nineteenth-century moral and political discourse—as an abstract noun derived from the adjective *responsible*—in coordination with the expansion of democracy. But there are also numerous historical connections between the rise of democracy and the development of modern technology. On the theoretical level, the possessive individualism of *homo faber*, developed by Thomas Hobbes and John Locke, prepared the way for democracy and the new industrial order. On the practical level, democratic equality and technology clearly feed off one another.

But the connection goes deeper. According to McKeon, responsibility was introduced into the political context because of the breakdown of the old social order based on hierarchy and duty, and the inability of a new one to function based strictly on equality and self-interest. Whereas the former was no longer supported by the scientific worldview, the latter led to the worst exploitative excesses of the Industrial Revolution. To address this crisis there developed the ideal of relationship, in which individuals not only pursued their own self-interest but also tried to recognize and take into account the interests of others.

Something similar was called for by industrial technology. Good artisans, who dutifully followed the ancient craft traditions, were no longer enough, yet neither should they just be turned loose to invent as they pleased. Thomas Edison, after creating a vote register machine for a legislature, in which he subsequently discovered the legislature had no interest, resolved never again to invent simply what he thought the world needed without first consulting the world about what it wanted. The new artisan must learn to respond to a variety of factors—the material world, the economy, consumer demand, and more. This is what turns good artisans into responsible inventors and engineers. As their technological powers increase, so will their need to respond to an increasing spectrum of factors, to take more into account. Carl Mitcham (1994) has described this as a duty *plus respicere*, from the Latin to include more in one's circumspection.

Another argument to this effect is provided by John Ladd (1981) who, in considering the situation of physicians, argues that the expansion of biomedical technology has increased the private practitioner's dependence on technical services and undermined professional autonomy. Moral problems concerning physicians and society can no longer rest on an ethics of roles but involve the ethics of power, "the ethical side of [which] is responsibility" (p. 42).

The metaphysical elaboration of responsibility has taken place primarily in European philosophy. Lucien Levy-Bruhl's treatise titled *The Idea of Responsibility* (1884) is its starting point. After sketching a history of the idea from antiquity to the late nineteenth century, Levy-Bruhl argues surprise that a concept so basic to morality and ethical theory had not previously been subject to systematic investigation, especially since it is also manifested in a variety of ways across the whole spectrum of reality. There is responsibility or responsiveness at the level of physical matter, as atoms and molecules interact or respond to each other. Living organisms are further characterized by a distinctive kind of interaction or responsiveness to their environments and each other.

Extending this metaphysical interpretation Hans Jonas (1984), another philosopher in the European tradition, explored implications for science and technology. Responsibility is not a central category in previous ethical theory, Jonas argued, because of the narrow compass in premodern scientific knowledge and technological power. "The fact is that the *concept* of responsibility nowhere plays a conspicuous role in the moral systems of the past or in the philosophical theories of ethics." The reason is that "responsibility ... is a function of power and knowledge," which "were formerly so limited" that consequences at any distance "had to be left to fate and the constancy of the natural order, and all attention focused on doing right what had to be done now" (p. 123).

> All this has decisively changed. Modern technology has introduced actions of such novel scale, objects, and consequences that the framework of former ethics can no longer contain them.... No previous ethics had to consider the global condition of human life and the far-off future, even existence, of the race. These now being an issue demands ... a new conception of duties and rights, for which previous ethics and metaphysics provide not even the principles, let alone a ready doctrine. (pp. 6 and 8)

The new principle thus made necessary by technological power is responsibility, and especially a responsibility toward the future.

What for Jonas functions as a deontological principle, Caroline Whitbeck (1998) has argued may also name a virtue. When children are described as reaching "an age of responsibility," this indicates that they are able to "exercise judgment and care to achieve or maintain a desirable state of affairs" (p. 37). Acquiring the ability to exercise such judgment is to become responsible. At the same time, the term *responsibility* continues to name distributed obligations to practice such a virtue derived either from interpersonal relationships or from special knowledge and powers. "Since few relationships and knowledge are shared by everyone, most moral responsibilities are special moral responsibilities, that is, they belong to some people and not others" (p. 39).

Consideration of the special responsibilities that belong to scientists and engineers has been a major theme in advancing discussions of science, technology, and ethics. Although overlapping, these two discussions have nevertheless mostly taken place among different professional groups.

Scientific Responsibility

Efforts to define the social responsibility of scientists have involved an refinement of the representative Enlightenment view that science has the best handle on truth and is thus essentially and under all conditions beneficial to society. From such a perspective, the primary responsibility for scientists is thus to pursue and extend their disciplines.

Historically this responsibility found expression in Isaac Newton's hope for science as theological insight, Voltaire's belief in its absolute utility, and Benedict de Spinoza's thought that in science one possesses something pure, unselfish, self-sufficient, and blessed. A classic manifestation is the great French *Encyclopédie* (1751–1772), which sought "to collect all the knowledge that now lies scattered over the face of the earth, to make known its general structure to the men among whom we live, and to transmit it to those who will come after us." Such a project, wrote Denis Diderot, demands "intellectual courage."

The questioning of this tradition has roots in the Romantic critique of scientific epistemology and industrial practice, but did not receive a serious hearing among scientists themselves until after World War II. Since then one may distinguish three phases.

PHASE ONE: RECOGNIZING RESPONSIBILITIES. In December 1945 the first issue of the *Bulletin of the Atomic Scientists* led off with a statement of the goals of the newly formed Federation of Atomic (later American) Scientists. Members should "clarify . . . the . . . responsibilities of scientists in regard to the problems brought about by the release of nuclear energy" and "educate the public [about] the scientific, technological, and social problems arising from the release of nuclear energy." Previously scientists would have described their responsibilities as restricted to doing good science, not falsifying experiments, and cooperating with other scientists. Now, because of the potentially disastrous implications of at least one branch of science, scientists felt their responsibilities enlarge. They were called on to take into account more than the procedures of science; they must respond to an expanded situation.

The primary way that atomic scientists responded over the next decade to the new situation created by scientific weapons technology was to work for placing nuclear research under civilian control in the United States and to further subordinate national to international control. They did not, however, oppose the unprecedented growth of science. As Edward Teller wrote in 1947, the responsibility of the atomic scientists was not just to educate the public and help it establish a civilian control that would "not place unnecessary restrictions on the scientist," it was also to continue to pursue scientific progress. "Our responsibility," in Teller's words, "is [also] to continue to work for the successful and rapid development of atomic energy" (p. 355).

PHASE TWO: QUESTIONING RESPONSIBILITY. During the mid-1960s and early 1970s, a second-stage questioning of scientific responsibility emerged. Initially this questioning arose in response to the growing recognition of the problem of environmental pollution—a phenomenon that cannot be imagined as alleviated by simple demilitarization of science or increases in democratic control. Some of the worst environmental problems are caused precisely by democratic availability and use—as with pollution from automobiles, agricultural chemicals, and aerosol sprays, not to mention the mounting burden of consumer waste disposal. Rachel Carson's *Silent Spring* (1962) was an early statement of the problem that called for an internal transformation of science itself. But an equally focal experience during this second-stage movement toward an internal restructuring of science was the Asilomar Conference of 1975, which addressed the dangers of recombinant DNA research.

After Asilomar, the dangers of recombinant DNA research turned out to be not as immediate or as great as feared, and some members of the scientific community became resentful of post-Asilomar agitation—although others actually argued for even more stringent guidelines than those proposed (Sinsheimer 1976, 1978). Increased possible consequences nevertheless again broadened the scope of what could be debated as the proper responsibility of scientists. Robert L. Sinsheimer, for instance, himself a respected biological researcher and chancellor of the University of California, Santa Cruz, argued that modern science was based on two faiths. One is "a faith in the resilience of our social institutions . . . to adapt the knowledge gained by science . . . to the benefit of man and society more than the detriment"—a faith that "is increasingly strained by the acceleration of technical change and the magnitude of the powers deployed" (Sinsheimer 1978, p. 24). But even more telling is

> a faith in the resilience, even in the benevolence, of Nature as we have probed it, dissected it, rearranged its components in novel configurations, bent its forms, and diverted its forces to human purpose. The faith that our scientific probing and our technological ventures will not displace some key element of our protective environment, and thereby collapse our ecological niche. A faith that Nature does not set booby traps for unwary species. (Sinsheimer 1978, p. 23)

This new argument was commensurate with the development of what Jerome R. Ravetz (1971) saw as the replacement of "academic science" by "critical science"—which is in turn related to what others have termed public interest science. Or as William W. Lowrance (1985) argued, beyond responsibility in the first-stage sense, there is a need to incorporate in science itself what he referred to as principles of "stewardship."

PHASE THREE: REEMPHASIZING ETHICS. The attempt to transform science from within was overtaken in the mid-1980s by a new external criticism not of scientific products (knowledge) but of scientific processes (methods). A number of high-profile cases of scientific misconduct raised questions about whether public investments in science were being wisely spent. Were scientists simply abusing a public trust? Moreover, some economists began to question whether, even insofar as scientists did not abuse the public trust, but followed ethical research practices—which was surely mostly the case—scientific research was as much of a stimulus to economic progress as had been thought.

The upshot was that the scientific community undertook a self-examination of its ethics and its efficiency. Efforts to increase ethics education, or education in what became known as the responsible conduct of research, became required parts of science education programs, especially in the biomedical sciences at the graduate level. And increased efficiency in grant administration and management became issues for critical assessment. Since the 1990s scientists have increasingly been understood to possess social responsibilities that include the promotion of ethics and efficiency in the processes of doing science.

At the same time, scientists have also attempted to reemphasize the importance of science to national health care, the economy, environmental management, and defense. In the face of the AIDS epidemic, biomedical research presents itself as the only answer. Computers and biotechnologies are offered as gateways to new international competitive advantage and the creation of whole new sectors of jobs. Global climate change, it is argued, can be adequately assessed only by means of computer models and the science of complexity. Finally, especially since 9/11, new claims have been made for science as a means to develop protections against the dangers of international terrorism. The social responsibility of science is defended as the ethically guided production of knowledge that addresses a broad portfolio of social needs: the promotion of health, the creation of jobs, the protection of the environment, and the defending of Western civilization.

Engineering Responsibility

Applied science professionals such as technologists and engineers are more subject than scientists to both external (legal, political, or economic) and internal (ethical) regulation. Indeed, engineers have since the early twentieth century attempted to formulate explicit principles of professional responsibility—precisely because of the technological powers they wield. Historically, similar discussions did not originate among scientists until the second half of the twentieth century, and scientific organizations remain in the early twenty-first century less likely to have formal codes of conduct than engineering associations.

Engineering associations aspire to the formulation of codes of conduct similar to those found in medicine or law. But unlike medicine, which is ordered toward health, or law, the end of which is justice, it is less obvious precisely what constitutes the engineering ideal that could serve as the basis for a distinctive internalist ethics of responsibility. The original engineer (Latin *ingeniator*) was the builder and operator of battering rams, catapults, and other "engines of war." Engineering was originally military engineering. As such, the power of engineers, no matter how great, was significantly less than the organized strength of the army as a whole. Moreover, as with all other soldiers, their behavior was guided primarily by their obligations to obey hierarchical authority.

The eighteenth-century emergence of civil engineering in the design of public works such as roads, water supply and sanitation systems, lighthouses, and other nonmilitary infrastructures did not initially alter this situation. Civil engineers were only small contributors to larger processes. But as technological powers in the hands of engineers began to enlarge, and the number of engineers increased, tensions mounted between subordinate engineers and their superiors. The manifestation of this tension is what Edwin T. Layton Jr. (1971) called the "revolt of the engineers," which occurred during the late nineteenth and early twentieth centuries. It is in association with this revolt and its aftermath that *responsibility* enters the engineering ethics vocabulary.

One influential if failed effort at formulating engineering responsibility led to what was known as the technocracy movement and its idea that engineers more than politicians should wield political power. Henry Goslee Prout, a former military engineer who had become general manager of the Union Switch and Signal Company, speaking before the Cornell Association of Civil Engineers in 1906, described the profession in just such leadership terms: "The engineers more than all other men, will guide humanity forward.... On the engineers ... rests a responsibility such as men have never before been called upon to face" (quoted in Akin 1977, p. 8). At the height of this dream of expanded engineering responsibility, Herbert Hoover became the first civil engineer to be elected president of the United States, and an explicit technocracy movement fielded its own candidates for elective office. The ideology of technocracy sought to make engineering efficiency an ideal analogous to medical health and legal justice.

During World War II a different shift took place in the engineering conception of responsibility: not from company and client loyalty to technocratic efficiency but from private to public loyalty. A chastened version of responsibility nevertheless emphasized the potential for opposition between social and corporate interests. Having failed in trying to be responsible for everything, engineers came to debate the scope of more limited responsibilities—to themselves, to employers, and to the public. The need for this debate is still clearly dictated by the powers at their command and the problems such powers pose, even though it is not obvious that engineering entails responsibilities of any specific character.

With engineering under attack as a cause of environmental pollution, for the design of defective consumer goods, and as too willing to feed at the trough of the defense contract, one American engineer writing in the mid-1970s summed up the situation as follows. He first admitted that,

> Unlike scientists, who can claim to escape responsibility because the end results of their basic research can not be easily predicted, the purposes of engineering are usually highly visible. Because engineers have been claiming full credit for the achievements of technology for many years, it is natural that the public should now blame engineers for the newly perceived aberrations of technology. (Collins 1973, p. 448)

In other words, engineers had oversold their responsibilities and were being justly criticized. The responsibilities of engineers are in fact quite limited. They have no general responsibilities, only specific or special ones:

> There are three ways in which the special responsibility of engineers for the uses and effects of technology may be exercised. The first is as individuals in the daily practice of their work. The second is as a group through the technical societies. The third is to bring a special competence to the public debate on the threatening problems arising from destructive uses of technology. (Collins 1973, p. 449)

This debate, formalized in various technology assessment methodologies and governmental agencies, can be read as a means of subordinating engineers to the larger social order. In comparing responsibility in engineering with responsibility in science, it may thus appear that there has been more of a contraction than an expansion. Yet the issue of responsibility has so intensified that engineers now consciously debate the scope of their responsibilities in relationship to issues not previously acknowledged.

Too Much Responsibility?

One common worry about certain technologies is that they undermine human responsibility. For instance, reliance on computers in medical diagnostic processes or strategic missile defense systems transfers some decision making responsibilities from human beings to computers. But the same computer systems that assume practical responsibility for diagnosis or defense call for the exercise of a higher ideal of responsibility in their design and deployment. It is precisely because modern technology calls for so much responsibility at the ideal level that observers can be so sensitive to the issue at the practical level. It is not at all clear, for instance, that computers have in any way deprived human beings of responsibilities they formerly had. What physicians of the early nineteenth-century would have been responsible for diagnosing and then treating the array of obscure diseases for which twenty-first-century physicians are held accountable? It is more likely that new technologies make possible certain responsibilities which they can also be configured to assist.

But this raises a question: Are the responsibilities thus called forth truly reasonable? From the perspective of prudence, one should not take on or give to another too much responsibility. To do so is to invite failure if not disaster. Although exact boundaries are not easy to determine in advance, once overstepped they are difficult to recover. In light of this principle of prudence, then, one must ask: Can the principle of responsibility, and those who are called to live up to it, really bear the added burden being placed on it and them by contemporary science and technology?

CARL MITCHAM

SEE ALSO *Christian Perspectives; Engineering Ethics; Responsible Conduct of Research.*

BIBLIOGRAPHY

Akin, William E. (1977). *Technocracy and the American Dream: The Technocrat Movement, 1900–1941.* Berkeley and Los Angeles: University of California Press.

Collins, Frank. (1973). "The Special Responsibility of Engineers." In "The Social Responsibility of Engineers," ed. Harold Fruchtbaum. Spec. issue, *Annals of the New York Academy of Sciences*, 196(10): 448–450.

Durbin, Paul T., ed. (1987). "Technology and Responsibility." In *Philosophy and Technology*, vol. 3. Boston: Dordrecht, Netherlands: D. Reidel. Seventeen papers from a conference; includes an annotated bibliography on the theme.

Greenman v. Yuba Power Products, Inc., 59 Cal. 2d 57 (1963).

Hart, H. L. A. (1968). *Punishment and Responsibility: Essays in the Philosophy of Law.* New York: Oxford University Press. See especially the "Postscript: Responsibility and Retribution."

Jasanoff, Sheila. (1995). *Science at the Bar: Law, Science, and Technology in America.* Cambridge, MA: Harvard University Press. Good on changes in the character of tort law in relation to technology.

Jonas, Hans. (1984). *The Imperative of Responsibility: In Search of an Ethics for the Technological Age*, trans. Hans Jonas and David Herr. Chicago: University of Chicago Press.

Ladd, John. (1981). "Physicians and Society: Tribulations of Power and Responsibility." In *The Law-Medicine Relation: A Philosophical Exploration*, ed. Stuart F. Spicker, Joseph M. Healey Jr., and H. Tristram Engelhardt Jr. Dordrecht, Netherlands: D. Reidel.

Layton, Edwin T., Jr. (1971). *The Revolt of the Engineers*. Cleveland: Press of Case Western Reserve University. Reprint, with new introduction, Baltimore: Johns Hopkins University Press, 1986.

Levy-Bruhl, Lucien. (1884). *L'idée de responsabilité* [The idea of responsibility]. Paris: Hachette.

Lowrance, William W. (1985). *Modern Science and Human Values*. New York: Oxford University Press.

McKeon, Richard. (1957). "The Development and the Significance of the Concept of Responsibility." *Revue Internationale de Philosophie* 11(1:39): 3–32.

Mitcham, Carl. (1987). "Responsibility and Technology: The Expanding Relationship." In *Technology and Responsibility*, ed. Paul T. Durbin, pp. 3–39. Dordrecht, Netherlands: D. Reidel. The present analysis is based on this earlier work.

Mitcham, Carl. (1994). "Engineering Design Research and Social." In Kristin Shrader-Frechette, *Ethics of Scientific Research*, pp. 153–168. Lanham, MD: Rowman and Littlefield.

Niebuhr, H. Richard. (1963). *The Responsible Self*. San Francisco: Harper and Row.

Ravetz, Jerome R. (1971). *Scientific Knowledge and Its Social Problems*. Oxford: Clarendon Press.

Rylands v. Fletcher, LR 3 HL 330 (1868).

Sinsheimer, Robert L. (1976). "Recombinant DNA—on Our Own." *BioScience* 26(10): 599.

Sinsheimer, Robert L. (1978). "The Presumptions of Science." *Daedalus* 107(2): 23–35.

Teller, Edward. (1947). "Atomic Scientists Have Two Responsibilities." *Bulletin of the Atomic Scientists* 3(12): 355–356.

U.S. Committee on Science, Engineering, and Public Policy. Panel on Scientific Responsibility and the Conduct of Research. (1992–1993). *Responsible Science: Ensuring the Integrity of the Research Process*. 2 vols. Washington, DC: National Academy Press.

Whitbeck, Caroline. (1998). *Ethics in Engineering Practice and Research*. Cambridge, UK: Cambridge University Press.

ANGLO-AMERICAN PERSPECTIVES

In the English language *responsibility* is generally defined as a quality or state of being answerable or accountable for acts or decisions. However, the term *responsibility* and its cognatex *responsible* are used in a variety of ways. H .L. A. Hart illustrated that variety with the following story of a drunken sea captain who lost his ship at sea.

> As captain of the ship, X was responsible for the safety of his passengers and crew. But on his last voyage he got drunk every night and was responsible for the loss of the ship with all aboard. It was rumoured that he was insane, but the doctors considered that he was responsible for his actions. Throughout the voyage he behaved quite irresponsibly, and various incidents in his career showed that he was not a responsible person. He always maintained that the exceptional winter storms were responsible for the loss of the ship, but in the legal proceedings brought against him he was found criminally responsible for his negligent conduct, and in separate civil proceedings he was held legally responsible for the loss of life and property. He is still alive and he is morally responsible for the deaths of many women and children" (Hart 1968, p. 211).

Four Types of Responsibility

Hart uses this story to identify four different senses of responsibility: role responsibility, causal responsibility, liability responsibility, and capacity responsibility. Role responsibility refers to the duties and obligations a person has by virtue of occupying a role such as mother, doctor, or captain of a ship. When a person occupies a role, others expect certain kinds of behavior and hold that person accountable for failure to do what is expected. In this context individuals have duties to behave in certain ways that can be referred to as role responsibilities. Causal responsibility is attributed to things and events as well as persons. In the case of events one might say of the terrorist attack on September 11, 2001, that the event has been causally responsible for instilling fear in many U.S. citizens. In the case of persons a particular action by a person is specified as the cause of or the major causal contribution to an untoward event or occurrence. For example, a person's failure to stop at a stop sign may be said to be causally responsible for the ensuing accident. Causal responsibility may or may not be connected to blameworthiness. Thus, if the person failed to stop at the stop sign because she had a heart attack, she may not be blameworthy but her failure to stop is still causally responsible for the accident. Similarly, even if a person unknowingly or under coercion pressed a button that detonated a bomb, that person would be causally responsible for the resulting damage.

Liability responsibility often refers to legal liability and identifies the person or group that is expected to pay damages or make compensation or sometimes explain (give an account of what happened) in situations in which harm is done. Liability often but not always accompanies causal responsibility or blameworthiness. Strict liability refers to holding an individual liable—to pay damages, make compensation, or give an explanation of what happened—when that individual is not causally connected to the event and has done nothing wrong. An example would be holding a company liable for harm that resulted from a defect in one of its products despite the fact that the company did everything possible to make the product safe. Capacity responsibility refers to the capability (generally psychological) a person must possess to be considered morally responsible for his or her behavior. For example, if an individual lacked the ability to reason and to understand and control his or her behavior, it would be inappropriate to hold that person responsible for his or her actions.

In describing this fourfold distinction it is helpful to bring in the notion of blameworthiness. Being blameworthy or at fault is another sense of responsibility that depends on the other uses of that term. A person typically is considered blameworthy when (1) the person had capacity responsibility (that is, had the ability to understand and control his or her behavior); (2) the person did something he or she was not supposed to do (such as fail to perform a role-responsibility); and (3) the person's act or omission was causally responsible for an untoward event or harm. For example, a person would be blameworthy if while working as a night security person for a bank (and having the capacities of most human beings) he or she forgot to check to see if a door was properly locked and consequently allowed a burglar to get into the bank and steal money.

In addition to Hart's fourfold distinction and the concept of blameworthiness, moral philosophers have distinguished many different kinds of responsibility, including personal, collective, moral, legal, diminished, prospective, and retrospective responsibility. Thus, discussions of responsibility must attend carefully to the differing meanings of the term.

Analytic moral philosophers have focused largely on capacity responsibility and especially the connection between freedom and responsibility. For individuals to be responsible for their behavior, it would seem that they must be free to act as they do. If individual behavior were entirely determined, say, because it is predetermined by God or results from external causal forces such as genetics, upbringing, and circumstances, it would seem that individuals could not be held responsible for what they do: Their behavior is not in their control.

With this in mind, moral philosophers have focused on giving an account of human freedom without denying the various factors that influence human behavior. Often scholarship on this topic has focused on what it means to say that a person is free or "could have done otherwise."

By contrast, some philosophers have argued that ascriptions of responsibility should be seen as forward-looking (prospective) social practices. In this context human freedom is not a requirement. For example, ascriptions of responsibility can be understood to be mechanisms for exerting pressure on individuals to behave in certain ways. Society holds individuals responsible for their behavior to exert pressure on them to behave in socially desirable ways. When individuals behave in socially undesirable ways, society disapproves and tells them they are bad. Society uses the law to threaten and actually punish individuals when they engage in undesirable behavior. This is done to instill in individuals a sense of responsibility for their actions, a sense of responsibility that influences how they behave. Understanding responsibility in this way gives responsibility ascriptions a utilitarian and deterministic foundation. Responsibility ascriptions are utilitarian practices aimed at achieving good results. This account eliminates an element at the heart of notions of responsibility and at the core of the connection between freedom and being human: a sense that what it means to be human involves carrying the weight of responsibility for one's actions.

Responsibility in Science and Technology

A host of important responsibility issues arise in the fields of science, engineering, and technology. The issue that has received the most attention involves the responsibilities of scientists and engineers for the production of scientific knowledge and technological products. Because science and engineering give human beings enormous power for good and ill, questions about the responsibility of scientists and engineers, both individually and collectively, have always surrounded scientific and technological endeavors. The question became particularly prominent in the twentieth century with the creation and use of the first atomic bomb and later with the production of civilian nuclear power. The question persists in the early twenty-first century in regard to genetic engineering, surveillance technologies, cloning, and biological weapons. Are scientists and engineers considering the social and moral implications of what they are doing? Do they have a responsibility to stop what they are doing or to speak out when they think the risks of their work or that of their colleagues are too great?

Evidence of concern about the scientists' or engineers' responsibility for their work is seen, for example, in the ongoing fascination with Mary Shelley's *Frankenstein* (1818), a science fiction story in which a doctor-scientist uses scientific and technical prowess to bring a humanlike monster composed of separately acquired body parts to life. Doctor Frankenstein is horrified at the sight of his creation and immediately flees his laboratory; he does nothing until the beast begins to interfere in his life. Left to its own devices the beast wreaks havoc on the lives of Doctor Frankenstein and others.

The Frankenstein story is an indictment of those who fail to think about the implications of their attempts to create new knowledge, products, and techniques; it is an indictment of those who refuse to take responsibility for what they create. Whatever Mary Shelley's intentions were in writing *Frankenstein,* the story serves as a morality tale for a technoscientific world. Its relevance to a world in which biological weapons, clones, and powerful surveillance technologies have already been created is evident.

Failure and Disaster

The Frankenstein story suggests that scientists and engineers should consider the implications of their work before they do it and take responsibility for that work after it is done. More often than not responsibility issues arise after knowledge has been created and technological endeavors have been undertaken and some sort of failure subsequently leads to a disaster. Then attempts are made to trace back role responsibilities and identify who is to blame. For example, when the *Challenger* spaceship and more recently the *Columbia* crashed, public attention turned to figuring out what went wrong and who was responsible. Engineers, as well as managers, were put on the spot. Who made the decision to launch? Were there not signs that a problem existed? Who had failed to fulfill their responsibilities?

Similar questions arise for all technological failures, especially those which have catastrophic results, such as the Three Mile Island accident; the disaster at Bhopal, India; the DC10 airplane crash; and the Hyatt Regency hotel collapse. After September 11, 2001, questions were raised about the structural design of the World Trade Center as well as the failure of American intelligence organizations.

Although responsibility issues can and do arise independent of science and technology, the issues surrounding technological disasters seem particularly daunting because of their complexity. Modern technologies are so complex that the individuals involved in their development, production, distribution, and use often cannot understand fully the projects to which they are contributing. Because of that complexity there must be a division of labor, and this means that engineers and scientists often work on pieces of a larger project. This challenges traditional notions of responsibility, for how can individuals be responsible for what they are doing when they cannot fully comprehend what they are doing?

Information technology is a good example of this issue. Many computer programs consist of millions of lines of computer code. Can a single individual be responsible for all the lines of code in a program? No one can be expected to understand the entire program, and so how can particular individuals be held responsible for the program? Computer scientists develop testing procedures and standards for reliability, but there are limits to what they can be expected to do. Moreover, when projects are divided into parts, there is a danger of something falling into the cracks or of error being introduced when the parts are put together. The complexity of modern technologies poses daunting challenges both retrospectively in tracing back failure and prospectively in assigning responsibilities for large projects in a way that minimizes the likelihood of failure.

Many scientific and engineering professional associations acknowledge that their members have social and professional responsibilities both individually and collectively. Professional organizations are an important means of addressing some of those responsibilities. One method professional societies use is to adopt and promulgate codes of ethical and professional conduct.

DEBORAH G. JOHNSON

SEE ALSO *Engineering Ethics; Normal Accidents; Unintended Consequences.*

BIBLIOGRAPHY

Feinberg, Joel. (1970). *Doing and Deserving.* Princeton, N.J.: Princeton University Press.

Hart, Herbert Lionel Adolphus. (1968). "Chapter IX Postscript: Responsibility and Retribution." In *Punishment and Responsibility: Essays in the Philosophy of Law.* Oxford: Clarendon Press.

Johnson, Deborah G. (1989). "The Social/Professional Responsibility of Engineers." *Annals of The New York Academy of Sciences* 577: 106–114.

Shelley, Mary. (1995). *Frankenstein.* New York, Pocket Books. Originally published in 1818.

Zimmerman, Michael J. (2001). "Responsibility." In *Encyclopedia of Ethics,* 2nd edition, ed. L. C. Becker and C. B. Becker. New York: Routledge.

GERMAN PERSPECTIVES

In the German philosophical tradition the concept of responsibility (*Verantwortung*) has been accorded special and extensive treatment, especially in relation to science and technology. The following introduction to this tradition begins with a description of responsibility as a relational construct and then distinguishes three basic levels of responsibility: action responsibility, role responsibility, and universal moral responsibility.

Basic Concept

The German word *Verantwortung* derives from the Middle High German and originally meant simply "to answer," probably in response to an accusative question such as "Did you do X?" The concept of responsibility is thus evaluative and attributive as well as descriptive. A person can be *held* (to be) responsible, which introduces the normative or ethical dimension into human experience.

The concept of responsibility implies a multidimensional structure linked to assignment, attribution, and imputation, in ways that may be analyzed and interpreted with respect to the following model:

Someone S (the subject or bearer of responsibility, which can be a person or a corporation)

is responsible for A (actions, consequences, situations, tasks)

to O (addressees or "objects" of responsibility)

under the supervision or judgment of J (some judging or sanctioning agent)

in relation to N (a prescriptive or normative criterion of attribution)

and accountable within context C (a sphere or realm of human activity).

For example, a person (S) is responsible to other motorists and pedestrians (O) for stopping at traffic lights (A) under the supervision of the police or courts (J) in relation to the traffic laws (N) when driving an automobile (C). This makes responsibility a five- or six-place relation, although some of the relations may overlap. For instance, it is possible for an addressee (O) and supervisor (J) to be the same.

Following work in the development of attribution theory by the social psychologist Fritz Heider (1896–1988) and the social phenomenologist Alfred Schutz (1899–1959), it was the Polish logician I. M. Bochenski (1987 [1947]) who first defined responsibility in terms of the logic of relations. For Bochenski, however, responsibility was a two- or perhaps a three-place relation: Someone (S) is responsible for action (A) to another person (O).

As an attributive, relational construct, responsibility is also an interpretative concept with social functions. It can be expressed as an attributive, relational norm (controlling expectations regarding action and behavior). Responsibility further implies that a person (S) must justify actions, action consequences, situations, tasks, and so forth (A) in front of an addressee (O) and before an agent (J) in respect to which the responsible party has obligations or duties in accordance with standards, criteria, or laws (N). Responsible parties are accountable for their own actions or under specified conditions for the actions of others. Parents, for example, are liable for certain behaviors of their children, and corporations for certain behaviors of their employees. (This tends to apply more to wrongdoings than to achievements.) The concept of responsibility thus structures social reality and social relations.

One may further differentiate between the typical bearers of responsibility in terms of active roles and observer roles. Specifically, one may impute or attribute a particular responsibility to oneself as an actor or to others from the multiple perspectives of a participant, observer, or scientist, in relation to general rules and norms. Particular cases of attribution instantiate general patterns of responsibility. The attribution of responsibility is an active process both in self-interpretation and in the interpretation of the actions of others. The concept of responsibility is thus implicated in self-understandings and projections of ideals for social order.

Types and Levels of Responsibility

Types of responsibility occur at three basic levels: individual actions, social roles, and universal moral principles. Such distinctions are justified by appeal to "ideal typ(ic)al" prevalence, similar but not identical to Max Weber's *Idealtypen* or ideal types. In what follows, diagrammatic schema are used to condense and illustrate hierarchical models of different types of responsibility, with different levels or strata referring to different dimensions of interpretation. The first diagram is more abstract and calls for more interpretative constructs, such as particular kinds of responsibilities, than the others.

QUALIFICATIONS. In general, the three levels are constituted by analytic and perspectival constructs that may overlap and all apply (although in different ways) to a single real case of responsibility. That is, concrete instances of responsibility attribution may be analyzed not only on a formal or abstract level (as illustrated in the first diagram) but also from a more concrete point of view (as with role or moral responsibility). Although usually any one analysis on a specific level is tied to a certain interpretation (e.g., some particular role), this does not preclude another interpretation (from, say, the moral point of view).

Within the different levels of these schematic constructs are further analytic constructs that are also able to be attributed to individuals or groups. Even in their more concrete forms, constructs are to be understood as analytic distinctions. That is, collective or group responsibility seldom precludes individual or personal responsibility, although collective responsibility cannot be reduced to or derived from individual or personal responsibility alone. The same applies to institutional responsibility. Moreover, there are conceptual connections or analytic relations between some juxtaposed or subordinated subtypes.

ACTION RESPONSIBILITY. The most obvious and general level of responsibility is that which involves being responsible for the results or consequences of one's own actions. This may be termed the prototyp(ic)al case of (causally oriented) action responsibility. A subject is held responsible for the outcomes of his or her actions in an instance for which he or she is accountable. An engineer designing a bridge or a dam is responsible to the supervisor, employer, client, and/or general public for his or her design in terms of technical correctness, safety, cost, feasibility, and more. A scientist is not responsible for the outcome of an experiment or research project but is responsible for the conduct of the research and the reporting of its results.

Frequently, accountability questions are raised in negative cases, when one or more of these criteria are not fulfilled. The breaking of a dam may be the result of such factors as honest mistakes in statics or dynamics analyses; careless, negligent, or even criminal misconduct; incompetence; and the use of substandard materials. The need to withdraw or revise technical reports in science may likewise be attributable to honest mistakes or malfeasance. In any particular case it is important to identify the particular negative action responsibility. Professional scientists and engineers have responsibilities to the public to ensure high standards in their work, to avoid risks of disasters insofar as this is compatible with reasonable costs, and to report results fully and completely without fabricating or falsifying data. The responsibility to avoid mistakes, failures, and poor quality products, processes, systems, and so on is part and parcel of action responsibility. Different types of action responsibility are shown in Figure 1.

The most commonly discussed cases of action responsibility are individual action responsibility. But if a group is acting collectively or if individuals participate in joint group action, then what may be called coresponsibility arises as a distinctive phenomenon. Coresponsibility is the sharing of responsibility by participating members in a group action. Responsibility for group actions is also sometimes called collective or group responsibility, and the circumstances in which this can be legitimately attributed to groups—especially large ones such as a nation-state or ethnic classification—are highly contentious. Mostly such attributions are rejected or justified only under very special cases on the grounds that groups should not be punished (or rewarded) for the actions of individuals. In practice, however, such punishments are quite common (as in warfare where they may be apologized for as "collateral damage").

ROLE RESPONSIBILITY. A second level of responsibility is constituted by role and universal moral responsibility. In accepting a role or fulfilling a task (e.g., by taking on a well-defined job) a role holder usually bears some responsibility for acceptable or optimal role fulfillment. Role responsibility is not opposed to or fundamentally different than individual action responsibility, but manifests action responsibility at a level other than that of human action as such. Indeed, as the examples already cited in discussing action responsibility indicate, most of these roles will entail individual action responsibilities, or can be thought of as constituting particular instances of individual action responsibility.

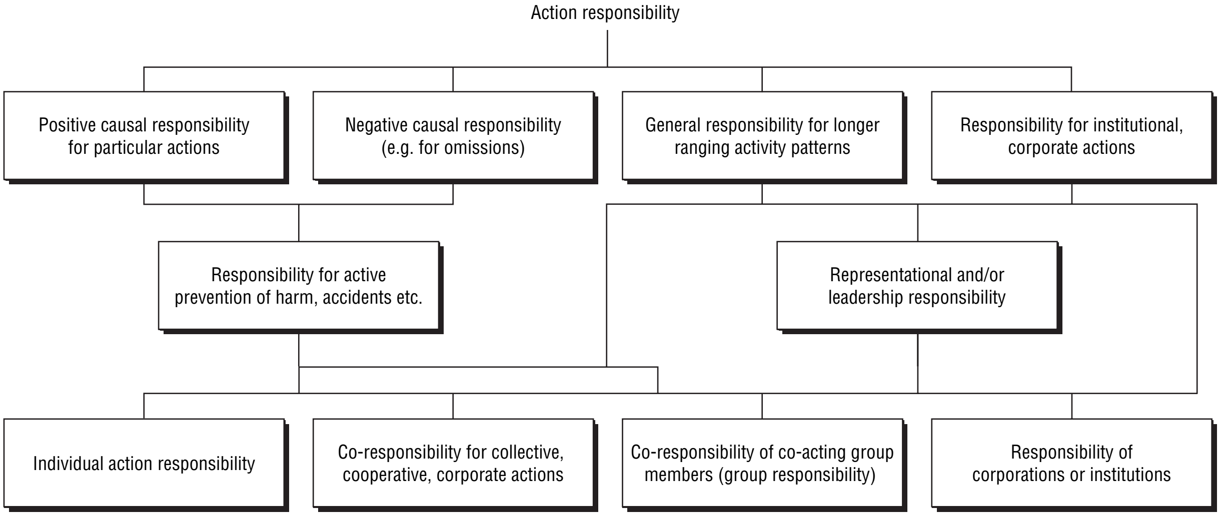
These roles or duties might be assigned in a formal way or be more or less informal. They can even be legally ascribed or at least legally relevant. Different types of roles and responsibilities, including legal responsibilities, are presented in diagrammatic form in Figure 2.

In corporate or institutional settings, role patterns include leadership responsibility (with respect to external and internal instances, addressees, and agents) as a special form of associated institutional role responsibility. In addition, there is the corporate responsibility of firms, corporations, or other social institutions such as government agencies and even nongovernmental organizations insofar as these have special tasks to perform or obligations to fulfill with respect to clients, the public, or members of the organization or corporation. This type of responsibility can also have a legal, moral, or neutral character, which may or may not coincide with group or institutional responsibility.

Other examples of role responsibility that deserve explicit mention include not only legal responsibility but also pedagogical responsibility, religious responsibility, political (citizen) responsibility, and more. In an

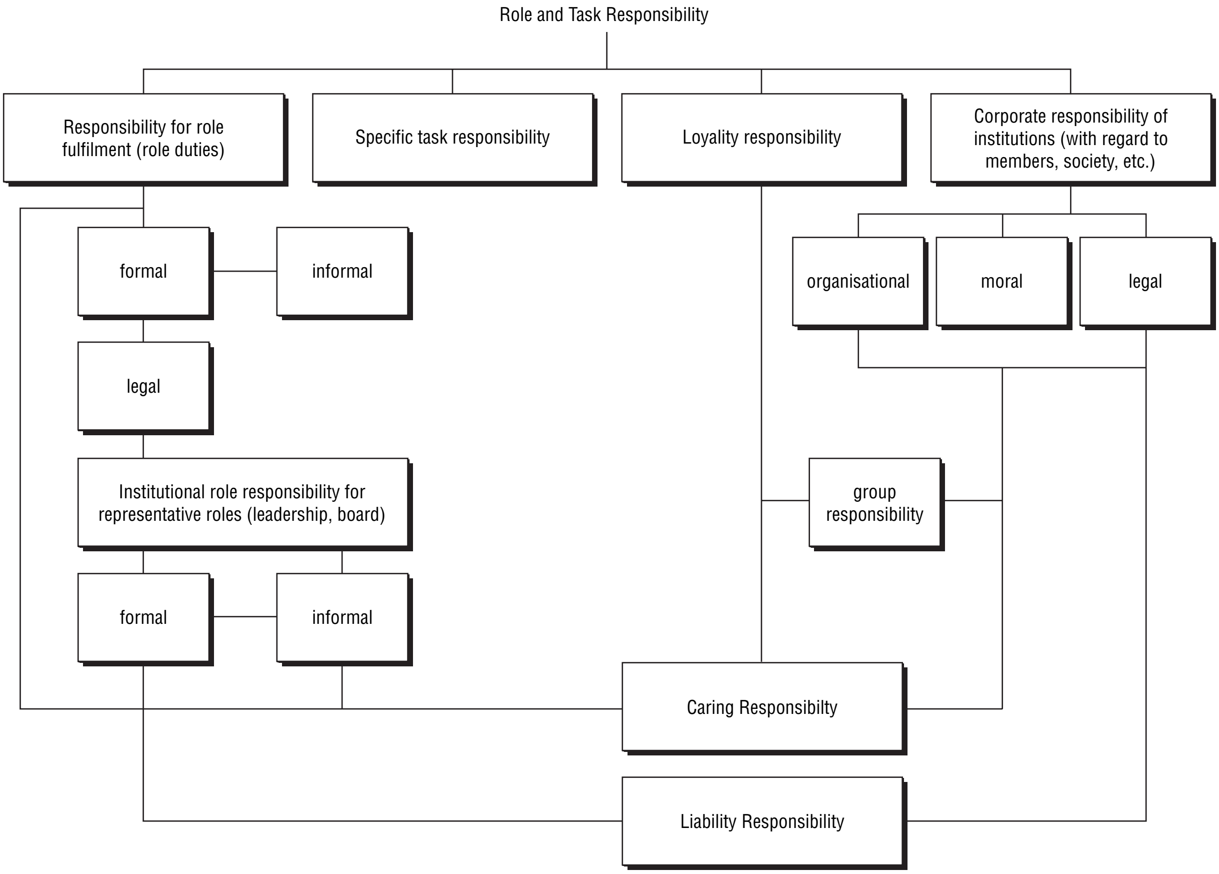
FIGURES 1–2

Figure 1: Action Responsibility



SOURCE: Courtesy of Hans Lenk.

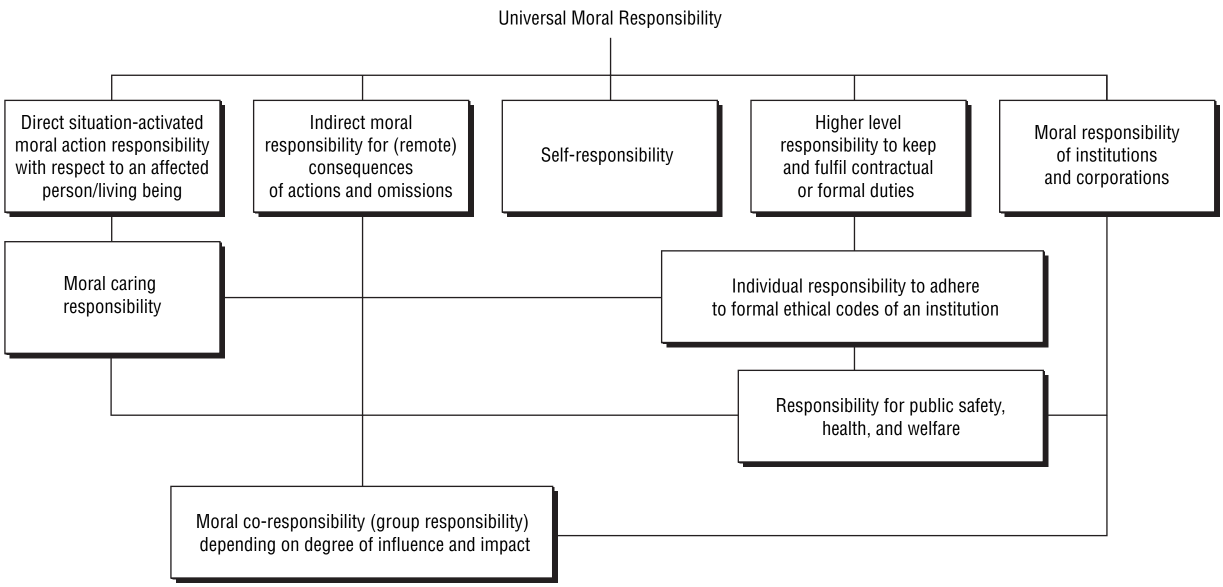
Figure 2: Role and Task Responsibility



SOURCE: Courtesy of Hans Lenk.

FIGURE 3

Universal Moral Responsibility



SOURCE: Courtesy of Hans Lenk.

advanced scientific and technological society one might also speak of consumer responsibility.

UNIVERSAL MORAL RESPONSIBILITY. Universal moral responsibility provides a different specification for the functioning of individual action responsibility than that associated with role responsibility. Not all action responsibility and role responsibility is specifically moral in character or moral to the same degree. To have a responsibility to be on time for an appointment because of a particular role has more an efficiency than a moral character; it is a responsibility that keeps some particular organizational system functioning more smoothly than would otherwise be the case.

Action responsibility and role responsibility take on a specifically moral character when an agent's actions and the results of those actions are directed toward persons or living beings (including even the agent) whose well-being is directly affected by the agent's activity. With regard to others such affects can be direct or indirect, can be defined by contractual or formal duties, and can inhere in institutions or corporations. By way of diagrammatic summary, see Figure 3.

For Hans Jonas (1984) universal moral responsibility can become pronounced with regard to the uses of technology that have the potential for environmental or human destruction such as nuclear weapons or genetic engineering. Caring responsibility is not only role related (with different kinds of scientists or engineers exhibiting it in different degrees) but also general for those who inhabit a highly scientific and technological society—that is, those who promote and benefit from advanced scientific and technological activities. According to Jonas's argument, members of a scientific and technological society, by virtue of participating in such a society, and because of the tremendous potential for intentional and nonintentional destruction present in the society, become responsible for ensuring the well-being of all persons and other living beings affected by their specific actions in the form of a general and permanent obligation.

A few more restricted observations on various types of universal moral responsibility related especially to science and technology are as follows:

- The remote consequences of an agent's activity—possibly combined with the impacts of other people's commissions or omissions—may create an indirect moral (co-) responsibility. For instance, neglecting a safety check or wrongly certifying the airworthiness of an airplane could contribute to loss of life when coupled with a less than expert pilot or other crew member.
- Corporate moral responsibility frequently coincides with, but need not be identical to, the moral cor-

esponsibility of members of a decision-making board. Therefore corporate moral responsibility is not to be analytically confused with the moral coresponsibility of group members partaking in a collective action or decision-making process. (Questions of responsibility distribution are increasingly important in assessing responsibility in the virtual environments created by computers and information systems, where teams of programmers have created web-based utilities in which people differentially interact to produce multiple types of products.)

- To abide by the ethics code of a professional society is a combination of indirect responsibilities. As such it is certainly a moral obligation. Thus beside immediate action- or impact-oriented responsibilities, scientists and especially engineers take on, through their professions, higher-level moral responsibilities to fulfill contractual or role duties and promises and to live up to the ethical standards of their professional organizations, not to infringe established laws, and more, inasmuch as the fulfillment of a task, contract, or role does not contradict another overriding moral norm or right. In engineering ethics codes the responsibility to protect public safety, health, and welfare has (since World War II) increasingly been considered paramount.

General Commentary

The previous review aims to summarize in somewhat schematic or outline form the consensus of an extended tradition of critical reflection on responsibility in the German philosophical traditions. These traditions run at least from Gottfried Wilhelm Leibniz (theodicy) through Immanuel Kant (categorical responsibility) and G. W. F. Hegel (idealist responsibility) and Karl Marx (economic responsibility) to the phenomenological tradition (Edmund Husserl through Martin Heidegger to Schutz) and critical social theory versus systems theory (Jürgen Habermas versus Niklas Luhmann). Since World War II, discussions within the Verein Deutscher Ingenieure (Society of German Engineers) have been especially concerned with conceptualizing responsibility in relation to science and technology. The 2002 "Fundamentals of Engineering Ethics" highlights the topic of responsibility in its first major paragraph. The most general discussion of responsibility in this context has occurred in the work of such philosophers as Karl Jaspers, Günther Anders, and Hans Jonas—drawing attention to new moral responsibilities engendered by nuclear weapons, environmental pollution, and genetic engineering. Hans Lenk and Matthias Maring have since the 1980s worked to synthesize the many achievements within these traditions.

One of the important notes to emphasize about this schematic synthesis is that there exists a differentiated interplay among the identified levels and types of responsibilities, universal moral obligations being but one case. Moral responsibility may be activated by a special type of action and in connection with a special role, but its key characteristic is universality. Moral responsibility as such is not peculiar to a specific person or role but applies to everyone in a similar situation or role. Moral responsibility is nevertheless individualized in the sense that it cannot be delegated, substituted, displaced, replaced, or off-loaded by the respective person, corporation, or organization. Neither can it be diminished, divided, dissolved, or done away with by being shared by a number of people. Moral responsibility is both irreplaceable and unable to be diminished.

With regard to conflicts between different responsibilities or types, priority rules have been developed for adjudicating, regulating, or at least mitigating conflicts and for combining different responsibilities when they are present at the same time. In the last analysis, the presence of a situation- and context-dependent responsibility under the auspices of practical (concrete) humanity should, from the moral point of view, prevail or override any partial and nonmoral responsibility. That is, human rights trump role responsibility rights. One of the challenges of a technoscientific society is to explore ways in which such a priority can be operationalized in and through scientific and technological developments, not just among technical professionals but in society as a whole.

HANS LENK

SEE ALSO *Technology Assessment in Germany and Other European Countries.*

BIBLIOGRAPHY

Über einige strukturelle Probleme der Verantwortung." In *Über den Sinn des Lebens und über die Philosophie,* ed. J. M. Bochenski. Freiburg, Basel, Vienna: Herder.

French, Peter A. (1984). *Collective and Corporate Responsibility.* New York: Columbia University Press.

Jonas, Hans. (1984). *The Imperative of Responsibility: In Search of an Ethics for the Technological Age,* trans. Hans Jonas and David Herr. Chicago: University of Chicago Press.

Lenk, Hans. (1982). *Zur Sozialphilosophie der Technik* [Toward a social philosophy of technology]. Frankfurt am Main: Suhrkamp.

Lenk, Hans. (1987). "Ethikkodizes für Ingenieure" [Codes of ethics for engineers]. In *Technik und Ethik* [Technology and ethics], ed. Hans Lenk and Günter Ropohl. Stuttgart: Reclam.

Lenk, Hans. (1992). *Zwischen Wissenschaft und Ethik* [Between science and ethics]. Frankfurt am Main: Suhrkamp.

Lenk, Hans. (1994). *Macht und Machbarkeit der Technik* [Power and feasibility of technology]. Stuttgart: Reclam.

Lenk, Hans. (1998). *Konkrete Humanität: Vorlesungen über Verantwortung und Menschlichkeit* [Concrete humanity: Lecture on responsibility and humanity]. Frankfurt am Main: Suhrkamp.

Lenk, Hans. (2003). "Responsibility for Safety and Risk Minimization: Outline of an Attribution-Based Approach Regarding Modern Technological and Societal Systems." *Human Factors and Ergonomics in Manufacturing* 13(3): 203–222.

Lenk, Hans, and Matthias Maring. (2001). "Responsibility and Technology." In *Responsibility: The Many Faces of a Social Phenomenon*, ed. Ann Elisabeth Auhagen and Hans-Werner Bierhoff. London: Routledge.

Lenk, Hans, and Günter Ropohl, eds. (1987). *Technik und Ethik* [Technology and ethics]. Stuttgart: Reclam. 2nd edition, 1993.

Schutz, Alfred. (1967). *The Phenomenology of the Social World*, trans. George Walsh and Frederick Lehnert. Evanston, IL: Northwestern University Press.

Werhane, Patricia H. (1985). *Persons, Rights, and Corporations*. Englewood Cliffs, NJ: Prentice-Hall.

RESPONSIBLE CONDUCT OF RESEARCH

The *responsible conduct of research* (RCR) is one of two major components of research ethics. The essence of the concept is that RCR is central to the practice of science: " [T]he responsible conduct of research is not distinct from research; on the contrary, competency in research *encompasses* the responsible conduct of that research and the capacity for ethical decision making" (Institute of Medicine 2002, p. 9). The emphasis is on professional responsibilities and the extent to which the scientific research community and its members, as a profession, determine, recognize, and adhere to professional standards and values (Carr-Saunders and Wilson 1933). RCR assumes that: (1) there are identifiable, shared standards of practice and behavior that can and should be made explicit; (2) these standards are, consciously or unconsciously, acknowledged by members of the community; and (3) they are standards that research supervisors are expected to instill in trainees.

History

The term RCR is closely related to that of *research integrity*, which it tended to replace as a term of art in the 1990s. It is probably derived from the 1989 Institute of Medicine document *Responsible Conduct of Research in the Health Sciences* (1989) and the concept is further reinforced and reflected in the National Institutes of Health (NIH) requirement that pre- and post-doctoral trainees funded by the NIH receive some formal education in the proper conduct and reporting of research (NIH 1989). However its roots no doubt date from the 1980s when various professional scientific societies, including, for example, the American Chemical Society and Sigma Xi, developed and promulgated codes of conduct for their members (Sigma Xi 1984, Jorgensen 1995, Johnson 1999). In the 1990s the NIH requirement is credited with motivating the biomedical research community to develop educational programs to formalize and make explicit to trainees the expectations of the scientific community with regard to the procedures and processes involved in carrying out and publicizing the results of scientific investigation.

Although inherent in the notion of RCR is professional competence and integrity, education and training in RCR includes many other aspects of scientific research practice. Common usage of the term RCR is a bit of a misnomer because, in point of fact, it includes a wide range of elements beyond the conduct of research that are fundamental to the practice of scientific research. It encompasses not only the experimental process itself, but also closely associated processes such as the dissemination of research findings, the implications of competition among colleagues and its potential impact on the evaluation of research results, and the training of future scientists. As the leading agency emphasizing the importance of education in RCR, the Office of Research Integrity (ORI) in the Office of Public Health and Science in the U.S. Department of Health and Human Services (DHHS) has identified elements central to research practice and appropriate for explicit discussion in the context of RCR (Office of Research Integrity 2005). These topics are:

- data acquisition, management, sharing, and ownership;
- humane treatment of research subjects including both humans and laboratory or other non-human animals;
- allegations of research misconduct;
- recognition of, and management or elimination of, conflicts of interest and conflicts of commitment;

- the mentor/trainee relationship and associated responsibilities;
- publication practices and the responsibilities of authorship;
- the peer review process;
- the expectations of collaborators regarding the nature of collaborative research, appropriate recognition of contributions to the work, and the allocation of responsibility.

Assessment

RCR, in contrast to most formulations of scientific misconduct and integrity, does not solely nor primarily focus on the more egregious and unacceptable practices of fabrication, falsification, and plagiarism (FFP). Instead the notion of RCR implies that there are less responsible, as well as irresponsible, practices. Put another way, there are a range of research practices from the preferred, through accepted but discouraged to prohibited practices. Serious deviation from accepted practices in carrying out research, or in reporting the results of research, may be considered unacceptable by some members of the scientific research community.

A major emphasis of RCR is education in the form of making explicit for both trainees and peers what is often implicit in research practice. However debate continues over how best to assess the efficacy of that education. This stems in part from a lack of consensus on the extent to which the goals of RCR education should include not only explicit understanding of the standards and values of the community and the expectations of both colleagues and society regarding professional behavior, but also training in ethical decision making (Institute of Medicine 2002).

STEPHANIE J. BIRD

SEE ALSO *Misconduct in Science.*

BIBLIOGRAPHY

Carr-Saunders, Alexander P., and Wilson, P. A. (1933). *The Professions*. Oxford: Oxford University Press.

Institute of Medicine. (1989). *Responsible Conduct of Research in the Health Sciences*. Washington, DC: National Academies Press.

Institute of Medicine. (2002). *Integrity in Scientific Research: Creating an Environment That Promotes Responsible Conduct*. Washington, DC: National Academies Press.

Johnson, David. (1999). "From Denial to Action: Academic and Scientific Societies Grapple with Misconduct." In *Perspectives on Scholarly Misconduct in the Sciences*, ed. John M. Braxton. Columbus: Ohio State University Press.

Jorgensen, Andrew. (1995). "Survey Shows Policies on Ethical Issues Still Lacking Enforcement Mechanisms." *Professional Ethics Report* 8(1): 1, 6.

National Institutes of Health (NIH). (1989). "Reminder and Update: Requirement for Programs on the Responsible Conduct of Research in National Research Service Award Institutional Training Programs." *NIH Guide for Grants and Contracts* 18.

Sigma Xi, The Scientific Research Society. (1984). *Honor in Science*. Research Triangle Park, NC: Author. 2nd edition, revised and enlarged, 1986.

INTERNET RESOURCE

Office of Research Integrity. Available from http://ori.hhs.-gov. Web site of the organization.

RESTORATION ECOLOGY

SEE *Ecological Restoration.*

RHETORIC OF SCIENCE AND TECHNOLOGY

Rhetorical inquiry is a multidisciplinary field of study devoted to the critical examination of discourse. Initiated in classical times, it cultivates an "ability, in each [particular] case, to see the available means of persuasion" (Aristotle 1991, p. 36). As an academic field, rhetoric of science and technology is the study of how scientists and non-scientists use arguments to advance claims about science and technology.

The idea that there is a *rhetoric* of science and technology may strike some as perverse and others as obvious. In popular parlance, the term rhetoric connotes something less than truthful, the ranting of politicians who evade substantive dialogue. When tied to science and technology, rhetoric can sound like a curse, staining the purity of certain knowledge and precise measurement with the mark of ideological bias and political maneuvering. But to those who study the rhetoric of science and technology, the term has no such connotation. Instead it is steeped in its ancient tradition and denotes the careful study of how texts are designed to seek the assent of an audience. When those texts are from the realm of science and technology, the means of persuasion utilized include such factors as appeals to disciplinary assumptions and values, the demonstration of methodological rigor, and the selection of language that suggest the neutral observation of nature.

Historical Development

The negative connotations attached to rhetoric are largely the result of a lengthy conflict with philosophy, in which the latter claimed the more valued side of oppositions between opinion and truth, form and content, passion and reason. Yet recent developments in philosophy and other fields recognize these dichotomies as problematic, resulting in a general resurgence of interest in the tradition of rhetorical inquiry, a tradition maintained by enclaves of scholars working mostly in departments of Speech Communication and English in the United States.

Developments in the philosophy, sociology, and history of science have also contributed to the rise of scholarship on the rhetoric of science and technology. Science studies scholars have shown that what one era recognizes as the truth of a scientific theory is seen by a later era as mere opinion, supplanted when an authorizing scientific community accepts a new truth claim. The fact that this transformation occurs by way of arguments addressed to a particular audience, that it often entails a significant shift in values and beliefs by people with an investment in the outcome of those arguments, and that it is frequently marked by controversy, makes rhetorical inquiry a natural approach to the study of such moments.

The idea that communication between scientists and the public might have a rhetorical dimension, or that new technologies may be promoted through rhetorical means, is rarely disputed. Thus the rhetorical examinations of these aspects of science and technology are likewise promising scholarly pursuits in an age when science and technology play such an important role in the development of public attitudes and policies.

The first hint that rhetorical inquiry might be applied to scientific discourse began appearing in the journals of rhetoricians in the 1970s. There were theoretical essays exploring the developments in philosophy and sociology of science that contributed to the possibility for a rhetoric of science (Weimer 1977; Overington 1977), research that began to examine the persuasive nature of specific scientific texts (Campbell 1975), and a general call for scholarship in this new area (Wander 1976). The birth of the field was announced when two books appeared almost simultaneously with nearly identical titles: Lawrence J. Prelli's *A Rhetoric of Science* (1989) and Alan G. Gross's *The Rhetoric of Science* (1990). Both fruitfully applied classical rhetorical concepts to the study of scientific truth claims.

In 1991 Randy Allen Harris wrote a thorough review of the nascent field, defining its relationship to other fields and organizing the scattered research into useful taxonomic categories. In 1993 the American Association for the Rhetoric of Science and Technology held its inaugural meeting at the National Communication Association convention, where it continues to meet annually. The field has continued to develop with the aid of such professional supports as the University of Iowa's Project on the Rhetoric of Inquiry, graduate programs specializing in the study of rhetoric in science and technology at the University of Pittsburgh and the University of Minnesota, and a series of books on the Rhetoric of the Human Sciences published by the University of Wisconsin Press. Research has generally grown along two paths: studies of the arguments made by scientists when they address other scientists, and scholarship that focuses on the relationship between science or technology and the public.

Internal Rhetorics of Science

The most heavily researched area in this growing field is the internal rhetoric of scientists, that is, the discourse scientists use when addressing other scientists, either within their own discipline or across disciplines. Because most people think the internal discourse of scientists is resistant to rhetorical scrutiny, scholars blazing the trail have focused on establishing that even the most specialized communication can be examined usefully through the lens of rhetorical analysis. The prototypical scientific research article has been the subject of much research. For example Watson and Crick's famous 1953 *Nature* report, "A Structure for Deoxyribose Nucleic Acid," has been examined in several unrelated studies that explain its persuasive design through rhetorical theories pertaining to voice, ethos, irony, kairos, stasis, and narrative (Bazerman 1988, Halloran 1984, Gross 1990, Miller 1992, Prelli 1989, Fisher 1994). An entire volume of essays has been written on the rhetoric of a single journal article by Stephen Jay Gould and Richard Lewontin (Selzer 1993).

More evidence that the research report was the primary focus for early rhetoricians of science is the fact that some of the first books in the field were devoted to illuminating writing practices in this genre. For example Charles Bazerman's *Shaping Written Knowledge* (1988) contrasts the scientific article with other forms of academic discourse and traces historical changes and disciplinary differences in the design of the experimental report. It shows how even scientists "use, transform, and invent tools and tricks of the symbolic trade" to shape claims so that they are judged novel and truthful by other scientists (p. 318). In *Writing Biology* (1990), Greg Myers looks at the review process to examine the way authors and editors, operating with different interests, negotiate the status of a scientific claim in a journal article. His book further traces the way two controversies are played out in scientific journals, where scientists interpret their own words and those of their opponents as freely and expertly as any debater in the public forum.

In addition to the rhetoric of the experimental article, landmark scientific monographs such as Newton's *Opticks* (1704) and Darwin's *On the Origin of Species* (1859) and have received sustained attention from scholars of rhetoric seeking to understand how scientists persuade their colleagues to accept radical new theories. The most successful scientists are often the ones who are also master rhetors, capable of adapting new ideas to the presuppositions of their audiences rather than making a frontal assault on a standard paradigm with the irresistible force of a revolutionary theory.

Rhetorical studies have done a particularly good job of showing how the style in which a scientific claim is communicated has an influence on how a scientific community thinks about that claim, and vice versa. Jeanne Fahnestock's careful account of rhetorical figures in science demonstrates that language does "much of our thinking for us, even in the sciences, and rather than being an unfortunate contamination, its influence has been productive historically, helping individual thinkers generate concepts and theories that can then be put to the test" (Fahnestock 1999, p. xi).

Because facilitating the growth of knowledge is the central activity of scientists, the way in which scientists use the tools of language and argument to advance knowledge claims has received the most attention from scholars of the rhetoric of science. Another internal rhetoric of science that receives less attention, either because it is considered less central or because its character is less contested and thus less shocking when discovered, is the way in which scientists persuade one another that a particular line of research holds future promise. Myers devotes a chapter of his book to the rhetoric of the grant proposal, a genre of scientific writing that must convince reviewers a research program deserves funding because of its potential interest to the scientific community and the professional ethos of the authors. Leah Ceccarelli (2001) examines motivational texts of science to show that scientists who employ a strategic ambiguity of language are better able to persuade colleagues from different disciplines to overcome barriers separating their fields and engage in new interdisciplinary lines of research. These internal discourses of science that do not seek the assent of colleagues to a particular truth claim, but instead seek future action from fellow scientists, have been less studied by rhetoricians, but may be just as important to the ultimate development of science.

For the most part, research on internal rhetorics of science tends to be descriptive and explanatory in nature, uncovering the rhetorical practices at the heart of scientific activity. But some of it has an implicit prescriptive character, suggesting other resources of language and argument that scientists might use to shape science in more useful or ethical ways. In contrast research on external rhetorics of science and technology tends to be more explicit in its criticism of current communication practices and more direct in its recommendations for change.

External Rhetorics of Science and Technology

The ways in which scientists communicate with the public and the ways in which nonscientists communicate about scientific or technological issues are more obviously rhetorical in nature, and ripe for critical commentary. Popularization is one genre of scientific writing that is a natural subject for rhetorical analysis. By contrasting journal articles written for specialists with popularizations on the same topics, rhetorical inquiry has shown that popular accounts remove hedges and qualifications for scientific claims while emphasizing the uniqueness of observations (Fahnestock 1986). Because of these changes, the public may get a distorted view of the certainty and significance of a scientific knowledge claim, something that can be dangerous when the subject has important social implications. Rhetorical analysis contrasting internal rhetorics of science with popularizations has also demonstrated that while the former emphasize the activities of the scientists and the conceptual structure of the discipline in which they are working, the latter emphasize the activities of the objects being studied (Myers 1990). Again distortion may result, with public audiences developing an image of science as the unmediated observation of external nature, without the interference of scientists who employ theoretical apparatus or make methodological decisions.

Rhetorical inquiry has also brought critical attention to the situation in which an expert takes a new scientific theory away from its disciplinary origins and argues before public audiences, thus eluding accountability to the controls of a specialized scientific community (Lyne and Howe 1990). Popularization may be the genre of science writing that does the most to break down the barrier that exists between the two cultures of scientists and nonscientists, but its tendency to misrepresent science as a non-controversial activity of observation by disinterested individuals has ethical consequences, especially when the public is asked to make decisions about matters for which science and technology do not have indisputable answers.

Situations in which the public must act on technical matters despite a lack of scientific consensus have been the subject of several case studies in the rhetoric of science and technology. Examining cases as diverse as the recombinant DNA controversy of the 1970s (Gross 1990, Waddell 1990) and disputes over the accuracy of missile defense technology in the 1980s and 1990s (Mitchell 2000), rhetorical critics have analyzed debates about the public control of contemporary scientific and technological developments. Most have supported the findings of an early study of the discourse surrounding the Three Mile Island incident (Farrell and Goodnight 1981). When technical reason usurps the place of more appropriate modes of public deliberation about matters of social or political import, a crisis of communication is the result. In each case study, rhetorical patterns that promote democratic participation are endorsed as an alternative to the dysfunctional assumption that people can rely on science and technology to solve their most serious public problems.

Another type of scholarship on external rhetorics of science and technology takes a more historical approach, scrutinizing the documentary evidence surrounding a particular scientific field or technological development to uncover the specific discursive forms that reflect and shape public attitudes. The scope of such rhetorical histories can be broad, as it is in Celeste Condit's 1999 study of public debates about human heredity from 1900–1995, or narrow, as in Charles Bazerman's 1999 study of how Thomas Edison and the people around him represented light to the public from 1878–1882. In both cases though, the purpose of the rhetorical study is not to critique the oversimplification of popularizations, nor to valorize public deliberation over technological decision making, but to demonstrate the complicated ways in which science, technology, and culture interact in the public mind.

Conclusion

Although the rhetorical study of science and technology can be broadly divided into the examination of internal and external communication, there is work within the field that breaks out of this neat mold. For example the rhetoric of technology typically makes no distinction between internal and external genres, but examines both in the patterns of communication unique to "enterprises concerned with the development, production, and marketing of artifacts and practices" (Miller 1994, p. 92). There also are various fields of rhetorical study that intersect with the rhetoric of science and technology, but are not typically considered a part of it, such as the rhetorical study of medicine, mathematics, economics, or communication technologies.

Study of rhetoric in science and technology is an important but young field that sometimes suffers lack of confidence in communicating outside its peer group. A scan of citation practices in the literature demonstrates that most rhetoricians of science and technology are familiar with related research done in philosophy, history, and sociology of science, but the reverse is rarely true. Publishing mostly in journals read by other rhetoricians, or in books that are marketed to Speech Communication and English departments, they do little to communicate their findings to other science studies scholars or to scientists and the public. This is unfortunate, as the rhetorical critic's tools of close reading and argument analysis illuminate aspects of texts and debates that would benefit scholars in other fields. Perhaps with time, the rhetoric of science and technology will mature into a field that acts as a full and equal participant in the community of science studies scholars. At that point perhaps it will also do more to export its findings especially to scientists and citizens who must evaluate scientific discourse to make fully informed ethical decisions about science and technology.

LEAH CECCARELLI

SEE ALSO *Communication Ethics; Discourse Ethics; Knowledge; Science, Technology, and Literature.*

BIBLIOGRAPHY

Aristotle. (1991). *On Rhetoric: A Theory of Civic Discourse*, trans. George A. Kennedy. New York: Oxford University Press. Classical work on rhetoric that is still much used.

Bazerman, Charles. (1988). *Shaping Written Knowledge: The Genre and Activity of the Experimental Article in Science*. Madison: University of Wisconsin Press.

Bazerman, Charles. (1999). *The Languages of Edison's Light*. Cambridge, MA: The MIT Press.

Campbell, John Angus. (1975). "The Polemical Mr. Darwin." *Quarterly Journal of Speech* 61: 375–390. An early essay in the author's corpus on Darwin's Origin.

Ceccarelli, Leah. (2001). *Shaping Science with Rhetoric: The Cases of Dobzhansky, Schrödinger, and Wilson*. Chicago: University of Chicago Press.

Condit, Celeste Michelle. (1999). *The Meanings of the Gene: Public Debates about Human Heredity*. Madison: University of Wisconsin Press.

Fahnestock, Jeanne. (1986). "Accommodating Science: The Rhetorical Life of Scientific Facts." *Written Communication* 3: 275–296.

Fahnestock, Jeanne. (1999). *Rhetorical Figures in Science*. New York: Oxford University Press.

Farrell, Thomas, and G. Thomas Goodnight. (1981). "Accidental Rhetoric: The Root Metaphors of Three Mile Island." *Communication Monographs* 48: 271–300.

Fisher, Walter R. (1994). "Narrative Rationality and the Logic of Scientific Discourse." *Argumentation* 8: 21–32.

Gross, Alan. (1990). *The Rhetoric of Science*. Cambridge, MA: Harvard University Press. The second printing, 1996, has a new preface that reviews some work in the field.

Halloran, S. Michael. (1984). "The Birth of Molecular Biology: An Essay in the Rhetorical Criticism of Scientific Discourse." *Rhetoric Review* 3: 70–83.

Harris, R. Allen. (1991). "Rhetoric of Science." *College English* 53: 282–307.

Lyne, John, and Henry F. Howe. (1990). "The Rhetoric of Expertise: E. O. Wilson and Sociobiology." *Quarterly Journal of Speech* 76: 134–151.

Miller, Carolyn. (1992). "*Kairos* in the Rhetoric of Science." In *A Rhetoric of Doing: Essays on Written Discourse in Honor of James L. Kinneavy*, eds. Stephen P. Witte, Neil Nakadate, and Roger D. Cherry. Carbondale: Southern Illinois University Press.

Miller, Carolyn. (1994). "Opportunity, Opportunism, and Progress: *Kairos* in the Rhetoric of Technology." *Argumentation* 8: 81–96.

Mitchell, Gordon. (2000). *Strategic Deception: Rhetoric, Science, and Politics in Missile Defense Advocacy*. East Lansing: Michigan State University Press.

Myers, Greg. (1990). *Writing Biology: Texts in the Social Construction of Scientific Knowledge*. Madison: University of Wisconsin Press.

Overington, Michael A. (1977). "The Scientific Community as Audience: Toward a Rhetorical Analysis of Science." *Philosophy and Rhetoric* 10: 143–164.

Prelli, Lawrence. (1989). *A Rhetoric of Science: Inventing Scientific Discourse*. Columbia: University of South Carolina Press. Introduces readers to classical rhetorical theory, then adjusts that theory to apply it to science.

Selzer, Jack, ed. (1993). *Understanding Scientific Prose*. Madison: University of Wisconsin Press. Various critics apply different methods to analyze a single scientific essay.

Waddell, Craig. (1990). "The Role of *Pathos* in the Decision-Making Process: A Study in the Rhetoric of Science Policy." *Quarterly Journal of Speech* 76: 381–400.

Wander, Philip C. (1976). "The Rhetoric of Science." *Western Journal of Communication* 40: 226–235.

Weimer, Walter B. (1977). "Science as a Rhetorical Transaction: Toward a Nonjustificational Conception of Rhetoric." *Philosophy and Rhetoric* 10: 1–29.

RIGHTS AND REPRODUCTION

It is in the context of reproduction, interpreted broadly, that many of the issues concerning the ethics of science and technology have arisen. The birth of the first so-called "test tube" baby in 1978 set in motion an ongoing process of questioning interventions such as assisted reproduction, embryo research, and cloning.

The notion that human beings possess a legitimate inclination to conceive and bear children is part of traditional natural law teaching. For instance, Thomas Aquinas (1225–1274) argued that human beings share those inclinations "which nature has taught to all animals," such as sexual intercourse, education of offspring, and so forth (*Summa theologiae* I–II, Q. 94, a.2). As traditional natural law was transformed into modern natural right, and human sexuality became increasingly mediated by science and technology so as to become both more productive and subject to human control, the intersection of human rights and having children (termed variously both reproduction and procreation) became increasingly contentious.

One contention centers around what are termed *reproductive rights*, generally indicating women's right to control whether, when, and how they bear children. There is clearly an important gender dimension to the issues. The right to be free from interference such as sterilization, on the one hand, and the right to abortion, on the other, have been important historical landmarks in women's control over their fertility.

Historically, the content of the reproductive rights has gradually increased, however, beyond freedom from interference to include a right with a much wider scope, such as the right to positive assistance in reproduction (that is, the use of technology in the case of infertility); and also to choice of the *kind* of children one has (for example, sex selection and genetic factors). Reproductive rights in this sense remain hotly contested at least to some degree: While there is widespread acceptance of in vitro fertilization, some potential means of assisted reproduction continue to be regarded by many as unacceptable, such as reproductive cloning. The right to choose to avoid preventable genetic disorder in one's children is also regarded as problematic by those who find such choices expressive of intolerance towards difference.

Disagreements depend to a considerable extent on different views on what the fundamental basis of the right is—for example, on whether the right to reproduce is claimed a natural right, or as an aspect of autonomy—and on how these concepts themselves are understood. For example, it might appear strained to argue for a *natural* right to reproduce by *artificial* means, unless it is argued that the artificial is necessary in order to fulfill a natural purpose of human life. Should infertility be regarded as a disease that needs treatment, or just an unfortunate inability to satisfy one's wishes? Again, while on the one hand an autonomy argument might be deployed to suggest that the right to reproduce is an aspect of doing as one wants with one's body, on the other hand, in so far as reproduction has effects on others and requires the allocation of health care resources, it is difficult to see how the argument can, by itself, provide an argument for the cooperation of others. The welfare of future children is a consideration that may compete with that of the reproductive rights of adults.

RUTH CHADWICK

SEE ALSO *Assisted Reproduction Technology (ART); Eugenics.*

RIGHTS THEORY

Rights are generally defined as justified claims for the protection of general interests. In this sense, human beings have been described as having rights to property, "to life, liberty, and the pursuit happiness" (United States Declaration of Independence, 1776), as "free and equal in rights" (Declaration of the Rights of Man and Citizen, 1789), and as having rights "to share in scientific advancement and its benefits" (Universal Declaration of Human Rights, 1948). More recently civil rights or liberties to freedom of speech and assembly have been complemented by proposals for social, economic, and welfare rights to minimum levels of shelter, food, and medical care. What was initially a quite limited relation of rights to science and technology, insofar as their advancement rested on the protection of intellectual property rights, has become increasingly a question of consumer rights to certain levels of material benefit and safety related especially to technology. The assessment of such diverse claims nevertheless requires appreciation of the broader philosophical discussion of rights and various analytic distinctions introduced to clarify numerous complications.

Fundamental Distinctions

As initial observations have already indicated, the notion of rights has become deeply embedded in modern societies, but it has critics precisely because of its origin in particular socio-cultural contexts and because of its relationship to individualism. "Rights express the idea that respect for a given interest is to be understood from the point of view of the individual whose interest it is" (Waldron 1993, p. 576). While this statement arguably overlooks the fact that it is not only individuals but also groups that may be held to have rights, as seen in debates about rights of particular minorities, it soon becomes clear that this does not avoid questions of individual rights: Some of the most difficult issues with group rights concern relationships of the individual *to* the group.

The classic and most systematic attempt to delineate different kinds of rights was that of Wesley Hohfeld (1919), who identified a number of distinct categories. Some of the ways in which the term *rights* would be used, he argued, would be more accurately captured by the term *privileges*. These are to be contrasted with rights "in a strict sense," which Hohfeld categorized as claim-rights.

If a person X has a claim-right, in Hohfeld's sense, there must be at least one person who has a duty to X with regard to that claim. This is the thesis of correlativity of rights and duties: A claim can normally be met only through the efforts, or at least the non-interference, of others. This thesis has come to be regarded as definitive of rights.

To say that X has a privilege, however, has no such implication. A privilege is a liberty to do something, which may be either of a general or a special kind. In the general sense a privilege to act in a certain way is simply the absence of a duty to avoid doing it. No one is in a position to make a counter-claim against the person. In the special sense, however, a privilege is a liberty that is *exceptional,* that is, it is not enjoyed by other persons—for example, informed consent on the part of patients allows health care professionals certain liberties to do things to them which may be invasive, which would not be permissible in other circumstances. Hohfeld also distinguished claim-rights from other terms such as powers and immunities.

Questioning Correlativity

The thesis of the correlativity of rights and duties is problematic. First, different aspects of correlativity have been distinguished: the moral and the logical (Feinberg 1973). The moral correlativity thesis states that in order to have rights individuals must have and accept duties themselves. This is controversial because it would rule out the rights of persons with mental incapacity. Some would argue that all human beings have rights, pre- as well as postnatally, even if it is not possible to hold them to be subject to duties.

The logical correlativity thesis is concerned with what X's rights imply for others' duties. In terms of Hohfeld's claim-rights, which are *defined* in terms of the duties they imply for others, then questions arise about what those duties are, for where rights *do* imply duties, these may be of different kinds. For example, if X has a right to something, while it may not be the case that there is any person Y in particular who has a duty to do anything to help X to get that something, it may yet be appropriate to say that everyone has a duty not to *prevent* X from getting it.

More generally, however, the question has to be asked whether the correlativity thesis is true of all rights. The term *rights* has certain uses in political discourse, which go beyond claim-rights. This is described as the rhetorical or "manifesto" use. Thus Onora O'Neill writes: "A 'right to food' could be satisfied by earning enough money to buy food, by having enough land to grow it or by having friends and family with obligations to provide it; in each case there would be an entitlement to food . . . But without one or other determinate institutional structure, these supposed economic rights amount to rhetoric rather than entitlement" (O'Neill 2000, p. 125). Such "rights" arguably do not imply duties on the part of anyone in particular.

Furthermore, even where rights imply duties, it does not appear to be the case that the converse applies: That where there are duties there are always corresponding rights. If one accepts that X has a right to the fulfilment of a promise, there must be someone who has a duty to fulfil it, and if Y has a duty to fulfil a promise, there must presumably be someone who has a right to have that duty fulfilled. Promising involves correlativity of this kind. Other duties, however, such as those involved in scientific inquiry, for example, are not of this type. Duties to pursue truth, avoid fraud, and publish results are arguably not best explained in terms of other people's rights, but arise from the nature and purpose of the activity itself.

Claim Elements

If one accepts that in addition to claim-rights in the strict sense there are also wider uses of the term, it is still possible nevertheless to regard rights as including a claim *element*. In order for a claim to be a right, however, it must be justified. The two elements, a claim and a justification, are common to both Hohfeldian claim-rights and manifesto rights. Different moral theories will attempt to justify rights in different ways, however, and it is the type of justification to which appeal is made that categorizes a right as of one sort or another. In the case of a claim-right to the fulfilment of a promise, that the promise was made, and thus a duty incurred, will form part of the justification. In the case of a manifesto right, however, the justification could be in terms of moral judgments about what should be the case, and may be based more on moral ideals of principles of justice than on duties.

There are at least two further distinctions it is important to consider in thinking about the claim element of a right: the contrast between *negative* and *positive* and the importance of rights of *voice* and rights of *exit*. The distinction between negative and positive rights depends on what they imply for others—either non-interference or positive action, respectively. The right to freedom of scientific inquiry, for example, might be construed negatively as a freedom right not to be prevented from pursuing a particular line of research. At the same time, it might be argued that freedom of scientific inquiry is meaningless unless research is funded, which might imply positive action on the part of others such as governments and research councils.

Claim-rights may change their content over time from negative to positive, depending on the social context. Thus at one time the right to reproduce was construed as a negative right to be free from interference: the right to choose whether or not to reproduce. Over time, however, it has been argued to include not only the right to decide on the number and spacing of one's children, but also, by some, the type of children one has. This has led to arguments about the extent of the different duties for others, including the provision of contraception advice, assisted reproduction where necessary, and sex selection. Again, X's right to life implies a duty on everyone not to kill X, but might also require, in a certain circumstance, that a bystander who has the ability to save X from drowning has a duty to do so.

The distinction between *rights of voice* and *rights of exit* (see Hirschman 1970) is particularly prominent in discussions of group rights. Rights of exit include the right not to participate—that is, the right to choose not to accept traditional practices of the group, such as practicing a certain religion. There is a view that the individual's right to exit from a group is essential if groups are to claim rights. A formal right of exit, however, may be insufficient to protect some oppressed group members, such as in the case of women traumatized by domestic violence. Rights of voice, as the name implies, involve the ability to participate in decision-making and to express one's preferences in, for example, political decision-making. The relationship between the two is complex: Arguably individuals should not need to exit if they have a right to exercise their voice within the group so that things can be changed from within.

The debate about rights of voice and rights of exit demonstrates the close association of rights talk with liberalism. Historically rights emerged in the context of liberalism, being concerned with essential freedoms and limiting government power, but there is an issue concerning the extent to which they should be limited to freedoms *to* do certain things, such as freedom of speech and movement, or whether they also embrace freedoms *from* such conditions as poverty. The distinction between negative and positive rights, describable as a distinction between freedom rights (liberal, freedom *to* rights) and rights of recipience or welfare rights, reflects underlying differences in political philosophy and justification.

Natural Rights

In moral and political argument, rights are used sometimes as starting points, sometimes as conclusions. A prominent example of the use of rights as starting points is to be found in Robert Nozick's *Anarchy, State and Utopia* (1974), the first sentence of which states: "Individuals have rights, and there are things no person or group may do to them (without violating their rights)." Nozick sees himself as operating in the tradition of the seventeenth-century philosopher John Locke (1632–1704), arguing that human beings have certain "natural" rights.

The notion depends on state of nature theory and natural law. The idea of a state of nature is a hypothetical state external to society, in which human individuals are unaffected by social conditioning, and which operates as a device for critical reflection on existing societies. The laws of different societies assign to their citizens or subjects different rights and duties. But beyond this, it is argued, there are natural laws and natural rights, which provide a point from which to criticize the laws in any particular society (such as laws that allow for institutions such as slavery). Locke argued that in a state of nature there would be a natural law that "no-one should harm another in his life, liberty or property" (*Two Treatises of Government*, ed. Peter Laslett, 2nd edition, Cambridge University Press, 1967).

The idea of natural rights has been heavily criticized, most notably by Jeremy Bentham (1748–1832) who described it as "nonsense upon stilts." Bentham argued: "From real laws come real rights; from imaginary laws come imaginary rights." ("Anarchical Fallacies" in *The Works of Jeremy Bentham*, Vol. II, ed. J. Bowring; Edinburgh: William Tait 1843). The doctrine of natural law confuses the questions of what the law is and what the law ought to be. While one can criticize the law from a moral point of view, in order to do this one needs a perspective such as that of utilitarianism, not the notion of natural law.

The idea of the state of nature has also been criticized as ahistorical by Marxist and feminist critics. The objection is that there is no universal human nature, no pre-social state of nature. What people are like, as well as their values and expectations, are the products of the society in which they live. There is a strand in natural law thinking that natural rights should be *evident* to everyone. But even those philosophers who employ the notion of a state of nature differ over how it is to be understood, and there is further disagreement over what rights there are. Property, for example, is high on the list of Locke and Nozick, but it is by no means evident to all that it is a *natural* right. From an opposing point of view the so-called "natural" right to property is a historically conditioned expression of the interest of those who have it. Rights are seen as institutionalizing certain interests at the expense of others. The debate about property rights has been particularly pertinent in science and technology, in the context of intellectual property and patenting, for example in relation to the human genome. The distinction between what is discovered and what is invented relies on a notion of what exists by nature, but controversy continues over what can legitimately be patented.

Human Rights

Nevertheless the idea that there are universal and timeless rights grounded in enduring features of human nature has persisted. The United Nations Declaration of Human Rights (1948) and the European Convention on Human Rights (1950) are expressions of this idea, although dispute has raged over how many of the rights contained in these documents are real rather than manifesto rights.

Despite traditional criticisms of natural rights, Tom Campbell (1983) has argued that socialists need not object to the notion of human rights as protectors of fundamental human interests, if this notion is divorced from the ahistorical concept of a state of nature and from the traditional view about what rights human beings have. On this view, the problem with the tradition of liberal western democracy in which the notion of natural rights flourished has been the concentration of thinkers in that tradition on "freedom" rights at the expense of "welfare" rights. To focus on freedom rights can seem callous when people's basic food needs are not being met.

The objection to this from those who favor freedom rights is that welfare rights cost money, and therefore are not always feasible. In order to count as a genuine human right, any given right must be "practicable, universal, and paramount." Consider again the example of the right to reproduce. If this is understood as the right to be free from interference, then it might appear to cost nothing. If it is interpreted as a right to in vitro fertilization (IVF), however, the costs could spiral out of control. Nevertheless, the so-called freedom rights also cost money and it might be better to think in terms of basic rights rather than accepting the negative-positive distinction (see Shue 1980). The right to freedom from interference in one's private life, for example, might require the provision of some machinery of justice, including a police force.

Thus the idea of natural rights as starting points runs into difficulties, while the notion of human rights has become a site of political struggle between competing political ideologies. So on what basis can an argument for rights be put forward? It is possible to put forward arguments on utilitarian grounds, giving reasons why people should be free to do certain things or why they should receive particular goods and services: in other words, that they should have rights to do x and y or to receive p and q because to do so leads to good consequence. In this sense the term *right* is quite vulnerable to being trumped by other considerations, as this way of reasoning does not regard rights as attaching to individuals in quite the same way as in the natural rights tradition: as integral to what is understood by a human being.

Rights as Conclusions

Ronald Dworkin (1977) has argued that rights themselves should be regarded as trumps over some background justification for political decisions that state a goal (such as one based on utilitarian reasoning) for the community as a whole. An example would be that if someone has a right to publish pornography, this means that it is for some reason wrong for officials to act in violation of that right, even if they (correctly) believe that the community as a whole would be better off if they did.

Dworkin argues for a "rights-based morality" in contrast to one based on either duties or goals. His arguments started with the claim that government must treat those whom it governs with equal concern and respect. He identified his aim as that of examining how far a theory of rights can be constructed from the abstract idea that government must treat people as equals. It was Dworkin's contention that utilitarianism does not do this. Despite its claim that "each counts for one and no one for more than one," he argued that utilitarianism is corrupted by external preferences, where external preferences are preferences we have regarding other people. An example might be that people who are homophobic do not only have a preference regarding their own sexuality but also have an external preference that others should not be free to embrace homosexuality. If the majority shared these external preferences the minority could experience discrimination and hardship. In the context of science and technology, some people object so strongly to possibilities such as human reproductive cloning that they not only wish not to engage in it themselves, but want it to be universally prohibited, although others argue that it could be contemplated as an application of the individual's right to reproduce.

Therefore in a society where the background justification is utilitarian, rights are needed to act as trumps over the outcome of utilitarian calculations. It is important to note that Dworkin does not want to exclude all external preferences (for example, charitable ones), but only those that fail to treat human beings with equal concern and respect. Thus he argues for basing political morality around a fundamental right to equal concern and respect.

Objections to Rights-Based Morality

Rights-based morality nevertheless overlooks crucial features of the moral landscape (see, for example, O'Neill 2000). Rights are adversarial, and may be useful when opposing oppressive governments—perhaps particularly in drawing attention to the plight of particular groups—but apart from such situations it may be more appropriate to look to another framework, such as that of duties. This way of looking at things, drawing more on the thought of Immanuel Kant (1724–1804), directs attention to what people ought to *do* rather than what they ought to get. Duties "formulate the requirements to which Declarations of Rights merely gesture," but rights have acquired popularity, argues O'Neill, because they appear to offer something to everyone (O'Neill 2000) without focusing on the associated and varied costs. While rights-talk is pervasive, it is important always to be alert to the question of justification of any particular rights claim.

As should be clear from the present discussion, although rights are easily asserted with regard to many aspects of science and technology, the full legitimization of such assertions is much more difficult. It may be that individuals have rights to intellectual property in particular forms of scientific inquiry, and that consumers have rights to be protected from invasions of privacy by means of surveillance technologies. It may be that individuals have a right to exit certain aspects of scientific and technological development, and that different publics have the right to a voice in the governance of science. However, for what are often no more than manifesto rights to become fully warranted claims will in many instances require further reflective consideration than has to date been achieved.

RUTH CHADWICK

SEE ALSO *Human Rights; Right to Die; Right to Life; Rights and Reproduction.*

BIBLIOGRAPHY

Campbell, Tom. (1983). *The Left and Rights: A Conceptual Analysis of the Idea of Socialist Rights*. London: Routledge & Kegan Paul. An examination of the extent to which socialist rights, as opposed to liberal rights, can be upheld.

Dworkin, Ronald. (1977). *Taking Rights Seriously*. London: Duckworth. Argues for the priority of the right to equal concern and respect.

Feinberg. Joel. (1973). *Social Philosophy*. Englewood Cliffs, NJ: Prentice-Hall. Contains a very useful introduction to the concept of rights.

Hirschman, Albert O. (1970). *Exit, Voice and Loyalty: Response to Decline in Firms, Organizations, and States*. Cambridge, MA: Harvard University Press. Argues for the distinction between rights of voice and rights of exit.

Hohfeld, Wesley N. (1919). *Fundamental Legal Conceptions as Applied in Judicial Reasoning*. New Haven, CT: Yale University Press. A classic categorization of rights.

Nozick, Robert. (1974). *Anarchy, State, and Utopia*. Oxford: Blackwell. Takes rights as starting points.

O'Neill, Onora. (2000). *Bounds of Justice*. Cambridge, UK: Cambridge University Press. Argues for treating principles of obligation as more basic than rights.

Shue, Henry. (1980). *Basic Rights: Subsistence, Affluence, and U.S. Foreign Policy*. Princeton, NJ: Princeton University Press. Argues for "basic" rights rather than prioritizing "freedom" or "welfare" rights.

Waldron, Jeremy, ed. (1984). *Theories of Rights*. Oxford: Oxford University Press. A collection of essays on topics such as natural rights. Includes an essay by Ronald Dworkin on rights as trumps.

Waldron, Jeremy. (1993). "Rights." In *A Companion to Contemporary Political Philosophy*, ed. Robert E. Goodin and Philip Pettit. Oxford: Blackwell. An overview.

RIGHT TO DIE

For literally hundreds of thousands of years, human beings recognized death as inevitable feature of the human condition—to be avoided when possible, but ultimately accepted as necessity. Indeed, one of the distinctive features of moral reflection involved considerations of how properly to approach death. The idea that one had a right to die rather than a necessity to accept death with grace would have been inconceivable. In the last half of the twentieth century, however, advances in scientific medicine and technology fundamentally altered the traditional framework of reflection on death. As it becomes increasingly possible to prolong death and to extend the life span, it becomes necessary not simply to accept death but to consider a possible right and in some cases even responsibility to die.

The claim that the individual has a right to die presupposes not only advances in science and technology however but also individualism: It requires a view about the individual having control over his or her own life. This is by no means a claim that has won universal support. In some societies the individual life has been regarded as belonging to the king or ruler who could command its sacrifice; another view is that it is for a divine being either to bestow or to take away life.

Even within an individualistic framework, however, the basis and limits of a right to die are not always clear. First, as rights are commonly supposed to impose duties on others, a right to die may require others at least to refrain from interfering, and possibly also to provide assistance, so speaking of a right to die may have a number of meanings, such as death through assisted suicide; rejection of treatment, food, and hydration; and euthanasia. Common to all these may be an argument that the individuals should be free, where possible, to choose the timing and manner of their death. They differ in their implications for other people involved (that is, what exactly other people have to do or refrain from doing in order to allow the individual to exercise their right).

Arguments for a Right to Die

To be free to choose to die, when life has ceased to hold any attraction or meaning, might be supported on the basis of a respect for autonomy. The simplest case appears to be that of the individual who both wants, and has the means, to commit suicide. The implications for third parties in this case are simply to refrain from interference. The German philosopher Immanuel Kant (1724–1804), however, argued that the rational agent could not consistently will to end one's own life, for this would mean that the same will that naturally wanted to extend life at the same time wanted to end it, and this involved a contradiction. He also argued that to commit suicide involved failing to treat rationality in one's own person as an end. There are clearly difficulties with this Kantian argument, because it fails to recognize any circumstances in which ending one's own life would be a rational course of action. It is significant, however, that mental health legislation has commonly regarded suicidal impulses as evidence of lack of rationality.

If autonomy is interpreted in the manner of the English philosopher John Stuart Mill (1806–1873), then there are strong grounds supportive of a right to die. Mill argued that when people interfere on paternalistic grounds to prevent persons from harming themselves, it is likely they will interfere wrongly, because individuals are in general the best judges of what is in their own interests. This suggests that an individual may very well be in a good position to know when life no longer has any meaning or value for the individual whose life it is. The onlooker may try to engage in rational argument, but should not forcibly interfere.

The issues become more complicated when the duties that the right implies for others involve positive assistance, such as in assisted suicide, which is distinguished from voluntary euthanasia on the grounds that the patient remains the agent. Apart from the legal requirements that may apply in different jurisdictions, there are questions about what obligations, if any, there are to assist. This is particularly problematic where individuals who wish to die do not have the means or ability to take their own life—for example, when they are incapacitated to the extent that they cannot help themselves. The assistance required may be providing the means, such as administering a drug, or withdrawing of food and fluids. There are issues here, also, about *who* is being asked to provide assistance—whether it is a friend, or family member, or a health professional. There are special questions about professional roles and the extent to which the obligations of professionals differ from those of others. Withdrawal of food and fluids may be regarded not as treatment, which an individual is entitled to refuse, but as a basic human right that is inalienable, or as basic care that should never be withdrawn.

Several key cases have addressed the issues of the right to die in the absence of the capacity for autonomous decision-making. The 1976 Karen Quinlan case (In re Quinlan, 70 NJ 10, 355 A.2d 647 [1976]) in the United States decided that Quinlan's right to privacy supported her right to be removed from a ventilator. In the United Kingdom, the 1993 Tony Bland case (Airedale NHS Trust *v.* Bland [1998] HL) concerned a patient who had been in a persistent vegetative state for more than three years when the hospital sought a declaration that it could lawfully withdraw all forms of life support. The case went up to the House of Lords, who argued not that it was in Bland's best interests to die but that it was not in his best interests to prolong his life in those circumstances, and that it was lawful to withdraw feeding.

In 2005 the case of Terri Schiavo, a Florida woman in a persistent vegetative state for more than a decade, became a cause célèbre because of basic disagreements between her husband and her parents over whether a feeding tube should be removed. For the husband, consistently supported by the courts, this would allow her to die in accord with previously expressed desires not to become dependent on extraordinary technological means. For the parents and many religious supporters, this was tantamount to murder.

The sense that individualism, and individual choice, need to be mediated by a sense of natural limits, also has the potential to facilitate acceptance of a responsibility to die, especially at a time of ever increasing possibilities for intervention.

RUTH CHADWICK

SEE ALSO *Death and Dying; Euthanasia; Euthanasia in the Netherlands; Persistent Vegetative State.*

BIBLIOGRAPHY

Brock, Dan W. (1993). *Life and Death: Philosophical Essays in Biomedical Ethics*. Cambridge: University Press. Includes essays on life and death decisions in the clinic, and on the value of prolonging life.

Callahan, Daniel. (1987). *Setting Limits: Medical Goals in an Aging Society*. New York: Simon and Schuster. An argument against prolonging life at all costs.

Regan, Tom, ed. (1980). *Matters of Life and Death: New Introductory Essays in Moral Philosophy*. New York: Random House. Includes discussions of suicide.

Singer, Peter. (1996). *Rethinking Life and Death: The Collapse of Our Traditional Ethics*. New York: St. Martin's Griffin. Includes a discussion of the Bland case.

RIGHT TO LIFE

What was once considered fate or a gift, that is, human life, is increasingly thought of as subject to manipulation or control by means of scientific research and biomedical technology. The ability to regulate fertility and pregnancy on the basis of knowledge and desire, along with psychological studies of child development and the potentials of genetic engineering—not to mention the potential of nuclear weapons and other runaway technologies to destroy all life on the Earth—have conspired to promote consideration of possible rights to existence of those forms of life that have become increasingly subject to the unintended impacts or conscious manipulation of others.

The Right to Life: The Narrow Sense

When the right to life is spoken of, it is normally human life that is meant, although there are arguments for extending the scope of the right to other life forms. To restrict the right to the human species may attract the charge of speciesism. For present purposes, however, the discussion will be confined to humans.

The force of the right to life, insofar as it imposes obligations on others, is normally to stress the wrongness of killing, rather than a positive right to be brought into existence. This is because it is difficult if not impossible to identify someone who would be wronged by not being brought into existence. There is also controversy over whether someone can be wronged *through* being brought into existence, as in the debate about "wrongful life." It does not follow, however, that the right to life has no implications for positive aid. There are differences of opinion about the extent to which a right to life could impose obligations to *save* another's life.

One of the most difficult problems facing a right to life, however, concerns the definition of human life—especially with regard to its beginning and ending. There is disagreement both about when life begins and about when it ends. Some would say that the question of when life begins is not the right question, because life is ongoing. The germ cells are alive and life continues from generation to generation. What is normally meant, however, is the life of an identifiable individual—but even this is not clear-cut, with some putting more emphasis on the concept of the person than on that of human being. There is a similar issue at the end of life—whether what is important is the death of the organism or the end of everything one recognizes as personhood.

Arguments for a Right to Life

Not all arguments for the view that killing a human being is wrong use the terminology of rights. It might depend upon a view about the sanctity of human life. The doctrine of the sanctity of human life might be religiously informed: Life is a gift from God and therefore sacred. It is a way of expressing the view that life has intrinsic value—it is valuable in itself, from beginning to end, and it is wrong to destroy it.

Those who support the sanctity of life doctrine typically also take a conservative view about the beginning and ending of life, the presumption being that there is something of intrinsic value from the moment of conception, and that while there is life there is a being worthy of respect at the end of life. On the sanctity of human life view there can be no trade-offs. In other words, it would not be permissible to kill one innocent person in order to raise the quality of life of others, or even because of the opinion that a person's quality of life is no longer worth living. Critics point out that this has implications for social policy. How can there be justification for taking money away from life-saving enterprises and giving it to those that can at best only improve quality of life for some people? Upholders of the sanctity of life doctrine here fall back on a distinction between negative and positive, holding that the doctrine imposes the obligation not to kill, but not necessarily to save at all costs.

Ronald Dworkin has stressed the importance of distinguishing the sanctity of life view from the view that the individual is a person with rights and interests. According to the doctrine of the sanctity of life, life has intrinsic value even if it is not in a person's own interests to continue living, and even if the focus of discussion is not a person with interests of its own. Thus the sanctity of life doctrine provides an objection to abortion even if is not presumed that the fetus is a person.

Arguments that do depend on rights, however, have to face the problem that different rights of different individuals may conflict, and it is not always clear how they are to be balanced against each other. Utilitarianism offers a way in which to balance the interests of different persons. It is sometimes criticized for being willing to sacrifice one life to save more, because the individual life is not regarded as sacred. Although killing is directly wrong, it is not *absolutely* wrong on this view. For a utilitarian, killing is wrong because of its consequences, both for the person concerned and for third parties. It is wrong to the extent that it prevents happiness, destroys a "worthwhile life," or creates misery. The person killed loses the chance of any future happiness. Third parties may suffer side effects such as distress at the loss of the person and fear for their own fate if the protection against killing is weakened.

A potential killer may nevertheless judge that the person in question does not have a life worth living. While side effects provide some protection against someone carrying out this sort of calculation, there is still a problem in hypothetical situations where adverse side effects can be ruled out. A further argument is that if someone wants to go on living, that is evidence that they have a life that is worthwhile.

If what is valued is the *amount* of happiness or worthwhile life, rather than the intrinsic value of the individual life, then in some circumstances this can be maximized by killing one person to save five. In many cases, again, this objection can be met by pointing to the undesirable side effects of a policy that is willing to sacrifice individuals. At the same time, because utilitarians see consequences as more important than the means of arriving at those consequences, they are less impressed by the distinction between killing and failing to save. Failing to help a person when help is available can be just as bad.

Hard Cases

For some, the right to life is inalienable—it cannot be given up. Others take the view that it can be forfeited; for example, by murderers, so that capital punishment becomes a justifiable form of killing. The greatest controversy, however, occurs over the issues of euthanasia, embryo experimentation, and abortion. In the latter two cases the disagreement is not so much over the right to life *per se* as over the status of the embryo and fetus. What some regard as the possessor of rights, others regard as a collection of cells and the issue has to be resolved by social decision-making, such as laws permitting embryo experimentation for a certain limited time.

Broader Views

A wider interpretation of the right to life could embrace notions of the right to survival of the human species overall. Concerns about environmental degradation and human conflict have led to calls for a balance between the quality of the environment and the sanctity of the dollar, rather than a focus on quality of life and sanctity of life in medical interventions. Such a global bioethics stresses the importance of acceptable survival for the human species. Others go beyond the survival of the human species, expanding the circle of morality to include other species, and respect for all life.

RUTH CHADWICK

SEE ALSO *Abortion.*

BIBLIOGRAPHY

Dworkin, Ronald. (1993). *Life's Dominion: An Argument about Abortion, Euthanasia, and Individual Freedom.* New York: Knopf. Argues that liberals and conservatives have misunderstood each other's positions. Attempts to clarify what it means to say that life is intrinsically valuable.

Glover, Jonathan. (1977). *Causing Death and Saving Lives.* Harmondsworth: Penguin. A classic study of the arguments relating to killing and letting die, including the sanctity of life, autonomy and rights.

Harris, John. (1985). *The Value of Life.* London: Routledge and Kegan Paul. Presents an argument about what it means to value life, with reference to a number of specific areas.

Potter, Van Rensselaer (1988). *Global Bioethics.* East Lansing: Michigan State University Press. Offers an account of bioethics that includes biology and humanistic knowledge to promote acceptable survival.

Singer, Peter (1981). *The Expanding Circle: Ethics and Sociobiology.* Oxford: Clarendon Press. A discussion of expansion of ethical concern.

RIGHT TO REPRODUCE

SEE *Rights and Reproduction.*

RISK AND EMOTION

Technologies, particularly if they are new, often give rise to emotional reactions that are based on perceived risks. Recent examples of such technological risks involve cloning and genetically modified food; the use of nuclear energy continues to spark heated and emotional debates. Empirical research has shown that people rely on emotions in making judgments about what constitutes an acceptable risk (Slovic 1999). However, this does not answer the question of whether judgments that are based on emotions can provide a better understanding of the moral acceptability of risks than do judgments that do not take the emotions into consideration. Many scientists dismiss the emotions of the public as a sign of irrationality. Should engineers, scientists, and policy makers involved in developing risk regulation take the emotions of the public seriously?

Emotions and Moral Judgments

There are two major traditions in modern moral theory that deal with the role of emotions, going back to the Enlightenment thinkers David Hume (1711–1776) and

Immanuel Kant (1724–1804). For the Scottish philosopher Hume ethics is based not on reason but on the emotions, particularly the sentiment of benevolence, which reason assists in achieving its goals. In opposition to that view the German philosopher Kant maintained that ethics depends on the rational determination of human conduct, with the emotions tending to function as distractions. In neither case, however, are the emotions understood to function in a cognitive manner to reveal something about the world. They are either the noncognitive source of moral value or a noncognitive distraction from moral rationality.

A quite different minority tradition in moral theory, however, grants the emotions cognitive value. This line of thought goes back to Aristotle (1925) who argued that through emotions we perceive morally salient features of concrete situations. In Hume's time the economist Adam Smith (1723–1790) suggested in *Theory of the Moral Sentiments* (1759) that emotional sympathies for others through imaginative identification with their pleasures and pains can provide knowledge about how other people experience the world. For Max Scheler the emotions are the motivators of decent behavior; they reveal the basic moral facts of life (Scheler 1913–1916).

In the 1970s such theories of the cognitive power of the emotions were given new support by developments in neurobiology, psychology, and the philosophy of the emotions. For scholars as diverse as Ronald De Sousa (1987), Robert Solomon (1993), Antonio Damasio (1994), and Martha Nussbaum (2001) emotions and cognitions are not mutually exclusive. Rather, to have moral knowledge, it is necessary to experience certain emotional states.

To be able to have moral knowledge, a person has to know or be able to imagine how it feels to be in a certain situation and to be treated by others in certain ways as well as how it feels when one is humiliated and hurt or cherished and embraced. These emotions are fundamental features of human life that point to what morality is really about. It is not possible to understand moral life without knowing these emotions and without having the ability to feel sympathy and compassion for others. Hence, only beings with the ability to have emotions can make justified moral judgments. The moral point of view implies that people can feel with others or at least imagine what their emotions might be like and that people care about morally important aspects of the lives of others (Schopenhauer 1969, Scheler 1970).

Emotions and Judging the Acceptability of Risks

A cognitive theory of emotions provides new insights about emotions toward acceptable risks. With the traditional picture one would have to choose between the horns of the Hume-Kant dilemma: either take emotions seriously but forfeit claims to rationality or emphasize rationality at the expense of the emotions. With a cognitive theory of emotions, however, one can argue for taking emotions seriously in order to achieve a more comprehensive rationality, particularly with respect to the moral acceptability of technological risks.

As an example, if people are forced against their will to do something they consider dangerous, this is most likely to result in emotions of anger or frustration. However, that is a completely reasonable response. A prima facie injustice has been done to them, and only if they can be persuaded that there are good reasons why they should undergo this specific risk will their anger subside. In contrast, if no good explanation can be given, they will remain upset. In fact, one might find a person irrational who would not get upset by such an injustice. One would judge a person confused who said, "I know company X is not respecting my rights by building this chemical plant in my neighborhood without informing me or asking my consent, and I think it is not fair, but I don't care." A moral judgment that does not lead to an appropriate emotion is seriously flawed.

Some cognitive theories of emotions would take this analysis even further and claim that without certain feelings or emotions a person is unable to have appropriate moral judgments (e.g., De Sousa 1987, Solomon 1993, Damasio 1994, Nussbaum 2001). When people fail to become outraged in response to abridgments of their autonomy, they may not fully grasp the injustice being done to them.

Moreover, people find it morally reasonable not only for the victim of an injustice to be outraged but also for witnesses to be affected in the same way. People even expect that those who inflict an injustice on others should be forced to reassess their actions if they truly care about those they harm. When such agents are unmoved by feelings of sympathy, they are thought of as hard-hearted and egoistical. Emotions thus help assess not only one's own situation but that of others as well as one's own actions in relation to others. In such ways emotions may lead to fairer social arrangements concerning technological risks.

Evaluation of Emotions Concerning Risks

The idea that emotions are useful pathways to moral knowledge concerning risks does not entail the idea that emotions are infallible as normative guides. Emotions also can be wrongheaded or misguided. Emotions can help people focus on certain salient aspects, but they also can lead people astray. Engineers may be enthusiastic about their products and overlook certain risks. The public may be ill informed and thus focus only on risks and overlook certain benefits. Both parties may be biased, and their emotions may reinforce those biases.

In such situations followers of Hume might claim that emotions should rule. Followers of Kant, by contrast, might argue that emotions should be set aside in favor of purely rational analysis. Those who adopt a cognitive theory of the emotions would defend the emotions as a potential source of new knowledge. Not only can reason be brought to bear in a critical manner on the emotions, the emotions may be used as a basis for critical assessments of reason. Indeed, the emotions themselves may be played off against each other in pursuit of mutual emotional assessment. One example would be the development of affective appreciation through sympathy with opposing perspectives. Engineers might try to make an emotional identification with the perspectives of the public, and vice versa, and those who benefit from technology might try to appreciate the perspectives of those who incur its costs. Without emotions being brought into the mix, well-founded judgments about the moral acceptability of technological risks are unlikely.

SABINE ROESER

SEE ALSO *Emotion; Emotional Intelligence; Hume, David; Kant, Immanuel; Risk; Risk Assessment; Risk Perspection; Risk Society.*

BIBLIOGRAPHY

Aristotle. (1925). *Nichomachean Ethics*, trans. W. D. Ross. London: Oxford University Press. A classic source of emotional cognitivism in ethics.

Damasio, Antonio. (1994). *Descartes' Error: Emotion, Reason, and the Human Brain*. New York: Putnam. Readable classic in recent neuropsychology, arguing that without emotions, people cannot be practically rational.

De Sousa, Ronald. (1987). *The Rationality of Emotion*. Cambridge, MA: MIT Press.

Nussbaum, Martha. (2001). *Upheavals of Thought*. Cambridge, UK: Cambridge University Press. A strong defense of cognitivism in the philosophy of emotions.

Scheler, Max. (1913–1916). *Der Formalismus in der Ethik und die Materiale Wertethik. Formalism in Ethics and Non-Formal Ethics of Values: A New Attempt toward a Foundation of an Ethical Personalism* (1973), trans. Manfred S. Frings and Roger L. Funk. Evanston, IL: Northwestern University Press.

Scheler, Max. (1970). *The Nature of Sympathy*, trans. Peter Heath. New York: Archon Books. A philosopher from the continental phenomenological tradition argues that people acquire moral knowledge through sympathy.

Schopenhauer, Arthur. (1969). *The World as Will and Representation*, trans. E. F. J. Pane. New York: Dover. Originally published as Die Welt Als Wille und Vorstellung (1819). Defends the importance of sympathy in ethics.

Slovic, Paul. (1999). "Trust, Emotion, Sex, Politics, and Science: Surveying the Risk-Assessment Battlefield." *Risk Analysis* 19: 689–701. Psychologist who studies the role of the emotions in assessing risk.

Smith, Adam. (1976). *Theory of Moral Sentiments*. Oxford: Oxford University Press. Defends the importance of moral emotions.

Solomon, Robert. (1993). *The Passions: Emotions and the Meaning of Life*. Indianapolis: Hacket. Solomon started a renewed interest in emotional congitivism in philosophy in the 1970s.

RISK AND SAFETY: OVERVIEW

Risk and safety are polyvalent concepts with numerous and overlapping ethical complexities in relation to science and technology. As such they are dealt with in a number of different entries.

In technical terms, scientific phenomena may exhibit certainty, risk, or uncertainty. Situations of *certainty* have a probability of 1. For example, all things being equal, it is certain (probability = 1) that water freezes when cooled below 0° Celsius. Cases of *risk* have some numerical probability between 0 and 1, based on a known or assumed model of what causes the outcome under study. For instance, the risk of tossing "heads" on a fair coin has a probability of 0.5, because the model is known. In risk assessment, the risk of something is typically defined as the average annual estimated probability of causing a fatality. Cases of *uncertainty* cannot be defined *a priori* in terms of probabilities, because of inadequate knowledge. To assign legitimate or scientifically valid probabilities, one needs experimental or frequency/statistical data; an example is data on automobile accidents for drivers of a given age. In many cases of uncertainty there may simply be no adequate data.

Despite the name, "risk assessors" typically do not assess cases of risk (with known or well-established probability between 0 and 1), but situations of great uncertainty.When people have "risk" knowledge, they do not need risk assessment. In part because they address uncertainty in extremely complex situations, risk assessments usually err between four to six orders of magnitude

(Shrader-Frechette 1991). That is, fatalities predicted by risk assessments typically are (later proved to be) wrong by factors of 10,000 to 1,000,000. Most predictions are too low and exhibit an "overconfidence bias" in favor of some technology (Kahneman and Tversky 2000; Kahneman, Slovic, and Tversky 1982).

It is against this technical background that the following entries on risk need to be read: "Risk Assessment," "Risk Ethics," and "Risk Perception." Other entries—such as "Risk and Emotion" and "Risk Society"—make an effort to move beyond the more strictly technical understanding of risk.

There is no technical concept of safety analogous to that of risk. Nevertheless, according to an influential analysis by William W. Lowrance, safety can be defined in terms of risk: "A thing is safe if its risks are judged to be acceptable" (1976, p. 8). Mike W. Martin and Roland Schinzinger pointed out as early as 1983 that this definition needs a qualifier: The judgment of acceptability needs to be done with adequate knowledge. Free consent is not enough; it must be free and informed.

Langdon Winner, however, has gone further and warned against defining safety in terms of risk. According to Winner, traditional efforts to promote safety had a clear goal of eliminating certain "workplace dangers" or "health hazards." But when the promotion of safety involves assessing risks in terms of their acceptability, the goal fades into "studying, weighing, comparing, and judging circumstances about which no simple consensus is available" (1986, p. 143). It is against this critical background that the articles on "Safety Engineering: Historical Emergence," "Safety Engineering: Practices," and "Safety Factors" need to be considered.

There are also a number of articles that are related to the concepts of risk and safety. Among these it is useful to mention "Exposure Limits" and "Hazards." Even more specific topics include "Radiation" and "Regulatory Toxicology."

CARL MITCHAM

BIBLIOGRAPHY

Kahneman, Daniel, and Amos Tversky, eds. (2000). *Choices, Values, and Frames*. New York: Russell Sage Foundation; Cambridge, UK: Cambridge University Press.

Kahneman, Daniel; Paul Slovic; and Amos Tversky, eds. (1982). *Judgment under Uncertainty: Heuristics and Biases*. Cambridge, UK: Cambridge University Press.

Lowrance, William W. (1976). *Of Acceptable Risk: Science and the Determination of Safety*. Los Altos, CA: William Kaufmann.

Martin, Mike W., and Roland Schinzinger. (1983). *Ethics in Engineering*. New York: McGraw-Hill. 4th edition, 2005.

National Research Council. Committee on Risk Characterization. (1996). *Understanding Risk: Informing Decisions in a Democratic Society*. Washington, DC: National Academy Press.

Resnik, Michael D. (1987). *Choices: An Introduction to Decision Theory*. Minneapolis: University of Minnesota Press. A good introduction to distinctions between certainty, risk, and uncertainty.

Shrader-Frechette, Kristin S. (1991). *Risk and Rationality: Philosophical Foundations for Populist Reforms*. Berkeley: University of California Press.

Winner, Langdon. (1986). *The Whale and the Reactor: A Search for Limits in an Age of High Technology*. Chicago: University of Chicago Press.

RISK ASSESSMENT

Many decisions involve an intuitive assessment of risk; this subjective risk assessment is usually called *risk perception*. Risk assessment is also a formalized approach to evaluating risk, often defined as a function of the probability and magnitude of loss or harm from an event. Risk assessment is often thought of as ethically obligatory, but since it can be done in more than one way, it is itself subject to ethical assessment.

Risks are routinely assessed formally for a wide variety of human endeavors, from drinking tap water to operating nuclear power plants; for natural hazards such as earthquakes, hurricanes, and floods; and for the human use of and exposure to chemicals and other substances such as arsenic or phthalates. Risks may also be defined and assessed in terms of specific harms or losses to people, for example a person's lifetime risk of dying of heart disease, or aquatic ecosystem risks from anthropogenic eutrophication (that is, being overburdened with nutrients as a result of human action). While failing to assess risk can lead to Faustian bargains with the future, risk assessments for public policy can be risky in themselves, as illustrated by the effects of transnational debates about risk assessments of genetically modified organisms, vaccines, and terrorism.

Methods

As described in *Risk Assessment in the Federal Government* (known as the "Red Book," 1983), risk assessment consists of four steps: hazard identification, dose-response assessment, exposure assessment, and risk characterization. More broadly, risk assessment entails identifying and characterizing an underlying hazard—including its sources, pathways, effects for given exposures, and mitigating factors, and estimating the associated contingent probabilities. In effect, formal risk assessment requirements are intended to insure that human and even ecological health is considered in decisions with other primary objectives.

For example, product risk assessment may be required by law, as in the case of new pharmaceuticals in the United States. In the United States, the Food and Drug Administration (FDA) assesses the adequacy of new drug risk assessments, including how they are conducted. The FDA also determines what constitutes permissible risk for a licensed product. As risk assessments are generally conducted in the service of specific risk management objectives, the two are mutually dependent (Committee on Risk Assessment of Hazardous Air Pollutants 1994). In some venues separation of risk assessment and risk management is considered critical to protect the science of risk assessment from contamination by management or political pressures. However, many formal risk assessment processes now include participation by multiple stakeholders to deliberate about risk management objectives and values, in addition to experts' technical analyses (Stern and Fineburg 1996).

Human health risk assessments are of necessity carried out at a population or group level—that is, for a statistical person rather than an identified individual. They are based on extrapolations from animal studies; on experimental tests of human product use, which usually involve relatively small samples; or on epidemiological studies, which rely on statistical controls. Recent developments in risk assessment have included the ability to tailor risk assessment results interactively for subpopulations, as is illustrated by online risk calculators that determine an individual's risk based on a few personal characteristics. But individual differences can make the population health risk assessments applied in policy decisions more or less applicable, for which reason minority populations may be poorly served by general risk assessments. An example in point is airbags in cars, which when designed to optimally protect average adults may harm or kill children.

Environmental risk assessment, as required for example in environmental impact statements, has focused largely on risks to human health and the economy, but increasingly addresses ecological endpoints. Because selection of assessment endpoints can determine the structure and outcome of decisions, it is inherently controversial. Assessing risks from ozone only in terms of economic loss from damage to automobile tires paints a very different picture of the size of the risks than if the assessment also takes into account acute respiratory or cardiovascular events triggered by exposure to ozone, or possible ecological effects of ozone, such as reduced growth rates and plant deformation.

Basic Issues

By focusing on probabilistic loss, risk assessment frames management choices in terms of threat reduction and loss avoidance. Common criticisms of risk assessments have included that they are based on an overly narrow conceptualization of benefits, or that the dimensions of harm included are insufficient or inappropriate. It is difficult to incorporate into a risk assessment even proxy measures for intangibles—such as quality of life—or other poorly defined or understood endpoints. In part to take into account uncertainties, risk assessments are sometimes designed to produce estimates of risk that err on the high side, for example by using upper bounds of estimated risks, rather than averages. Those risk assessment procedures that have been codified by government entities incorporate scientific procedures, including requirements for representative empirical data, statistical analyses, and quality control in the form of peer review. Some also include ethical requirements, such as human subjects review, or the participation of parties who may have a substantive interest in the value at risk.

Four issues are key to risk assessment as currently practiced. The first is what is valued, how and by whom it is valued, and the distributive implications thereof. The selection of assessment endpoints can have far-from-obvious implications, as the airbag example illustrates. Assessing values remains a methodological and ethical challenge (Fischhoff 1991, Slovic 1995).

The second is the treatment and interpretation of uncertainty—both uncertainty stemming from limits to what is known, and uncertainty stemming from inherent variability (see Morgan and Henrion 1990). Especially in the case of extremely rare and catastrophic events, the selection of a distribution function or simulation procedure with which to analyze uncertainties can influence the outcome of the assessment considerably. Similarly, choosing how to represent the results of the risk assessment and the uncertainty therein can influence how recipients interpret and use the assessment.

The third key issue is the substitutability implied or assumed by risk assessment, as it often requires comparative values. As has been illustrated in discussions of protected values and irreversible effects, in reality trade-offs are sometimes impossible or unethical.

Fourth is that technically competent risk assessment requires significant resources, is both analytically and data-intensive, and can be difficult to interpret. Risk assessments that are carried out for new drugs, for example, require expertise in toxicology and epidemiology and investments in large studies, which still may not be large enough to discover devastating rare or long-term adverse effects.

Risk assessments may produce risk characterizations that are not readily used to compare or prioritize risks. For example, ecological risk assessments may conclude simply that a specific species is at some risk of extinction, while a human health risk assessment may produce an estimated probability of a specific health endpoint within a given timeframe, for example a five percent probability of being diagnosed with breast cancer within five years. Comparing the two is difficult.

For this reason it is desirable that risk assessment outcomes be translatable to a common measure, such as an abstract measure of utility, or monetary value. Summary endpoints like the probability of human mortality or morbidity, or economic loss, can be presented in a common metric that facilitates at least some comparisons, such as disability adjusted life years, or monetary value. But choice of a common metric itself can be problematic, both because individuals may not agree on the equivalence of different forms of bodily injury or harm and because not all endpoints can be equally well represented by all measures. In addition, some measures, such as dollars, carry their own meaning, which may or may not facilitate the risk assessment depending on how that meaning is construed.

However, no single metric or endpoint necessarily constrains environmental, technological, or human health risk assessments. Although many risk assessors with economic training might prefer to use dollars as a summary endpoint, doing so is not a requirement of risk assessment, but a methodological choice with ethical implications. The identification and definition of possible endpoints to consider, the valuation of these, and the estimation of their contingent probabilities all entail some degree of judgment and choice.

ANN BOSTROM

SEE ALSO *Risk; Risk and Emotion; Risk-Cost-Benefit Analysis; Risk Ethics; Risk Perception; Risk Society.*

BIBLIOGRAPHY

Committee on the Institutional Means for the Assessment of Risks to Public Health, Commission on Life Sciences, National Research Council. (1983). *Risk Assessment in the Federal Government: Managing the Process*. Washington, DC: National Academy Press. Known as the "Red Book," this is probably the most cited publication on risk assessment.

Committee on Risk Assessment of Hazardous Air Pollutants, Board on Environmental Studies and Toxicology, Commission on Life Sciences, National Research Council. (1994). *Science and Judgment in Risk Assessment*. Washington DC: National Academy Press. An update on the "Red Book."

Fischhoff, B. (1991). "Value Elicitation: Is There Anything in There?" *American Psychologist* 46(8): 835–847. Summarizes the literature on value elicitation succinctly and with eloquence.

Morgan, M. Granger, and Max Henrion, with Mitchell Small. (1990). *Uncertainty: A Guide to Dealing with Uncertainty in Quantitative Risk and Policy Analysis*. Cambridge, UK: Cambridge University Press. A key publication on uncertainty.

Slovic, P. (1995). "The Construction of Preference." *American Psychologist* 50(5): 364–371. A must-read for anyone interested in values or preferences.

Stern, Paul C., and Harvey V. Fineberg, eds. (1996). *Understanding Risk: Informing Decisions in a Democratic Society*. Washington, DC: National Academy Press. Articulates the importance of deliberation as well as analysis in risk assessment.

UK Royal Society. (1992). *Risk Analysis, Perception, and Management: Report of a Royal Society Study Group*. London: The Royal Society. An important summary of EU perspectives on risk assessment and related issues.

RISK ETHICS

Risk ethics is an emerging branch of philosophy that investigates the moral aspects of risk and uncertainty. Although one originating motivation in the pursuit of science and technology was an effort to reduce risk and uncertainty present in the natural world, it has been increasingly appreciated that the scientific and technological world presents its own constructed risks. Recognizing that one form of risk (natural) is overcome only at the cost of another form of risk (involved with science or technology) has stimulated critical reflection on risk in ways that did not occur in the absence of technological risk.

A Brief Introduction to Risk Concepts

Risk has vernacular and technical meanings. In everyday language a risk is simply a danger. But in relation to science and technology, risk is often defined as the probability of some harm. The probability of a benefit is often called a chance. According to another common definition, risk is identified with the value obtained by multiplying the probability of some harm or injury by its magnitude. With any attempt to spell out the details of how this might be done, however, problems arise since it is not clear that there is a single measure for all harms or injuries. Attempts have been made to measure all health effects in terms of quality-adjusted life years (Nord 1999). Risk-benefit analysis goes one step further and measures all harms in monetary terms (Viscusi 1992). However, as several critics have pointed out, such unified approaches depend on controversial value assumptions and may be difficult to defend from an ethical point of view (Shrader-Frechette 1992).

Independent of methodological issues, however, are the assumptions of traditional moral philosophy, which has focused on situations in which the morally relevant properties of human actions are both well-determined and knowable. In contrast, moral problems in real life often involve risk and uncertainty. According to common moral intuitions it is unacceptable to drive a vehicle in such a way that the probability is 1 in 10 that one runs over a pedestrian, but acceptable if this probability is 1 in 1 billion. (Otherwise one could not drive at all.) It is far from clear how standard moral theories can account for the difference and explain where the line should be drawn.

Utilitarianism

In utilitarian ethics, all moral appraisals are reducible to assignments of utility, a (numerical) measure of moral value. Furthermore, the utility of human actions is assumed to depend exclusively on their consequences. According to utilitarianism one should always choose the alternative that has the highest utility, that is, the best consequences.

One utilitarian approach to risk is *actualism*, according to which the moral value of a risky situation is equal to the utility of the outcome that actually materializes. For example, suppose that an engineer decides not to reinforce a bridge in advance of it being subject to an exceptionally heavy load, although there is a 50 percent risk that the bridge will collapse under such use. If all goes well and the bridge carries the load, then according to the actualist standpoint what the engineer did was right. But examples such as this show that actualism cannot provide meaningful action guidance. Even if actualism is accepted as a method for retrospective moral assessment, another theory is needed to guide decision-making about the future.

One such theory is *expected utility maximization*, which has become the standard utilitarian approach to risk. According to this theory, the utility of the prospect that an outcome may occur is obtained by multiplying the utility of the outcome itself by its probability. Then, the action with the highest probability-weighted value should be chosen. According to this rule, an action with the probability 1 in 10 to kill a person is five times worse than an action with the probability 1 in 50 of the same outcome. This method for weighing potential outcomes is routinely used in risk analysis.

In intuitive arguments about risk, it is common to give the avoidance of very large disasters, such as a nuclear accident costing thousands of human lives, a higher priority than is warranted by probability-weighted utility calculations. For instance, people clearly worry more about the possibility of airplane crashes (low-probability but high-cost events) than automobile accident deaths (which are higher-probability but lower-cost events). Expected utility maximization disallows such cautious decision-making. Proponents of precautionary decision-making may see this as a disadvantage of utility maximization, whereas others may see it as a useful protection against costly over-cautiousness.

Just like other forms of utilitarianism, expected utility maximization is strictly impersonal. Persons have no role in the ethical calculus other than as bearers of utilities whose values are independent of those who carry them. Therefore, a disadvantage affecting one person can always be justified by a sufficiently large advantage to some other person. No moral distinction is made between the act of exposing oneself to a serious danger in order to gain some advantage and the act of exposing someone else to the same danger for the same purpose. This is a problematic feature of utilitarian theory in general that is often aggravated in problems involving risk.

Duty- and Rights-Based Theories

A moral theory that is based on duties (rather than on the consequences of actions) is called deontological or duty-based. A moral theory in which rights have the corresponding role is called rights-based.

Robert Nozick formulated the problem for rights-based theories in dealing with risks in this way: “Imposing how slight a probability of a harm that violates someone’s rights also violates his rights?” (Nozick 1974, p. 7). Similarly, one may ask the following question about deontological theories: “How large must the probability be that one's action will in fact violate a duty for that action to be prohibited?"

One possible answer to these questions is to prescribe that a (rights- or duty-based) prohibition to bring about a certain outcome implies a prohibition to cause an increase in the probability of that outcome (even if the increase is very small). But such a far-reaching extension of rights and duties is socially untenable. Human society would be impossible if people were not allowed to perform actions such as car driving that involve a small risk of developing into a violation of some prohibition.

It seems clear that rights and prohibitions may lose their force when probabilities are sufficiently small. The most obvious way to account for this is to assign to each duty or right a probability limit below which it is not valid. However, no credible way to derive such a limit has been proposed. It is also implausible to draw the line between acceptable and unacceptable probabilities of harm with no regard to the benefits involved. (In contrast, such weighing against benefits is easily accounted for in utilitarian theories.)

Contract Theories

According to contract theories, the moral principles that rule humans' dealings with each other derive from a contract between all members of society. The social contract prohibits certain actions, such as actions that lead to the death of another person. Under what conditions should it also prohibit actions with a low but nonzero probability of leading to the death of another person? The most obvious response to this question is to extend the criterion that contract theory offers for the determinate case, namely consent among all those involved, to cases involving risk and uncertainty. This can be done in two ways because consent, as conceived in contract theories, can be either actual or hypothetical.

According to the criterion of actual consent, all members of society would have a veto over actions that expose them to risks. This would make it virtually impossible, for example, to site industries that are socially necessary but give rise to emissions that may disturb those living nearby. With a rule of actual consent, a small number of nonconsenting persons would be able to create a society of stalemates, to the detriment of everyone else. Therefore, actual consent is not a realistic criterion in a complex society in which everyone performs actions with marginal effects on the lives of many others.

Contract theory has a long tradition of operating with the hypothetical consent that is presumed to be given by every hypothetical participant in an ideal decision situation such as described in John Rawls's "original position." Unfortunately, none of the ideal situations constructed by contract theorists seems to have made the moral appraisal of risk and uncertainty easier or less dependent on controversial values than the corresponding appraisals in the real world.

Widening the Issue

Many discussions of risk have been limited by an implicit assumption that excludes important ethical aspects. It is assumed that once we have moral appraisals of actions with determinate outcomes, we can more or less automatically derive moral appraisals of actions whose outcomes are "probabilistic mixtures" of such determinate outcomes. Suppose, for instance, that moral considerations have led us to attach well-determined values to two outcomes *X* and *Y*. Then we are supposed to have the means needed to derive the values of mixed options such as 70 percent chance of *X* and 30 percent chance of *Y*. The crucial assumption is that the probabilities and values of nonprobabilistic alternatives completely determine the values of probabilistic alternatives.

In real life, however, there are always other factors in addition to probabilities and utilities that properly influence our moral appraisals of an uncertain or risky situation. We need to know not only the values and probabilities of potential outcomes, but also who exposes whom to risk and with what intentions, the extent to which the exposed person was informed, whether or not the person consented, and more.

Perhaps the most important foundational problem in risk ethics is the conflict between two principles that both have intuitive appeal. They can be called the collectivist and the individualist principles in risk ethics (Hansson 2004). According to the collectivist principle of risk ethics, exposure of a person to a risk is acceptable if and only if this exposure is outweighed by a greater benefit either for that person or others. According to the individualist principle, exposure of a person to a risk is acceptable if and only if this exposure is outweighed by a greater benefit for that person only.

The collectivist principle dominates traditional risk analysis, but if carried to extremes it will lead to neglect of individual rights. The individualist principle is equally problematic, because it allows minorities to prevent social progress. It is a major challenge for risk ethics to find a reasonable and principled compromise between these two extreme positions.

SVEN OVE HANSSON

SEE ALSO *Risk Assessment; Risk Perception.*

BIBLIOGRAPHY

Hansson, Sven Ove. (2003). "Ethical Criteria of Risk Acceptance." *Erkenntnis* 59(3): 291–309. Discusses how risks can be dealt with in different moral theories.

Hansson, Sven Ove. (2004). "Weighing Risks and Benefits." *Topoi* 23: 145–152. Discusses different ways to weigh risks against benefits.

Hansson, Sven Ove, and Martin Peterson. (2001). "Rights, Risks, and Residual Obligations." *Risk, Decision, and Policy* 6(3): 157–166. Discusses the obligations that follow from exposing the public to risk.

Nord, E. (1999). *Cost-Value Analysis in Health Care: Making Sense Out of QALYs.* Cambridge, UK: Cambridge University Press. One unified measure of human injuries.

Nozick, Robert. (1974). *Anarchy, State, and Utopia*. New York: Basic Books. Discusses rights-based approaches to risk.

Shrader-Frechette, Kristin. (1992). "Science, Democracy, and Public Policy." *Critical Review* 6(2–3): 255–264. A critical appraisal of cost-benefit analysis.

Thomson, Judith. (1985). "Imposing Risk." In *To Breathe Freely: Risk, Consent, and Air*, ed. Mary Gibson. Totowa, NJ: Rowman and Allanheld. Person-related aspects of risk exposure.

Viscusi, K. (1992). *Fatal Tradeoffs: Public and Private Responsibilities for Risk.* New York: Oxford University Press. The author is a leading proponent of risk-benefit analysis.

RISK PERCEPTION

Risk perception has been defined variously as perceived or subjective probability estimates of death, other judgments of probable harm or loss, psychological states such as fear or traumatic stress, beliefs about causal processes resulting in harm or loss—that is, mental models of hazardous processes, or attitudes toward the activity, event, product, or substance in question. Risk perception, in which risk is assessed subjectively, often without formal decomposition into probability and harm, is frequently treated as folk or lay *risk assessment*.

When elicited as subjective probability or frequency of mortality, risk perceptions can agree or disagree with actuarial information, where such exists, and can in some instances be validated or invalidated by science. Comparisons of lay and expert risk perceptions, together with research on the effects of risk communication, illustrate that expertise and information can have large effects on risk perceptions. Such comparisons have been used to make the ethical claim that non-experts are irrational when they fear risks that experts deem acceptable, such as risks from genetically modified organisms. Shrader-Frechette points out that those framing risk questions control the answers, and suggests that to deal with the great uncertainties surrounding, for example, ecological risks, the burden of proof should fall on those proposing that a risk is acceptable. Shrader-Frechette also proposes a three-category framework for risk, as an alternative applying the effect-no effect (or acceptable-unacceptable) dichotomized view of science to risks. In her view, serious risks for which the complexities and uncertainties are so great that we lack sufficient information to make a decision fall into a third category (e.g., Shrader-Frechette, 1994). However, as intuitive statisticians, both experts and non-experts are subject to predictable judgmental biases (Fischhoff, Bostrom, and Jacobs Quadrel 2002; Gilovich, Griffin, and Kahneman 2001; Kahneman, Slovic, and Tversky 1982). Personal experiences also affect risk perceptions, though if not repeated their effects may disappear over time. That communities enact policies to reduce their seismic risks following large earthquakes and resist or ignore them at other times testifies to this, as do differences between life scientists and other scientists in their risk perceptions.

Schools of Thought

Risk perception research since the 1970s has been characterized by several schools of thought, each of which is associated with particular disciplinary backgrounds and methodological predilections. Psychometric research and cultural theory are among the most widely acknowledged.

Psychometric research on risk perception proceeded by analogy with measurements of physical perceptions—such as light, weight, or heat—in attempting to establish reliable, validated psychological scales for perceived risk. By eliciting people's judgments on dimensions such as dread, familiarity, catastrophic potential, and control, researchers were able to predict, to some extent, risk acceptance judgments. This research produced a risk factor space, the two dimensions of which were how familiar, controllable, and understood risks are, and how much people dread them, including judgments of catastrophic potential. For example, the risks from nuclear power are typically perceived as highly unknown and dreaded, landing in the upper right quadrant of those two dimensions, where as the risks from bicycles are perceived as known and are not dreaded, putting them in the lower left quadrant. This vein of research is best characterized in works by Paul Slovic, Baruch Fischhoff, Sarah Lichtenstein, and colleagues (Slovic 2000).

Cultural theory stems from anthropologist Mary Douglas's writings on risk and culture. Among the best-known tests of cultural theory are those that employ grid/group theory, in which it has been shown that people's attitudes toward risks are a product of their degree of individualism, egalitarianism, and hierarchy or collectivism. Related research on worldviews posits that risk perceptions are a function of attitudes toward science and technology in particular, but also other attitudes.

Another approach is to treat risk perception as an instance of information processing. Information processing is cognitive, social, and affective (Damasio 1994). Cognitive processes such as categorization, similarity judgments, and inference from mental models are, from an information processing perspective, all components of risk perception. Recent research shows that there is a strong relationship between affect and perceived risk. There is a commonly observed inverse relationship between perceived risk and perceived benefit. Under time pressure, which limits analytic thought and increases reliance on affect, this inverse relationship strengthens (Finucane, Alhakami, Slovic, and Johnson 2000). Further, introducing information that changes one's affective evaluation of an item, for example information that associates nuclear power with clean air and pastoral scenes, can systematically change both the related risk and benefit judgments.

People seem prone to using an "affect heuristic" that improves judgmental efficiency by deriving both risk and benefit evaluations from a common source: affective reactions to the stimulus item. The mechanisms for these effects may be hardwired in our brains, in the amygdala, through which all thought passes. Animal studies suggest that the amygdala coordinates multiple fear systems, and that fear is a potent determinant of memory, learning, and salience.

Ethical Issues

People's behavior depends on their risk perceptions. Given this dependency, whose risk perceptions should prevail to determine societal priorities is often contested. Further, technical risk assessments generally apply to a statistical person or to a population, and so are not directly applicable to an individual or that individual's perceptions of his or her own risk. Therein lies the central ethical dilemma posed by risk perceptions, exacerbated by their variability and vulnerability to judgmental biases.

In addition, overarching ethical principles conflict with manipulations of risk perceptions that may, at face value, seem in the public interest. Principles such as those in the U.S. Bill of Rights are vulnerable to perceived needs precipitated by risk perceptions. As the U.S. Public Law 107–56 (commonly known as the U.S. Patriot Act, 2001) and the U.K. Anti-Terrorism, Crime, and Security Act (also 2001) illustrate, it is easy to delimit transparency of government, judicial checks on legislative and executive branches, and civil liberties and equal treatment of citizens under the guise of reducing risks, even without evidence that the measures enacted will actually reduce risks.

The literature on risk perception across different domains of science and technology is daunting. Health, environmental, and technological risk perception, and to some extent hazard perception, are largely separate bodies of research. Health risk perception research is rooted primarily in social psychology, and has been dominated by the health belief model, the theory of reasoned action, and variants thereon. This research is influenced by the extended parallel process model, which predicts that people who believe something poses a serious risk to them personally will engage in fear control rather than risk control if they do not believe that they can control the risk effectively (Witte 1992). Environmental and technological risk perception research has drawn more broadly on social and cognitive sciences, including the theories and models cited above. Methods have varied from informal and sometimes misleading reliance on casual observations, such as of focus groups, to carefully designed and implemented surveys and experiments. Anthropology and ethnographic methods of studying risk perceptions have grown in importance, as practitioners have recognized their value in improving the design of risk interventions, as well as providing a fuller account of how people perceive risk.

Spatial and temporal dimensions of risk perceptions remain to be fully explored, and will likely provide further insights into risk behaviors.

ANN BOSTROM

SEE ALSO *Risk; Risk and Emotion; Risk-Cost-Benefit Analysis; Risk Ethics; Risk Perception; Risk Society.*

BIBLIOGRAPHY

Damasio, Antonio R. (1994). *Descartes' Error: Emotion, Reason and the Human Brain.* New York: Putnam.

Douglas, Mary, and Aaron Wildavsky. (1983). *Risk and Culture: An Essay on the Selection of Technical and Environmental Dangers*. Berkeley: University of California Press.

Finucane, M.L.; A. Alhakami; P. Slovic; and S. M. Johnson. (2000). "The Affect Heuristic in Judgments of Risks and Benefits." *Journal of Behavioral Decision Making* 13: 1–17.

Fischhoff, B.; A. Bostrom; and M. Jacobs Quadrel. (2002). "Risk Perception and Communication." In *Oxford Textbook of Public Health,* 4th edition, ed. Roger Detels, et al. Oxford, UK: Oxford University Press.

Gilovich, Thomas; Dale Griffin; and Daniel Kahneman, eds. (2001). *Heuristics and Biases: The Psychology of Intuitive Judgment*. Cambridge, UK: Cambridge University Press.

Kahneman, Daniel; Paul Slovic; and Amos Tversky, eds. (1982). *Judgment Under Uncertainty: Heuristics and Biases*. Cambridge, UK: Cambridge University Press.

Shrader-Frechette, K. (1994). "Science, Environmental Risk Assessment, and the Frame Problem." *BioScience* 44(8), 548–552.

Slovic, Paul. (2000). *The Perception of Risk*. London: Earthscan.

Witte, Kim. (1992). "Putting the Fear Back into Fear Appeals: The Extended Parallel Process Model." *Communication Monographs* 59: 329–349.

RISK SOCIETY

The concept of risk, long associated with the language of maritime trade and insurance, has become a key term for characterizing contemporary Western societies. Important early contributions to the development of this analysis were the work of Patrick Lagadec (1981), who coined the term *risk civilization,* and that of Mary Douglas and Aaron Wildavsky (1982). However, Ulrich Beck's *Risk Society* (1992), originally published in German in 1986, was the decisive contribution to a new theory of society. Beck's conceptualization has inspired research that focuses on the implications of science and technology for the social and natural environment and on the increasing use of risk analysis in discussions of public policies related to science and technology, and which involve ethical questions.

Reflexive Modernity

Beck's theory represents a continuation of the German tradition of an ethical questioning of modernity, including science and technology, that runs from Max Weber (1864–1929) through Jürgen Habermas (b. 1929). In contrast to postmodern theories that present late twentieth-century social transformations as going beyond modernism, Beck argues that modernity is going through an unintended and unseen phase that is forcing it to confront the premises and limits of its own model. Modernization has become, in his words, "reflexive." The concept of reflexive modernization, which was introduced by Beck and developed in a subsequent work with Anthony Giddens and Scott Lash (Beck, Giddens, and Lash 1994), propounds a "radicalization" of modernity in which the dynamics of individualization, globalization, gender revolution, underemployment, and global risks undermine the foundations of classical industrial modernity and make old concepts obsolete. The internal dynamism of modernity brings it up against the previously unknown possibility of global self-destruction as a result of the risks generated by certain technologies.

Beck thus depicts the risk society as coextensive with reflexive modernity. In the same way that "simple modernity" produced goods and services that presented challenges involving just distribution, reflexive modernity is producing risks that must be distributed justly.

An Expanded Concept of Risk

Many theoretical works in other disciplines had previously analyzed the risk concept, although more narrowly: economics, behavioral theory (in particular decision making and game theory), anthropology, and technology assessment.

In economics, where the concept has always been fundamental, prevailing interpretations make a clear distinction between risk and uncertainty. Whereas risk can be assessed and calculated in terms of its numerical probabilities, uncertainty cannot be treated in that manner. Introduced at the beginning of the twentieth century by Frank Knight (1885–1972) and John Maynard Keynes (1883–1946), this distinction made possible the recognition of the ontologically contingent nature of economic behavior and its aggregate outcomes. An economic agent cannot avoid wide margins of uncertainty or eliminate it by means of the application of more information or scientific knowledge.

The anthropological work of Douglas and Wildavsky (1982) diverges from this classical approach in emphasizing the subjective aspect of risk and the ways in which risk is assessed and perceived by individuals. Their work helped significantly to shift attention away from a probabilistic approach to the cultural framework of risk perception. Variations in the understandings and perceptions of risk in different societies demonstrate the cultural relativism involved in judgments of risk.

Beck's main contribution was to build risk systematically into a theory of modern society and its dilemmas. Risk is seen as a defining feature of society itself, forming the dark side of industrial successes, technical and scientific progress, and economic growth. It has stimulated changes in social relations, family structure, political and cultural organization, and even the self.

Unlike the threats of early industrialization, the risks of "late modernity" (nuclear, chemical, genetic, ecological, etc.) are generated by techno-economic decisions and considerations of utility. The novel aspect of contemporary risk society is that people's decisions as a civilization lead to problems and dangers that radically contradict the established language of control and conventional techniques of calculation. Current risks are not socially, spatially, or temporally demarcated; there are no clear-cut solutions; and it is difficult to trace responsibility or assess compensation for those who are affected. In addition, human perception fails to notice many of the risks: they become visible only through scientific interpretation (as in the case of stratospheric ozone depletion), which in turn increases dependence on experts.

Beck focuses above all on environmental and health risks, especially genetic technology. He later extended the concept of risk to global financial crises and transnational terrorist networks (Beck 2002). Bringing together such disparate phenomena enables him to identify relevant trends in modern societies but has the drawback of implying a less fragmented world than that which Beck perceives.

Niklas Luhmann (1993 [1991]) has enriched "risk society" analysis with his theory of autopoietic systems. Here risk is a specific form of dealing with the future that has to be decided in the context of probability and improbability. The uncertain and unforeseeable nature of the future arises not only from complexity and people's cognitive limitations but also from the decision-making process itself. There is a long hiatus between when a decision is made and when its consequences are felt, with random factors affecting them. To talk of risks is to see future losses as the consequence of a decision that has been made. For Luhmann this is where "risk" differs from "danger," with danger being attributable to external causes and corresponding to those "affected" by decisions. Although the distinction is slight because "one person's risk is another person's danger," it points to the key issue of acceptance of risk decisions.

Developments and Implications

Beck's message on the relationship between science, technology, politics, and ethics in late modernity is that our language does not inform future generations of the dangers people create when they use certain technologies. As it develops technologically, society encounters the difference between two worlds: the language of quantifiable risk, in which people think and act, and that of nonquantifiable insecurity, which people also are creating. As risks become more complex and the need for precise calculations increases, there is growing doubt about the ability of science to control and foresee those risks. This situation has shaken the belief that technological and social progress go together and has forced science to acknowledge both its collateral effects and its inherent epistemological limitations. The concept of "world risk society" (Beck 1999) draws attention precisely to the limited controllability of globalized and artificially produced risks.

In these circumstances human responsibility for technological advancement is an ethical issue that is both relevant and complex. For Beck the processes and techniques of risk management block out responsibility. Modern society operates as a "laboratory" in which no one in particular must answer for the negative effects of technological experimentation. The institutions of modern society recognize the existence of risk but permit an "organized irresponsibility" (Beck 1995 [1988]). Pollution, along with its increasingly global impact in the form of climate change, graphically illustrates this paradox. The greater the environmental degradation is, the more laws and environmental regulations there are, but at the same time no institution seems to be specifically responsible.

Technologically induced risks lead to calls for the demonopolization of scientific expertise, its subjection to social scrutiny, and extension of democratic accountability to science, technology, economics, and government. For this to be achieved politics must "(re)-invent" itself and focus on issues previously regarded as apolitical. What once was the exclusive province of science has become the subject of intense political debate, as in the case of biotechnology. In this context individual citizens, movements, and interest groups participate and influence political decisions in the field that Beck describes as "sub-politics," which is located beyond the formal representative institutions of the political system.

Because the concept of risk is probabilistic in nature, it tends to deny inherent uncertainties and place greater emphasis on scientific control over randomness, contingencies, and chance. In the vast literature on risk there are authors who argue, however, that the language of uncertainty would be more appropriate for a better understanding of the current world, full of indeterminacies and contingencies, whether inherent in the world or epistemic. Underlying this argument would be lack of knowledge of the statistical probability of many of the possible outcomes, public distrust of the estimates produced by experts, potential margins of error, and the random unpredictability of nature and human behavior

(Martins 1998). This approach has affinities with the work of authors who underline the ontological nature of uncertainty that is inherent in the natural and social worlds and focus on "ignorance," "catastrophes," and "accidents" (see, for example, Perrow 1984). It differs from the work of those who stress above all the social perception of risks (such as Douglas and Wildavsky 1982).

Beck often is said to alternate between the realist and the constructivist approaches and to absorb uncertainty into the general category of risk. However, he cannot be said to limit risk to the perceptual aspect or to avoid a strong emphasis on uncertainty. There are several studies of practical situations in which risk is not limited to perceptions, such as the subpolitics of medicine. At the same time, in light of the emphasis Beck places on deregulation, uncertainty, and contingency, his "risk society" cannot properly be understood according to the probability model. In introducing the notions of "unintended consequences and unawareness" into his theory of reflexive modernity instead of emphasizing the "knowledge," as Giddens and Lash do, Beck recognizes that there are areas of unknowability, contingency, and ignorance. For this reason his theoretical approach lends itself to multiple interpretations that lie between the concepts of risk and uncertainty.

These issues are relevant because a decision based on risk or uncertainty is not neutral in its political consequences. Risk is associated with prevention, whereas uncertainty is associated with precaution (Godard et al. 2002). Risk may lead to a process of risk-mitigating negotiation and agreement, whereas uncertainty may lead to risk-avoiding prudence. The possibility of rejecting certain techno-economic decisions and actions has provoked a lively ongoing debate about the advisability of the "precautionary principle" at a time of rapid technological change.

HELENA MATEUS JERÓNIMO

SEE ALSO *Risk and Emotion; Risk Assessment; Risk-Cost-Benefit Analysis.*

BIBLIOGRAPHY

Beck, Ulrich. (1992 [1986]). *Risk Society: Towards a New Modernity,* trans. Mark Ritter. London: Sage.

Beck, Ulrich. (1995 [1988]). *Ecological Politics in an Age of Risk,* trans. Amos Weisz. Cambridge, UK: Polity Press.

Beck, Ulrich. (1999). *World Risk Society.* Cambridge, UK: Polity Press.

Beck, Ulrich. (2002). "The Terrorist Threat: World Risk Society Revisited." *Theory, Culture & Society* 19(4): 39–55.

Beck, Ulrich; Anthony Giddens; and Scott Lash. (1994). *Reflexive Modernization: Politics, Tradition and Aesthetics in the Modern Social Order.* Cambridge, UK: Polity Press.

Douglas, Mary, and Aaron Wildavsky. (1982). *Risk and Culture: An Essay on the Selection of Technical and Environmental Dangers.* Berkeley and London: University of California Press.

Godard, Olivier; Claude Henry; Patrick Lagadec; and Erwann Michel-Kerjan. (2002). *Traité des Nouveaux Risques: Précaution, Crise, Assurance.* Paris: Gallimard.

Keynes, John Maynard. (1921). *A Treatise of Probability.* London: Macmillan.

Knight, Frank H. (1921). *Risk, Uncertainty and Profit.* Boston: Houghton Mifflin.

Lagadec, Patrick. (1981). *La Civilisation du Risque: Catastrophes Technologiques et Responsabilité Sociale.* Paris: Seuil.

Luhmann, Niklas. (1993 [1991]). *Risk: A Sociological Theory,* trans. Rhodes Barrett. Berlin and New York: Walter de Gruyter.

Martins, Hermínio. (1998). "Risco, Incerteza e Escatologia: Reflexões sobre o *Experimentum Mundi* Tecnológico em Curso" [Risk, uncertainty and eschatology: Reflections on the ongoing experimentum mundi]. *Episteme* 2: 41–75.

Perrow, Charles. (1984). *Normal Accidents: Living with High-Risk Technologies.* New York: Basic Books.

ROADS AND HIGHWAYS

Roads and highways have been principal means by which entire economies and societies have emerged and grown over time. They have contributed positively to the spread of ideas, cultures, languages, inventions, goods, and services. Disease, enslavement, tribute, and warfare have also spread through networks of roads and highways to devastate entire peoples and areas and immeasurably alter the course of history.

Early Roads and Highways

The first roads dating back to the dawn of civilizations (c. 3000 B.C.E.) were little more than dirt paths worn down by frequent travel from one location to another via wheeled vehicles. Rivers were the main highways of this time period, as goods and people moved up and down their courses and any city that desired to rise to importance was located on a river. Yet within a period of a few hundreds of years, roads became a commonplace and began to reshape the geopolitical history of entire regions. Even during this period, rivers continued to be the most economical way to transport large quantities of goods, with roads being used to link river trade to cities and towns throughout entire regions.

The earliest roads were designed to bear the weight of wheeled traffic including carts, large wagons, and swift chariots. Within cities the main thoroughfares were paved and varied in width from two to ten meters. A series of "narrow streets" connected to these "broad streets" within cities and enabled populations within them to increase substantially in size. The Neo-Babylonians and Assyrians constructed royal roads that linked major cities across their empires. The Persians took over many of the practices of the Assyrians and maintained excellent royal roads, some as long as 2,670 kilometers (1,650 miles). These roads featured "excellent inns," as noted by the Greek historian Herodotus (c. 485–c. 425 B.C.E.), as well as special parks so that the king or his senior administrators could take their rest in leisure when traveling across the vast reaches of the Persian Empire. Similarly, in ancient Egypt roads were constructed both within large cities and linking cities and regions of Egypt and her territories to one another. The typical Egyptian road was about five meters in width. Outside of cities, most roads in the ancient Near East were unpaved but had been carefully prepared and leveled, and were regularly maintained. The ancient Greeks did not favor roads and built only a skeleton of dirt roads from one region to another until the time of Alexander the Great (356–323 B.C.E.), who saw the need for better roads linking the rapidly expanding segments of his empire.

The Romans, likely expanding upon earlier techniques of the Etruscans, took road building to new heights of engineering excellence, constructing two, four, six, and eight lane highways connecting all key parts of the Empire. Roads themselves became a symbol of the might of Rome and the certainty that if they were needed, a Roman army would arrive swiftly to deal with any sociopolitical unrest or the incursion of enemies from outside its borders. Roman surveyors determined the optimum location and direction of roads, favoring straight traces whenever possible. Roman engineers constructed roads that would last for centuries through careful attention to the underlying base materials, superb drainage to keep water away from the road and its foundation, the careful use of stones and cement, and regular repair. Many miles of these Roman roads survive throughout the former Empire and quite a few modern roads follow the exact course as their Roman predecessors. While originally designed for military purposes, the roads became the means by which Roman ideas, life, and culture spread across the Empire. All roads carried mileage markers, always delineated in terms of their distance from the imperial city of Rome, a reminder to all of the might and power of the Empire. By the time of Diocletian (245–c. 313), there were 372 main roads throughout the Empire, covering a distance of some 85,000 km (nearly 53,000 miles). The Romans went well beyond any of their predecessors in the extent and interconnectivity of the system of secondary and primary roads they created and maintained across the Empire. In Roman Britain alone, more than 9,656 km (6,000 miles) of roads were constructed and maintained. Bridges and tunnels, milestones to enable travelers to instantly know their location, wooden signposts, and many other "modern" features of roads and highways were common throughout the Empire. The roads created ideal conditions for the growth of a postal service for government use and also a private postal service employed by wealthy citizens. A series of posts were set up so that couriers only had to move from one posting station to another—a design that would later be used by the famous but short-lived Pony Express in the American West.

Roads were not a distinctly Roman and European phenomena. The Qin and Han dynasties of China created a highly integrated network of roads, mainly for military use, in the second century B.C.E. The first Qin Emperor, Qin Shihuangdi (c. 259–210 B.C.E.) constructed 7,000 km (4,350 miles) of roads radiating out from his capital city of Xianyang in northern China. One hundred years later, there were more than 35,000 km (21,750 miles) of roads in northern China serving an empire of some 4 million square kilometers (1.5 million square miles). Similarly, the Incas created an empire running from Ecuador to central Chile and held it together via a network of more than 10,000 roads built across some of the most difficult mountain terrain in the world. Remnants of these Incan royal highways still exist in the early twenty-first century, and many modern roads follow the traces of these roads as a continuing tribute to the foresight and skills of these early highway engineers in South America.

The road systems developed by the Romans throughout the western Empire declined considerably after the fall of Rome, while those in the East continued to be maintained to a reasonable degree both under the Eastern Roman emperors and their Muslim conquerors. Many medieval roads in Europe declined to little more than dirt roads and were subject to flash floods and steady deterioration.

Modern Roads and Highways

Roads in the West began to be vigorously revived in the seventeenth century with the introduction of street lighting, ferry services, and emerging regulations from local, regional, and national governments. Central governments began to assume more direct responsibility and control for roads and centralized planning and maintenance became common, supported by general tax revenues.

Pierre Trésaguet (1716–1796), director of the École des Ponts et Chaussées in Paris in the mid-eighteenth century, had studied long and well the achievements of the Romans. His department had responsibility for some 40,000 km (25,000 miles) of roads throughout France, many built in the exact traces of earlier Roman roads. Trésaguet ensured that exacting road preparation methods were employed, following earlier Roman techniques, and the road system throughout France improved dramatically under his tenure. Two Scottish engineers made similar improvements throughout Britain in the early nineteenth century. Thomas Telford (1757–1834) built an exquisite model road between London and Holyhead demonstrating the superiority of preparing a very solid and carefully constructed roadbed before providing surfacing materials. While expensive to build, it was vastly superior to other roads. John McAdam (1756–1836), his fellow Scot, pioneered the use of natural materials as the base of a roadbed and developed methods to highly compact these materials to provide the same type of firmness that Telford achieved, only with much lower production costs. The surface material used on his road and the entire type of road took its name after him—macadam. By the late nineteenth century, the use of asphalt and portland cement (first used in Scotland in 1865) also became common and the maintenance required for roads became much less labor intensive.

Roads, including early toll roads such as the Lancaster Turnpike in Pennsylvania where travelers had to pay a fee to enter and/or exit the road, were a principal means of commerce in colonial America, and traces to the American West eventually were turned into roads that enabled white settlers to push rapidly westward in search of new lands and opportunities.

The advent of trains and railroads in North America, Europe, and elsewhere provided new opportunities to create many smaller secondary roads that linked many smaller towns and farming areas to commercial nodes. Consequently, these roads became the means by which goods and services circulated far more widely than was economically feasible before with attendant mobility of goods, people, and ideas. The combination of railroads and roads during the Civil War, for example, enabled large and rapid movements of troops and influenced the outcome of many a Civil War battle.

The nineteenth century saw the introduction of steam-powered equipment to construct roads, with the most important invention being the steamroller of Louis Lemoine and Amedee Jean Ballaison. These steamrollers quickly found their way to India and other nations far from Europe and the United States. New gasoline powered vehicles provided even more powerful machines to build roads and also led to more plentiful traffic for roads, resulting in yet further expansion of networks of roads across nations. By the nineteenth century it was common for city roads to be made of portland cement, and bitumen (pitch) or concrete used for cross country routes. Rural roads in the hinterlands continued to consist of dirt and packed gravel.

The first multi-lane, limited access highway in North America was constructed during 1917–1925 as the Bronx River Parkway, a New York thoroughfare still in use in the twenty-first century. The first bona fide superhighway in the United States was the 160-mile Pennsylvania Turnpike from Middlesex to Pittsburgh that opened in 1940 and quickly outdistanced expectations as 2.4 million vehicles used it annually within the first few years. Adolf Hitler (1889–1945) and Benito Mussolini (1883–1945) were aficionados of superhighways, and under their direction, massive superhighways were constructed in Italy and Germany in the 1930s that enabled the rapid movement of troops. President Franklin Delano Roosevelt appointed a National Interregional Highway Commission in 1941 and a Federal Aid Highway Act was approved in 1944 that authorized $1.5 billion for interstate highway construction. By the time of the Eisenhower administration, the federal highway legislation resulted in the construction of more than 64,000 km (40,000 miles) of highways running across the United States in both north and south and east and west orientations. Many states, such as New York, Pennsylvania, Ohio, and Illinois, also built their own extensive toll roads that connected in networks running particularly throughout the northeast. In the early twenty-first century similar highway systems can be found throughout the world, and the proportional number of miles of such highways within a nation serves as a rough gauge of its economic status in the world. These massive networks of superhighways and their linked secondary roads enabled the massive growth of suburbs and attendant suburban "flight," substantially altering the tax base and quality of life of central cities–a situation readily observed in places such as Atlanta, Boston, Chicago, London, Los Angeles, Paris, and Philadelphia.

Highway Engineering and Ethical Issues

Highway planning in the early 2000s is a complex branch of civil engineering that is designed to move goods and people efficiently, effectively, and safely across large distances. It includes attention to forecasting demand, acquiring land from various parties, designing roads and arteries that make for safe and aesthetically pleasing experiences for highway users, moderating costs, and providing for long-term maintenance and expansion when needed. Traffic volume is generally measured in terms of annual average daily traffic, which allows for derivation of a figure that avoids the inevitable peaks and troughs of traffic flow in any given day, week, or month. An entire route is divided into zones and then estimates are made about travel between zones and the amount of travel that will be undertaken by different modes of transport (for example, trucks, cars, buses). A maximum theoretical traffic flow rate is calculated using reasonable parameters of environmental, highway, and traffic conditions. A further factor taken into account in planning is what level of service the road will need to bear that will be acceptable to its users. Travel is an inherently subjective experience, and planners attempt to find an acceptable level of service (LOS), avoiding the extremes of very good (index A) and very poor (index F).

A number of additional factors need to be considered. All human technological applications have environmental effects. Highways directly affect matters such as noise pollution from horns, tires on road surfaces, engines, the speed of traffic, and shock effects from heavy loads on road surfaces; air pollution due to carbon monoxide, nitrogen oxides, volatile hydrocarbons, sulfur oxides, and particulate matter from exhaust fumes as well as evaporation from road surfaces; water pollution due to runoff that picks up oils, trash, and other materials from road surfaces; and environmental effects from the initial siting of the highway and its continued maintenance. These latter effects can include changing migration patterns and habitats of birds, mammals, amphibians, fish, and other creatures, as well as increased road kills (which number substantially more than one million mammals per year in America alone). Sometimes road kills result in the total extinction of a species or a severe threatening of its existence, such as with the Florida panthers.

Highway design includes attention to both aesthetics and safety issues. Each highway has to surmount certain physical challenges that the land presents, and decisions have to be made about how much to use the natural features of the land in construction or to substantially alter them. Modern highways attempt to utilize natural materials and natural roadbeds as much as possible, because it is far cheaper than completely excavating and hauling away such materials and replacing them with others. Sometimes the natural material base is not conducive to the type of heavy travel a particular road will be required to bear and then such steps have to taken.

A much larger portion of land is required than just that needed for the roadway itself. Most highways require a median that is almost equal in size to the width of the one or more lanes on one side of a divided highway. Then the outer edge of the driving lane requires a shoulder so that vehicles have a space to move off the road safely when they encounter vehicular or other problems. A drainage ditch is usually found outside the shoulder to handle runoff from the driving lanes, which are sloped in such a way that water runs off the highway quickly. The ditch also serves as the means to handle runoff from surrounding land on either side of the road cut to keep water off the road surface and prevent erosion from undermining the pavement or roadbed.

Pavement materials for roads and highways have to meet technical standards in order to be used. All materials must be sufficiently strong and durable to meet the required criteria that planners have established for that particular type of road. A typical highway is a composite of many different types of materials that are laid down in a carefully defined sequence and constantly checked to verify that they meet required specifications. Materials include sand, gravel, crushed rock, portland cement, asphaltic cement, lime, and, increasingly frequently, recycled materials such as crushed glass, scraps from old roadways, and pulverized tires.

Road geometry takes account of the steepness of curves, the slope of hills and valleys (road grades), passing maneuvers on varied terrain, and the need to maximize clear lines of sight. This is further complicated by situations where two highways meet one another, where a whole series of considerations must be addressed to plan and construct effective intersections and interchanges that enable a smooth and safe flow of traffic.

The actual siting of highways is always a complex decision that involves balancing factors such as travel time, vehicle operation cost, accessibility, environmental effects, societal acceptability, safety, total cost of construction, and viable alternative routes. Increasingly, local, state, and federal governments in many countries have to use the concept of eminent domain to assert their primary claim over land held by owners reluctant to relinquish their claims, frequently because they are opposed to the siting of the highway through their property. Government agencies generally are required by law to provide a fair-market value price to the owners.

The impact of interstate highways on commerce, migration, immigration, and employment growth has been the subject of much study. The overall findings indicate that, in general, counties or administrative units that reside alongside interstate highways see an increase in net immigration, employment growth, and commercial activity, while counties that have been bypassed by the interstate suffer net migration, a loss of employment over time, and declining commercial activity. The large amounts of particulate matter generated from major roadways has been identified as a source of chronic exposure that produces negative health effects within communities, especially in children and adults suffering from various respiratory preconditions.

Roads and highways also have to be managed by agencies to ensure that traffic flow is maintained at a reasonable level and that users of the roadway obey traffic laws that are designed to maintain such flows. Traffic signals of many different varieties have been developed, and a set of international standards have been developed for signs so that drivers can travel virtually around the globe and know what they are supposed to do in particular situations. Toll booths, highway exit and entry, emergency breakdown services, quick response to traffic accidents, enforcing traffic laws, and many other facets of roads and highways are generally under-appreciated by users but essential to maintaining a working system of roads and highways. Driver error, including falling asleep at the wheel, is by far the most common source of traffic accidents and deaths and injuries to drivers, pedestrians, and wildlife.

Future Developments

Computerization is the next major innovation in roads and highways, and virtually every industrialized nation has a wide range of current applications in the area of intelligent transportation systems (ITS). These include automated toll booths where vehicles with appropriate stickers on their vehicles can pass through the booth and automatically be billed for their trip rather than having to stop and manually deliver money or tokens to a human or automated operator. Many interstates or roads in heavily congested areas of the world use computers to regulate entry into the highway as traffic lights and barriers allow only one vehicle at a time onto the highway such that mergers happen more seamlessly and the flow of traffic on the road is not impeded by entering traffic. Many cities have sophisticated computer systems that regulate traffic signals across the city with the timing of signals changing throughout the day to accommodate the daily ebb and flow of traffic to and from major zones within the city. Cameras placed in strategic positions in cities and mobile camera units elsewhere increasingly document speeding vehicles with attendant tickets being subsequently issued to the offenders. Global positioning technology makes it feasible to track vehicles anywhere in the world, and many large transport companies already utilize this technology to keep track of their vehicles both on the road and also across railroad systems in seamless global transportation networks that enable managers to ensure that their products arrive at required destinations in a timely manner and in good condition.

ITS planners have created plans for intermodal transport systems that utilize advanced telecommunications and computer systems to move goods across entire continents through underground tunnels or highways dedicated solely to the movement of freight. These intelligent systems would only require human operators on points of entry or exit within the system, and once on the network, goods could be accelerated greatly in their passage to desired destinations. Similar designs exist for automobiles of the future that would go on "autopilot" once the human operator had placed the vehicle on the superhighway. Computers would then guide the vehicle to the required exit point and then the human operator would take over control functions to move the vehicle safely off the superhighway. Such a system would alleviate the traffic jams so familiar to major interstate highway systems during peak flow times and enable resources to be used more efficiently.

The widespread use of ITS raises a host of ethical issues, many not particularly unique to these applications but part of a broad set of issues common to technological innovations. Increasingly the operators of these systems would have knowledge of one's whereabouts and be able to track the movement of a single individual across a city, state, or even potentially around the globe as these various systems come online and interconnect both operationally and informationally. Technical managers would also be able to shape human perceptions and experiences of reality by varying conditions on these systems—for example, deciding that today's optimal travel time from point A to point B will be 25.8 minutes, and programming the system to deliver these results. It should be noted, however, that highway engineers have always shaped human perceptions of the surrounding environment and influenced ways of life going back to where the first roads were constructed (all artifacts have politics, as Langdon Winner has argued), how structures actually are designed (for example, low bridges on the Wantagh Parkway in New York designed by Robert Moses (1888–1981) specifically to keep buses off the parkway), and via the distinct sociotechnical roles that engineers play in public policy making.

DENNIS W. CHEEK

SEE ALSO *Networks.*

BIBLIOGRAPHY

Adkins, Lesley, and Roy A. Adkins. (1994). *Handbook to Life in Ancient Rome*. New York: Facts on File. A one volume reliable reference that includes numerous references to Roman roads.

Astour, Michael C. (1995). "Overland Trade Routes in Ancient Western Asia." In *Civilizations of the Ancient Near East,* ed. Jack M. Sasson. New York: Scribners. A definitive treatise summarizing current historical and archaeological information on this topic.

Carlson, Daniel. (1995). *At Road's End: Transportation and Land Use Choices for Communities*. Washington, DC: Island Press. A study of the complex set of factors that should be considered in planning and siting of highways.

Chen, Wai-Fah, and J. Y. Richard Liew, eds. (2003). *The Civil Engineering Handbook,* 2nd edition. Boca Raton, FL: CRC Press. A massive standard reference work that provides copious details about the construction of highways and other matters in civil engineering.

Dorsey, David A. (1997). "Roads." In Volume 4 of *The Oxford Encyclopedia of Archaeology in the Near East,* ed. Eric M. Meyers. New York: Oxford University Press. A summary article by a noted expert on roads in the ancient world and particularly the Middle East.

Garrison, William L., and Jerry D. Ward. (2000). *Tomorrow's Transportation: Changing Cities, Economies, and Lives*. Boston, MA: Artech House. Explores key options and tradeoffs concerning future transportation needs, challenges, and opportunities.

Lewis, Tom. (1997). *Divided Highways: Building the Interstate Highways, Transforming American Life*. New York: Viking. A journalistic depiction of the ways in which interstate highways transform culture with a focus on the situation in the United States.

Motavalli, Jim. (2001). *Breaking Gridlock: Moving Toward Transportation that Works*. San Francisco: Sierra Club Books. Argues for a more environment-friendly approach to transportation systems while avoiding simplistic solutions.

Rose, Mark H., and Bruce E. Seely. (1990). "Getting the Interstate System Built: Road Engineers and the Implementation of Public Policy, 1955–1985." *Journal of Policy History* 2(1): 23–55. An important study of a neglected topic: How do engineers interact with policymakers to help shape public decisions about transportation systems?

Sachs, Wolfgang. (1992). *For Love of the Automobile: Looking Back into the History of Our Desires,* trans. Don Reneau. Berkeley: University of California Press. A provocative, wide-ranging, sociological study of the ways in which the automobile shapes desires and the ways in which automobiles are designed to appeal to basic human desires.

Sussman, Joseph. (2000). *Introduction to Transportation Systems*. Boston: Artech House. An expert summary of all major issues related to transportation systems that grew out of a course the author has taught on this topic for many years at the Massachusetts Institute of Technology.

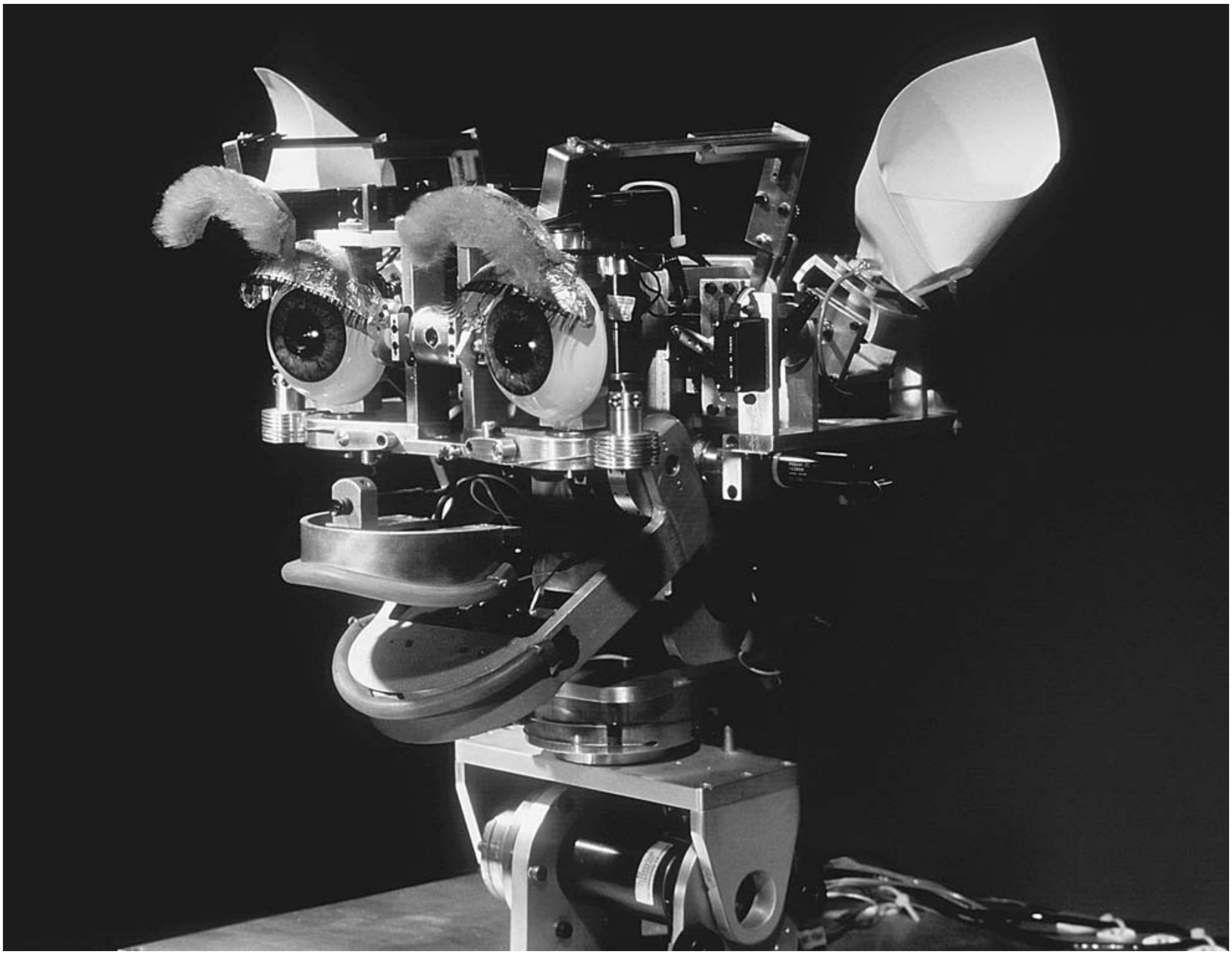
Vance, James E., Jr. (1990). *Capturing the Horizon: The Historical Geography of Transportation since the Sixteenth Century*. Baltimore, MD: Johns Hopkins University Press. The definitive one-volume history in English of transportation in modern times.

Winner, Langdon (1986). *The Whale and the Reactor: A Search for Limits in an Age of High Technology*. Chicago: University Of Chicago Press. A series of important essays by a noted political scientist about technology; see especially chapter two, "Do Artifacts Have Politics?" for a discussion of Robert Moses and the Wantagh Parkway.

ROBOTS AND ROBOTICS

Robots are programmable machines capable of moving around in and interacting with their physical environment. The word *robot* was popularized by Karel Capek (1890–1938) in his play *R.U.R.,* where he used it to refer to a race of manufactured humanoid slaves; robots are machines that can do the work of humans. It is debatable whether merely remote-controlled devices should count as robots, although many devices popularly thought of as robots are of this nature. Similarly, computer programs such as virtual "autonomous agents" and web "'bots" are not, strictly speaking, robots as they lack the ability to manipulate the physical world.

The term *robotics* was coined by Isaac Asimov and refers to the study and use of robots. Research into robotics began in the 1940s, alongside research into cybernetics and computers. The first commercial robots were produced for industrial applications in manufacturing in the 1960s. As computing technology began to improve rapidly in the 1980s and 1990s, a number of writers such as Hans Moravec (1998) and Ray Kurzweil (1992) made arguably exaggerated claims on behalf of robots, suggesting that they would soon possess consciousness and intelligence. Major limitations on the tasks that can be performed by robots—especially in real environments—remain, largely due to a lack of success in reproducing "intelligence" and robust locomotive and sensory systems. The vast majority of existing robots



Kismet, a robot created by Dr. Cynthia Breazeal at MIT. She developed Kismet for her doctoral research in expressive social exchange between humans and humanoid robots. *(© Rick Friedman/Corbis.)*

are industrial robots, which perform a limited range of repetitive tasks in a controlled environment.

The ethical, political, and legal issues surrounding robots can be roughly grouped into two categories: those that are raised by existing technologies and a more speculative set that would arise if genuinely "intelligent" or conscious robots were to become a reality.

Existing technologies largely raise questions relating to their social impact (Weiner 1961). The main impact of robotics thus far has been to displace persons from jobs in manufacturing industries. It might be argued that by replacing workers in industries where jobs tended to be both highly paid and skilled, robots have had a negative impact on human happiness. Alternatively, it might be argued that robots have contributed to human happiness by eliminating the necessity of repetitive and occasionally dangerous work. The economies of scale and other increases in efficiency that robotics have made possible would also need to be taken into account in this calculation. Access to robots could conceivably become a source of inequality in a society where robots play a significant role.

Another area where it seems likely that robots will have dramatic social impacts is warfare. A number of types of remote control and semi-autonomous devices are already deployed by militaries around the world. It seems likely that fully autonomous robots will play a role in wars conducted by industrialized nations in the future.

The use of robots in military contexts raises many difficult ethical and legal issues. They offer to reduce casualties amongst friendly combatants, but in doing so may decrease the threshold of war. "Smart weapons" may allow commanders to attack military targets with greater precision and thus lower the risk of civilian casualties in war. However, the possession of such weapons by one side only may increase the likelihood and extent of asymmetrical warfare and consequently of increased civilian casualties. There are also ethical and legal questions surrounding the allocation of responsibility for deaths caused when such weapons go astray, resulting in attacks on targets that are not legitimate under the rules of war.

More prosaically, a number of quite advanced robots are now manufactured as entertainment devices and "robot pets." The development of robot toys suggests that there is a need to scrutinize the educative and communicative functions of these robots. There are also questions surrounding the ethics of human/robot interactions. Are robots appropriate objects of emotional attitudes? If not, then designing robots to encourage such investment may be wrong.

A much larger, more complex, but also speculative, set of issues would arise if robots were to achieve any degree of consciousness, or genuine intelligence.

At what point would such creations deserve moral concern? What rights should they have? While these questions are regularly raised by writers in the area, little serious philosophical work has been done on these subjects, perhaps reflecting a lack of faith that the technology will become a reality.

Yet much contemporary moral theory, which grounds moral status in the capacities of individuals, suggests that sentient robots would be deserving of the same moral regard as other sentient creatures. If robots can feel pain, then humans will have obligations to avoid causing them pain. If they become self-conscious, can reason, and have future-oriented desires, then they will be worthy of the same moral regard and respect as human persons. This suggests that it would be entirely appropriate to feel grief stricken by the "death" of a robot, to feel remorse for killing a robot, and even sometimes to choose to save the life of a robot over that of a human being.

This last scenario might serve as a test of the moral status of robots. Humans will know that robots are moral persons when they feel that the choice between the survival of a robot and of a person is a genuine moral dilemma. This might be called the "Turing Triage Test," after Alan Turing's famous test for when a machine can be said to think. If this test is a valid one, it suggests that what is required for robots to become persons may include the ability to express subtle and complex emotional states through their bodily appearance.

As well as the question of how people should treat robots, there is also the question of how robots are expected to treat people. What ethical precepts should they be designed to obey? Isaac Asimov's " three laws of robotics" are a famous attempt to answer some of these questions. Yet, as Asimov's stories demonstrate, much more will need to be done before humans become confident that intelligent robots could safely take their place alongside humanity. These questions would become especially urgent if artificially intelligent robots might be capable of reproducing themselves and thereby pose a threat to the human species. If robotics researchers *are* on the verge of creating entities that will be more intelligent than humans and that may compete with humanity for dominance over the planet, then this is a momentous decision, which should only be made after extensive public deliberation.

ROBERT SPARROW

SEE ALSO *Androids; Artificial Intelligence; Artificial Morality; Asimov, Isaac; Robot Toys; Turing Tests.*

BIBLIOGRAPHY

Asimov, Isaac. (1950). *I, Robot.* New York: Gnome Press. A collection of science fiction short stories that did much to popularize the idea of robots.

Brooks, Rodney Allen. (2003). *Robot: The Future of Flesh and Machines.* London: Allen Lane. A popular account of the history and probable future of robots and robotics by a leading robotics researcher.

Kurzweil, Ray. (1992). *The Age of Intelligent Machines.* Cambridge, MA: MIT Press. A history of research into "artificial intelligence" alongside an extremely speculative discussion of possible future developments in this area, including the ethical and social issues that they may raise.

Menzel, Peter, and Faith D'Aluisio. (2000). *Robo Sapiens: Evolution of a New Species.* Cambridge, MA: MIT Press. A survey of the state of robotics research at the beginning of the twenty first century in the form of a photo-essay and a set of interviews with researchers from around the world.

Moravec, Hans. (1998). *Robot: Mere Machine to Transcendent Mind.* New York: Oxford University Press. An extremely speculative discussion of the possible future of robotics, which argues that machines will be more intelligent than humans by the year 2050.

Turing, Alan. (1950). "Computing Machinery and Intelligence." *Mind* 59(236): 433–460. An influential paper in which Turing sets out his famous "imitation game" as a means of determining when a machine can properly be said to think.

Wiener, Norbert. (1961). *Cybernetics: Or Control and Communication in the Animal and the Machine,* 2nd edition. Cambridge, MA: MIT Press. An important work that sets out the theoretical basis for the discipline of *cybernetics*—and therefore for robotics. It also includes discussion of the possible social impact of the development of robots.

ROBOT TOYS

Robots combine sensors, computation, and motors to interact intelligently with their environment. Robot *toys* need to be so cheap and robust that they can be used as playthings. While there is a long history of toys that look like robots, only recently has the cost of computation dropped sufficiently to allow the sale of truly functional robotic toys. This entry focuses on three examples of this new genre of toy that should be of interest from the ethics perspective: Lego MindStorms robot construction sets and Furby interactive robotic pet by Tiger Toys, and Sony Aibo robot dog.

Lego and Furby: Some Contrasts

These two very different kinds of robotic toys were both introduced in 1998, had a large impact, and contrast in several interesting ways. Lego MindStorms and Furby represent two types of toys that Gary Cross (1997) finds typical of twentieth century U.S. toy production: the educational and the novelty toy. Lego MindStorms Robotics Invention System extended the Lego Technic construction system to include a programmable computer controller brick (the RCX), sensors and motors, and computer interface and programming environment. Lavish documentation and support (reflecting a long nurturing by educators) allowed users to build a variety of working robots, ranging from traditional light-guided rovers to static room alarms. Although MindStorms was expensive, included more than 700 pieces, and required considerable assembly and a personal computer, it was nevertheless an immediate success with both children and adults. It became widely used in schools and colleges and has remained in production for a number of years.

By contrast Furby was a plush but inexpensive, stand-alone, interactive toy. Multiple sensors (light, touch, sound, infra-red) drove a single motor, which, via a series of ingenious cams, controlled several motions of the ears, eyes, eyelids, mouth, and rear body (Pesce 2000). Enormously popular in its first season, with long lines at toy stores and price premiums featured on TV news, more than 12 million Furbys were sold in one year. Yet just as quickly the fad passed and in the early twenty-first century Furbys are no longer produced.

Robotic toys fall into two groups: the programmable and the pre-programmed. MindStorms takes programmability to the limit: One can choose which of several general purpose programming languages to use. The Furby was pre-programmed.

Another contrast is in terms of transparency and openness. MindStorms was released as a normal, closed (although very well documented) product. That is, one could run its code but not change it except in predefined ways. After a brief struggle with fans and hackers, Lego agreed to release the technical specifications and allow programming access to the RCX's ROMs. As a result MindStorms became an extensible open-source system for constructing robots. Indeed it has become a platform for a large variety of languages and operating systems. By contrast Furby remained a closed system. It was pre-programmed and an epoxy blob hid its computational abilities and electronics. Moreover its capacities were not documented but shrouded in rumour and advertising hype, so it was difficult to know what the toy could actually do. Could Furbys really learn?

Ethics

Interactive robotic toys raise special issues for ethics. First, robot toys face some special ethical requirements. As robots they interact with children in the real world, so they must be safe. Contrast virtual robot-building software such as the early Apple computer game RoboWar. Virtual battle robots can *fire projectiles* at each other in their on-screen arena without endangering people. Real robot toys are different: As programmed robots, they are capable of initiating unexpected actions; as toys they cannot be cordoned off from human contact in the way that real factory robots typically are.

Second, more subtly, robot toys face design challenges to keep contact with the real world fun and educational. The environment is a great teacher, providing feedback on feasible design for free. But the price can be costly; think of testing whether a Furby can swim or a Lego robot can navigate in sand. The ideal of a platform is helpful here (Danielson 1999). For example MindStorms pushes most electrical considerations down into the platform it provides. The connectors allow polarity to be reversed, but otherwise the user need not be aware of the electrical properties of the sensors and motors.

Third, interactive robotic toys may even change moral categories. Surprisingly Sherry Turkle has found that children categorize their Furbys in a new way: "Children describe these new toys as *sort of alive* because of the quality of their emotional attachments to the Furbies and because of their fantasies about the idea that the Furby might be emotionally attached to them" (Turkle 2000). These children appear to be assigning interactive toys to a third class, between the animate and the inanimate, because of how they interact with them. In a related development, robotic toy pets have been found useful in rehabilitation in Japan (Goodale 2001). These preliminary research results suggest that human relations with emotionally evocative and involving robotic companions will be ethically complex.

Aibo

The third example, Sony's Aibo robotic dog, raises some additional contrasts and ethical issues. Aibo was introduced in 1999 in the United States and Japan. Although very expensive, it sold out in Japan "in just 20 minutes" (Yoshida 2001). Aibo has never sold very well outside of Japan. This difference points to Japan's distinctive history and culture with respect to robots in general and robotic toys in particular. While Aibo's price and sophistication place it with the Lego system, there was an ethically interesting contrast: When Aibo owners hacked its software in order to personalize and extend its capabilities, Sony reacted to block them and protect its intellectual property. Lego, in contrast, opened MindStorms by publishing its source code. Third, Aibo's advanced capabilities allow it to function as a pet much better than the much simpler Furby. Aibos' cognitive and moral status is thus much more ambiguous (see Turkle 1995, chap 3). On one side, the animal rights organization People for the Ethical Treatment of Animals (PETA) claims "the turn toward having robotic animals in place of real animals is a step in the right direction" (MacDonald 2004). But research on actual attitudes towards Aibo find that owners "rarely attributed moral standing" (Peter Kahn, Friedman, and Hagman 2002).

Future Developments

Robotic toys will become ever more sophisticated interactively. Furby, for instance, gave rise to the more capable and expensive Aibo. Robotic toys may thus be a mechanism for increasing the pace of ethically challenging technological change. The toy industry is well known for driving down costs, in order to sell large volume blockbusters. (Furby was brought to market in less than a year and at less than one-half the expected price point.)

In the wake of Furby, there thus exists an increasing number of young new users of a technology, acquired over a short time, along with the design and industrial capacity to make more of the next version very quickly. MIT roboticist Rodney Brooks, for example, has predicted that the first robots to establish a wide household presence will be robotic toys. This is a recipe for rapid technological and attitude change and little time for ethical reflection.

PETER DANIELSON

SEE ALSO *Education; Entertainment; Popular Culture; Robots and Robotics; Safety Engineering: Practices.*

BIBLIOGRAPHY

Cross, Gary. (1997). *Kids' Stuff: Toys and the Changing World of American Childhood.* Cambridge, Mass: Harvard University Press.

Danielson, Peter. (1999). "Robots for the Rest of Us or for the 'Best' of Us." *Ethics and Information Technology* 1:77–83.

Goodale, Carol. (2001). "Researchers Study How Robots Interact with Children." *IEEE Spectrum,* November 2001.

MacDonald, G. Jeffrey. (2004). "If you Kick a Robotic Dog, Is It Wrong?" *Christian Science Monitor,* Feb. 05 2004.

Pesce, Mark. (2000). *The Playful World : How Technology Is Transforming Our Imagination.* New York: Ballantine Books.

Kahn, Peter, Jr., Batya Friedman, and Jennifer Hagman. (2002). "I care about him as a pal: Conceptions of Robotic Pets in Online AIBO Discussion Forums." Paper read at CHI 2002, at Minneapolis, Minnesota.

Turkle, Sherry. (1995). Life on the Screen: Identity in the Age of the Internet. New York: Simon and Schuster.

Yoshida, Noriyuki. (2001). "Robot People and Robo Cats and Dogs." *Look Japan,* October 2001.

INTERNET RESOURCE

Turkle, Sherry. (2000). "A New Kind of Object: From Rorschach to Relationship." Available from http://www.edge.org/3rd_culture/story/101.html.

ROTBLAT, JOSEPH

The physicist Sir Joseph Rotblat (b. 1908), born in Warsaw, Poland, on November 4, was a member of the Manhattan Project, which developed the atomic bomb in the United States. In November 1944, when it became clear that Nazi Germany would not be able to develop a bomb and affect the outcome of World War II, he became the only scientist working on the weapon who

Joseph Rotblat, b. 1908. Rotblat is a Polish physicist who received the Nobel Peace Prize in 1995 in conjunction with the Pugwash Conferences on Science and World Affairs, for their efforts towards nuclear disarmament. *(Hulton Archive/Getty Images)*

resigned prior to its being used against Japan. This principled stand, that the benefits of nuclear power should only be used for peaceful purposes, has been a hallmark of Rotblat's career and was instrumental in his sharing the 1995 Nobel Peace Prize with the Pugwash Conferences on Science and World Affairs, the organization he helped found in 1957 to work for the complete elimination of nuclear weapons.

After earning his doctorate in physics from the University of Warsaw in 1937, Rotblat moved to the United Kingdom in 1939 where he worked with James Chadwick at the University of Liverpool on the feasibility of atomic fission.. Having lost his family in his native Warsaw when the Nazis invaded Poland in September 1939, Rotblat soon moved with other émigré scientists to Los Alamos, New Mexico, to contribute to the Manhattan Project. Following his resignation from the project, he moved back to the United Kingdom where he took up positions as Director of Research in Nuclear Physics at the University of Liverpool (1945–1949) and then as Professor of Physics at the University of London (1950–1976), specializing in the medical applications of nuclear radiation.

From his early years working with Chadwick to his association with Bertrand Russell and Albert Einstein as a signatory of the famous 1955 Russell-Einstein Manifesto, which called on scientists to work for the abolition of warfare and nuclear weapons, Rotblat has dedicated his professional and personal life to exposing the fallacy of nuclear deterrence and arguing for the immorality and illegality of nuclear weapons. Because of the role of scientists in creating first the atomic and then the hydrogen bombs, Rotblat believed scientists had both moral and professional duties to ensure that such weapons would not be used against humanity. From the first Pugwash Conferences meeting held in Pugwash, Nova Scotia, in July 1957, to the 2003 Pugwash annual conference that returned to Nova Scotia, he worked tirelessly in calling upon the global scientific community to maximize only the beneficial applications of science and technology.

In his final speech as President of Pugwash in 1997, Rotblat reiterated the principle that led to his resignation from the Manhattan Project in 1944: "Many scientists are still not willing to face reality. Many discourage or actively hamper young scientists from being concerned with the social impact of science . . . Scientists have to realize that what we are doing has an impact . . . on the whole destiny of humankind" (Rotblat 1997, pp. 248–249). Still active in Pugwash and in the movement to eliminate nuclear weapons in his nineties, Rotblat has been a source of inspiration for several generations of scientists around the world with his fundamental belief in the promise of science and technology to improve the human condition and eliminate war as a social institution.

JEFFREY BOUTWELL

SEE ALSO *Atomic Bomb; Pugwash Conferences.*

BIBLIOGRAPHY

Hinde, Robert, and Joseph Rotblat. (2003). *War No More: Eliminating Conflict in the Nuclear Age*. London: Pluto Press.

Rotblat, Sir Joseph. (1967). *Pugwash: A History of the Conferences on Science and World Affairs*. Prague: Czechoslovak Academy Of Sciences.

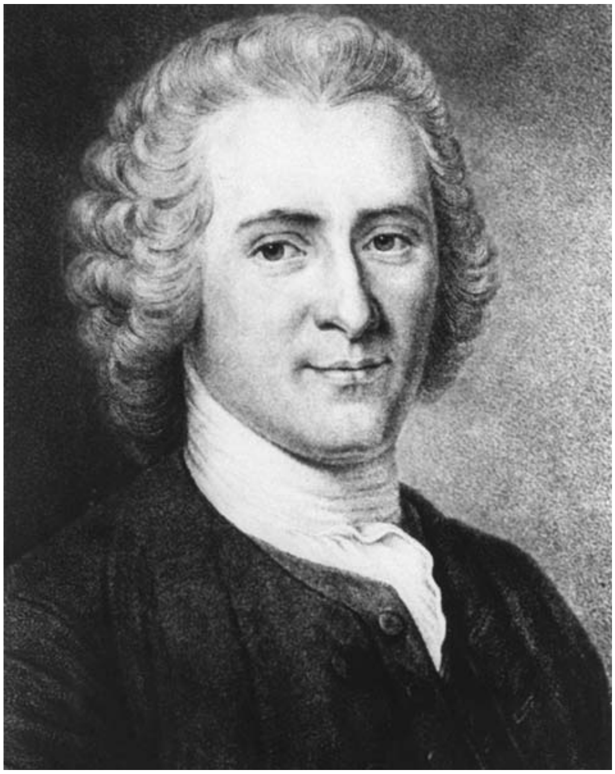
Rotblat, Sir Joseph. (1972). *Scientists in the Quest for Peace: A History of the Pugwash Conferences*. Cambridge, MA: MIT Press, 1972.

Rotblat, Sir Joseph, ed. (1998). *Nuclear Weapons: The Road to Zero* Boulder, CO: Westview Press.

ROUSSEAU, JEAN-JACQUES

Jean-Jacques Rousseau (1712– 1778), who was born in Geneva on June 28 and died on July 2 in Paris, was a self-taught genius who became the leading critic of the Enlightenment vision of an essential harmony between science and society, technology and ethics. As a mid-century member of a circle of intellectuals working on the *Encyclopédie*, a comprehensive attempt to synthesize scientific knowledge and technological skills for social utility, Rousseau's questioning nevertheless had the effect of contributing to the French Revolution and extending modernity.

Brilliant, intellectually disciplined, independent minded, and well-educated, Rousseau arrived in Paris in 1741 and proceeded to impress and become friends with some of the notable Enlightenment intellectuals, especially Denis Diderot (1713–1784) and Jean le Rond d'Alembert (1717–1783). Yet his independent free-thinking temperament found outlet in two prize-winning essays that attacked modern science, technology, enlightenment, and early modern political philosophy as undermining virtue and happiness: *The Discourse on the Arts and Sciences* (1750) subsequently called *The First Discourse*; and *The Discourse on the Origin and Foundation of Inequality Among Men* (1753), subsequently called *The Second Discourse*.



Jean-Jacques Rousseau, 1712–1778. The Swiss-born philosopher, author, political theorist, and composer ranks as one of the greatest figures of the French Enlightenment. *(AP/Wide World Photos.)*

The First Discourse waged war against the modern project as a dangerous dream, corrupt and corrupting in its origin, means, ends, and consequences. The essential features of the dream are fundamental yet simple: The universe is matter in motion, neutral, even hostile to humankind: It was neither created by God for, nor naturally ordered to, human good. Yet knowledge of a certain kind is possible (mathematical physics) and can constitute power over nature, render it predictable and hence controllable for human ends. The pursuit of human good, in turn, is to be guided by calculative, rational, enlightened self-interest ultimately oriented to peace, health, material prosperity, comfort, and bodily pleasure. The climactic scene is to be life in healthful longevity and pleasurable prosperity. There looms on the horizon the specter of universal gratification, even if by means of the scientific manipulation of human nature itself.

The core of Rousseau's response is that because scientific knowledge can be useful, the talented few may seek it with different motives and purposes. Some will be moved by pride, seeking honor, glory, and even tyranny. Others are ultimately moved by fear, especially of death as well as of pain and suffering. Yet desires for peaceful prosperity are but vain diversions from the hard facts of life, recognition of which is required for the possible achievement of true virtue and happiness.

The Second Discourse deepens the argument by suggesting that the root of the problem is reason itself. First, reason includes the human ability to compare oneself with others. This capacity makes possible pride, the love of self over all others. Thus reason contributes to the human selfishness that engenders tyranny. Second, reason can also construct ideas, even of time, and hence of the future. This ability of reason brings the idea of one's ultimate future to mind—that is, death and its terrors—and hence breeds the fear of death. Whereas reason had been previously considered natural to human beings and good, Rousseau argues that in some way it is neither.

Rousseau's argument rests on a reinterpretation of human history. Whereas Aristotle (384 B.C.E.–322 B.C.E.), for instance, considered human history to be cyclical, believers in the Bible saw history as providentially headed toward the end-time, and the moderns argued for history as human progress, Rousseau proposed that human history is in large measure decay from the natural goodness of an early time. From Rousseau's perspective, reason itself is an accidental, artificial acquisition that separates humans from our natural goodness, so that nurture becomes opposed to nature.

In this way Rousseau raised the question, Why reason or science? After all, he claimed, the purpose of science cannot be known by science. Neither can science answer the most important questions—Is life good and What is the good life?

Rousseau's own answer to this fundamental question may be sketched as follows: Tyranny not death is the greatest preventable evil; hence issues of justice and political philosophy are more important than science. Additionally, human sociability, virtue, and happiness are rooted less in reason than in the passions, particularly sentiments such as love, beauty, romance, and pity or sympathy and compassion. Hence, Rousseau's novels and memoirs such as *Julie, Or, The New Heloise* (1761) and *Emile: Or, On Education* (1762) contain striking portraits of the loving, romantic couple; the joys of family life; the sense of community in the tribe or nation; as well as the pleasing sentiment associated with life itself.

As fundamental and coherent as Rousseau's attack on and attention to science and enlightenment may be, he was—and remains—a paradoxical, if not contradictory, teacher. Alongside attacks on reason are to be found high praise of Isaac Newton (1642–1727), René Descartes (1596–1650), and especially Francis Bacon (1561–1626) as the preceptors of the human race. Socrates (c. 470 B.C.E.–399 B.C.E.) (or Plato [428 B.C.E.–347 B.C.E.]) is his self-proclaimed master, as a genius moved by pure not vain curiosity. Moreover, Rousseau did not live the life he taught as good. He philosophized while directing others to find happiness in noble sentiments.

Perhaps these tensions may be explained by Rousseau's vision of the human as a complex being oriented to conflicting goods: the goods of the body and of the soul, of the community and the individual, of life and truth, and, moreover, of the good of the few, theoretical pursuits, and the good of all others, practical pursuits, of theory and practice. The least one can conclude is that perhaps Rousseau took his stand as a middle-man, as the in-between being, as philosopher also concerned with the happiness of humankind, and, as such, forged his own place among the future teachers of the human race. Certainly many of the questions he raised have subsequently become themes in on-going discussions of science, technology, and ethics, even when they are not always explicitly referenced to Rousseau.

LEONARD R. SORENSON

SEE ALSO *Education; French Persepctives; Nature; Social Contract.*

BIBLIOGRAPHY

Masters, Roger D. (1968). *The Political Philosophy of Rousseau*. Princeton, NJ: Princeton University Press. A comprehensive account of Rousseau's complexity through the lens of his political philosophy.

Masters, Roger, and Christopher Kelly, eds. (1990–present). *The Collected Writings of Rousseau*. Hanover, NH: University Press of New England.

Melzer, Arthur M. (1990). *The Natural Goodness of Man: On the System of Rousseau's Thought*. Chicago: University of Chicago Press. Argues for the unity of Rousseau's thought in his notion of natural goodness.

Scott, John T. (1992). "The Theodicy of the Second Discourse: The Pure State of Nature and Rousseau's Political Thought." *American Political Science Review* 81: 696– 711.

Sorenson, Leonard R. (1990). "Natural Inequality and Rousseau's Political Philosophy in his *Discourse on Inequality*." *The Western Political Quarterly* 763–788. Proposes that Rousseau cannot be understood without a full account of his vision of philosophy.

Sorenson, Leonard R. (1992–1993). "Rousseau's Socratism." *Interpretation* 20: 135– 155.

Strauss, Leo. (1947). *Natural Right and History*. Chicago: University of Chicago Press. Explains the practical intent and consequences of Rousseau's teaching.

Strauss, Leo. (1947). "On the Intention of Rousseau." *Social Research* 14: 455–487. Explores the theoretical intention of Rousseau.

Velkley, Richard, L. (2002). *Being After Rousseau: Philosophy and Culture in Question*. Chicago: University of Chicago Press. A fine account of Rousseau's influence on Kant and Heidegger.

ROYAL COMMISSIONS

Royal Commissions, or commissions of inquiry, are part of the executive arm of some Commonwealth governments that are rooted in the British parliamentary system. Their main function is to inform the government and often to deal with broad topics of social, cultural, or economic importance. The reports of Royal Commissions, whether interim or final, are tabled before a nation's parliament and regularly released as parliamentary papers.

Formation and Composition

In the United Kingdom a Royal Commission consists of three or more (usually five) Commissioners, including the Lord Chancellor, who are privy counselors appointed by letters patent to perform certain functions on the queen's behalf (United Kingdom Parliament 2003). Canadian or Australian counterparts sometimes produce minority reports that are more significant than the majority findings (Canadian Press Newswire 1996).

The 1868 Inquiries Act in Canada initiated a process by which Royal Commissions could be appointed by the cabinet to carry out full and impartial investigations of specific national problems. The terms of reference for the commission and the powers and names of the commissioners are stated officially in an order-in-council. The findings are reported to the cabinet and the prime minister for appropriate action. The names of commissions usually refer to the chair or commissioners. An example is the Royal Commission on National Development in the Arts, Letters, and Sciences, which was named the Massey Commission after Vincent Massey, who chaired it from 1949 to 1950 ("Index to Federal Royal Commissions" 2003).

Australia and New Zealand have implemented Royal Commissions as a means to find out facts. As in all other jurisdictions Royal Commissions in those countries are given special powers to compel the attendance of witnesses, compel the production of documents, and give special privilege to persons who give evidence before the commission so that they cannot be prosecuted or subjected to subsequent legal actions (Fitzsimmons 2003).

Scientific, Technological, and Ethical Issues

Royal Commissions have been used frequently to deal with significant scientific, technological, and ethical issues. New Zealand established the Royal Commission on Genetic Modification to develop suggestions for a new regulatory structure for its agri-food (agribusiness) sector. That commission looked for possible strategies for co-managing the range of interested parties involving new corporatist and managerial dimensions of food governance (Le Heron 2003). The Australian Aboriginal Deaths in Custody Commission, which sat from 1987 to 1991, made 339 recommendations in an attempt to prevent more deaths (Fitzsimmons 2003).

Canada's 1989 Royal Commission on New Reproductive Technologies was established to act as the official forum for public deliberation on a complex issue. According to Francesca Scala (2002), the commission showed great promise for defining questions of infertility treatment and related scientific research questions and matters of public concern. Scala argues, however, that the commission's stance in favor of reproductive technologies resulted from the government's capitulation to the powerful interests of the biomedical industry.

Controversies

At their best Royal Commissions are seen as independent bodies that allow for significant public input. They are, however, not without controversy and often are used by governments to gain breathing room on controversial issues, with costs running into the tens of millions of dollars and reports that take years to produce, with no obligation on the part of the government to act on those recommendations.

The Royal Commission on New Reproductive Technologies was launched in 1989 and released its final report in 1993. It received advice from 40,000 individuals and organizations with an interest in the matter (Wood 2002). After expenditures of more than $30 million the bottom line recommendation was that Canada needed laws to govern reproductive and genetic technologies (RGT). As a result the federal government placed a moratorium on nine controversial issues, including sex selection, human embryo cloning, and the buying and selling of eggs, sperm, and embryos. The resulting introduction of Bill C-47 died on the on the order table when the 1997 election was called. The second attempt to create RGT laws, Bill C-247, failed during its second reading in the Canadian parliament.

The Massey Commission in Canada submitted 146 recommendations under eight headings. As a result of those recommendations a federal scientific research policy was created, the National Library (now Library and Archives Canada) was created, actions were taken to create the Natural Sciences and Engineering Research Council and the Social Sciences and Humanities Research Council, and additional resources were provided to support universities as well as students. The impact of the commission's recommendations continues to affect research communities across Canada more than fifty years after the publication of its report.

The Royal Society of New Zealand considered the Royal Commission on Genetic Modification to be part of an effort "promoting excellence in science and technology" (Royal Society of New Zealand). The commission provided a forum for the submission of reports from a diverse range of sources that included the Maori

Congress, Friends of the Earth, New Zealand Biotechnology Association, Human Genetic Society, Grocery Marketers Association, Quakers, Anglicans, DuPont, CarterHolt, and Greenpeace.

Despite criticism regarding costs, political diversion, and lack of direct influence on final decisions, Royal Commissions often provide vital material for long-range policy decisions and are valuable as vehicles for consciousness-raising (O'Malley 2002). Ted Hodgetts, a retired political science professor who worked on Royal Commissions, stated that it sometimes takes years to measure a commission's value, particularly if a commission deals with longer-term arrangements. However, through the process of osmosis and seepage, the ideas enter the general discourse.

Royal Commissions maintain an arm's-length distance from the government of the day and provide impartiality and great inclusively of ideas, especially for ideas and opinions that do not correspond to the dominant political ideology. They generally avoid getting bogged down in party politics, as occurred with the hearings dealing with former U.S. President Bill Clinton's involvement in the Whitewater land deal and the raid on the Branch Davidian compound in Waco, Texas (Canadian Press Newswire 1996). Their usefulness in dealing with complex societal, scientific, technological, and ethical issues probably will continue far into the future.

PETER LÉVESQUE

SEE ALSO *Bioethics Committees and Commissions;Enquete Commissions*.

BIBLIOGRAPHY

Harrison, Barry. (2002). "A Comparative Examination and Assessment of National Study Commissions (Canada, United States)." Ph.D. diss., West Virginia University, Morgantown, WV.

Le Heron, Richard (2003). "Creating Food Futures: Reflections on Food Governance Issues in New Zealand's Agri-Food Sector." *Journal of Rural Studies* 19(1): 111–125.

Scala, Francesca. (2002). "Experts, Non-Experts, and Policy Discourse: A Case Study of the Royal Commission on New Reproductive Technologies." Ph.D. diss. Carleton University, Ontario, Canada.

INTERNET RESOURCES

Canadian Press Newswire. (1996). "Litigation Slows Inquiries, Raising Questions about Their Effectiveness: Instead of Giving Answers, Some Royal Commissions Create Questions." Available at http://www.dialogweb.com/servlet/logon?Mode=1

Fitzsimmons, Hamish. (2003). "Royal Commission Effectiveness Questioned." ABC Online. Available at http://www.abc.net.au.

"Index to Federal Royal Commissions." National Library of Canada. Available at http://www.nlc-bnc.ca/7/6/g6-120-e.html.

O'Malley, Martin. (2002). "An Inquiry into Inquiries." CBC News Online. Available at http://www.cbc.ca/news/indepth/background/royal_commissions.html.

Royal Society of New Zealand. (2003). "The Royal Commission on Genetic Modification." Available at http://www.rsnz.govt.nz/.

United Kingdom Parliament. (2003). "Royal Commissions." Available at http://www.parliament.the-stationary-office.-co.uk/pa/ld.htm.

Wood, Owen. (2002). "Laws: Reproductive Technologies." CBC News Online. Available at http://www.cbc.ca/news/indepth/background.html.

ROYAL SOCIETY

Dating itself from 1660, the Royal Society of London originated with informal gatherings that began fifteen years earlier and then received its Royal Charter in 1662 as one of the first institutions devoted to the advancement of science. It has been the model for many scientific organizations formed since, not only in the United Kingdom but throughout the world. An independent charitable organization whose members have been selected for their eminence in the fields of science, technology, or medicine since the middle of the eighteenth century, the Royal Society was historically influential in establishing the processes of science and the scientific method as we understand them today.

Historical Impact

From the earliest days of the Society, religious or political affiliation was not a membership criterion. In principle, anyone could be a member; there was even a membership category for foreign nationals. In practice, however, the difficulties of travel kept many potential members from joining a group that met weekly in London, and membership fees were steep enough to exclude many others. In addition, lack of government financing spurred the Society to seek members from the upper social strata who presumably would be generous with their support. This may have inhibited lower-ranked individuals from joining a group that set a high social tone (Hunter 1982). Moreover, it has been suggested that the evolving criteria used for establishing scientific credibility deliberately excluded women and people of color (Harraway 1997). It was not until 1945 that the first woman was elected to the Fellowship. It was not until the tail end of the twentieth century that programs addressing diversity issues were put in place.

Henry Oldenburg (1615–1677), a man of German birth, was the first secretary of the Society (from 1660 to 1677), and as such became responsible for soliciting reports from around the world for publication in the *Philosophical Transactions of the Royal Society*, the oldest science journal still in publication. He was also instrumental in devising methods to secure works against plagiarism, a common problem of the day. These processes were precursors of contemporary notions of peer review and the credit due the first to publish a result. Moreover, in assessing the credibility of reports received, the Royal Society played a central role in establishing scientific norms for impartiality and absence of bias.

The inductive method as expressed by Francis Bacon (1561–1626) was the source of inspiration for many early members of the Society, including Robert Boyle (1627–1691) and Sir Isaac Newton (1642–1727). Adherents to this method proceed by gathering facts through experimentation and observation and then using such collected facts to infer general relationships. Boyle, one of the founding members, was instrumental in defining the experimental method, developing procedures for conducting, validating, documenting, and interpreting experiments. Newton served from 1703 to 1727 as the twelfth president of the Royal Society, the first scientist to hold the title.

Given the lack of external funding and the consequent need to solicit membership from the aristocracy, it was not until the 1800s that membership became the province of professional scientists. During this timeframe the government increasingly looked to the Royal Society for advice on matters of science and technology—a relationship that continues into the twenty-first century. The Royal Society also became increasingly successful in gaining government support for scientific expeditions, particularly to the Arctic and Antarctic. In mid-century, the government initiated a yearly science research grant program, the funds of which were administered by the Royal Society.

This century also saw increasingly successful efforts by the Royal Society to influence the legislative process. One notable example was an effort to modify the proposed language of the Cruelty to Animals Act of 1876, which would have eliminated experiments using animals not directly related to "saving or prolonging human life, or alleviating human suffering." The bill in its original form would have absolutely prohibited the use of dogs or cats in research. As passed, the prohibition against experimentation on cats and dogs was removed and restrictions generally loosened, though a license and inspection process was put in place (Hall 1984).

Recent Impact

At the beginning of the twenty-first century, the goals of the Society are to "push back the frontiers of knowledge and to improve the quality of life in Britain and globally" (Royal Society 2005). The Society continues to publish the *Philosophical Transactions* as well as other peer-reviewed science publications, and rewards achievement through induction of new Fellows and by bestowing medals and other awards to deserving individuals. The Society also acts as the United Kingdom's Academy of Science, providing scientific advice on science policy issues such as funding, and on public policy issues with a scientific or technical component such as cloning. It further represents UK science internationally. The Society continues to act as a funding agency, providing grant support to researchers as well as resources for science and math teachers.

ETHICS OF SCIENCE. The Royal Society does not have a written ethics policy, though the "quality of life" clause in the Society's mission statement could be taken for the beginnings of one. The statutes of the society allow for expelling a Fellow for conduct injurious to the character or interests of the Society.

During his 2004 Anniversary Address to the Society, Lord Robert May, its president, addressed the work the Society had done over the previous year in assessing scientific rules of conduct, specifically in regards to biological research. Among a variety of other issues, May noted his concerns about the peer review process, the unwillingness of some to consider other scientific views, and publication policies.

SCIENCE IN SOCIETY. In 1985, the Royal Society published a report on the public understanding of society that took the view that the general public did not know enough about science to make informed decisions and that more education was needed to correct this. However, given the negative reaction to the handling of science issues since then, including public concerns about genetically modified foods, the Society's approach to policy issues that affect the public has changed.

One outcome of this change was the establishment of a Science in Society program. This program has several components, one of which, the Dialogue initiative, is set up as a series of workshops between scientists and people of all walks of life. The purpose of these workshops is to develop consensus recommendations on topics of science or technology. The Royal Society carries these recommendations forward to the appropriate policy makers. Recent topics included trust in science, genetic testing, and cybertrust and information security.

Another component of the Science in Society program is a scheme whereby individual Members of Parliament (MPs) and a scientist from their district are paired up and allowed to experience each other's world. The scientists are briefed on the workings of government and accompany their MP during their daily activities. The MPs reciprocate by spending time in the scientist's laboratory. The aim is to both establish mutual understanding as well as to develop relationships.

SCIENCE POLICY. Each year, the Society provides reports on a wide variety of policy issues. In early 2005, the major policy topics included animals in research, bioweapons, climate change, the military use of depleted uranium, the environment, stem cells and cloning, nanoscience and nanotechnology, infectious diseases in livestock, humans in research, and genetically modified plants.

Increasingly these reports include sections summarizing societal concerns and the various ethical viewpoints held by stakeholders. Generally these reports do not choose a specific ethical standpoint; leaving that to society and the legislative process, but there are exceptions. For example, the 2003 report *Measuring Biodiversity for Conservation* takes the view that as a minimum "each generation should pass on a set of opportunities no less than what itself inherited."

RUTH DUERR

SEE ALSO *American Association for the Advancement of Science; National Academies; Newton, Issac.*

BIBLIOGRAPHY

Atkinson, Dwight. (1999). *Scientific Discourse in Sociohistorical Context: The Philosophical Transactions of the Royal Society of London, 1675–1975*. Mahwah, NJ: Lawrence Erlbaum. A rhetorical and multidimensional analysis of the contents of the Philosophical Transactions and how that has changed over the life of the Royal Society.

Hall, Marie. (1984). *All Scientists Now: The Royal Society in the Nineteenth Century*. Cambridge, UK: Cambridge University Press. Recounts the history of the Royal Society during the period where it transitioned from a society consisting largely of wealthy amateurs to its modern form where membership is selected based on scientific distinction.

Haraway, Donna J. (1997). *Modest-Witness@Second-Millennium.FemaleMan-Meets-OncoMouse: Feminism and Technoscience*. New York: Routledge.

Hunter, Michael. (1982). *The Royal Society and its Fellows 1660–1700: The Morphology of an Early Scientific Institution*. Bucks, UK: The British Society for the History of Science. A scholarly analysis of the membership and activities of the Royal Society during its formative years.

Hunter, Michael. (1989). *Establishing the New Science: The Experience of the Early Royal Society*. Woodbridge, UK: Boydell. A series of essays on the activities and problems faced by the Royal Society during its early years.

Purver, Margery. (1967). *The Royal Society: Concept and Creation*. London: Routledge and Kegan Paul. A scholarly assessment of the activities that led to the formation of the Royal Society.

Royal Society of London. (1985). *The Public Understanding of Science*. London: Author.

Royal Society of London. (2003). *Measuring Biodiversity for Conservation*. London: Author.

INTERNET RESOURCE

Royal Society of London. (2005). Available from http://www.royalsociety.org/. A good overview of the Royal Society, its history, and current activities.

RUSSELL, BERTRAND

Bertrand Arthur William Russell (1872–1970) was a British philosopher, logician, mathematician, and essayist as well as a champion of humanitarian ideals and influential critic of nuclear weapons. Best known as one of the founders of analytic philosophy, Russell was born into an aristocratic family in Trelleck, Monmouthshire, Wales, on May 18. In 1890, he entered Trinity College, Cambridge, where he later held a professorship until he was dismissed in 1916 for writing pacifist propaganda and leading anti-war protests. Russell then traveled, lectured, and continued to write both philosophical treatises and social and moral essays. He rejoined the faculty at Trinity College in 1944 and received the Nobel Prize in Literature and the British Order of Merit in 1950. After World War II, he became a leading figure in the effort to control nuclear weapons proliferation. Russell died at Penrhyndeudraeth, Wales, on February 2.

Logic, Mathematics, and Philosophy

Through his early examination of the philosophy of G. W. Leibniz, Russell became convinced that logical analysis is the most important method for philosophical investigation. So motivated, he set about the tasks of

Bertrand Russell, 1872–1970. The Welsh mathematician, philosopher, and social reformer made original and decisive contributions to logic and mathematics and wrote with distinction in all fields of philosophy. *(The Library of Congress.)*

making logic a more robust and powerful field and clearing away conceptual difficulties that had impeded its progress. One such difficulty was posed by a paradox that Russell himself discovered in 1901: The set of all sets that are not members of themselves is a member of itself if and only if it is not a member of itself. Russell's Paradox undermined naïve set theory, which served as the foundation of mathematics. Russell's own solution to the paradox was his theory of types of sets, which led to the foundation of modern axiomatic set theory. In his seminal work, *Principia Mathematica* (1910–1913), written jointly with Alfred North Whitehead (1861–1947), he attempted to derive all of mathematics from a restricted set of logical axioms. Although undermined by Gödel's proof that some propositions in any axiomatic system of suitable complexity remain undecidable, the formal system was a major intellectual achievement.

Along with G. E. Moore (1873–1958), Russell is credited with founding analytic philosophy, which rejected idealism and what is regarded as meaningless or incoherent philosophy in favor of clear and precise propositions. For Russell the application of analytic methods to traditional philosophical problems could resolve long-standing disputes. For example, in "On the Relations of Universals and Particulars" (1911) he claimed that logical arguments could resolve the ancient problem of universals. Among his most important contributions to the philosophy of language is his "theory of descriptions" expounded in "On Denoting" (1905). Russell was also a teacher of Ludwig Wittgenstein (1889–1951), the founder of that version of analytic philosophy known as linguistic philosophy, who later eclipsed his mentor in terms of philosophical importance. Karl Popper (1902–1994) and W. V. Quine (1908–2000) were also heavily influenced by Russell, and in fact Popper once referred to him as "the greatest philosopher since Kant" (1976, p. 109).

Science and Technology in Society

In his autobiography (1967–1969), Russell divulged that he was moved by a profound sympathy for the suffering of humankind. This motivated him to write about political and moral issues and to practice social activism. His ethical writings include *Why I Am Not a Christian* (1927) and *Marriage and Morals* (1929), both of which aroused popular antipathy. In fact, he lost a lectureship at City College in New York in 1940 because he was deemed "morally unfit" to teach. Russell's experiments in social and political activism included peace protests during World War I (for which he served six months in jail), three unsuccessful campaigns for a seat in Parliament, and founding and operating an experimental school from the late 1920s to the early 1930s. He also served as president of the International War Crimes Tribunal in 1967, which investigated the conduct of the United States during the Vietnam War.

Russell's views about the role of science in society are outlined in such works as Icarus, or the Future of Science (1924), in which he fears "that science will be used to promote the power of dominant groups, rather than to make men happy. Icarus, having been taught to fly by his father Daedalus, was destroyed by his rashness. I fear that the same fate may overtake the populations whom modern men of science have taught to fly" (p. 1).

In *The Impact of Science on Society* (1951) Russell discussed the potential for science to be utilized for mass psychological propaganda, and he made an unsettling observation about the potential for biological warfare to limit human population growth. In a 1958 essay, "The Divorce between Science and 'Culture'," he argued that governments and citizens must have better science education in order to avoid the potential disasters presented by modern science and technology.

Although he maintained a general optimism about science, including some controversial applications, Russell was concerned about a cultural lag in which human knowledge was expanding more quickly than the ability to utilize it wisely. Nowhere was this concern more evident than in his efforts to fight nuclear weapons and their international proliferation. The opening lines of "The Bomb and Civilization" (1945) expressed both his faith in science and his panic about how science can be easily misused: "It is impossible to imagine a more dramatic and horrifying combination of scientific triumph with political and moral failure than has been shown to the world in the destruction of Hiroshima." It should be noted, however, that while the United States still had a monopoly on nuclear arms, Russell advocated a preemptive war against Stalin, whom he argued was as evil as Hitler (Johnson 1989).

In 1954 Russell delivered his "Man's Peril" broadcast on the BBC, condemning the hydrogen bomb test at Bikini Atoll. The following year Russell and Albert Einstein issued the Russell-Einstein Manifesto, which called for a conference of scientists to discuss "what steps can be taken to prevent a military contest of which the issue must be disastrous to all parties?" This manifesto stimulated the first Pugwash Conference on Science and World Affairs in 1957.

In 1958, Russell became the founding president of the Campaign for Nuclear Disarmament (CND), which promoted nonviolent demonstrations to eradicate nuclear weapons and other weapons of mass destruction. In 1961 (at age 89), he was imprisoned for one week in connection with anti-nuclear protests. Two years later, he established the Bertrand Russell Peace Foundation, to promote his vision of peace, human rights, and social justice. Russell's last essay, "1967," took up the immanent doom presented by nuclear weapons in the scenario of obstinate sovereign states and argued that the only solution is to realize that "peace is the paramount interest of everybody."

CARL MITCHAM
VOLKER FRIEDRICH

SEE ALSO *Atomic Bomb; Haldane, J. B. S.; Pugwash Conferences.*

BIBLIOGRAPHY

Johnson, Paul. (1989). *Intellectuals*. New York: Harper and Row. Exposes the hypocrisies in the private lives of several intellectuals. The pertinent section on Russell is pp. 204–207.

Popper, Karl. (1976). *Unended Quest: An Intellectual Autobiography*, rev. edition. LaSalle, IL: Open Court.

Russell, Bertrand. (1903). *Principles of Mathematics*. London: Cambridge University Press.

Russell, Bertrand. (1905). "On Denoting." In *Mind*, Vol. 14. Reprinted in Bertrand Russell, 1973, *Essays in Analysis* (London: Allen and Unwin).

Russell, Bertrand. (1911). "On the Relations of Universals and Particulars." *Proceedings of the Aristotelian Society* 12: 1–24. Reprinted in Bertrand Russell, 1956, *Logic and Knowledge* (London: Allen and Unwin).

Russell, Bertrand. (1924). *Icarus, or the Future of Science*. New York: E.P. Dutton.

Russell, Bertrand. (1927). *Why I Am Not a Christian*. London: Watts.

Russell, Bertrand. (1929). *Marriage and Morals*. London: George Allen and Unwin.

Russell, Bertrand. (1951). *The Impact of Science on Society*. New York: Columbia University Press.

Russell, Bertrand. (1967, 1968, 1969). *The Autobiography of Bertrand Russell*, 3 vols. London: George Allen and Unwin.

Whitehead, Alfred, and Bertrand Russell. (1910–1913). *Principia Mathematica*, 3 vols. Cambridge: Cambridge University Press.

INTERNET RESOURCES

Russell, Bertrand. (1945). "The Bomb and Civilization." *Glasgow Forward* 39(33): 1, 3. Available from: http://www.humanities.mcmaster.ca/~russell/brbomb.htm#table

Russell, Bertrand. (1967). "1967," Available from: http://www.humanities.mcmaster.ca/~russell/bressay.htm

RUSSIAN PERSPECTIVES

Russian perspectives on science, technology, and ethics come from two sources: those outside and those inside Russia. Because of the historical impact of the Communist Revolution of 1917, the absorption of Russia into the Soviet Union (1922–1991) for much of the twentieth century, the role of Marxism as the official Soviet ideology, and a strong expatriate intellectual community, scholars outside Russia have created a substantial body of literature analyzing Russian-Soviet-Marxist-Communist perspectives on science and technology, including much related to ethics. While referencing some of this literature, the present entry nevertheless emphasizes discussions as they have developed within Russia itself.

Russian discussions of ethics in relation to science and technology have exhibited both strong positivist commitments to scientific and technological progress and equally vigorous criticisms of science and technology as destructive of traditional Russian values. A brief introduction to these discussions, emphasizing technology, may be divided into three periods: pre-Soviet, Soviet, and post-Soviet. The post-Soviet period has revived and extended some perspectives prominent during the pre-Soviet period.

Originating Discussions

Pre-Soviet Russian history may be divided from the point of view of the scientific and technological progress into three major periods. The first runs from the invasion of the legendary Scandinavian warrior Rurik in the 800s through Mongol (or Tartar) invasions in the 1200s to the rise of Ivan the Terrible in the 1500s and then to the beginning of the Romanov reign in the 1600s. The second takes place during the reign of Peter the Great (1682–1725). In his lifetime, two special schools for training engineers were established, the Engineering School in 1700, and the Mathematical-Navigation School in 1701. Peter the Great introduced engineering training into the Naval Academy, regimental schools, and even religious colleges. He founded the St. Petersburg Academy of Sciences in 1724. As the great modernizer of Russia, it was Peter who brought modern science and technology into the motherland, and thus it was during this second period that discussions relevant to science, technology, and ethics increasingly came to the fore.

The third period begins from the foundation of the first high engineering schools and runs to the Communist Revolution (1917). In 1809, the Institute of the Corps of Engineers of Rail Transport was set up in Russia for theoretical training for engineers and higher technological education. At that time, many vocational and secondary technical schools had already been transformed into higher technical schools and institutes. The Technological Institute in St. Petersburg, for example, had been created in 1862 as a school for foremen from the lower social strata, such as peasants and artisans. In Moscow, a Higher Technical School was established in 1868 following the reorganization of a vocational school (dating from 1830). These new higher educational establishments concentrated on the theoretical side of their curricula (Gorokhov 1998).

One of the most important contributors to such discussions was the Russian engineer Peter K. Engelmeyer (1855–1942). Engelmeyer's positivism is evident in the following words: "Our nineteenth, technological century is . . . the century of unprecedented conquest of the forces of nature. Technology has conquered for us space and time, matter and power, being the power itself that irrepressibly turns the wheel of progress" (Engelmeyer 1898, p. 6). For Engelmeyer the technological worldview dominated the nineteenth century because of an inward tendency of European culture to address real problems with real power. The genius of humanity over the previous two centuries had constructed a human-made microcosm within the larger natural one, making it possible for human beings to satisfy their physical needs to an extent previously unknown. Because of this Engelmeyer saw engineers as the leaders or technological elite in society, and argued for a new system of engineering education to promote the realization of this ideal. The emergence of technocracy in the twentieth century revealed how "efficient" such societal management can be. But it was difficult to anticipate the unintended consequences of this boundless scientific and technological progress, especially in the military sphere.

During this same period Russia was also home to an opposed school of religious and cultural criticism of technology. Sergei N. Bulgakov (1871–1944), in an article titled "The Main Problems of the Theory of Progress," published in 1902, emphasized that in the twentieth century technological change was becoming a kind of theology. By means of modern technology all people of the future were supposed to be happy, proud, and free. To bring happiness to as many people as possible was taking the form of a super modern religion in which society equipped with technological knowledge played the role of God. But according to Bulgakov such technological optimism, which tries to create a material heaven on Earth and even obtain cosmic power, inevitably leads to immoral practices. Technology begins to dominate human beings rather than serve them, making them not happy but miserable. The state, having become the patron of science and technology, inevitably begins to demand that science and technology serve economic and military ends.

During the Soviet Period

In the seven decades from the Communist Revolution to the collapse of the Soviet Union, science and technology were treated in two different ways. On the one hand, they were given unquestioned ideological support; socialism itself was said to be scientific and to provide the strongest support for technology. On the other, political interference in both science and technology compromised their autonomy and efficiency.

The common view in the West that this was simply a corruption of science and technology has been challenged by, for instance, Nikolai Krementsov (1997). Krementsov distinguishes the period of the initial Stalinization of science (1929–1939), its achievements during World War II and up to Joseph Stalin's death (1940–1953), and the post-Stalin consolidation. For Krementsov, Soviet science was "big science" that, as in the United States, it involved a convergence of party-state agencies and the scientific community. Its dramatic achievements—from the atomic and hydrogen bombs (1949 and 1953) to *Sputnik I* (1957)—should not be overlooked. Even in areas of health and medicine Soviet science realized important human benefits. As Vadim J. Birstein (2001) and others have documented, however, science was also used to experiment on human beings; like scientific experimentation that amounts to torture anywhere, this presents a major challenge to the ethics of the scientific community.

> Yet from the beginning of the 1930s, the general ideological atmosphere in the Soviet Union radically changed; from now on the only way to create the new human being was to be sought not in biological, but in social changes. . . . Meanwhile a lot of medical research done in the Soviet Union sometimes posed ethical and legal problems. The first attempt on the part of the authorities to regulate medical research took place in 1936. Narkomzdrav [the name of the Ministry of Health at that time] of the Russian Federation issued regulations determining the conditions of testing new medical devices and methods, which could be dangerous to the health and life of patients. . . . These rather progressive regulations, however, were issued at the same time, when in the depths of the KGB, the secret "Laboratory X" worked on the creation and testing of toxic substances. . . . There are some indications that the laboratory tried to create toxins which could be impossible to detect after victim's death; these substances were tested on prisoners." (Yudin 2004)

During the post-Stalin era impressive attempts were made to adopt cybernetics in order to deal with the emerging problems of a command model of science and technology policy. Additionally, the theory of a new Scientific Technology Revolution (STR) that integrated science and technology anticipated by decades Western European notions of technoscience—and sought to maintain a close link between technoscience and social values.

Among the most insightful non-Russian scholars of Russian science and technology in relation to questions of ethics and politics is Loren R. Graham. In *What Have We Learned about Science and Technology from the Russian Experience?* (1998), he summarizes a life of research on this topic. Although he admits that this short book is more about science and technology than Russia, it nevertheless draws useful conclusions about science and technology in Russia. According to Graham,

> The enormous Soviet scientific establishment, the world's largest, performed rather well in many areas, provided for the nation's military strength, and supplied most of the needs of heavy industry. But it did not do so well in terms of intellectual breakthroughs or outstanding achievements. . . . Political freedom may not be as necessary for the development of natural science as many of its advocates have claimed, but a combination of political freedom and generous financial support *are* necessary for the most creative achievements. One of the tragedies of Russian history is that science there has never enjoyed both financial support and political freedom, either under the Soviet system or today, although, in chronological sequence, it had first the one and then the other. (pp. 132–133)

Another tragedy, however, is the degree to which despite all the rhetoric about their socialist-humanist character under Communism, from the 1930s through the 1980s Soviet science and technology was also deeply antihuman and destructive of the environment.

Post-Soviet Discussions

One major reason for the collapse of the Soviet Union was its failures in regard to the development of an ethics of science and technology that was anything more than their simple promotion for political purposes. The ideology that science and technology might perfect the future of humanity makes no difference to the happiness of the present generation. Indeed, the contemporary squandering of natural resources and contamination of the environment are sacrifices of the future as well as the present, and call for the response of a new ethics (Danilov-Danilian 1999). It is just such a felt need to rethink the uses of science and technology that has led to a reconsideration of the ideas of some of those who were driven out of Russia by the Soviet regime.

One of these thinkers whose ideas have been resurrected is Nikolai Berdyaev (1874–1948). From the 1930s Berdyaev argued that the domination of technology would destroy the person and lead inevitably to dehumanization. To struggle against the hegemony of technology was thus necessary to save humanity. Once everything can be transformed or constructed then this power will be applied even to the human psyche. This precisely was embodied in the unprecedented program for the remolding of the people from the capitalist past in the forge of socialist reconstruction (Gorokhov 1992).

For Berdyaev technology is dehumanizing because it opposes the humanistic ideals of Renaissance culture. But Renaissance ideals also place human beings in an antagonistic relationship with the environment. The main contradiction of contemporary technological civilization is that modern technology creates unprecedented opportunities for human beings to invent needs and wants, which are then satisfied by destroying the natural world. Berdyaev sees the basic problem as a split between indifferent and apocalyptic attitudes toward technology. The former interprets technology as a personal matter of inventors and engineers, and assumes no responsibility for the results of human activity. The latter interprets technology as anathema, the triumph of the Antichrist. But neither response is satisfactory. One contemporary alternative has been the Russian "cosmicism" (Stepin 2002), which "opposes physicalist thinking in order to develop ideas of unity between human beings and the cosmos," both in religious and natural scientific terms.

Along with the work of Berdyaev, the thought of Bulgakov has also once again become important in Russia. Although he was educated initially as an economist with Marxist sympathies, Bulgakov's studies of agrarian life led him to criticize Marxist proposals for the centralization of agriculture. Then in the early 1900s, after a religious crisis, he rejected Marxism completely in favor of a "sophiological" interpretation of Russian orthodoxy and undertook studies for the priesthood. After teaching political economy and theology at a university in the Crimea, in 1922 he was exiled from Russia and eventually took part in establishing the Institute of Orthodox Theology (St. Sergius Theological Institute) in Paris, where he remained until his death.

For Bulgakov human beings must accept their own nature as well as the natural environment as given. To reject either nature is to invite disaster, personal or environmental. To live with the impression of their ever-increasing power may open boundless vistas for "cultural creativity," but it also places humans in increasing danger. The way out of the antagonism between economic activity based on scientific research into the mechanisms of nature and nature itself is the gradual "digestion" of the human-made back into the natural. Bulgakov's philosophy stimulates discussions of low-waste and environmentally friendly technology, as has indeed been the case in Russia during the early 2000s—although against the background of the triumphant march of technological civilization, such an appeal remains the voice of one crying in the wilderness. Yet contemporary efforts to develop a theory of sustainable development correlates to a great extent with the ideas of Bulgakov.

In post-Soviet Russia it is thus common to argue that there are limits to scientific and technological progress. It is not possible to realize, implement, or produce only what is planned, designed, and projected in scientific forecasts; not all the negative effects of the technological activity can be accurately projected. It is only possible to foresee certain risks with new scientific technologies. But this requires the development of moral responsibility in science and professional ethics in engineering. Yet the invention of nuclear weapons and other large-scale technologies has also revealed the limits of individual ethical responsibility for those operating in sociotechnical systems (*Inshenernaja etika* 1998). In biotechnology and genetic engineering there is also a need to develop a scientific and engineering ethics that would guide natural scientific and engineering research (Frolov and Yudin 1989).

An increasing interest in environmental ethics has thus become a significant part of Russian discussions. No longer can humans trust in the power of nature to take care of itself.

> The natural mechanisms are not sufficient at present to preserve the biosphere. New methods for regulations, based on the understanding of natural processes and to some degree also the management of such processes, are required. Anthropogenic regulation can forestall natural cataclysms and decrease the speed of dangerous processes. We must choose between immediate profit and long-term revenues in the usage of natural resources. (Marfenin 2000, p. 8)

In Russia there is concern that when human beings are too eager to dominate nature with science and technology, they may destroy nature and, at the same time, their ongoing economic growth. When humans threaten the biosphere as a whole they also threaten human society. The alternative is a new paradigm in science and technology based on an equal partnership between humans and the environment (Danilov-Danilian and Losev 2000).

Such critical reflections point toward the need for ethical assessments of science and technology. In the words of Stepin again:

> Scientific cognition and technological activity . . . involve a wide range of possible development trajectories . . . and are always faced with the problem of choosing a certain scenario out of the variety of possible scenarios of development. And

> the landmarks for this choice are not only knowledge but also the moral principles that ban the methods of experiment and transformation that are dangerous for people. More and more often contemporary complex research programs and technological projects require the social expertise that includes some ethical components.... Human society must find the way-out of the global crises, but to do this we shall have to come through an epoch of spiritual transformation and elaboration of a new system of values. (Stepin 1988, pp. 19–20)

Concern for the practical elaboration of a new paradigm of scientific and technological development, one that does not separate theory and practice nor ethical responsibilities and scientific-technological power, that respects both society and nature, thus animates current Russian perspectives on science, technology, and ethics.

VITALY GOROKHOV

SEE ALSO *Berdyaev, Nikolai; Communism; Lysenko Affair; Marxism; Sakharov, Andrei; Tolstoy, Leo.*

BIBLIOGRAPHY

Bailes, Kendall E. (1978). *Technology and Society under Lenin and Stalin: Origins of the Soviet Technical Intelligentsia, 1917–1941.* Princeton, NJ: Princeton University Press. One of the most comprehensive and insightful externalist studies.

Berdyaev, Nikolai. (1949). *Der Mensch und der Technik.* Berlin: Cornelsen. English version of one essay in this book, "Man and Machine," included in *Philosophy and Technology,* ed. Carl Mitcham and Robert Mackey (New York: Free Press, 1972).

Birstein, Vadim J. (2001). *The Perversion of Knowledge: The True Story of Soviet Science.* Boulder, CO: Westview Press.

Bulgakov, Sergei N. (1990 [1912]). *Filosofija Khoziaistva.* Moscow: Nauka. Translation by Catherine Evtuhov as *Philosophy of Economy: The World as Household* (New Haven, CT: Yale University Press, 2000).

Danilov-Danilian, Viktor I. (1999). "Novaja etika i ekologicheskij vysov" [New ethics and environmental challenge]. In his *Ustoichivoie razvitie i problemy ekologicheskoj politiki* [Sustainable development and problems of environmental policy]. *ECOS: Federalnyj vestnik ekologicheskogo prava* [Federal journal of environmental law], no. 5: 75–91.

Danilov-Danilian, Viktor I., and Kim S. Losev. (2000). *Ekologicheskij vyzov i ustojchivoje razvitije* [Ecological challenge and sustainable development]. Moscow: Progress-Traditzija.

Engelmeyer, Peter K. (1898). *Tekhnicheskij itog 19 veka* [The technological outcome of the nineteenth century]. Moscow: Tip. Kaznacheeva.

Frolov, Ivan T., and Boris G. Yudin. (1989). *The Ethics of Science: Issues and Controversies,* trans. Lilia Nakhapetyan and Valentin Parnakh. Moscow: Progress Publishers.

Gorokhov, Vitaly G. (1992). "Politics, Progress, and Engineering: Technical Professionals in Russia." In *Democracy in a Technological Society,* ed. Langdon Winner. Dordrecht, Netherlands: Kluwer Academic.

Gorokhov, Vitaly G. (1997). *Peter Klimentievich Engelmeyer: Ingener mekhanik i filosopf tekhniki (1855–1941)* [P. K. Engelmeyer: Mechanical engineer and philosopher of technology (1855–1941)]. Moscow: Nauka.

Gorokhov, Vitaly G. (1998). "Technological Enlightenment in Russia in the 19th and Early 20th Century and the Problems of Advancement in the Philosophy of Technology." In *Techne* 3(2).

Gorokhov, Vitaly G. (2001). *Technikphilosophie und Technikfolgenforschung in Russland.* Bad Neuenahr-Ahrweiler, Germany: Europäische Akademie zur Erforschung von Folgen wissenschaftlich-technischer Entwicklungen.

Gorokhov, Vitaly G. (2003). "Philosophie der Technik von P. K. Engelmeyer als technischer Optimismus." In *Jahrbuch des Deutsch-Russisches Kollegs 2001–2002,* ed. Vitaly G. Gorokhov. Aachen: Shaker Verlag.

Graham, Loren R. (1972). *Science and Philosophy in the Soviet Union.* New York: Knopf. Sees dialectical materialism as a major intellectual achievement that serves as a unifying theme across Soviet physics, cosmology, genetics, biology, chemistry, cybernetics, physiology, and psychology. See also Graham's *Science, Philosophy, and Human Behavior in the Soviet Union* (New York: Columbia University Press, 1987) and *Science in Russia and the Soviet Union* (Cambridge, UK: Cambridge University Press, 1993).

Graham, Loren R. (1993). *The Ghost of the Executed Engineer: Technology and the Fall of the Soviet Union.* Cambridge, MA: Harvard University Press.

Graham, Loren R. (1998). *What Have We Learned about Science and Technology from the Russian Experience?* Stanford, CA: Stanford University Press.

Inshenernaja etika v Rossii i USA: Istorija i sozialno politicheskij kontekst [Engineering ethics: History, context, and significance. Abstracts. American-Russian Workshop]. (1997). Moscow: Akademija menegementa innovatyij.

Inshenernaja etika v siseme obrayovanija [Designing engineering ethics education in Russia. Abstracts. American-Russian Workshop]. (1998). Moscow: Akademija menegementa innovatyij.

Krementsov, Nikolai. (1997). *Stalinist Science.* Princeton, NJ: Princeton University Press. Balanced account by a Russian historian of science, with some emphasis on the case of T. D. Lysenko.

Marfenin, Nikolai N. (2000). "Ecology and Humanism." In *State of Russia in the Surrounding World, 2000: The Analytical Series,* abstracts, ed. Nikolai N. Marfenin. Moscow: IIUEPS Press, 8–9.

Medvedev, Zhores A. (1978). *Soviet Science.* New York: Norton. A short historical overview by an insider arguing the moral of a need to protect science from possible misuse.

Stepin, Viatcheslav S. (1998). "Ustojchivoje razvitije i problema tzennostej" [Sustainable development and the problem of values]. In *Tekhnika, obshestvo, okrushajushjaja Sreda: Materialy meshdunarodnoj nauchnoj konferentyii (18–19.06.1998, Moskva)* [Technology, society, and environment: Proceedings of an International Conference, 18–19 June 1998, Moscow], ed. Vitaly G. Gorokhov. Moscow: RAN, MNEPU.

Stepin, Viatcheslav S. (2002). *Civilization, Science, Culture.* Karlsruhe: German Russian College, University of Karlsruhe; Moscow: State University of Humanities, Institute of Philosophy of the Russian Academy of Sciences.

Stepin, Viatcheslav S. (2005). *Theoretical Knowledge.* Synthese Library, Vol. 326. Heidelberg: Springer.

Yudin, Boris. (2004). "Medical Ethics in Russia, History, Contemporary Period." In *Encyclopedia of Bioethics,* 3rd edition. New York: Macmillan Reference USA.

Yudin, Boris. (2004). "Human Experimentation in Russia/the Soviet Union." In *Twentieth Century Ethics of Human Subjects Research,* eds. V. Roelcke and G. Maio. Stuttgart: Franz Steiner Verlag.

ENCYCLOPEDIA OF science technology AND ethics

EDITORS AND CONSULTANTS

ENCYCLOPEDIA OF science technology AND ethics

EDITED BY
CARL MITCHAM

volume
4
S–Z
appendices
index

MACMILLAN REFERENCE USA
An imprint of Thomson Gale, a part of The Thomson Corporation

THOMSON
GALE

Detroit • New York • San Francisco • San Diego • New Haven, Conn. • Waterville, Maine • London • Munich

Encyclopedia of Science, Technology, and Ethics

Carl Mitcham, Editor in Chief

For more information, contact
Macmillan Reference USA
An imprint of Thomson Gale
27500 Drake Rd.
Farmington,
Hills, MI 48331-3535
Or you can visit our Internet site at
http://www.gale.com

LIBRARY OF CONGRESS CATALOGING-IN-PUBLICATION DATA

Encyclopedia of science, technology, and ethics / edited by Carl Mitcham.
p. cm.
Includes bibliographical references and index.
ISBN 0-02-865831-0 (set, hardcover : alk. paper)—ISBN 0-02-865832-9 (v. 1) —
ISBN 0-02-865833-7 (v. 2)—ISBN 0-02-865834-5 (v. 3)—ISBN 0-02-865901-5 (v. 4)
1. Science—Moral and ethical aspects—Encyclopedias.
2. Technology—Moral and ethical aspects–Encyclopedias.
I. Mitcham, Carl. Q175.35.E53 2005
503—dc22 005006968

This title is also available as an e-book.
ISBN 0-02-865991-0
Contact your Thomson Gale representative for ordering information.

Printed in the United States of America
10 9 8 7 6 5 4 3 2 1

S

SAFETY ENGINEERING

Historical Emergence
Practices

HISTORICAL EMERGENCE

The protection of people from harm increasingly has been a focus of many fields of engineering since the nineteenth century. At the dawn of the Industrial Revolution (c. 1750–1850) engineers, as the term is used today, devoted their efforts almost entirely to making devices that functioned reliably and profitably, but with little attention to safety. One notable exception is James Watt (1736–1819), the so-called inventor of the steam engine. Despite introducing numerous improvements on the Newcomen steam engine, Watt intentionally resisted building a high-pressure engine because of the dangers it posed to those working with it. In fact, when Richard Trevithick (1771–1833) began experiments with the high-pressure steam engine, which increased both efficiency and power, Watt (and his partner Matthew Boulton) petitioned Parliament to pass an act outlawing the use of such engines as a public danger.

The second generation masters of steam power for railroads and steam boats thus brought with them boiler explosions, brakeman maimings, and wrecks causing astonishing loss of life. In *Life on the Mississippi* (1883) and again in *Huckleberry Finn* (1894) Mark Twain described in vivid detail the explosion of steam ships and the resultant death and injury of passengers. Manufactories too subjected workers (and often those living nearby) to industrial accidents, toxic fumes, and loss of hearing. Although those risks were hardly unknown, they were accepted by workers and the public as a necessary concomitant to technological progress.

However, over the course of the nineteenth century the protection of human safety became an increasingly important priority for engineers, companies, and eventually federal and state governments. Indeed, the first scientific research contract from the federal government was issued to the Franklin Institute in Philadelphia in 1830 to investigate the causes of steamboat boiler explosions and to propose solutions (Burke 1966).

As each new technology matured to the point where advances in performance were incremental, a poor safety record became a barrier to increased public acceptance and use. Workers began to organize into unions and insist that they be better protected from workplace hazards. Engineering societies, whose original charters tended to stress the promotion and facilitation of the profession's work, by the mid-twentieth century began to impose safety as a primary ethical duty of the engineer. The end of the nineteenth century also witnessed the development of safety codes and standards governing the use of natural gas and electricity, the design of building and steam boilers, and the storage and use of explosives.

In the twenty-first century nearly every engineering code of ethics stresses the safety of workers and the public. The American Nuclear Society's Code of Ethics (2003) states:

> We hold paramount the safety, health, and welfare of the public and fellow workers, work to protect the environment, and strive to comply with the principles of sustainable development in the performance of our professional duties. The first commitment in the Code of Ethics for the Insti-

> tute of Electrical and Electronic Engineers mandates that members . . . accept responsibility in making engineering decisions consistent with the safety, health and welfare of the public, and to disclose promptly factors that might endanger the public or the environment (Institute of Electrical and Electronic Engineers 1990).

All licensed professional engineers are bound by the Code of Ethics for Engineers promulgated by the National Society of Professional Engineers. Both Fundamental Canon No. 1 and the first Rule of Practice impose on the engineer a duty to "hold paramount the safety, health and welfare of the public" (National Society of Professional Engineers 2003).

Apart from these commitments by long-standing communities of engineers there are many engineers whose work is devoted entirely to the protection of the public and workers from the hazards of technology and natural phenomena: Fire protection engineering, automobile safety engineering, and industrial safety engineering are a few examples. Safety engineering is itself an engineering discipline; its practitioners attempt to understand the ways in which technological systems fail and discover ways to prevent such failures. The American Society of Safety Engineers, founded in 1911 and now numbering over 30,000 members, is devoted to being "the premier organization and resource for those engaged in the practice of protecting people, property and the environment, and to lead the profession globally" (American Society of Safety Engineers 2004).

The intertwining of engineering and safety probably will intensify in the future in response to constantly rising public expectations. Two prominent engineering scholars in Lancaster University's Department of Engineering have observed the large gap between the safety expectations of today and those in the early days of modern technologies:

> Safety is rapidly becoming a means by which the public and governments judge the viability of organisations involved in safety-related processes, possibly more so than environmental issues. Many large organisations could not afford a single, large-scale incident as a result of an inferior safety culture, despite buoyant economics. This is a significant dynamic departure from past public acceptability of fatal incidents (Joyce and Seward 2004).

The dedication of the engineering profession to safety as a primary goal and an ethical duty is in accordance with this change in public expectations.

WILLIAM M. SHIELDS

SEE ALSO *Engineering Ethics; Safety Factors.*

BIBLIOGRAPHY

Burke, John G. (1966). "Bursting Boilers and the Federal Power." *Technology and Culture* 7:1 (1–23). A widely reprinted article. For critical comment, see Richard N. Langlois, David J. Denault, and Samson M. Kimenyi, "Bursting Boilers and the Federal Power Redux: The Evolution of Safety on the Western Waters," *University of Connecticut Department of Economics Working Papers Series* (May 1994).

Joyce, Malcolm J., and Derek W. Seward. (2002). "Innovative M.Sc. in Safety Engineering—A Model for Industry-Based Courses in the 21st Century?" *Engineering Education 2002: Professional Engineering Scenarios* 2002/056: (2: 28/6).

INTERNET RESOURCES

American Nuclear Society. Code of Ethics. (2003). Available at www.ans.org.

American Society of Safety Engineers. (2004). Vision Statement. Available at www.asse.org.

Institute of Electrical and Electronic Engineers. Code of Ethics. (1990). Available at www.ieee.org.

National Society of Professional Engineers. Code of Ethics. (2003). Available at www.nspe.org.

PRACTICES

Safety is one of the primary goals of engineering. In most ethical codes for engineers safety is mentioned as an essential area of professional competence and responsibility.

In everyday language, the term *safety* is often used to denote *absolute safety*, that is, certainty that accidents or other harms will not occur. In engineering practice, safety is an ideal that can be approached, but never fully attained. What can be achieved is *relative safety*, meaning that it is unlikely but not impossible that harm will occur. The safety requirements in regulations and standards represent different (and mostly high) levels of relative safety. Industries with high safety ambitions, such as airway traffic, are characterized by continuous endeavors to improve the level of safety.

The ambiguity between absolute and relative safety is a common cause of misunderstandings between experts and the public. Both concepts are useful, but it is essential to distinguish between them.

In decision theory, lack of knowledge is divided into the two major categories: "risk" and "uncertainty." In decision-making under risk, the probabilities of possible outcomes are known, whereas in decision-making under uncertainty, probabilities are either unknown or known with insufficient precision. In engineering practice, both risk and uncertainty have to be taken into account. Even when engineers have a good estimate of the probability (risk) of failure, some uncertainty remains about the correctness of this estimate.

Safety has often been defined as the antonym of risk, but that is only part of the truth. In order to achieve safety in practical applications, the dangers that originate in uncertainty are equally important to eliminate or reduce as those that can be expressed in terms of risk. Many safety measures in engineering are taken to diminish the damages that would follow from possible unknown sources of failures. Such measures protect against uncertainty rather than risk.

Several methods are used by engineers to achieve safety in the design and operation of potentially dangerous technology.

Inherently safe design. The first step in safety engineering should always be to minimize the inherent dangers in the process as far as possible. Dangerous substances or reactions can be replaced by less dangerous ones. Fireproof materials can be used instead of flammable ones. In some cases, temperature or pressure can be reduced.

Safety reserves. Constructions should be strong enough to resist loads and disturbances exceeding those that are intended. In most cases, the best way to obtain sufficient safety reserves is to employ explicitly chosen safety factors.

Negative feedback. Dangerous operations should have negative feedback mechanisms that lead to a self-shutdown in critical accident situations or when the operator loses control. Two classical examples are the safety valve that lets out steam when the pressure becomes too high in a steam boiler and the "dead man's handle" that stops the train when the driver falls asleep. One of the most important safety measures in the nuclear energy industry is to ensure that a nuclear reactor closes down automatically when a meltdown approaches.

Multiple independent safety barriers. In order to avert serious dangers, a chain of barriers is needed, each of which is independent of its predecessors so that if the first fails, then the second is still intact, and so on. Typically the first barriers are measures to prevent an accident, after which follow barriers that limit the consequences of an accident, and finally rescue services as the last resort. One of the major lessons from the *Titanic* disaster (1912) is that an improvement of the early barriers is no excuse for reducing the later barriers (such as access to lifeboats).

Maintenance and inspections. Many severe accidents have resulted from insufficient maintenance of installations or pieces of equipment that were originally in excellent shape. Regular inspections by persons with sufficient competence and mandate are an efficient means to prevent this from happening.

Educated and responsible operators. Human mistakes are an important source of accidents. An efficient countermeasure is to educate workers, authorize them to temporarily stop processes they consider to be acutely dangerous, and encourage them to take initiatives to improve safety.

Incidence reporting. Experience from air traffic and nuclear energy shows that systems for reporting and analyzing safety incidents are an efficient means to prevent accidents. Systems for anonymous reporting facilitate the reporting of human mistakes.

Safety management. Safety can be achieved only in an organization whose top management gives priority to safety and aims at continuous improvement.

SVEN OVE HANSSON

SEE ALSO *Airplanes; Automobiles; Aviation Regulatory Agencies; Building Destruction and Collapse; Engineering Ethics; Fire; Regulatory Toxicology; Robot Toys; Safety Factors.*

BIBLIOGRAPHY

Marshall, Gilbert. (2000). *Safety Engineering,* 3rd edition. Des Plaines, IL: American Society of Safety Engineers. General safety principles and their application on industrial workplaces.

SAFETY FACTORS

A safety factor (also called an uncertainty factor or assessment factor) is a number by which some variable such as load or dose is multiplied or divided in order to increase safety. Safety factors are used in engineering design, toxicology, and other disciplines to avoid various types of failure.

The sources of failure that safety factors are intended to protect against can be divided into two major categories: (a) the *variability* of conditions that influence the risk of failure, such as variations in the strength of steel and in the sensitivity of humans to toxic substances, and (b) the *uncertainty* of human knowledge, including the possibility that the models used for risk assessment may be inaccurate.

Safety factors are used to obtain a safety reserve, a margin between actual conditions and those that would lead to failure. Safety reserves can also be obtained without the use of explicitly chosen safety factors.

At least since antiquity, builders have obtained safety reserves by adding extra strength to their constructions. The earliest known use of explicit safety factors in engineering dates from the 1860s. In modern engineering, safety factors are used to compensate for five types of failure:

(1) higher loads than those foreseen,

(2) worse properties of the material than foreseen,

(3) imperfect theory of the failure mechanism in question,

(4) possibly unknown failure mechanisms, and

(5) human error in design or calculations.

The first two of these can in general be classified as variabilities, whereas the last three belong to the category of (genuine) uncertainty.

In order to be an efficient guide for safe design, safety factors should be applied to all the integrity-threatening mechanisms that can occur. For instance, one safety factor may be required for resistance to plastic deformation and another for fatigue resistance. A safety factor is most commonly expressed as the ratio between a measure of the maximal load not leading to the specified type of failure and a corresponding measure of the applied load. In some cases it may be preferable to express the safety factor as the ratio between the estimated design life and the actual service life.

The use of explicit safety factors in regulatory toxicology dates from the middle of the twentieth century. In 1954 Arnold J. Lehman and O. Garth Fitzhugh, two U.S. Food and Drug Administration (FDA) toxicologists, proposed that ADIs (acceptable daily intakes) for food additives be obtained by dividing the lowest dose causing no harm in experimental animals (counted per kilogram body weight) by 100. This value of 100 is still widely used. It is now often accounted for as being the product of two subfactors: one factor of 10 for interspecies (animal to human) variability in response to the toxicity and another factor of 10 for intraspecies (human) variability in the same respect. Higher safety factors such as 1,000, 2,000, and even 5,000 can be used in the regulation of substances believed to induce severe toxic effects in humans.

The effect of a safety factor on the actual risk depends on the dose–response relationship. If the risk is proportionate to the dose (linear dose–response relationship), then the risk reduction will be proportionate to the safety factor. If the dose–response relationship is nonlinear, then the reduction in risk can be either more or less than proportionate. Because the dose–response relationship at very low doses is always unknown, the exact effect of using a safety factor cannot be known with certainty.

Natural organisms often have safety reserves that can be described in terms of safety factors. Structural safety factors have been calculated for mammalian bones, crab claws, shells of limpets, and tree stems. Natural safety reserves make the organism better able to survive unusual conditions. Hence, the extra strength of tree stems makes it possible for them to withstand storms even if they have been damaged by insects. But safety reserves also have their costs. Trees with large safety reserves are better able to resist storms, but in the competition for light reception, they may lose out to tender and high trees with smaller safety reserves.

At least two important lessons can learned from nature in this context. First, resistance to unusual loads is essential for survival. Second, a balance will nevertheless always have to be struck between the dangers of having too little reserve capacity and the costs of having an unused reserve capacity. Perfect safety cannot be obtained, but a chosen balance between safety and costs can be implemented with the help of safety factors and other regulation instruments.

SVEN OVE HANSSON

SEE ALSO *Bioengineering Ethics; Engineering Ethics; Safety Engineering.*

BIBLIOGRAPHY

Dourson, Michael L., and Jerry F. Stara. (1983). "Regulatory History and Experimental Support of Uncertainty (Safety) Factors." *Regulatory Toxicology and Pharmacology* 3(3): 224–238. Safety factors in toxicology.

Randall, F. A. (1976). "The Safety Factor of Structures in History." *Professional Safety*, January: 12–28. Safety factors in engineering design.

SAKHAROV, ANDREI

Theoretical physicist and the "father of the Soviet H-bomb," Andrei Sakharov (1921–1989), who was born in Moscow on May 21, became a prominent human rights

Andrei Sakharov, 1921–1989. Sakharov, one of the Soviet Union's leading theoretical physicists and regarded in scientific circles as the "father of the Soviet atomic bomb," also became Soviet Russia's most prominent political dissident in the 1970s. *(© Bettmann/ Corbis.)*

activist and the first Russian to win the Nobel Peace Prize.

Sakharov's father was a physics teacher and popular science author. World War II shortened his study of physics at Moscow University. After two years of work in a munitions factory, in 1945 he went on to graduate study in theoretical physics under Igor Tamm (1895–1971). In 1948 the Soviet government assigned Tamm's group, including Sakharov, to research the feasibility of a thermonuclear bomb. In a few months Sakharov suggested a new idea that was instrumental in the development of the first Soviet thermonuclear bomb (which was tested in 1953). In 1951 he pioneered the research of controlled thermonuclear fusion that led to the tokamak reactor. He was also the main developer of the full-fledged Soviet H-bomb tested in 1955: Unlike the 1953 design, the yield of the 1955 design was potentially unlimited. He was amply rewarded by 'the government, with membership of the Soviet Academy of Sciences (1953), three Hero of Socialist Labor medals (1954, 1956, and 1962), the Stalin Prize and Lenin prize, and a luxury dacha, or villa.

In 1958 Sakharov calculated the number of casualties that would result from an atmospheric test of the "cleanest" H-bomb: 6,600 victims per megaton for 8,000 years. "What moral and political conclusions must be drawn from these numbers?" he asked in an article published that year. He answered: "The cessation of tests will lead directly to the saving of the lives of hundreds of thousands of people and will have the more important indirect result of aiding in reducing international tensions and the danger of nuclear war" (1958, p. 576). Sakharov was proud of his contribution to the 1963 test ban treaty, which stopped atmospheric nuclear testing of the United States, the USSR, and the United Kingdom.

In the 1960s Sakharov returned to pure physics. His most important contribution was a 1966 explanation of the disparity of matter and antimatter in the universe, or baryon asymmetry. The major turn in Sakharov's political evolution took place in 1967 to 1968, when antiballistic missile (ABM) defense became a key issue in U.S.-Soviet relations. Sakharov wrote the Soviet leadership to argue that the moratorium proposed by the United States on ABM work would benefit the Soviet Union, because an arms race in this new technology would increase the likelihood of nuclear war. The government ignored his letter and refused to let him initiate a public discussion of ABM in the Soviet press.

An insider's view of how the upper echelons of the Soviet regime functioned led Sakharov to the conclusion that the goals of peace, progress, and human rights were inextricably linked. He made his views public in the 1968 essay "Reflections on Progress, Peaceful Coexistence, and Intellectual Freedom," published in samizdat (underground self-publishing in the Soviet Union) and in the West in the summer of 1968. The secret father of the Soviet H-bomb emerged as an open advocate of peace and human rights.

Sakharov was immediately dismissed from the military-scientific complex. He then concentrated on theoretical physics and human rights activity. The latter brought him the Nobel Peace Prize in 1975 and internal exile in 1980, after he had been stripped of all honors including the title of Hero of Socialist Labor. In 1985 the European Parliament established the annual Sakharov Prize for Freedom of Thought, given for outstanding contributions to human rights.

In December 1986 the new Soviet leader Mikhail Gorbachev (b. 1931) released Sakharov from internal exile. Upon his return he enjoyed three years of freedom, including seven months of professional politics as a member of the Soviet parliament. The latter were the last months of his life.

For many years Sakharov lived intoxicated by socialist idealism. He later said in his memoirs that he "had subconsciously . . . created an illusory world to justify" himself. Totalitarian control over information enabled Soviet propaganda to brainwash even the most intelligent. Sakharov wanted to make his country strong enough to ensure peace after a horrible war. Experience brought him to a "theory of symmetry": All governments are bad and all nations face common dangers. In his dissident years he realized that the symmetry "between a normal cell and a cancerous one" could not be perfect, although he kept thinking that the theory of symmetry did contain a measure of truth.

Sakharov saw "striking parallels" between his own life and the lives of the two American physicists Robert Oppenheimer (1904–1967) and Edward Teller (1908–2003), who crossed in the "Oppenheimer Affair" (1953–1954). Sakharov did not believe that he had "known sin," in Oppenheimer's expression, by creating nuclear weapons. Nor did he try to persuade the government, as did Teller, of the need for a hydrogen bomb. Having disagreed with Teller on the prominent issues of nuclear testing and antimissile defense (e.g., the "Star Wars" program), Sakharov, nevertheless, believed that American physicists had been unfair in their attitude toward Teller following his clash with Oppenheimer. Sakharov felt that in this "tragic confrontation of two outstanding people," both deserved equal respect, because "each of them was certain he had right on his side and was morally obligated to go to the end in the name of truth" (Memoirs).

For Sakharov the statement that "the future is unpredictable" was meaningful far beyond quantum physics. It supported his personal responsibility for the future of humanity. For him knowledge was not only power but also professional and moral responsibility.

GENNADY GORELIK

SEE ALSO *Oppenheimer, J. Robert; Russian Perspectives; Teller, Edward; Weapons of Mass Destruction.*

BIBLIOGRAPHY

Gorelik, Gennady. (1999). "The Metamorphosis of Andrei Sakharov." *Scientific American* 280(3): 98–101. An explanation of Sakharov's transformation into public and political figure.

Gorelik, Gennady, with Antonina W. Bouis. (2004). *The World of Andrei Sakharov: A Russian Physicist's Path to Freedom*. New York: Oxford University Press. The first authoritative study of Andrei Sakharov as scientist as well as public figure relies on previously inaccessible documents, recently declassified archives, and personal accounts by Sakharov's friends and colleagues.

Sakharov, Andrei D. (1958). "Radioaktivnyi uglerod iadernykh vzryvov i neporogovye biologicheskie effekty" [Radioactive carbon in nuclear explosions and nonthreshold biological effects]. *Atomnaia energiia* 4, no. 6: 576–580. In *Soviet Scientists on the Danger of Nuclear Tests,* ed. A. V. Lebedinsky. Moscow: Foreign Lang. Publ. House, 1960. The first of Sakharov's writing involving moral and political issues.

Sakharov, Andrei D. (1968a). "Thoughts on Progress, Peaceful Coexistence and Intellectual Freedom." *New York Times* Jul 22, 1968, 14–17. The first instance of Sakharov's writing manifesting his political dissent with the Soviet regime.

Sakharov, Andrei D. (1968b). *Progress, Coexistence, and Intellectual Freedom*. New York: Norton. Includes the essay of the previous citation.

Sakharov, Andrei. (1990). *Memoirs,* trans. Richard Lourie. New York: Knopf.

INTERNET RESOURCE

"Andrei Sakharov: Soviet Physics, Nuclear Weapons, and Human Rights." American Institute of Physics, Center for History of Physics. Available from http://www.aip.org/history/sakharov/.

SANGER, MARGARET

Margaret Sanger (1879–1966), born in Corning, New York on September 14, was an internationally renowned leader in the movement to secure reproductive rights for women. Founder of the first birth-control clinic in the United States and later, of the Planned Parenthood Federation of America and the International Planned Parenthood Federation, Sanger was a controversial figure with militant feminist and socialist views, working for change in areas of strong traditional values and cultural resistance.

Sanger was the sixth of eleven children born to a devout Catholic Irish-American family. To escape what she saw as a grim class heritage, she worked her way through school and chose a career in nursing. Although she married and had three children, Sanger maintained an intellectual and professional independence. She immersed herself in the radical bohemian culture of intellectuals and artists that flourished in New York City's Greenwich Village. She also joined the Women's

Margaret Sanger, 1879–1966. The pioneering work of this American crusader for scientific contraception, family planning, and population control, made her a world-renowned figure. *(The Library of Congress.)*

Committee of the New York Socialist Party and participated in labor strikes organized by the Industrial Workers of the World.

Working with poor families on the Lower East Side of New York City, Sanger increasingly focused her attention on sex education and women's health and reproductive rights. She argued that a woman's right to control her own body was the foundation of her human rights, that limiting family size would liberate working-class women from the economic burdens associated with unwanted pregnancies, and that women are as much entitled to sexual pleasure and fulfillment as men.

Sanger's ideas have remained controversial. Those who oppose family planning point to her adherence to certain popular ideas of her time as proof that the movement is fundamentally flawed. Sanger advocated birth control as a means of reducing genetically transmitted mental and physical defects, even going so far as to call for the sterilization of the mentally incompetent. But her thinking differed significantly from the reactionary eugenics that eventually became the centerpiece of the Nazi party platform. Sanger never condoned eugenics based on race, class, or ethnicity, and in fact her writings were among the first banned and burned in Adolf Hitler's Germany.

Sanger called for the reversal of the Comstock Law and related state laws banning the dissemination of information on human sexuality and contraception. In 1914, indicted for distributing a publication that violated postal obscenity laws, she fled to England, where she was deeply influenced by the social and economic theories of Britain's radical feminist and neo-Malthusian intelligentsia. Separated from her husband and exploring her own sexual liberation, Sanger had affairs with several men including the psychologist Havelock Ellis (1859–1939) and the author and historian H. G. Wells (1866–1946). She returned to the United States in 1915 to face the charges against her, hoping to use her trial to capture media attention. But the sudden death of her five-year-old daughter generated public sympathy, and the government dropped the charges. She then embarked on a national tour and was arrested in several cities, attracting even greater publicity for herself and the birth-control movement.

Sanger founded a number of important organizations and institutions to advance the cause of reproductive rights. In 1916 she opened the first birth-control clinic in the United States in the Brownsville section of Brooklyn, New York. Nine days later, Sanger and her staff were arrested. She then opened a second clinic, the Birth Control Clinical Research Bureau, staffed by female doctors and social workers, which became important in collecting clinical data on the effectiveness of contraceptives. In 1921 Sanger founded the American Birth Control League, which later merged with the Birth Control Clinical Research Bureau to form the Birth Control Federation of American, forerunner of the Planned Parenthood Federation of America. In 1930 she founded a clinic in Harlem, and she later founded "the Negro Project," serving African Americans in the rural South. Of Sanger's work, Martin Luther King Jr. (1929–1968) said, "the struggle for equality by nonviolent direct action may not have been so resolute without the tradition established by Margaret Sanger and people like her."

After World War II, Sanger shifted her concerns to global population growth, especially in the Third World. She helped found the International Planned Parenthood Federation, serving as its president until 1959. Sanger helped find critical development funding for the birth-control pill and fostered a variety of other research efforts including the development of spermicidal jellies and spring-form diaphragms. She died only a few months after birth control became legal for married couples, a 1965 decision that reflected the influence of Sanger's long years of dedication to radical, visionary social reform.

JENNIFER CHESWORTH

SEE ALSO *Birth Control; Eugenics.*

BIBLIOGRAPHY

Chesler, Ellen. (1992). *Woman of Valor: Margaret Sanger and the Birth Control Movement in America*. New York: Simon & Schuster.

King, Martin Luther Jr. (1966). "Family Planning—A Special and Urgent Concern." King's acceptance speech upon receiving the Margaret Sanger Award from the Planned Parenthood Federation of America.

Valenza, Charles. (1985). "Was Margaret Sanger a Racist?" *Family Planning Perspectives* 17(1): 44–46.

INTERNET RESOURCE

The Margaret Sanger Papers Project. Available from http://www.nyu.edu/projects/sanger/index.html.

SARTRE, JEAN-PAUL

SEE *Existentialism.*

SCANDINAVIAN AND NORDIC PERSPECTIVES

The term "Scandinavia" traditionally includes the so-called Scandinavian countries Denmark, Norway and Sweden. Sometimes "Scandinavia" is given a broader definition that also covers the two remaining "Nordic" countries Finland and Iceland. The Scandinavian and Nordic countries are highly industrialized countries that have attempted to combine economic development with social welfare and democratic planning. Technological change has been considered in relation to competing values and interests, and ethics has played a role in this context.

The development of technology and ethics in Scandinavian and Nordic countries is characterised by some general trends that are very similar to Denmark, Norway, Sweden, Finland and Iceland. Traditionally there has been a lot of scientific and cultural exchange among these countries and therefore one finds similar theoretical trends and movements among the Nordic countries. In particular can be mentioned positivistic and instrumental positions, Marxistic postions, positions from applied ethics traditions, critical environmental positions, and positions from postmodern continental philosophy.

Historical Background

The most famous case of science and technology ethics in the Nordic countries is the criticism of the Danish physicist and Nobel Prize winner Niels Bohr (1885–1962). Bohr was paradoxically one of the physicians participating in the "Manhattan Project" during World War II that lead to the creation of the nuclear bomb. Bohr has said that it was only after that the United States dropped the bomb on Hiroshima and Nagasaki that he fully became aware of the ethical responsibility of science (Rendtorff 2003). After he realized the deadly consequences of the use of nuclear bombs Bohr became an active opponent of nuclear arms and he sent several letters to the United Nations urging avoidance spread of nuclear mass destruction weapons and prevention of a nuclear war.

Although many Nordic scientists joined Bohr in his criticism of the military use of science and technology, the spirit of science and technology during the first part of the twentieth century was in general determined by a belief in the norms of science as universal and neutral creation of knowledge for the benefit of humankind.

During the 1960s there was a general belief in technology in the Scandinavian and Nordic countries. This period was characterized by a strong belief in the progress of science and technology. The spirit of research was instrumental, pragmatic and positivistic. In the 1970s, however, many critical movements emerged. In particular, many Marxist criticisms of technology were published. Marxist critiques treated technology as an aspect of the increasing oppression of people by a capitalist society. Marxist positions were influential because they contributed to the establishment of classes on society and technology in many universities.

The well known Finnish philosopher Georg Henrik von Wright published a path-breaking critical work in technology ethics in 1986, one of the most important contributions to technology ethics in Finland and perhaps also in the rest of the Nordic countries. In his book about science and rationality the basic argument is a deep scepticism towards the possibilities of humanity to deal with technological progress and its problems. A true humanism must be based on a deep understanding of human nature and the acceptance of the natural limits on human activities and the interventions of beings in their natural and cultural environment (von Wright 1986).

In Denmark there have also been many publications on the limits of growth. The theologian Ole Jensen (1976) wrote *I Vækstens Vold* (Submitted to growth) on that subject and the philosopher Villy Sørensen and colleagues (1978) proposed a discussion aimed at overcoming the Marxist opposition to the role of technology in society and proposing a new vision of a society in harmony with technology.

In addition to Marxist positions there emerged a strong ecological movement focusing on the negative environmental consequences of science and technology in an industrial society. Discussions of environmental ethics were extensive, and in Norway the deep ecology movement represented by the philosopher Arne Næss (1976) proposed a paradigm of the relationship between humankind and nature that became influential worldwide.

During the 1980s the Danish philosopher Peter Kemp attempted to integrate the humanities and technology. Drawing on the philosophies of Hans Jonas (1903–1993), Paul Ricoeur (b. 1913) and Emmanuel Levinas (1906–1995), he argued for a symbiotic relationship between the two cultures and an ethics of technology in *The Irreplacable* (1991), which was his second doctoral habilitation at the university of Göteborg.

Bioethics

During the 1990s the focus shifted from technology ethics to bioethics and medical ethics. In Norway a debate on principles resulted from discussions about the national biotechnology legislation that was enacted at the beginning of the decade. The Norwegian parliament invented the concept of "mixed ethics," a collection of deontological, utilitarian, and cultural approaches, as the basis for biotechnology legislation. Sweden discussed these matters in the framework of the Swedish Council for medical ethics, an advisory body to the Swedish government.

In Norway technology ethics and bioethics were integrated in the so-called Ethics Research program of the Norwegian Government, which opened opportunities for many doctoral candidates to start a carrier in technology ethics. That program also involved strengthening bioethics research. The professor of medical ethics Jan Helge Solbakk (1994) was influential in developing medical ethics in that country on the basis of the work of one of the founders of Norwegian medical ethics, Knud-Erik Tranøy (1992).

In Sweden utilitarian bioethics was defended by the consequentialist Torbjörn Tjansöe, who became a professor of philosophy in Stockholm. Tjansöe has radical views on bioethics and once was a dogmatic Marxist. A Kantian position in favor of human dignity has been defended by Matts Hannson (1991), who is the director of the Swedish ELSA program (Ethical, Legal, and Social Aspects of genetic technologies) based in Uppsala. In addition, there is an influential interdisciplinary research unit on bioethics and technology ethics at Linköping University, where the Danish professor Thomas Achen has worked on gene technology and law in Scandinavia (Achen 1997).

In Denmark discussions of bioethics emerged from debates in the Danish Council of Ethics, which was established in 1987. Two research programs that were sponsored by five Danish Research Councils in 1993 were especially important in the development of the bioethics research environment in that country.

The first program, Gran (Foundations and Applications of Bioethics) explored the foundations and applications of ethics and collaborated closely with the Danish Council of Ethics by arranging hearings about bioethics issues. Svend Andersen, a professor of theology at the University of Aarhus, who had been one of the first members of the Danish National Council of Ethics, directed this research project. The Danish philosopher and theologian Knud Ejler Løgstrup was the inspiration for Andersen's position on theoretical ethics. Andersen had also been responsible for an important report on research ethics for the ministry of research in 1994 (Andersen 1994, Rendtorff 2003). However, Andersen also collaborated with Peter Sandøe, a consequentialist who later worked on animal bioethics and in 1998 established a Center for Risk Assessment for Human and Animal Biotechnology based in the Royal Danish Vetenary School.

The second project, which was based in the Center for Ethics and Law at the University of Copenhagen, explored the relationship between biotechnology, ethics, and the law. It also collaborated with the Danish Council of Ethics in the organization of international conferences on bioethics and biolaw. Peter Kemp, a technology ethicist who in the 1980s had done work on medical ethics, became the director of the center, which published several works on bioethics and law. This project applied a phenomenological approach to the ethics of biotechnology (Rendtorff 1999). In addition, the

Center for Ethics and Law was responsible for a European research project sponsored by the BIOMED-II program of the European Commission, Basic Ethical Principles in European Bioethcis and Biolaw, that led to the publication of a two-volume research report (Rendtorff and Kemp 2000). The report investigated the ideas of autonomy, dignity, integrity, and vulnerability as guiding ideas for future European bioethics and biolaw.

In Finland there has also been much public debate about different issues of bioethics: abortion, euthanasia, genetic engineering, inequalities in health, decline of the natural environment, overpopulation, and scarcity of medical resources. Like many European countries, Finland has established a national council of ethics to advise government about ethical issues in health care, science, and technology. Academic debates about bioethics in Finland has mostly been inspired by the Anglo-American approaches in the field. The discussions are characterized by confrontations between consequentialist and deontological and right-based approaches to applied ethics (Rendtorff and Kemp 2000).

Icelandic approaches to bioethics follow the same patterns of confrontation between principles and pragmaticism. Recent discussions have been focussed on the development of an Icelandic biotechnology industry. A thought-provoking case is the fact that the Icelandic government has allowed a privately-owned enterprise to make a bio-bank with blood samples and genetic information from the 280,000 citizens of Iceland (Rendtorff 2003). The Icelandic genetic patrimony is unique because of the small genetic variation within a homogenous population; therefore there might be opportunities to discover new knowledge about genetics. The firm "decode" collaborates with international biotechnology companies; they have procured a number of patents and other rights to the genetic samples that constitute a unique opportunity to do research in genetic basis of disease and possible improvement of medicines for treatment of genetic diseases. Critical voices in the public debate have argued that this common gene pool poses serious problems of data protection, privacy, and anonymity. Moreover, it is stated that the Icelandic government has been too quick in allowing extended commercialization of genetic information and private ownership of blood samples from human bodies. However, this debate about bio-banks and uses of genetic technologies represent features that seems to be fairly common among all the Nordic countries.

Technology Ethics

Parallel to the discussions in bioethics, a scholarly literature has evolved that is concerned with the relationship of technology and society. In this literature attempts are made to understand the interrelationships between technological change and social concerns. The concept of ethics also is important in this context, but it is not always used in the strict philosophical sense of the word.

The Scandinavian and Nordic countries all have a tradition of social planning. All three countries were industrialized at a relatively late stage and at a slow pace. This has allowed for peaceful processes of industrialization with attention paid to the welfare state and social welfare. As a consequence, labor unions, among other groups, have played a crucial role in social development and various traditions of democracy and welfare planning have evolved that have a strong influence on Scandinavian societies.

This may explain why several issues in ethics, social policy, and technology have been formulated in a relatively constructive and formative rather than reactive way. In the initial stages two scholarly traditions seemed important: working life science and a critique of technology.

WORKING LIFE SCIENCE. This tradition began in the late 1960s. In 1971 the Norwegian Iron and Metal Workers' Union initiated an important project with Kresten Nygaard that dealt with planning methods for the trade unions (Fuglsang 1993). The aim of the project was to strengthen the trade unions' influence on new computer technologies. In 1975 the Swedish National Federation of Labour Unions (LO) sponsored a similar project, DEMOS, which dealt with democratic control and planning in working life. The aim of the project was to support workers' influence on the new technology. In Denmark Project DUE, which dealt with democracy, development, and data processing, was initiated. Some of these projects were inspired in part by Harry Braverman's work on the degrading and controlling aspects of work (Braverman 1976), but their aim clearly went beyond Braverman's objectives. They were not limited to studying the negative consequences of technology but instead were intended to formulate an approach to a constructive development of technology.

One of the computer scientists who took part in those discussions, Pelle Ehn, published a book explaining these aims (Ehn 1988). In that book the Scandinavian approach was seen as standing in opposition to the so-called sociotechnical approach, a functional approach in which social and technical systems were understood as being interdependent. By contrast, in Ehn's view workers should be able to participate directly in the development of computer systems.

CRITIQUE OF TECHNOLOGY. This tradition evolved from a combination of philosophical and sociological approaches. In Norway, Arne Næss developed his ecophilosophy, which was concerned, among other things, with the inability of engineers to take into consideration the wholeness of humankind and nature in which they were situated (Næss 1976). Sigmund Kvaløy (1976) developed a critique of the complexity of industrialism. The sociologist Dag Østerberg (1974) was concerned with the way in which technology could be understood as materialized social relations interacting with human activity.

In Denmark, Hans Siggard Jensen and Ole Skovsmose published a critique of technology in which they argued for a nonteleological or deontological ethical approach to technology (Jensen and Skovmose 1986). They positioned themselves in relation to the work of the philosophers Immanuel Kant (1724–1804) and Jürgen Habermas (b. 1929). Anker Brink Lund, Robin Cheesman, and Oluf Danielsen published a book in which they criticized technocratic approaches, particularly in the area of electronic media, and pointed to possibilities for a more democratic model of technological change (Lund et al. 1981).

Tarja Cronberg (1987) has developed a distinct approach to technology that focuses on the relationship of technology and everyday life. Cronberg came to see Danish social experiments with technology as a kind of laboratory for dialogue and research inspired by phenomenological approaches and critical theories of communication (Habermas 1984).

In Sweden, Andrew Jamison and Aant Elzinga have tried to work out historical perspectives on science and technology policy. They also stress the impact of culture (Elzinga and Jamison 1981). Jamison (1982) has been interested in the concept of "national styles" in an attempt to determine how national culture plays a formative role in relation to science and technology; this is implicitly a deontological approach.

The two initial traditions of working life science and technology critique have been conducted in various ways in small scholarly communities. In computer science the tradition of working life science has involved differing understandings of computer design and human-computer interactions. The journal *Computer Supported Cooperative Work* has been important in this work. An influential semiethical orientation in Scandinavian computer design is "activity theory," which is present in the work of the Danish working life scientist Susanne Bødker. Technology is seen as a tool that mediates between an individual and a social object or social role in an organization. For this relationship to become meaningful, it is necessary to design and integrate computer programs in an artful way. In Finland, this tradition of activity theory has become a very important contribution to work development research through the work of Yrjö Engeström (Engeström et al. 1999) and his Centre for Activity Theory and Developmental Work Research at the University of Helsinki.

A critique of technology seems not to have developed in a systematic way in Scandinavian philosophy. Some works have been published, but they have not led to the development of distinct philosophical traditions. At the Department of Management, Politics and Philosophy in the Copenhagen Business School in Denmark some scholars have developed the notion of "ethical budgets" and values-driven management for firms, which seems to be related to technology and ethics (Ole Thyssen 1997), and other philosophical contributions in the areas of ethics, innovation, and technology have been produced.

In Finland, a tradition of engineering ethics and responsibility of scientists has developed through such organizations as the Finish nongovernmental organization Technology for Life, and the Association of Swedish-Speaking Engineers in Finland, which has created a code of ethics for its members. Attempts are here made to sustain civil courage and find ways for engineers to demonstrate loyalty to third party (the future, the nature, humankind) rather than merely to business or within professions. Engineering ethics is taught in some engineering schools and technical universities in the Scandinavian countries even though these courses are not, or at most are seldom, compulsory. At the Helsinki University of Technology, a one-year course has been created with the help of Technology for Life.

Science, Technology, and Society Studies

A small tradition of science and technology studies (STS) has developed primarily in the three Scandinavian countries (Denmark, Norway, Sweden). It has, in parallel with working life science, attempted to focus more on the development of than on the impact of technology. In Norway two STS institutions have been created that serve as examples of this work.

One is the Center for Technology and Human Values (now the Centre for Technology, Innovation and Culture), which was headed by Francis Sejersted in the period 1988–1998. Sejerstedt (1993) examined how a special form of capitalism has developed in Norway that is anchored in democratic, egalitarian, and local values in contrast to Chandler's (1990) notions of corporate and competitive capitalism in Germany and United States. Other researchers at this institution have shown how the transfer of technology to Norway as well as innovation processes can be seen as being intertwined with regional social structures and local values, leading to special forms of localized innovation (Wicken 1998).

A second STS institution is at the Norwegian University of Science and Technology in Trondheim, headed by Knut H. Sørensen. In his research Sørensen has been occupied with studying what he calls the domestication and cultural appropriation of technology in everyday life, which may be seen as part of a deontological, nonteleological tradition (Lie and Sørensen 1996, Sørensen 1994, Andersen and Sørensen 1992).

In Sweden several STS units have been created, such as Tema T in Linköping and Science and Technology Studies at Göteborg University. Those groups conduct research on various aspects of technology and ethics, such as the role of expertise, technology in everyday life, technology and gender, technology and identity, technology and large technological systems, and public engagements with science.

These institutions focus largely on technology *development* rather than the *consequences* of technology, and in terms of ethics they may be seen to underline mostly a deontological approach in which social values come first and technology comes second.

In Denmark and later in Norway a tradition of technology *assessment* has developed. The most important contribution in this field is probably the Danish "consensus conference," which involves laypeople in the ethical assessment of technology. The laypeople are appointed much as a jury is appointed in a court. They question experts during a three-day session. Afterward they withdraw and formulate a verdict in the form of a consensus report. This approach can be associated with a nonteleological or deontological approach to ethics and technology.

Ethics of Science

In Scandinavia debates on the ethics of science have involved research on both ethics in technology and bioethics research. However, only with the establishment of specific committees for the ethics of science has this become an integrated part of work on the ethics of technology.

In Denmark the ethics of science was prominently present in the medical research community, which had to deal with serious problems with scientific fraud. The central committee on the ethics of science was influential in resolving problems among scientists with regard to this issue.

In 1998 the Danish Committee on Scientific Fraud and Integrity in Science (Udvalgene Vedrørende Videnskabelig Redelighed) was established as a subcommittee to the national committee for medical research. This committee formulated a number of rules for the ethics of science and publication ethics. The committee was allowed to process individual complaints against scientists (Rendtorff 2003, p. 63).

In this context, an intense debate about the ethics of science emerged as a reaction to the work of the political scientist Bjørn Lomborg (2002), director of a newly established Institute for Assessment of Environmental Protection. Lomborg had argued that most of the environmental sciences had been too pessimistic with regard to their conceptions of the dangers of an environmental crisis. Lomborg's work was brought to the committee in 2002 by a number of scientists who complained that Lomborg was guilty on scientific fraud because they did not believe in his methods and research results. It was argued that Lomborg did not work with a satisfactory scientific method. Lomborg had illustrated his argument with statistical material, and many ecological scientists thought that this constituted scientific fraud because he used statistical material to illustrate arguments that, according to the ecologists, could not be defended on those grounds. Lomborg's opponents argued that Lomborg's book could not be regarded as science, but rather as a contribution to the public debate. Moreover, it was argued that Lomborg as a social scientist did not have sufficient knowledge, which led to incorrect and hasty conclusions. The Committee on Scientific Rraud and Integrity investigated the issue, based on dialogue with international experts, and in spring 2003 (Rendtorff 2003, p. 9–10) Lomborg was judged by the committee to have committed not subjective but objective scientific fraud; according to the committee, he did not understand his research subject. This led to a violent debate about environmental technology in Denmark, and after that time the ethics of science became a very widely discussed subject.

In January 2004 the Ministery for Research of the Danish liberal-conservative government intervened. They came up with a very critical assessment of the decision in the Lomborg case. However, the Ministery wanted to protect people who were charged of scientific fraud; it therefore did not accept the decision of the Committee for Scientific Fraud in the Lomborg case. So Lomborg, in the end, was not convicted of scientific fraud and the official inquiry ended in January 2002. But even though the case of Lomborg did not get a clear closing and decision about whether it really was a case of scientific fraud, it illustrates many of the basic dilemmas of the ethics of science in Scandinavian countries: problems of the definition of scientific fraud and the integration of the public in scientific debates.

LARS FUGLSANG
JACOB DAHL RENDTORFF

SEE ALSO *Bioethics; Environmental Ethics; Kierkegaard, Søren; Marxism; Science, Technology, and Society Studies; von Wright, Georg Henrik.*

BIBLIOGRAPHY

Achen, Thomas. (1997). *Den bioetiske udfordring. Et retspolitisk studie af forholdet mellem etik, politik og ret i det lovforberedende arbejde vedrørende bio- og genteknologi i Danmark, Norge og Sverige* [The bioethical challenge. A study in legal politics of the preparatory work on laws on bio- and gene technology in Denmark, Norway and Sweden]. Linköping, Sweden: Linköpings Universitet.

Andersen, Håkon With, and Knut Holten Sørensen. (1992). *Frankensteins dilemma. En bok om teknologi, miljø og verdier.* [The dilemma of Frankenstein. A book about technology, environment and values]. Oslo: Gyldendal.

Andersen, Svend. (1994). *Forskningsetik. En Udredning* [Research ethics. A report]. Copenhagen: Forskningsministeriet.

Braverman, Harry. (1976). *Labour and Monopoly Capital: The Degradation of Work in the Twentieth Century.* New York: Monthly Review Press.

Bødker, Susanne. (1987). *Through the Interface: A Human Activity Approach to User Interface Design.* Århus, Denmark: Århus University, Computer Science Department: DAIMI PB (224).

Chandler, Alfred Dupont. (1990). *Scale and Scope: The Dynamics of Industrial Capitalism.* Cambridge, MA: Belknap Press of Harvard University Press.

Cronberg, Tarja. (1987). *Det teknologiske spillerum i hverdagen. En beskrivelse af hvordan telefonen, vaskemaskinen og bilen har påvirket hverdagslivet, og en modelteoretisk analyse heraf.* Copenhagen: Nyt fra samfundsvidenskaberne.

Ehn, Pelle. (1988). *Work-Oriented Design of Computer Artifacts.* Stockholm: Arbetslivscentrum.

Elzinga, Aant, and Andrew Jamison. (1981). *Cultural Components in the Scientific Attitude to Nature: Eastern and Western Modes?* Lund, Sweden: Reprocentralen.

Engeström, Yrjö, Reijo Miettinen, and Raija-Leena Punamäki-Gitai, eds. (1999). *Perspectives on Activity Theory.* Cambridge, UK: Cambridge University Press.

Fuglsang, Lars. (1993). *Technology and New Institutions: A Comparison of Strategic Choices and Technology Studies in the United States, Denmark, and Sweden.* Copenhagen: Academic Press.

Habermas, Jürgen. (1984). *The Theory of Communicative Action.* Boston: Beacon Press.

Hansson, Mats. (1991). *Human Dignity and Animal Well-Being: A Kantian Contribution to Biomedical Ethics.* Uppsala, Sweden: Almquist & Wiksell International.

Hybel, Ulla. (1998). *Forsøgspersoner. Om den retlige beskyttelse af mennesker, der deltager I biomedicinsk forskning* [Experimental subjects. About the legal protection of persons who participate in biomedical research]. Copenhagen: Jurist og Økonomforbundets forlag.

Jamison, Andrew. (1982). *National Components of Scientific Knowledge: A Contribution to the Social Theory of Science.* Lund, Sweden: Research Policy Institute.

Jensen, Hans Siggaard, and Ole Skovmose. (1986). *Teknologikritik.* Herning, Denmark: Systime.

Jensen, Ole (1976). *I Vækstens Vold* [Submitted to growth]. Copenhagen: Fremad.

Kemp, Peter. (1991). *Det uerstattelige. En teknologi etik* [The irreplacable. A technology ethics]. Copenhagen: Spektrum. Swedish translation, *Det Oerstättliga. En teknologietik.* Stockholm/Skåne: Brutus Östlings Bokforlag Symposion. German translation (1992), *Das Unersetzliche. Eine Technologie-Ethik.* Berlin: Wichern. Norwegian translation (1996), *Det uerstattelige. En teknologi-etikk.* Olso: Gyldendal. French translation (1997), *L'irremplaçable.* Paris: Éditions du Cerf.

Kemp, Peter; Mette Lebech; and Jacob Rendtorff. (1997). *Den bioetiske vending.* Copenhagen: Spektrum.

Kemp, Peter; Jacob Rendtorff; and Niels Mattson Johansen. (2000). *Bioethics and Biolaw,* vols. I and II. Copenhagen: Rhodos International Publishers.

Kvaløy, Sigmund. (1976). *Økokrise, natur og menneske: En innföring i økofilosofi og økopolitikk.* Oslo: Tapir.

Lie, Merete, and Knut H. Sørensen. (1996). *Making Technology Our Own? Domesticating Technology into Everyday Life.* Oslo: Scandinavian University Press.

Lomborg, Bjørn. (2002). *The Sceptical Environmentalist.* Cambridge, UK: Cambridge University Press.

Lund, Anker Bring; Robin Cheesman; and Oluf Danielsen. (1981). *Fagre elektroniske verden.* Copenhagen: Fremad.

Næss, Arne. (1976). *Økologi, samfunn og livsstil* [Ecology, society, and lifestyle]. Olso: Scandinavian University Press.

Østerberg, Dag. (1974). *Makt og materiell.* Oslo: Pax.

Rendtorff, Jacob Dahl. (1999). *Bioetik og ret. Kroppen mellem person og ting* [Bioethics and law. The body between person and thing]. Copenhagen: Gyldendal.

Rendtorff, Jacob Dahl. (2003). *Videnskabsetik* [The ethics of science]. Roskilde: Roskilde Universitetsforlag.

Rendtorff, Jacob Dahl, and Peter Kemp. (2000). *Basic Ethical Principles in European Bioethics and Biolaw,* vols. I and II. Copenhagen and Barcelona: Centre for Ethics and Law and Institut borja di bioètica.

Sejersted, Francis. (1993). *Demokratisk kapitalisme*. Oslo: Universtetsforlaget.

Solbakk, Jan-Helge. (1994). *Medicinen som møtested og markedsplads* [Medicine as meeting place and market place]. Oslo: Forum.

Sørensen, Knut Holten, ed. (1994). *The Car and Its Environments: The Past, Present and Future of the Motorcar in Europe*. Brussels: COST Social Sciences Directorate General of Science, Research and Development.

Sørensen, Villy; Niels I. Meyer; and K. Helweg Petersen. (1978). *Oprør fra midten* [Revolt from the center]. Copenhagen: Gylden.

Tranøy, Knut-Erik. (1992). *Medisinsk etikk i vår tid* [Medical ethics in our time]. Oslo: Sigma forlag.

von Wright, Georg Henrik. (1986). *Vetenskapen Och Förnuftet* [Reason and science]. Stockholm: MånPocket.

Thyssen, Ole. (1997). *Værdiledelse* [Values-driven management]. Copenhagen: Gyldendal.

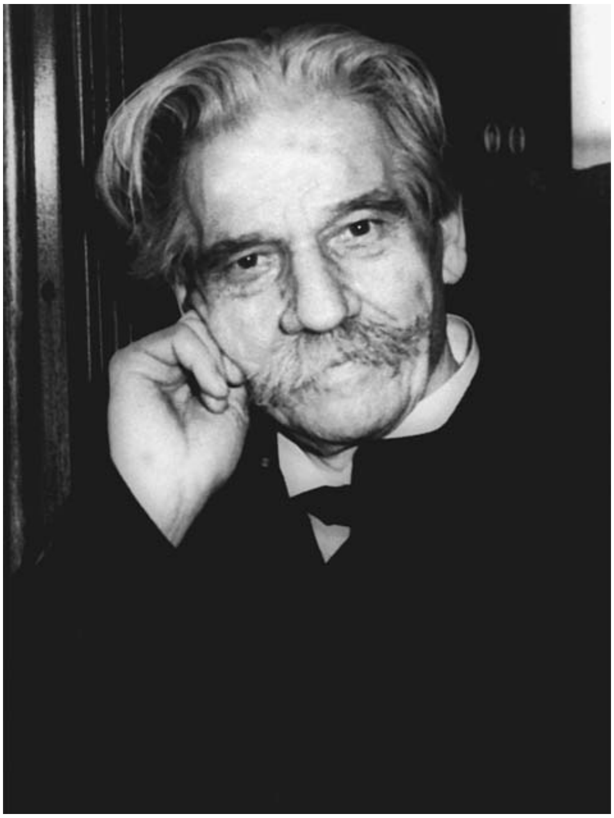
Wicken, Olav. (1998). "Regional Industrialization and Political Mobilization: Regions in Politcal Party Systems and Industrialization in Norway." *Comparative Social Research* 17: 241–271.

SCHWEITZER, ALBERT

Albert Schweitzer (1875–1965) was born in Kaysersberg, Germany (now part of France) on January 14, and became a theologian, physician, musician, and philosopher whose ethical theory argued the centrality of reverence for life. After a doctorate in philosophy from the University of Strasbourg (1899), Schweitzer received his licentiate in theology (1900), and from 1901 to 1912 held administrative posts in the Theological College of St. Thomas. In 1913, having earned an M.D. degree, he founded a hospital at Lambaréné, French Equatorial Africa (now Gabon). As a German citizen, he became a French prisoner during World War I, but returned to Lambaréné in 1924, where he spent the remainder of his life expanding, administering, and improving the hospital. Recipient of the 1952 Nobel Peace Prize, Schweitzer worked during his later years in the struggle to end the proliferation and testing of nuclear weapons. He died on September 4 and was buried at Lambaréné.

From Music to Philosophy

In 1905 Schweitzer, an accomplished organist, wrote a biography of Johann Sebastian Bach (1685–1750), and in 1906 *The Quest of the Historical Jesus* established him as a theological scholar. As a Christian, his faith guided his life as a physician at Lambaréné, where he unselfishly treated thousands of patients, including lepers. Although successful in diverse fields, Schweitzer considered his contributions to philosophy to be his most important achievements.



Albert Schweitzer, 1875–1965. Schweitzer was a German religious philosopher, musicologist, and medical missionary in Africa. He was known especially for founding the Schweitzer Hospital, which provided unprecedented medical care for the natives of Lambaréné in Gabon. *(AP/NYWTS/The Library of Congress.)*

Schweitzer's philosophy of culture and ethics sought to reorient material progress toward humanity as a normative ideal. In his *The Decay and the Restoration of Civilization* (1923) and *Civilization and Ethics* (1923)—brought together in *The Philosophy of Civilization* (1949)—Schweitzer interpreted World War I as the sign of a deep-rooted crisis of European culture. The Enlightenment ideals of progress and rationality had decayed and lost their ability to control the trajectory of science and technology. Philosophy and religion no longer provided intellectual and spiritual guidance. Human powers had outstripped human capacities for reason.

This asymmetry between human powers and the ability to wisely constrain and channel those powers for compassionate action underpinned Schweitzer's ethics. In *Civilization and Ethics*, he writes:

> The disastrous feature of our civilization is that it is far more developed materially than spiritually. . . . Through the discoveries which now place the forces of Nature at our disposal in such an unprecedented way, the relations to each other of individuals, of social groups, and of States have undergone a revolutionary change. . . . Advances in knowledge and power work out their effects on us almost as if they were natural occurrences. . . . Paradoxical as it may seem, our progress in knowledge and power makes true civilization not easier but more difficult. (pp. 86–87)

He did not conceive of his own ethical theory as completely novel, but rather as the revitalization and reformation of the ethical legacy of humanity in the twentieth century. His goal was to restore the binding character of humanity and humanitarianism as the common assets of world civilizations. Schweitzer drew not only from the Christian commandment of love but also from Asian philosophies. He held that his main principle of "devotion toward life born from reverence for life" was a plausible ethical guideline for any individual regardless of his or her culture or religion.

In contrast to the rational a priori approach of Immanuel Kant (1724–1804), Schweitzer grounded his ethics in the experience of life as an empirical hypothesis, and is in this sense closely related to Friedrich Nietzsche (1844–1900) and Arthur Schopenhauer (1788–1860). Reflecting upon life in this way, Schweitzer believed, would lead to the perspectives of reverence and responsibility. An experience of one's own "will to life," and the effort to avoid pain and seek pleasure, rationally compels an individual, under the auspices of a quasi-Kantian truthfulness, to acknowledge the same volition in others (see Meyer and Bergel 2002). This consciousness of being connected with other lives demands that people respect the moral rights of others, including plants and animals.

Schweitzer's ethics is contextual and situation-oriented and leads to a practical law that serves "concrete" humanity. He does not require an unbounded ethical responsibility beyond one's capability, but rather insists that it is most important to practice reverence for life within one's scope of action. He believed "abstraction is the demise of ethics" and that concrete humanity should always be promoted.

Ethics and Technology

Schweitzer was aware that life presented conflicting demands and that technological and scientific developments in modern civilization posed difficult challenges for practical responsibility. Yet he did not believe that this warranted the construction of dubious hierarchies and theoretical rankings of values that only solve problems in the abstract. His ethics does not promise a methodical and self-evident solution to difficult problems. Instead, the principle of reverence for life should be used as a general guideline for the process of critical thinking.

Schweitzer's ethics serves as a compass in the complex geography of modern problems to orient practical action toward responsibility and reverence for life. In his autobiography, *Out of My Life and Thought* (1990), Schweitzer describes the moment when the concept of reverence for life dawned upon him as he traveled through an African jungle in September 1915. He remembers, "Late on the third day, at the very moment when, at sunset, we were making our way through a herd of hippopotamuses, there flashed upon my mind, unforeseen and unsought, the phrase 'reverence for life.' . . . Now I had found my way to the principle in which affirmation of the world and ethics are joined together!" (p. 155).

Although he did not develop a special ethics for science and technology, Schweitzer's humanitarianism and reverence for life can be easily transferred to the moral problems in this field. For instance, he argued that because nuclear technology could not be controlled, it could by the same token not be responsibly used—a position that would, of course, have to be qualified by specific situations and contexts (Schweitzer 1958). In general, Schweitzer's advice for solving ethical problems, including those presented by science and technology, was to rely on and use practical reasoning, individual responsibility, and the ideal of concrete humanity.

CLAUS GÜNZLER
HANS LENK

SEE ALSO *Development Ethics; Environmental Ethics; Life.*

BIBLIOGRAPHY

Groos, H. (1974). *Albert Schweitzer—Größe und Grenzen* [Albert Schweitzer: greatness and limits]. Munich, Basel: E. Reinhardt.

Günzler, Claus. (1996). *Albert Schweitzer: Einführung in sein Denken* [Albert Schweitzer: introduction to his thought]. Munich: C. H. Beck.

Lenk, Hans. (2000). *Albert Schweitzer: Ethik als konkrete Humanität* [Albert Schweitzer: ethics as concrete humanity]. Münster, Germany: LIT.

Meyer, Marvin, and Kurt Bergel, eds. (2002). *Reverence for Life: The Ethics of Albert Schweitzer for the Twenty-First Century*. Syracuse, NY: Syracuse University Press. Includes excerpts from Schweitzer on the concept of reverence for life, contributions from others assessing the concept, and a concluding section on its import for education.

Miller, David C., and James Pouilliard, eds. (1992). *The Relevance of Albert Schweitzer at the Dawn of the Twenty-First Century*. Lanham, MD: University Press of America. Especially relevant to science, technology, and ethics, with chapters on nuclear arms reduction, medicine, human rights, and the environment.

Schweitzer, Albert. (1949). *The Philosophy of Civilization*, trans. C. T. Campion. New York: Macmillan. His major philosophical treatise, composed of *The Decay and the Restoration of Civilization* and *Civilization and Ethics*, both originally published in 1923 as *Verfall und Wiederaufbau der Kultur* and *Kultur and Ethik*.

Schweitzer, Albert. (1958). *Peace or Atomic War?* New York: Henry Holt. An essay divided into three parts—nuclear tests, atomic war, and negotiations—originally delivered as three broadcasts from Oslo, Norway.

Schweitzer, Albert. (1965). *The Teaching of Reverence for Life*, trans. Richard Winston and Clara Winston. New York: Holt, Rinehart and Winston. Begins with a basic treatment of ethics and develops Schweitzer's ethic concerning personal relations, culture, and atomic weapons.

Schweitzer, Albert. (1971–1974). *Gesammelte Werke* [Collected works], ed. R. Grabs. 5 vols. Munich: C.H. Beck.

Schweitzer, Albert. (1990). *Out of My Life and Thought: An Autobiography*, trans. Antje Bultmann Lemke. Rev. edition. New York: Henry Holt. Originally published in 1931.

Schweitzer, Albert. (1995–2005). *Werke aus dem Nachlass* [Posthumous works], ed. Richard Brüllmann, Erich Gräßer, Claus Günzler, et al. 9 vols. Munich: C.H. Beck. Includes the main philosophical work "Die Weltanschauung der Ehrfurcht vor dem Leben."

Schweitzer, Albert. (1999–2000). *Kulturphilosophie III*, ed. Claus Günzler and Johann Zürcher. Munich: C. H. Beck.

Steffahn, Harald. (1979). *Albert Schweitzer*. Reinbek, Hamburg: Rowohlt.

SCIENCE AND ENGINEERING INDICATORS

Science and Engineering Indicators is a term referring to efforts to measure the pursuit, support, and performance of science and engineering on scales that geographically extend from the local to the international. Their goal is usually to help direct policy programs in research, education, and industrial support.. The most prominent and celebrated of these is Science and Engineering Indicators (referred from here on as *Indicators*) published every two years in the United States by the National Science Board (NSB). NSB is the body that oversees the budget and policies of the National Science Foundation (NSF) and the report itself is prepared by NSF's Science and Resources Directorate.

As an NSF publication, *Indicators* was conceived after Congress, in 1968, broadened the NSF Charter to include more engineering and social sciences in the agency's support portfolio. Legislators desired a sense of the impact government support for research was having on the "health" of the national research system, and NSF, which already had an active statistics branch, broadened its ambitions to large-scale endeavors.

The first *Indicators* report was issued in 1972 as simply "Science Indicators" and ever since it has been the worldwide standard reference and model for the statistical treatment of science, engineering, and technology. *Engineering* appeared in its name in 1986 when the NSF, under Congressional pressure, sharply raised its budget for engineering research and elevated its interest in supporting partnerships between U.S. universities and industry.

No mandate, however, was established for assessing the social and economic impact of science and engineering. Editors of *Indicators* have been conscious of and curious about returns on government research investment. But they believe the report is already extensive enough and that performance indicators that assess such outcomes are, and always were, imposingly difficult areas to measure. Quantified data will probably always constitute the core of the *Indicators* endeavor.

As the research system has grown and changed over the years, *Indicators* has evolved in style, content, and presentation. The 1976 edition, reflecting a relatively simple time in the measurement of science and technology for policy, contained chapters titled "International Indicators of Science and Technology," "Resources for Research and Development," "Resources for Basic Research, Industrial R&D and Innovation," "Science and Engineering Personnel," and "Public Attitudes toward Science and Technology."

By comparison, the more voluminous and finely rendered 2002 edition mirrored the rise of new technologies, the increasing globalization of science and technology, and the wider mingling of corporate, university and government interests. Its chapters included "Elementary and Secondary Education," "Higher Education Science and Engineering," "Science and Engineering Workforce," "Funding and Alliances in U.S. and International Research and Development," "Academic Research and Development," "Industry, Technology, and the Global Marketplace," "Public Attitudes and Public Understanding of Science and Technology," and a special chapter entitled "Significance of Information Technology." By the increasing specificity of the chapter titles it was becoming clear that the *Indicators* editors were being nudged toward treating the facts and figures of science and engineering as more than self-referential measures of the enterprise.

The 2004 edition extended the publication's reach by introducing a chapter on state-by-state research and development statistics, mainly to reflect the importance states place on science and engineering for their economic development. But as to actual state-by-state outcomes, *Indicators* once more begged off entering with any sense of resoluteness an area in which statistics are, to them, impossible to gather.

The era of the Internet has improved the currency and relevance of *Indicators*. NSF has taken advantage of Internet technology by continually updating the data in its interactive online version. Thus, readers can no longer object, as they would in the past, that the publication's data were too out of date to be useful. Their objection was a valid one for scholarship: Upon the date of publication, many of *Indicators* data were often more than a year out of date.

Identifying exactly what science, engineering, and technology ought to indicate is a subject that is without a consensus but is ripe for speculation, especially in the ethical dimensions of the technical universe. Its chapters draw conclusions and projections, but the publication largely leaves it to the readers to interpret what the numbers mean. One certainty is that *Indicators* confirms that science and technology have shown huge growth both in complexity and scope since the report was first issued, raising issues related to how scientific and technological change affect, and indeed can improve on, human life.

As an information tool for ethical studies of science and technology, the best that can be said is that *Indicators* offers mountains of data for the taking—levels of funding by field of study, patent activity by universities, size of university department, and so on. But if the ethical subject is conflict of interest by scientists in universities, for example, *Indicators* will provide enough data on the extent of private funding for academic research, but offer nothing in the way of, for example, numbers of universities that require their faculties to adhere to a code of behavior in dealings with industry. If the query is numbers of litigation cases between universities and corporations over intellectual property, again, *Indicators* fails the test.

But on balance, a point can be reached where too much is asked of a report that was always meant to be statistical. *Indicators* is widely praised, universally used, and admiringly emulated. The problem for users with an interest in ethics and the social sciences is that the publication does not address societal and economic outcomes, leaving the reader with the sense that science mainly looks inward while growing in size and importance worldwide. As for technological growth, the reader has no guidance for judging its relative social benefits.

Science and engineering are such powerful forces for change that their statistical treatment will continue to evolve. Very little systematic research, however, has been done to better reflect the vast ramifications of science and technology on society and economies, raising the issue of what *Indicators* is in fact supposed to indicate. The Organization of Economic Cooperation and Development in Paris, established after World War II, began such metrics as part of the post-war reconstruction of Europe. The work of that organization continues with its periodic reports on various fields of technology, and their social and economic importance. And, of course, other countries, as mentioned, confidently persist in attempting to measure the social impact of science and technology.

By 2005 every industrial country as well as the twenty-five-member European Union (EU) had issued its own science and engineering indicators. The EU, Japan, and most of the large but less developed countries such as Brazil, India, and China tended to stress the societal dimensions as well as the purely statistical treatment of science and technology. The popularity of *Indicators* seems to support the notion that science and technology are increasingly indispensable tools of economic progress and that countries more than ever feel the need to keep pace with one another.

WIL LEPKOWSKI

SEE ALSO *Education; Social Indicators.*

BIBLIOGRAPHY

Godin, Benoît. (2002). *Are Statistics Really Useful? Myths and Politics of Science and Technology Indicators*. Project on the History and Sociology of S&T Statistics, Paper no. 20, 39 pages. Quebec City, Canada: National Institute of Scientific Research, University of Quebec.

Godin, Benoît. (2003). *The Most Cherished Indicator: Gross Domestic Expenditure on R&D (GERD)*. Project on the History and Sociology of S&T Statistics: Paper no. 22, 25 pages. Quebec City, Canada: National Institute of Scientific Research, University of Quebec.

Science and Public Policy. (1992): 19(5 and 6). Special issue.

SCIENCE EDUCATION

SEE *Activist Science Education; Education*.

SCIENCE FICTION

From its beginnings as a literary genre science fiction has displayed ambivalence toward the ethical implications of scientific discovery and technological development. As a form of literature devoted in large part to evoking the potential futures and possible worlds engendered by mechanical innovation, science fiction (SF) has emerged over the last century as the preeminent site within Euro-American popular culture where the social consequences of modern technology may be explored creatively and interrogated critically.

As Brooks Landon has argued, SF "considers the impact of science and technology on humanity" by constructing "zones of possibility" where that impact can be represented and narratively extrapolated (Landon 1997, pp. 31, 17). Landon's understanding of the genre builds on James Gunn's definition of SF as the "literature of change," a mode of writing that investigates the outcome of technological progress at a level "greater than the individual or the community; often civilization or the race itself is in danger" (Gunn 1979, p. 1). This broad focus on the promises and perils of techno-scientific transformation requires a degree of concern, however implicit, for its moral repercussions, and the best SF has not shrunk from ethical engagement.

From *Frankenstein* to *Brave New World*

If, as several critics have argued, Mary Shelley's *Frankenstein, or the Modern Prometheus* (1816) was the first true SF novel, the genre's founding text provides a paradigm of moral ambivalence toward the processes and products of scientific inquiry. Driven by an urge to unlock the secrets of nature, Victor Frankenstein is at once the genre's first heroic visionary and its first mad scientist. Indeed, these roles are inseparable: Frankenstein's bold commitment to unfettered experimentation makes him capable of both wondrous accomplishment—the creation of an artificial person endowed with superhuman strength and intelligence—and blinkered amorality. Unable to contain or control his creation, whose prodigious powers have been turned toward destructive ends, Frankenstein comes to fear that he has unleashed "a race of devils … upon the earth, who might make the very existence of the species of man a condition precarious and full of terror" (Shelley 1982, p. 163). *Frankenstein,* through its many cinematic incarnations, has bequeathed to contemporary popular culture an enduring myth of science as an epochal threat for humanity and a source of moral corruption.

Throughout the nineteenth century the maturing genre continued to manifest that dualistic response: on the one hand limning a world transformed by the relentless advance of modern science and industry and on the other hand depicting the corrosive effects of that transformation on traditional values and forms of life. Jules Verne's popular series of "Extraordinary Voyages," with their celebration of the wonders of technology, represented the former trend, whereas H.G. Wells's darker and more skeptical series of scientific romances, beginning with *The Time Machine* (1895), epitomized the latter response. Although Verne's *Twenty Thousand Leagues Under the Sea* (1870) contains a kind of mad scientist, Captain Nemo, he is more a misunderstood genius than a figure of Frankensteinian evil, and his futuristic submarine, the *Nautilus,* is more a marvel of invention than a lurking monster. That powerful machine may inspire fear, but this is the result of ignorance rather than intrinsic threat. By contrast, the eponymous character in Wells's *The Island of Dr. Moreau* (1896) is a power-mad fanatic whose creations, a horde of human-animal hybrids, clearly descend from Frankenstein's fiendish invention. Twisted parodies of natural forms, they point up the moral limitations of experimental science: Moreau's brilliance can mold a beast into a human semblance, but it cannot endow the result with virtue or a functioning conscience.

Emblematic though he may be of the ethical predicament of modern science, Dr. Moreau, like Victor Frankenstein, is just one man, and an isolated one, exiled on his island. In the twentieth century SF began to explore the possibility that individual overreaching might be generalized, wedding scientific novelty with industrial mass production to generate in the ironic title of Aldous Huxley's novel, a *Brave New World* (1932). Huxley's satirical vision of a future in which babies are grown in vats and emotions are managed technocratically by drugs and the mass media offers a wide-ranging

Scene from the 1954 science-fiction film "Gog." The human-vs.-robots theme is common in science fiction. *(The Kobal Collection.)*

indictment of a regimented society from which morality has been purged in favor of a coldly instrumental scientism. A triumph of scientific and social engineering, filled with technological marvels, that false utopia is ethically atrophied and spiritually void. Huxley's depiction of the dystopian implications of techno-scientific development in the capitalist west were echoed in Yvgeny Zamiatin's *We* (1924), which projected a future socialist Russia dominated by a grim totalitarianism. Though capable of tremendous feats of industrial engineering, this regime dehumanized its citizens, ruthlessly suppressing their artistic impulses, their sexual drives, and their moral aspirations.

A similar vision of simultaneous technological achievement and moral impoverishment is offered in Karel Çapek's *R.U.R.* (1920). That popular play coined the term *robots* to describe the mass-produced workers who, like Frankenstein's monster, finally rebel against their creators in an orgy of destruction. Çapek's robots, like the test-tube babies in Huxley's novel, are actually synthetic humans rather than the clanking machines their name implies. More conventional mechanical creatures figure in SF texts of the 1920s and 1930s, the most famous being the humanoid robot in Fritz Lang's *Metropolis* (1927), a sinister automaton used to manipulate and control the masses. In all its varieties the artificial person, following in the wake of *Frankenstein*, continued to provide a potent icon of moral ambivalence within the genre: Physically and intellectually superior creatures that symbolize at once the titanic capacities of modern technology and the potential perfectibility of humanity, they are ultimately soulless, wholly lacking in moral will.

An American Affirmation

Not all SF produced during that period was equally pessimistic, however. In the United States a more technophilic strain developed, associated with popular pulp magazines whose titles—*Amazing*, *Astounding*, *Won-*

der—suggest their wide-eyed enthusiasm for technological innovation. However, despite the celebratory tone of much of that material, a more cautionary note sometimes was sounded; indeed, the best pulp SF carried forward the ambivalence toward the moral implications of scientific progress that the European tradition had pioneered.

This attitude is especially visible in pulp SF depictions of artificial persons, such as Isaac Asimov's influential series of robot stories, published during the 1930s and 1940s and eventually gathered into his book *I, Robot* (1950). A large part of Asimov's purpose in the series is to overcome popular anxieties about mechanical beings as uncontrollable Frankenstein's monsters; to this end he develops an ethical code—"The Three Laws of Robotics"—that, hardwired into his robots' brains, ensures their virtuous behavior as protectors and servants of humanity. However, much of the narrative suspense of the stories lies in the various contraventions of the laws, with disobedient robots taking advantage of conflicts within the moral norms governing their operation. Clearly, if left to their own devices (i.e., if not programmed with ethical precepts), the robots would, as in Çapek's play, turn against humanity or at least refuse to accept their own servile status. Another pulp writer, Jack Williamson, pursued the logic of Asimov's Three Laws as moral safeguards to their *reductio ad absurdam* in his story "With Folded Hands" (1947), in which robots take their charge of protecting human beings from harm so seriously that they prohibit all risk taking, mandating comfort and safety through a regime of moralistic totalitarianism.

Still, within American pulp SF these moments of doubt about the ethical consequences of technological advancement were far outweighed by a resolutely affirmative vision of the overall role of science in reordering human life. John W. Campbell, Jr., who became the editor of *Astounding* in 1937 and presided over what has come to be known as SF's Golden Age in the subsequent decade, was famous for championing scientific literacy within the genre and embracing technocratic solutions to social problems. In the pages of *Astounding* and other SF pulps scientists and engineers emerged as an intellectual elite; as John Huntington has argued, a "myth of genius" (1989, p. 44) predominates, with readers encouraged to identify with superior, powerful technocrats whose expertise and pragmatic skill presumably transcend ethical doubts and hesitations. The writers most closely associated with this upbeat vision were Asimov, Robert A. Heinlein, and L. Sprague de Camp, all of whom were trained scientists.

In Heinlein's collection *The Man Who Sold the Moon* (1950) an entrepreneurial genius single-handedly pioneers space travel as a commercial venture, bypassing government control. The ethical-political complications surrounding this move into space are neatly evaded by associating moral questioning with bureaucratic inertia, a collective stagnation the confident capitalist transcends through bold individual action. De Camp's classic alternative-history novel *Lest Darkness Fall* (1941) contains a similar portrait of intrepid genius as a technologically adept time traveler from the twentieth century visits ancient Rome, deploying his expert knowledge to forestall the Dark Ages.

Such sweeping visions of techno-scientific accomplishment seemingly untroubled by ethical qualms were characteristic of much Golden Age SF, although, as Asimov's robot stories showed, a lurking anxiety about the potential perils of technological breakthrough could not be dispelled entirely.

The Return to Questions

That lingering subtext rose to the surface in American SF during the 1950s as the global repercussions of the atomic bombings that ended World War II began to be perceived fully. New SF magazines such as *Galaxy* and *Fantasy and Science Fiction* emerged as rivals to *Astounding,* and the stories they featured began to question, if not openly reject, Campbell's staunch commitment to the technocratic ideal. Although *Astounding* had published stories dealing with the coming dangers of atomic energy such as Lester Del Rey's tense novella "Nerves" (1942), which described an accident in a nuclear power plant, those tales generally had depicted enlightened engineers steadily learning to master the technology. After the horrors of Hiroshima and in the throes of a looming confrontation between rival superpowers armed with high-tech weapons, American SF began to doubt not only the moral competence of technocrats in their stewardship of the atomic age but also the very capacity of humanity to avert its self-destruction.

Still, as Paul Brians has argued, science seldom was blamed for that awful crisis: "Many science fiction writers understood that the power of the new weapon threatened civilization and perhaps human survival, but they placed the responsibility for the coming holocaust on the shoulders of politicians or military men and argued that science still provided humanity's best hope for the future" (Brians 1987, p. 29).

Nonetheless, by showing the likelihood as well as the catastrophic effects of global war, tales of nuclear holocaust strongly suggested that humans lacked the ethical resources needed to control this powerful new technology. For example, Judith Merril's novel *Shadow on the Hearth* (1950) focuses on the personal costs of atomic devastation for one typical American family, whose moral strength, although admirable, is insufficient in the face of a breakdown of civilized order. On a broader scale *A Canticle for Leibowitz* (1960) by Walter M. Miller, Jr., depicts a postholocaust culture governed by a Catholic Church unable to forestall, because of to the inherent sinfulness of human nature, a cyclical repetition of nuclear disaster.

At the same time such stories were appearing popular SF films began to deal with the nuclear menace, offering a series of alarmist portraits of the imagined effects of atomic radiation that ranged from giant mutant insects (e.g., *Them* [1954]) to *The Incredible Shrinking Man* (1957). Even the most optimistic cinematic handling of the postwar atomic threat, *The Day the Earth Stood Still* (1951), in which an alien representative of a cosmic civilization intervenes to prevent global war, suggests that human beings, if left to their own devices, are not fit to govern their planet or themselves.

During the 1960s and 1970s that downbeat attitude, in which humanity's technological reach is seen to escape its moral grasp, gained strength as a new generation of writers began to challenge the technophilia of their pulp forebears. The technocratic legacy of Campbell was interrogated skeptically, and in some cases definitively rejected, by what came to be known as SF's New Wave, a loosely affiliated cohort of authors, many writing for the British magazine *New Worlds*, who began to question if not the core values of scientific inquiry the larger social processes to which they had been conjoined in the service of state and corporate power. New Wave SF arraigned technocracy from a perspective influenced by the counterculture discourses of that period, such as student activism, second-wave feminism, anticolonial struggles, and ecological causes and in the process developed a more radical ethical-political agenda—as well as a more sophisticated aesthetic approach—than the genre had featured previously. As a result the New Wave established a crucial benchmark for modern SF's engagement with the serious moral issues surrounding science and technology.

New Wave stories with feminist, ecological, or antiwar agendas were often dire in their predictions of future developments, but their critiques of technocracy were guided by implicit ethics of gender equity, natural balance, and nonviolence. Often those different agendas were wedded, as in Ursula K. Le Guin's short novel *The Word for World Is Forest* (1976), in which the brutal military occupation of another planet directly involves the devastation of its physical environment by hypermacho men, and Thomas M. Disch's *Camp Concentration* (1968), which explores the roots of high-tech warfare in the flaws and insecurities of masculinity. The work of Alice Sheldon, most of it published under the pseudonym James Tiptree, Jr., also probes the nexus of gender hierarchy and militarist and ecological violence, seeming at times to endorse a despairing sociobiological vision in which male sexuality expresses itself through technologically augmented aggression.

The New Wave's ethical idealism thus often was tempered by pessimism, a grim assessment of the dystopian futures portended by out-of-control technology. A key New Wave theme involved the extrapolation of contemporary urban problems to hypertrophied extremes as humans find themselves immured in vast concrete prisons of their own making. Novels such as David R. Bunch's *Moderan* (1971) and Robert Silverberg's *The World Inside* (1971) present such grim portraits of claustrophobic environments that they verge on the Gothic: In these texts the universal triumph of technology predicted and celebrated in Golden Age SF has culminated in a brutal cityscape where beleaguered, stunted spirits struggle to preserve the tattered shreds of conscience and dignity. In the work of the British author J. G. Ballard the modern city emerges as a psychic disaster area. His controversial 1973 novel *Crash*, for example, depicts a denatured humanity bleakly coupling with machines, with the enveloping landscape of metal and concrete having unleashed a perverse eroticism that seeks fulfillment in violent auto wrecks. SF films of that period, such as *THX 1138* (1971), contained similarly harsh indictments of regimented megalopolises that have co-opted or paralyzed ethical judgment.

The Future of Humankind

Long-standing anxieties regarding high technology were amplified during that period by the new science of cybernetics, which claimed that no meaningful distinctions could be drawn between humans and complex machines. The emergence of so-called artificial intelligence posed a challenge to humanity's presumed supremacy, and SF took up that challenge largely by emphasizing the moral superiority of human beings over their intellectually advanced creations. Ernst Jünger's *The Glass Bees* (1957), for example, derives its satirical power from a pointed contrast between the eponymous robots, who dutifully pursue their assigned tasks, and the skeptical narrator, whose ethical questioning suggests a cognitive and spiritual autonomy denied to mere machines, however skillful or complex.

The work of the British author Arthur C. Clarke, such as his story "The Nine Billion Names of God" (1953), had long engaged the possibility that humanity might have spawned its betters in the form of powerful information machines. In 1969 Clarke collaborated with the director Stanley Kubrick to produce the popular film *2001: A Space Odyssey,* in which a sentient computer, the HAL 9000, displays at once its cognitive power and its ethical limitations, conspiring to take over an interplanetary mission, only to be foiled by human pluck and ingenuity. *2001* established a cinematic trend in which the supercomputer emerged as an instrument driven by an urge to domination, as in *Colossus: The Forbin Project* (1970).

If computers threatened to supplant human mental functions, sophisticated new forms of artificial persons seemed poised to replace humanity entirely. Philip K. Dick's novel *Do Androids Dream of Electric Sheep?* (1968) deals with this imminent danger as its policeman protagonist hunts down a group of renegade androids, synthetic duplicates that are indistinguishable on the surface from normal people. However, there is a crucial difference, and it is essentially an ethical one: Androids are incapable of genuine empathy for others. The moral quandary in the novel is that humans are seldom empathetic; moreover, the protagonist's job requires that he be efficient and ruthless—"something merciless that carried a printed list and a gun, that moved machine-like through the flat, bureaucratic job of killing" (Dick 1996, p. 158)—making him as coldly unfeeling as the androids he seeks to slay. Thus, even when a bright moral line seems to distinguish humans from machines, a technocratically regimented social system serves to obscure if not efface it.

Androids was filmed by Ridley Scott as *Blade Runner* (1982), a film that effectively captures the novel's morally ambiguous tone while pointing forward to subsequent "cyberpunk" treatments. The movie's bleak urban milieu, populated by cynical humans and idealistic machines, offers essentially the same fraught moral landscape that would be featured in novels such as William Gibson's *Neuromancer* (1984), in which artificial intelligences and other cybernetic entities seem more deeply invested with values such as freedom and autonomy than do the human characters.

Cyberpunk fictions of the 1980s and 1990s by Gibson, Bruce Sterling, Pat Cadigan, and others brought to a potent climax the trend toward ethical ambivalence that has marked SF's engagement with new technologies. Extrapolating the social futures portended by the proliferation of computers and their spin-off appliances, cyberpunk displays a humanity so morally compromised by high-tech interfaces—including powerful "wetware," machinic implants that radically alter the body and mind—that the capacity for ethical judgment has perhaps been lost. Yet even amid this spiritual collapse cyberpunk's antiheroes manage to salvage scraps of the decaying moral order, as occurs when the protagonist of *Neuromancer* refuses the quasisatanic lure of cybernetic immortality, affirming the finitude of the mortal self as an enduring ethical center, preserved somehow against the sweetest blandishments and the sternest threats of technology.

For nearly 200 years science fiction has provided windows onto futures transformed by modern science and technology. In that process it has shown both the resiliency and the limitations of ethical consciousness in confronting these potentially overwhelming changes.

ROB LATHAM

SEE ALSO *Asimov, Isaac; Brave New World; Frankenstein; Huxley, Aldous; Science, Technology, and Literature; Utopia and Dystopia; Zamyatin, Yevgeny Ivanovich.*

BIBLIOGRAPHY

Asimov, Isaac. (1950). *I, Robot.* New York: Gnome Press.

Ballard, J. G. (1973). *Crash.* London: Jonathan Cape.

Brians, Paul. (1987). *Nuclear Holocausts: Atomic War in Fiction, 1895–1984.* Kent, OH: Kent State University Press.

Bunch, David R. (1971). *Moderan.* New York: Avon.

Čapek, Karel. (1923 [1920]). *R.U.R.: A Fantastic Melodrama.* New York: Doubleday.

Clarke, Arthur C. (1953). "The Nine Billion Names of God." In *Star Science Fiction Stories,* ed. Frederik Pohl. New York: Ballantine.

De Camp, L. Sprague. (1941). *Lest Darkness Fall.* New York: Holt.

Del Rey, Lester. (1942). "Nerves." *Astounding Science Fiction* 30, no. 1 (September 1942): 54–90.

Dick, Philip K. (1996 [1968]). *Do Androids Dream of Electric Sheep?* New York: Del Rey.

Disch, Thomas M. (1968). *Camp Concentration.* London: Hart-Davis.

Gibson, William. (1984). *Neuromancer.* New York: Ace.

Gunn, James, ed. (1979). *The Road to Science Fiction #2: From Wells to Heinlein.* New York: Mentor.

Heinlein, Robert. (1950). *The Man Who Sold the Moon.* Chicago: Shasta.

Huntington, John. (1989). *Rationalizing Genius: Ideological Strategies in the Classic American Science Fiction Short Story.* New Brunswick, NJ: Rutgers University Press.

Huxley, Aldous. (1932). *Brave New World*. New York: Doubleday.

Jünger, Ernst. (1960 [1957]). *The Glass Bees*. Translated by Louise Bogan and Elizabeth Mayer. New York: Noonday.

Landon, Brooks. (1997). *Science Fiction after 1900: From the Steam Man to the Stars*. New York: Twayne.

Le Guin, Ursula K. (1976). *The Word for World Is Forest*. New York: Berkley.

Merril, Judith. (1950). *Shadow on the Hearth*. New York: Doubleday.

Miller, Walter M., Jr. (1960). *A Canticle for Leibowitz*. New York: Lippincott.

Shelley, Mary. (1982). *Frankenstein, or the Modern Prometheus*. Chicago: University of Chicago Press. Originally published in 1816 by Lackington, Allan and Company, London.

Silverberg, Robert. (1971). *The World Inside*. New York: Doubleday.

Verne, Jules. (1870). *Twenty Thousand Leagues Under the Sea*. Paris: Hetzel.

Wells, H.G. (1896). *The Island of Dr. Moreau*. London: Heineman.

Williamson, Jack. "With Folded Hands." *Astounding Science Fiction* 36, no. 2 (July 1947): 6–45.

Zamiatin, Evgeny. (1924). *We*. Translated by Gregory Zilboorg. New York: Dutton.

FILM

Blade Runner. (1982). Directed by Ridley Scott. Distributed by Columbia Tristar Pictures.

Colossus: The Forbin Project. (1970). Directed by Joseph Sargent. Distributed by Universal Pictures.

The Day the Earth Stood Still. (1951). Directed by Robert Wise. Distributed by Twentieth Century Fox.

The Incredible Shrinking Man. (1957). Directed by Jack Arnold. Distributed by Universal Pictures.

Metropolis. (1927). Directed by Fritz Lang. Distributed by Universum Film, A.G.

Them. (1954). Directed by Gordon Douglas. Distributed by Warner Brothers.

THX-1138. (1971). Directed by George Lucas. Distributed by Warner Brothers.

2001: A Space Odyssey. (1969). Directed by Stanley Kubrick. Distributed by Metro-Goldwyn-Mayer.

SCIENCE LITERACY

SEE *Public Understanding of Science*.

SCIENCE MUSEUMS

SEE *Museums of Science and Technology*.

SCIENCE: OVERVIEW

Science looms as large as any aspect of the contemporary world, with multiple moral and political engagements on its own as well as through its associations with technology. Both as a positive feature of the human world and as a phenomenon against which there are many reactions, science is a distinguishing feature of the contemporary ethical and political landscape. An overview of this landscape is facilitated by distinctions between science as a body of knowledge and as a human activity. As an activity science may be further examined as both a cognitive and a social process. Ethics is implicated in all three senses: knowledge, cognitive activity, and social process.

Body of Knowledge

In the public mind relations between science and ethics are commonly associated with the ethical and religious challenges from certain types of scientific knowledge—about the origins of life or the cosmos, about brain chemistry as the basis of mind, and more. But scientific knowledge can also be adopted to support received religious traditions and basic ethical assumptions—as when the Big Bang theory is interpreted as evidence of divine creation or quantum indeterminacy as the basis of free will.

RELIGIOUS ISSUES. Historically there have been persistent tensions between claims to revelation and knowledge acquired by natural means. During the Middle Ages Christian theology at one point sought to delimit Aristotelian natural science; specific propositions from Thomas Aquinas's effort to synthesize revelation and Aristotelian science were condemned by the bishop of Paris in 1277 (and not formally revoked until 1325). The trial of Galileo Galilei for his support of Copernican astronomy is another widely cited example. (The 1633 edict of the Inquisition was not formally revoked until 1992.) The 1925 trial of *Tennessee v. John Thomas Scopes* concerned with the teaching of Darwinian evolution in the public schools is yet another celebrated case, as is mentioned in an entry on its contemporary echo, the "Evolution–Creationism Debate."

Analyzing these and related cases scholars have distinguished a spectrum of possible interactions between science and religion, some focusing more on theological issues, others on ethics. No one has done more to parse these debates than the physicist and theologian Ian G. Barbour, winner of the 1999 Templeton Prize for Progress in Religion. According to Barbour (2000), there are at least four distinctive relations between science and religion: conflict, independence, dialogue, and integration. In a series of books published over a forty-year period, Barbour explores such relations across history, in different theological communities, and in diverse branches of science such as astronomy and cosmology, quantum physics, evolutionary biology, and genetics. At the same time, in contrast to evolutionary biologist Stephen J. Gould (1999) who argues for the independence of "non-overlapping magisterial (NOMA)" between science and religion, Barbour defends a relationship of dialogue and integration. The entry on "Christian Perspectives" makes further use of a version of this range of possibilities. Similar alternatives are also exemplified in entries on other religious traditions such as "Buddhist Perspectives" and "Jewish Perspectives."

ETHICAL ISSUES. As with religion, relations between scientific knowledge and ethics fall out into a number of different possible models: opposition (substantive ethical criticisms of science), separation (as in the fact/value dichotomy), reductionism (of ethics to science), and cooperation or partnership (in efforts to develop a scientific ethics or to use scientific knowledge to achieve ethical ends). A host of *Encyclopedia of Science, Technology, and Ethics* entries illustrate and deepen each of these models. Entries on particular branches of science, from "Astronomy" to "Psychology," tend to stress opportunities for syntheses. Entries on concepts such as "Determinism" and the "Fact/Value Dichotomy" highlight separations. Entries on "Evolutionary Ethics" and "Scientific Ethics" argue possibilities for basing ethics on science.

Increasing recognition within the scientific community of the importance of issues related to the human interpretation of scientific knowledge is reflected in the founding by the American Association for the Advancement of Science of a special Dialogue on Science, Ethics, and Religion, as described in the entry on the "American Association for the Advancement of Science." Substantive interpretations of the meaning of scientific knowledge remain an ongoing concern that has not been fully met by either scientific humanism, religious apologetics, or humanities reflection on the achievements of science—all of which are approaches represented in the present encyclopedia.

Cognitive Activity

Assessing science as a cognitive activity is the primary task of the philosophy of science and obviously overlaps with critical reflections on science as a body of knowledge. Yet in the philosophy of science the emphasis is less on the human or social meanings of scientific knowledge and more on examining the structure of such knowledge and analyzing its epistemological claims. Analyses of the structure of scientific knowledge involve three broad problem sets dealing with demarcation, confirmation, and explanation. How is scientific knowledge distinguished from pretensions to science (that is, pseudoscience) and other types of knowledge (using appeals to certainty, objectivity, reproducibility, predictive power)? What are the methods of scientific knowledge production (deduction, induction, verification, confirmation, falsification)? How do scientific explanations function (in their integration of observations, laws, and theories)?

With regard to epistemological claims, there are two major views of science: realism and instrumentalism. Realism argues that scientific propositions in some manner reflect the way the world really is, meaning they correspond to reality. By contrast, instrumentalism argues that scientific propositions are simply tools for explaining or manipulating phenomena. For the realist, the model of the atom provides a picture of what atoms actually look like. For the instrumentalist or antirealist, the differential equations used to predict the path of the Moon around Earth have no direct correspondence to the forces that actually move the Moon.

All basic philosophy of science texts cover these topic sets, as well as the debate between Thomas Kuhn and Karl Popper over the historical character of science that has been so prominent since the mid-1960s (see, e.g., the entries on "Kuhn, Thomas" and "Popper, Karl"). Increasingly there are also modest inclusions of arguments about values, especially the way gender bias may be operative in science. But in respect to values and ethics in science as a cognitive or knowledge-producing activity, it is discussions of fraud and misconduct in science, as covered by entries on "Scientific Integrity" and "Responsible Conduct of Research," that are most relevant. The most widely used introduction to these issues is the pamphlet *On Being a Scientist* (2nd edition, 1995), prepared by the U.S. National Academy of Sciences, National Academy of Engineering, and Institute of Medicine.

Social Process

Science is not only a cognitive activity but also a social process involving interactions on several levels from individual laboratories to academic disciplines and from corporations to national and international science policymaking organizations. Examination of these interactions has taken on increased importance as science has grown from a small community of practitioners to an abundant and widely dispersed "metropolis"—from small science to big technoscience. The focus of early modern philosophers, however, was on cognitive at the expense of social activities, and it was not until the 1930s that Robert Merton undertook to pursue the sociology of science.

According to Merton (as considered in the entry on "Merton, Robert"), science as a social institution rests on a normative structure that best flourishes in a democratic society because of a common ethos. Moreover, scientists ought to participate in the social order rather than pretend to a "sanguine isolationism." Indeed, World War II brought about a new era of increased participation by scientists in military and political affairs. Not only did this raise questions about their responsibility for the knowledge they produced and the products, processes, and systems such knowledge made possible, but it also posed dilemmas about the appropriate roles for scientists in political controversies. It was in the midst of such dilemmas that the "scientists' movement" (as described in Mitcham 2003) arose to help direct scientific developments toward particular ends.

Social disillusionment with science and technology in the 1960s and 1970s spurred the public understanding of science movement, which has made common cause with older traditions in the popularization of science. (See the entry on "Public Understanding of Science.") It was also related to developments in the history and philosophy of science. Against more rational reconstructionist arguments such as those of Popper, Kuhn argued that science does not progress toward reality or truth simply by the accretion of new discoveries. Rather scientific knowledge is best viewed as the product of a historically contingent group of practitioners operating from shared rules applied to a certain range of acceptable problems.

Though not his intention, Kuhn's work stimulated theories about the socially constructed nature of scientific knowledge, which in its strong form leads to relativism or antirealism, because scientific facts are deemed to be the result of network building and negotiating rather than approximating reality. But in its weak form the contextualization of science leads to the rather noncontroversial notion that knowledge is a product both of nature (a reality "out there") and human cultural and theoretical interests that condition particular trajectories of research. The move from internalist studies of science to contextual interpretations has given rise to interdisciplinary fields including science, technology, and society (STS) studies, the sociology of scientific knowledge (SSK), and rhetoric of science, all of which challenge the Mertonian ideals as fully adequate descriptions of the real social processes in science. (For more details, see the entries on "Science, Technology, and Society Studies" and "Rhetoric of Science and Technology.")

A perennial theme of science as a social process is the extent to which planning the agenda of (especially publicly funded) scientific research to meet explicit social and economic goals is feasible or desirable. In the United Kingdom during the 1930s this debate flared between supporters of Michael Polanyi and those who backed J. D. Bernal. (The encyclopedia has entries on both men.) Polanyi argued that autonomy and self-governance by science was the best way to meet social goals, whereas Bernal held that autonomous science was inefficient and needed external guidance. The same debate occurred in the United States after World War II between Vannevar Bush and Senator Harley Kilgore regarding the appropriate relationship between science and the federal government during peacetime. (See the entry on "Bush, Vannevar," as well as that on "Science Policy.") At issue are the criteria by which to judge scientific success and whether they should be internalist (e.g., peer review) or some external measure based on societal concerns.

Pressure to increase the social and fiscal accountability of publicly funded science emerged at the end of the Cold War. Related developments included science shops in Europe and other efforts to democratize science. In the United States, examples included the Office of Technology Assessment, the Ethical, Legal, and Social Implications (ELSI) research as part of the Human Genome Project and federally funded nanotechnology research, and the "broader impacts" criterion implemented by the National Science Foundation in 1997. (Further discussion can be found in entries on "Human Genome Organization," "Science Shops," "U.S. National Science Foundation," and related entries.)

Many of these developments are reactions to the fact that scientific research, despite its numerous benefits, does not yield unmitigated goods. Health and environmental risks as well as escalating arms races are familiar unintended consequences. Additionally, scientific knowledge can complicate decision making without always improving it, and has made its own share of mistakes with regard to recommendations of public interest. But the possibility of new "subversive truths" from genomic research, uncharacterized risks from nanotechnology, and the global threat of terrorism all raise the stakes of seeking new knowledge and crafting arrangements for directing it toward common goods.

Assessment

Throughout discussions of the relationship between science and ethics one core issue that remains is the proper extent and nature of scientific autonomy. David H. Guston (2000) has identified four reasons why science is often defended as special, each of which requires a degree of autonomy for its protection. Epistemological specialness refers to the notion that science searches for objective truth. Sociological specialness is the claim that science has a unique normative order that provides for self-governance. Platonic specialness refers to its esoteric, technical nature far removed from the knowledge of common citizens. Economic specialness is the claim that investments in science are crucial for productivity.

In each case there is some truth to the claims of specialness, which require the recognition of science as a unique enterprise needing some degree of separation from other social activities to ensure its smooth functioning. But as scientists as diverse as the physicist Alvin M. Weinberg (1967) and the geologist Daniel Sarewitz (1996) have argued, none of these cases should be taken as a license for absolute autonomy. Indeed the big science of the twenty-first century is so dependent on corporate and public investments that isolation is not a real option. More fundamentally, scientific knowledge is just one good to be considered among many competing goods. The ambiguity about the right level of autonomy has led to several interpretations about the proper role of science in society within various contexts, as well as criticisms of the ways in which scientific disciplines sometimes reinforce the self-perpetuating pursuit of new knowledge in the form of what Daniel Callahan (2003) has criticized as a "research imperative."

CARL MITCHAM
ADAM BRIGGLE

SEE ALSO *Ethics: Overview; Evolution-Creationism Debate; Expertise; Governance of Science; Humanization and Dehumanization; Technology: Overview; Unintended Consequences.*

BIBLIOGRAPHY

Balashov, Yuri, and Alex Rosenberg, eds. (2002). *Philosophy of Science: Contemporary Readings*. London: Routledge. Twenty-nine readings divided into six parts, the last of which considers science as a historical and social process.

Barbour, Ian G. (1966). *Issues in Science and Religion*. Englewood Cliffs, NJ: Prentice Hall.

Barbour, Ian G. (1974). *Myths, Models, and Paradigms: A Comparative Study in Science and Religion*. New York: Harper and Row.

Barbour, Ian G. (2000). *When Science Meets Religion: Enemies, Strangers, or Partners?* San Francisco: HarperSanFrancisco. This is a revised and (in the best sense) popular summary of the basic arguments from his Gifford Lectures volume, *Religion in an Age of Science* (San Francisco: Harper and Row, 1990), which was previously revised and expanded as *Religion and Science: Historical and Contemporary Issues* (San Francisco: HarperSanFrancisco, 1997).

Callahan, Daniel. (2003). *What Price Better Health? Hazards of the Research Imperative*. Berkeley and Los Angeles: University of California Press; New York: Milbank Memorial Fund.

Collins, Harry, and Trevor Pinch. (1998). *The Golem: What You Should Know about Science*, 2nd edition. Cambridge, UK: Cambridge University Press. Seven case studies arguing the social construction of scientific knowledge.

Curd, Martin, and J. A. Cover, eds. (1998). *Philosophy of Science: The Central Issues*. New York: Norton. A comprehensive anthology with forty-nine selections divided into nine sections.

Gould, Stephen J. (1999). *Rocks of Ages: Science and Religion in the Fullness of Life*. New York: Ballentine.

Guston, David H. (2000). *Between Politics and Science: Assuring the Integrity and Productivity of Research*. Cambridge, UK: Cambridge University Press.

Kitcher, Philip. (2001). *Science, Truth, and Democracy*. Oxford: Oxford University Press.

Klemke, E. D.; Robert Hollinger; David Wÿss Rudge; and A. David Kline, eds. (1998). *Introductory Readings in the Philosophy of Science*, 3rd edition. Amherst, NY: Prometheus Books. Thirty-three readings divided into six parts, the last of which deals with "Science and Values."

Mitcham, Carl. (2003). "Professional Idealism among Scientists and Engineers: A Neglected Tradition in STS Studies." *Technology in Society* 25(2): 249–262.

Newton-Smith, W. H., ed. (2000). *A Companion to the Philosophy of Science*. Malden, MA: Blackwell. Eighty-one articles covering key concepts and philosophers, with one entry on "Values in Science."

Rosenberg, Alex. (2000). *The Philosophy of Science: A Contemporary Introduction*. London: Routledge. An introductory monograph.

Salmon, Merrilee H.; John Earman; Clark Glymour; et al. (1992). *Introduction to the Philosophy of Science*. Englewood Cliffs, NJ: Prentice Hall.

Sarewitz, Daniel. (1996). *Frontiers of Illusion: Science, Technology, and the Politics of Progress*. Philadelphia: Temple University Press.

U.S. National Academy of Sciences; National Academy of Engineering; and Institute of Medicine. Committee on Science, Engineering, and Public Policy. (1995). *On Being a Scientist: Responsible Conduct in Research*, 2nd edition. Washington, DC: National Academy Press.

Weinberg, Alvin M. (1967). "The Choices of Big Science." Chap. 3 in *Reflections on Big Science*. Cambridge, MA: MIT Press.

SCIENCE POLICY

Science policy involves considerations of two fundamental human activities: science and policy. People make decisions in pursuit of valued outcomes, so thinking about science policy necessarily implicates science, its close associate science-based technology, and ethics. Although science policy is a topic central to all societies, particularly developed countries that devote significant public resources to science, for two reasons the focus here is on the United States. First, the United States is responsible for the largest share of global spending on science and technology. Second, for better or worse, the budgetary leadership role of the United States in science and technology since World War II has shaped how people around the world think about science, policy, and politics.

To place United States science and technology expenditures into context, consider that according to the Organisation for Economic Co-operation and Development (OECD) in 2003 the United States provided 38 percent of the approximately $740 billion world total (public and private) investment in research and development. The next largest funders were Japan with 15 percent, China with 8 percent, and Germany with 7 percent of the world total. Measured as a fraction of national economic activities, in 2001 total (public and private) expenditures on research and development varied from more than 4 percent in Sweden to 1.93 percent for the European Union (EU) to 2.82 percent in the United States. No country invests more than 1 percent of public funds in research and development, with Sweden investing 0.90 percent, the EU 0.65 percent, and the United States 0.81 percent.

Of course science policy is more than science budgets. The institutional structures and purposes of science are also issues of science policy. If science refers to the systematic pursuit of knowledge, and policy refers to a particular type of decision making, then the phrase science policy involves all decision making related to the systematic pursuit of knowledge. Harvey Brooks (1964) characterized this relation as twofold: *Science for policy* refers to the use of knowledge to facilitate or improve decision making; *policy for science* refers to decision making about how to fund or structure the systematic pursuit of knowledge.

Brooks's characterization of science policy as including both policy for science and science for policy has shaped thinking about science policy ever since, reinforcing a perception that science and policy are separate activities subject to multiple relations. But while Brooks's distinction has proved useful, reality is more complex, because the way society views science policy itself shapes the sorts of questions that arise in science policy debates. Science for policy and policy for science are each activities that shape the other—in academic jargon they are *coproduced*. Policy for science decisions about the structure, functions, and priorities of science directly influence the kind of science that will be available in science for policy applications, and the ways science is used in policy formation will influence in turn the policies formulated for science. Policy for science and science for policy are subsets of what might be more accurately described as a *policy for science for policy* (Pielke and Betsill 1997). To the extent that thinking about science policy separates decisions about knowledge from the role of knowledge in decision making, it reinforces a practical separation of science from policy.

From such a perspective, David Guston (2000) has argued the need to develop a new language to talk about science policy, one that recognizes how science and policy are in important respects inextricably intertwined; separation is impossible. Instead, however, the artificial separation of science from policy is frequently reinforced with calls for a new *social contract* between science and society. As Guston notes, "Based on a misapprehension of the recent history of science policy and on a failed model of the interaction between politics and science, such evocations insist on a pious rededication of the polity to science, a numbing rearticulation of the rationale for the public support of research, or an obscurantist resystemization of research nomenclature" (Guston 2000 Internet site)

The present analysis of science policy in the United States, with a particular focus on federally-funded science, thus begins by examining the value structure that underlies science and its relationship to decision making, and focuses on how science and policy have come to be viewed as separate enterprises in need of connection. This will set the stage for a discussion of an ongoing revolution in science policy that challenges conventional understandings of science in society. In the early years of the twenty-first century it is unclear how this revolution will play out. But a few trends seem well established. First, the science policies that have shaped thinking and action over the past fifty years are unlikely to continue for the next fifty years. Second, decision makers and society more generally have elevated expectations about the role that science ought to play in contributing to the challenges facing the world. Third, the scientific community nevertheless struggles to manage and meet these expectations. Together these trends suggest that more than ever society needs systematic thinking about science policy—that is research on science policy itself. And such research should center on issues of ethics and values.

Axiology of Science

A value structure is part of any culture, and the culture of science is no different. Alvin Weinberg (1970) suggests four explicitly normative *axiological attitudes*—statements of value—which scientists hold about their profession. Whereas Weinberg's concern was the physical sciences, such perspectives are broadly applicable to all aspects of science:

- Pure is better than applied.
- General is better than particular.
- Search is better than codification.
- Paradigm breaking is better than spectroscopy.

For Weinberg, these attitudes are "so deeply a part of the scientist's prejudices as hardly to be recognized as implying" a theory of value (Weinberg 1970, p. 613). But these values are critical factors for understanding both thinking about and the practice of science policy in the United States. And understanding why science policy is currently undergoing dramatic change requires an understanding of how Weinberg's theory of value, if not breaking down, is currently being challenged by an alternative axiology of science.

Understanding the contemporary context of science in the United States requires a brief sojourn into the history of science. In the latter part of the 1800s, scientists began to resent "dependence on values extraneous to science," (Daniels 1967, p. 1699) in what has been called "the rise of the pure science ideal" (Daniels 1967, p. 1703). The period saw such resentment come to a head.

> The decade, in a word, witnessed the development, as a generally shared ideology, of the notion of science for science's sake. Science was no longer to be pursued as a means of solving some material problem or illustrating some Biblical text; it was to be pursued simply because the truth—which was what science was thought to be uniquely about—was lovely in itself, and because it was praiseworthy to add what one could to the always developing cathedral of knowledge. (Daniels 1967, p. 1699)

Like many other groups during this era, the scientific community began to organize in ways that would facilitate making demands on the federal government for public resources. Science had become an interest group. Scientists who approached the federal government for support of research activities clashed with a federal government expressing the need for any such investments to be associated with practical benefits to society.

Expressing a value structure that goes back at least to Aristotle, U.S. scientists of the late-nineteenth century believed that the pursuit of knowledge associated with the pursuit of unfettered curiosity represented a higher calling than the development of tools and techniques associated with the use of knowledge. Hence, the phrase *pure research* came to refer to this higher calling with *purity* serving as a euphemism for the lack of attention to practical, real-world concerns (Daniels 1967). The first editorial published in *Science* magazine in 1883 clearly expressed a value structure:

> Research is none the less genuine, investigation none the less worthy, because the truth it discovers is utilizable for the benefit of mankind. Granting, even, that the discovery of truth for its own sake is a nobler pursuit. It may readily be conceded that the man who discovers nothing himself, but only applies to useful purposes the principle which others have discovered, stands upon a lower plane than the investigator (Editorial 1883, p. 1).

Some scientists of the period, including Thomas Henry Huxley and Louis Pasteur, resisted what they saw as a false distinction between *pure* and *applied* science (Huxley 1882, Stokes 1995). Some policy makers of the period also rejected such a distinction. For them, utility was the ultimate test of the value of science (Dupree 1957). The late 1800s saw different perspectives on the role of science and society coexisting simultaneously. But Weinberg's axiology of science emerged from the period as the value structure that would shape the further development of U.S. science policies in the first half of the twentieth century.

From Pure to Basic Research

In a well-documented transition, Weinberg's axiology of science stressed the primacy not so much of pure as of *basic* research. The term basic research was not in frequent use prior to the 1930s. But after World War II the concept became so fundamental to science policy that it is difficult to discuss the subject without invoking the corresponding axiology. The notion of basic research arose in parallel with both the growing significance of science in policy and the growing sophistication of scientists in politics. By the end of World War II and the detonation of the first nuclear weapons the acceleration of the development of science-based technology was inescapable. Throughout society science was recognized as a source of change and progress whose benefits, even if not always equally shared, were hard to dismiss.

The new context of science in society provided both opportunity and challenge. Members of the scientific community, often valuing the pursuit of pure science for itself alone, found themselves in a bind. The government valued science almost exclusively for the practical benefits that were somehow connected to research and development. Policymakers had little interest in funding science simply for the sake of knowledge production at a level desired by the scientific community, which itself had become considerably larger as a result of wartime investments. Support for pure research was unthinkable.

Congressional reticence to invest in pure science frustrated those in the scientific community who believed that, historically, advances in knowledge had been important, if not determining, factors in many practical advances. Therefore the scientific community began to develop a two-birds-with-one-stone argument to justify its desire to pursue truth and the demands of politics for practical benefits. The argument held that pure research was the basis for many practical benefits, but that those benefits (expected or realized) ought not to be the standard for evaluating scientific work. Because if practical benefits were used as the standard of scientific accountability under the U.S. system of government, then science could easily be steered away from its ideal—the pursuit of knowledge.

The scientific community took advantage of the window of opportunity presented by the demonstrable contributions of science to the war effort and successfully altered science policy perspectives. The effect was to replace the view held by most policymakers that science for knowledge's sake was of no use, and replaced it with the idea that *all research* could potentially lead to practical benefits. In the words of Vannevar Bush, the leading formulator of this postwar science policy perspective: "Statistically it is certain that important and highly useful discoveries will result from some fraction of the work undertaken [by pure scientists]; but the results of any one particular investigation cannot be predicted with accuracy" (Bush 1945, p. 81).

Central to this change in perspective was acceptance of the phrase basic research and, at least in policy and political settings, the gradual obsolescence of the term pure research. The term basic came without the pejorative notion associated with lack of purity imputed to practically focused work. More importantly, the term basic means in a dictionary-definition sense *fundamental, essential,* or *a starting point*. Research that was basic could easily be interpreted by a policymaker as being fundamental to practical benefits.

The Linear/Reservoir Model

Basic research would be connected to societal benefits through what has become frequently called the *linear model* of science. The linear model holds that basic research leads to applied research, which in turn leads to development and application (Pielke and Byerly 1998). To increase the output (that is, societal benefits) of the linear model, it is necessary to increase the input (support for science).

Bush's seminal report *Science—The Endless Frontier* (1945) "implied that in return for the privilege of receiving federal support, the researcher was obligated to produce and share knowledge freely to benefit—in mostly unspecified and long-term ways—the public good" (Office of Technology Assessment 1991, p. 4). One of the fundamental assumptions of postwar science policy is that science provides a reservoir or fund of knowledge that can be tapped and applied to national needs. According to Bush:

> The centers of basic research . . . are the wellsprings of knowledge and understanding. As long as they are vigorous and healthy and their scientists are free to pursue the truth wherever it may lead, there will be a flow of new scientific knowledge to those who can apply it to practical problems in Government, in industry, or elsewhere. (Bush 1945, p. 12)

Implicit in Bush's metaphor is a linear model of the relationship between science and the rest of society: basic-applied-development-societal benefit. This model posits that societal benefits are to be found *downstream* from the reservoir of knowledge. Others have described the liner model as a *ladder,* an *assembly line,* and a *linked-chain* (Gomory 1990, Wise 1985, Kline 1985).

The linear/reservoir model is a metaphor explaining the relationship of science and technology to societal needs. It is used *descriptively* to explain how the relation actually works and *normatively* to argue how the relation ought to work. The linear model appears in discussions of both science policy, where it is used to describe the relation of research and societal needs (Brown 1992), and in technology policy, where it is used to describe the relation of research and innovation (Branscomb 1992). The linear model was based on assumptions of efficacy, and not comparisons with possible alternatives. In 1974 Congressman Emilio Daddario (D-CT), a member of the Science Committee of the U.S. House of Representatives (Science Committee), observed that members of Congress defer to the claims of scientists that basic research is fundamental to societal benefits "and *for that reason, if for no other,* they have supported basic research in the past" (Daddario 1974, p. 140; emphasis added). So long as policymakers and scientists felt that science was meeting social needs, the linear model was unquestioned.

The notion of basic research and the linear model of which it was a part has been tremendously successful from the standpoint of the values of the scientific community. Indeed the terms basic and applied have thus become fundamental to discussions of science and society. For example, the National Science Foundation (NSF) in its annual report *Science and Engineering Indicators* uses precisely these terms to structure its taxonomy of science. Not only did the basic-applied distinction present a compelling, utilitarian case for government support of the pursuit of knowledge, it also explicitly justified why pure research "deserves and requires special protection and specially assured support" (Bush 1945, p. 83). The special protections included relative autonomy from political control and standards of accountability determined through the internal criteria of science. In a classic piece, Michael Polanyi (1962) sketched in idealized fashion how a *republic of science* structured according to the values of pure science provides an *invisible hand* pushing scientific progress toward discovering knowledge which would have inevitable benefits for society.

Seeds of Conflict: Freedom versus Accountability

From the perspective of the scientific community, from the prewar to postwar periods, the concepts of pure research and basic research remained one and the same: the unfettered pursuit of knowledge. For the community of policymakers, however, there was an important distinction—pure research had little to do with practical benefits but basic research representing the "fund from which the practical applications of knowledge must be drawn" (Bush 1945, p. 19). From the perspective of policymakers, there was little reason to be concerned about science for the sale of knowledge alone; they had faith that just about all science would prove useful.

TABLE 1

Four Definitions of Basic Research

By product:	Basic research refers to those activities that *produce* new data and theories, representing an increase in our understanding and knowledge of nature generally rather than particularly (National Science Board 1996, Armstrong 1994).
By motive:	Basic research is conducted by an investigator with a *desire* to know and understand nature generally, to explain a wide range of observations, with no thought of practical application (National Science Board 1996).
By goal:	Basic research *aims* at greater knowledge and mastery of nature (White 1967, Bode 1964).
By standard of accountability:	Basic researchers are free to follow their own intellectual interests in order to gain a deeper understanding of nature, and are *accountable* to scientific peers (Polanyi 1962, Bozeman 1977).

SOURCE: Courtesy of Roger A. Pielke, Jr.

The different interpretations by scientists and policymakers of the meaning of the term basic research have always been somewhat troubling (Kidd 1959). A brief review of the use of the term basic research by the scientific community finds at least four interrelated definitions of the phrase, as summarized in Table 1.

From the standpoint of policymakers, basic research is defined through what it enables, rather than by any particular characteristic of the researcher or research process. These different interpretations of basic research by policymakers and scientists have coexisted largely unreconciled for much of the postwar era, even as for decades observers of science policy have documented the logical and practical inconsistencies. René Dubos (1961) identified a *schizophrenic attitude* among scientists, succinctly described as follows: "while scientists claim among themselves that their primary interest is in the conceptual aspects of their subject, they continue to publicly justify basic research by asserting that it always leads to 'useful' results" (Daniels 1967, p. 1700) It is this schizophrenia that has allowed postwar science policy to operate successfully under the paradigm of the linear model, apparently satisfying the ends of both scientists and politicians. *Basic research* was the term used to describe the work conducted in that overlap. The situation worked so long as both parties—society (patron) and scientists (recipient of funds)—were largely satisfied with the relationship.

The Changing Context

In the 1990s both scientists and politicians began to express dissatisfaction with the science policy of the post-World War II era. For instance, in 1998 the Science Committee undertook a major study of U.S. science policy under the following charge:

> The United States has been operating under a model developed by Vannevar Bush in his 1945 report to the President entitled *Science: The Endless Frontier*. It continues to operate under that model with little change. This approach served us very well during the Cold War, because Bush's science policy was predicated upon serving the military needs of our nation, ensuring national pride in our scientific and technological accomplishments, and developing a strong scientific, technological, and manufacturing enterprise that would serve us well not only in peace but also would be essential for this country in both the Cold War and potential hot wars. With the collapse of the Soviet Union, and the de facto end of the Cold War, the Vannevar Bush approach is no longer valid. (U.S. Congress 1998)

While the congressional report acknowledged the need for a new science policy, it did not address what that new policy might entail. However an understanding of the tensions leading to calls for change point in various directions.

These tensions have been long recognized. George Daniels (1967) sketches those underlying contemporary science policy: "The pure science ideal demands that science be as thoroughly separated from the political as it is from the religious or utilitarian. Democratic politics demands that no expenditure of public funds be separated from political . . . accountability. With such diametrically opposed assumptions, a conflict is inevitable" (Daniels 1967, p. 1704) Such tensions were recognized even earlier, in 1960, by the Committee on Science in the Promotion of Human Welfare of the American Association for the Advancement of Science (AAAS): "Science is inseparably bound up with many troublesome questions of public policy. That science is more valued for these uses than for its fundamental purpose—the free inquiry into nature—leads to pressures which have begun to threaten the integrity of science itself" (AAAS 1960, p. 69). For many years under growing budgets in the context of the Cold War, postwar science policy successfully and parsimoniously evaded this conflict. Given pressures for accountability and more return on federal spending, conflict is unavoidable.

Why, more specifically, did postwar science policy remain largely unchallenged for a half century? From the point of view of society, it solved problems. First, science and technology were key contributors to victory in World War II. Infectious diseases were *conquered*. Nuclear technology ended the war and promised power *too cheap to meter*. From the point of view of the scientific community, most good ideas received federal funding. The U.S. economy dominated the world. In such contexts, there was less pressure from the public and its representatives on scientists for demonstrable results; there was less accountability. Scientists, policymakers, and the broader public were largely satisfied with national science policies.

But at the beginning of the twenty-first century new challenges arose. Some infectious diseases rebounded through resistance to antibiotics, and new diseases, such as severe acute respiratory syndrome (SARS), threatened health. For many, the cost of healthcare made world-leading medical technologies unaffordable. The events of September 11, 2001, demonstrated the risks to modern society at the intersection of fanaticism and technology. The availability of weapons of mass destruction makes these risks even more significant. New technologies, in areas such as biotechnology and nanotechnology, created new opportunities but also threatened people and the environment. Many problems of the past have been solved, but new ones are emerging, and science and technology are often part of both the problem and possible solutions. The question of how to govern science and technology to realize their benefits is thus increasingly important.

In addition, many scientists were unhappy as budgets failed to keep pace with research opportunities: As the scientific community has grown and as knowledge has expanded, more research ideas are proposed than there is funding to support. Strong global competition and demands for political accountability create incentives for policymakers to support research with measurable payoffs on relatively short timescales, while within the scientific community competition for tenure and other forms of professional recognition demand rigorous, long-term fundamental research. As the context of science changes, scientists share anxieties with others disrupted by global economic and social changes.

New Science Policy Debates

While scientists perceive their abilities to conduct pure research constrained by increasing demands for practical benefits, policymakers simultaneously worry that basic research may not address practical needs. Insofar as postwar science policy has weakened, discussion of science policy has moved beyond the partial overlap of motives that helped sustain postwar science policy. Scientists now speak of their expectation of support for pure research, and policymakers increasingly ask for direct contributions to the solution of pressing social problems.

In this situation the differing views of scientist and policymaker can create conflict as the shared misunderstanding of the term basic research threatens to become pathological. In the words of Donald Stokes:

> The policy community easily hears requests for research funding as claims to entitlement to support for pure research by a scientific community that can sound like most other interest groups. Equally, the scientific community easily hears requests by the policy community for the conduct of "strategic research" as calls for a purely applied research that is narrowly targeted on short-term goals. (Stokes 1995, p. 26)

For their part, scientists seek to demonstrate the value of research to the public, often through increasing skill in public relations and contracting with consultants to provide cost-benefit studies that show the positive benefits of research investments. With few exceptions, the result of such concerns has not been constructive change, but rather defense of the status quo. In 1994 the National Research Council (NRC) convened scientists and informed members of the broader community to begin a constructive dialogue on the changing environment for science. The group found the public policy problem to be primarily the amount of federal funds devoted to research. A later National Academy report, *Allocating Federal Funds for Science and Technology* (1995), recommended that U.S. science should be at least world-class in all major fields, in effect recommending an entitlement for research. Similarly the 1998 "Science Policy Study" of the Science Committee similarly concluded, "The United States of America must maintain and improve its pre-eminent position in science and technology in order to advance human understanding of the universe and all it contains, and to improve the lives, health, and freedom of all peoples" (U.S. Congress 1998 Internet site)

Other approaches relate research and national needs. The Government Performance and Results Act of 1993 legislates formal accountability by requiring all government programs, including research, to quantitatively measure progress against established goals. Yet experience shows that asking for performance measures and actually developing and applying meaningful measures can be difficult. Daniel Sarewitz offers a penetrating critique of current policy and general steps that would pull research closer to society without sacrificing critical values of science. In particular he recommends research on research: "how it can be directed in a manner most consistent with social and cultural norms and goals, and how it actually influences society" (Sarewitz 1996, p. 180). Donald Stokes (1995) resolves the dichotomy between research driven by purely scientific criteria and research responsive to societal needs by changing the single basic-versus-applied axis into a two-dimensional plane, with one dimension indicating the degree to which research is guided by a desire to understand nature, and the other indicating the degree it is guided by practical considerations. This conceptual advance demonstrates that *good science* can be compatible with practical application, but does not point to specific policy-relevant steps.

There is great potential for nations that have followed the Bush model, such as the United States, to learn from the experiences of those nations that have implemented differing science policies. What change will entail is not entirely clear, however, some trends are apparent. First, overall investments in science and technology show no signs of stagnation. If anything the world is investing more in science and technology, an amount that will in the near future exceed $1 trillion per year. These substantial investments are accompanied by increasing demands for accountability, relevance, and practicality. Such demands increasingly shape the context and practice of science in society. How science will shape and be shaped by these trends will undoubtedly mark a critical transition in science policy in the United States, and perhaps in the world.

ROGER A. PIELKE, JR.

SEE ALSO *Lasswell, Harold D.; Public Policy Centers; Social Theory of Science and Technology.*

BIBLIOGRAPHY

American Association for the Advancement of Science (AAAS). (1960). "Science and Human Welfare: The AAAS Committee on Science in the Promotion of Human Welfare States the Issues and Calls for Action." *Science* 132: 68–73.

Armstrong, John A. (1994). "Is Basic Research a Luxury Our Society Can No Longer Afford? *The Bridge* 24(2): 9–16.

Bode, Hendrik W. (1965). "Reflections on the Relation between Science and Technology." *Basic Research and National Goals: A Report to the Committee on Science and Astronautics, U.S. House of Representatives by the National Academy of Sciences*, pp. 71–76. Washington, DC.: Government Printing Office.

Bozeman, Barry. (1977). "A Governed Science and a Self-governing Science: The Conflicting Values of Autonomy and Accountability." Chapter 6 in *Science and Technology*

Policy, ed. Joseph Haberer. Lexington, MA: Lexington Books.

Branscomb, Lewis. (1992). "Does America Need a Technology Policy." *Harvard Business Review* 70: 24–31.

Brooks, Harvey. (1964). "The Scientific Advisor." In *Scientists and National Policymaking,* ed. Robert Gilpin and Christopher Wright. New York: Columbia University Press.

Brown, George E. (1992). "The Objectivity Crisis." *American Journal of Physics* 60(9): 776–863.

Bush, Vannavar. (1945). *Science—The Endless Frontier*. Washington, DC: Government Printing Office. Although its institutional recommendations were never fully adopted, this report is often referred to as setting the intellectual framework for thinking about science and its relationship to society for the post-World War II era.

Daddario, Emilio. (1974). "Science Policy: Relationships Are the Key." *Daedelus* 103: 135–142.

Daniels, George H. (1967). "The Pure-Science Ideal and Democratic Culture." *Science* 156: 1699–1706.

Dubos, René. (1961). "Scientist and Public: Why is the Scientist, Once a 'Natural Philosopher,' Now Considered a Barbarian by Many Educated Laymen?" *Science* 133: 1207–1211.

Dupree, A. Hunter. (1957). *Science in the Federal Government: A History of Policies and Activities to 1940*. Cambridge MA: Belknap Press of Harvard University Press.

"The Future of American Science." (1883). *Science* 1(1): 1–3. This is the first editorial that appeared in the journal *Science,* which in the early twenty-first century is one of the leading scientific journals in the world.

Gomory, Ralph. (1990). "Essay of Ladders, Cycles and Economic Growth." *Scientific American* June: 140.

Huxley, Thomas H. (1882). *Science and Culture, and Other Essays*. New York: D. Appleton and Company.

Kidd, Charles V. (1959). "Basic Research—Description versus Definition." *Science* 129: 368–371.

Kline, Stephen J. (1985). "Innovation Is Not a Linear Process." *Research Management* 28(4): 36–45.

National Science Board. (1996). *Science and Engineering Indicators*. Document NSB 96-21.Washington, DC: Government Printing Office. The U.S. National Science Board publishes data on a wide range of characteristics of science and engineering (e.g., funding, employment, disciplinary distributions of students, etc.) and as such provides an invaluable resource for characterizing the science and engineering communities and how they change over time.

Office of Technology Assessment. (1991). *Federally Funded Research: Decisions for a Decade*. OTA-SET-490. Washington, DC: Government Printing Office.

Pielke, Jr., Roger A., and Michele M. Betsill. (1997). "Policy for Science for Policy: Ozone Depletion and Acid Rain Revisited." *Research Policy* 26: 157–168.

Pielke, Jr., Roger A., and Radford Byerly, Jr. (1998). "Beyond Basic and Applied." *Physics Today* 51(2): 42–46.

Polanyi, Michael. (1962). "The Republic of Science." *Minerva* 1: 54–73. A classic piece that describes how the world would look if it operated under the norms of science.

Sarewitz, Daniel. (1996). *Frontiers of Illusion: Science, Technology and Politics of Progress*. Philadelphia: Temple University Press.

Stokes, Donald. (1995). "Sigma XI." In *Vannevar Bush II: Science for the 21st Century: Why Should Federal Dollars Be Spent to Support Scientific Research? Forum Proceedings, March 2–3,* ed. Kate Miller. Research Triangle Park, NC: Sigma XI Publications.

Stokes, Donald. (1997). *Pasteur's Quadrant: Basic Science and Technological Innovation*. Washington, DC: Brookings Institution Press. Offers a penetrating critique of post-World War II science policy and offers a clear conceptual alternative.

Weinberg, Alvin. M. (1970). "The Axiology of Science." *American Scientist* 58(6): 612–617.

White, Jr., Lynn. (1967). "The Historical Roots of Our Ecologic Crisis." *Science* 155: 103–1207.

Wise, George. (1985). "Science and Technology." *Osiris,* 2nd series 1: 229–246.

INTERNET RESOURCES

Guston, David H. (2000). "Retiring the Social Contract for Science." *Issues in Science and Technology Online* (Summer). A publication of the National Academy of Sciences, National Academy of Engineering, and Ida and Cecil Green Center for the Study of Science and Society. Available from http://www.nap.edu/issues/16.4/p_guston.htm.

U.S. Congress. (1998). Unlocking Our Future: Toward a New National Science Policy: A Report to Congress by the House Committee on Science, September 24, 1998. Available from http://www.house.gov/science/science_policy_report.htm.

SCIENCE SHOPS

Science shops provide independent, participatory research support in response to concerns experienced by civil society (Gnaiger and Martin 2001). Science in this context refers to all organized investigation, including the social and human sciences and arts, as well as the natural, physical, engineering, and technological sciences.

The concept of science shops was developed by students at universities in the Netherlands during the 1970s. This development was assisted by faculty and staff seeking to *democratize* the disciplinary hierarchies of the traditional university system. But arguably science shops are a manifestation of a movement stemming at least as far back as Thomas Jefferson's defense of the principle that "ideas should freely spread from one to another over the globe" (Jefferson 1813, Internet page).

The science shop concept spread worldwide in two waves. The first, in the late-1970s and early-1980s, was triggered by articles in *Nature* (Ades 1979) and *Science* (Dickson 1984) and led to initiatives in Australia, Austria, Belgium, Denmark, Northern Ireland, France, and Germany. The mid-1990s saw a resurgence based in large part on fast, inexpensive, and reliable communication technologies, such as the Internet. This growth led to new activities in England, Israel, South Korea, Malaysia, and New Zealand. Similar types of organizations have also been founded in Australia, Canada, South Africa and the United States but are referred to by other terms—Community-University Research Alliances, Community-based Research Centers, or Tecknikons.

There is significant variation in organizational structure among science shops, although three models dominate. The first is the university department model, where the science shop is attached to a disciplinary framework such as chemistry, biology, law, or physics. The second, most common model is the independent civil society organization, housing technical experts or brokering relationships with university or government researchers. The third model is the virtual alliance between partners in public, private, and not-for-profit sector institutions that jointly work on issues of mutual concern and benefit.

Despite differences in structure, Andrea Gnaiger and Eileen Martin point to six common elements found in all science shops. These include providing civil society with knowledge and skills through research and education; providing services on an affordable basis; promoting and supporting public access to and influence on science and technology; creating equitable and supportive partnerships with civil society organizations; enhancing understanding among policymakers and education and research institutions regarding the research and education needs of civil society; and enhancing the transferable skills and knowledge of students, community representatives, and researchers.

Science shops are closely associated with social justice, environmental, and community activist movements. The dominant research methodologies used include research mediation, participatory research, and participatory action research. The strengths of these approaches allow for the inclusion of the unique understanding of individuals and communities of their own local contexts, which helps establish causality of problems in a complex and diverse framework rather than in a reductionist manner. There is great adaptability and flexibility that allows for quick turnaround in problem identification and solving. The methods give people strong influence over both policy and practice at the local level. Local to global focus allows for scaling up of issues, providing grounded perspectives for national and international policies.

The principle weaknesses of the science shop methods are fourfold. Despite being a cost effective way of generating research, science shops suffer from chronic funding and resource shortfalls. With very few exceptions, unless funded through a philanthropic organization, government agency, or university, they spend almost as much effort on raising funds as they do performing research and advocacy work. Second, given their strong social justice tendencies, there appears to be institutional prejudice against working with corporations, governments, and intergovernmental agencies, or other organizations perceived to have a large *foot print*. This gap results in the absence of community partner and science shop perspectives in policy negotiations. Third, with the exception of the Netherlands, the lack of coordination among science shops and their relative absence from the dominant scientific communication streams means that there is a lack of comparability and a failure to generate commensurable information. This is currently being addressed by the creation of an International Science Shop Network, funded largely by the European Union. Finally, science shops have been accused of producing biased science, constructed to support the arguments of the clients they serve, a critique which is also aimed at scientists performing research for corporate clients. This criticism has been met by submitting research outputs to the same peer-review firewall that all scientific publication undergoes.

Science shops have proven to be an efficient and effective model for generating small-scale scientific and technological knowledge on issues of immediate and local concern. They provide a gateway for communities in gaining access to specialized data, information, and knowledge at a relatively low transaction cost. There are high residual effects within participating communities, leading to better understanding of science and technology as well as a critical capacity to assess the impact of scientific and technological issues on local social, economic, cultural, and environmental circumstances.

PETER LÉVESQUE

SEE ALSO *Global Climate Change; Governance of Science.*

BIBLIOGRAPHY

Ades, T. (1979). "Holland's Science Shops for 'Made To Measure' Research." *Nature* 281(18): B10.

Dickson, David. (1984). "Science Shops Flourish in Europe." *Science* 223: 1158–1160.

Gnaiger, Andrea, and Eileen Martin. (2001). *SCIPAS Report Nr.1, Science Shops: Operational Options*. Study financed by the European Commission DG XII Programme, "Improving the Human Research Potential and the Socio-Economic Knowledge Base (IHP), Strategic Analysis of Specific Political Issues (STRATA)" (HPV1-CT-1999-00001). Utrecht, Netherlands: Science Shop for Biology, Utrecht University.

Leydesdorff, Loet, and Peter Van Der Besselaar. (1987). "What We Have Learned from the Amsterdam Science Shop." In *The Social Direction of the Public Sciences, Sociology of the Sciences Yearbook*, Vol. 11, ed. Stuart Blume, Joske Bunders, Loet Leydesdorff, and R.D. Whitley. Dordrecht, Netherlands: Reidel.

Mulder, Henk; A.J. Thomas auf der Heyde; Ronen Goffer; and Carmen Teodosiu. (2001). *SCIPAS Report Nr. 2: Success and Failure in Starting Science Shops*. Study Financed by the European Commission-DG XII Programme, "Improving the Human Research Potential and the Socio-Economic Knowledge Base (IHP), Strategic Analysis of Specific Political Issues (STRATA)" (HPV1-CT-1999-00001). Utrecht, Netherlands: Science Shop for Biology, Utrecht University.

Sclove, Richard E. (1995). *Democracy and Technology*. New York: Guilford Press.

INTERNET RESOURCE

Jefferson, Thomas. (1743–1826). "Letter to Isaac Mcpherson Monticello, August 13, 1813" In *The Letters of Thomas Jefferson: 1743–1826: From Revolution to Reconstruction*. An .Html Project, Department of Alfa-Informatica, University of Groningen, The Netherlands. Available from http://odur.let.rug.nl/~usa/P/tj3/writings/brf/jefl220.htm.

SCIENCE, TECHNOLOGY, AND LAW

Law plays a growing critical role in the regulation of science and technology, including the ethical consequences of scientific research and new technologies. The relatively new field of *law, science, and technology* seeks to study systematically the diverse ways law interacts with science and technology. Law, science, and technology has been defined as "the discipline that deals with how our legal system can and must adjust to accommodate the problems created by the ever more urgent and ubiquitous impact of technology on society" (Wessel 1989, p. 260), and as seeking "to determine how the various processes of law—primarily judicial and legislative—respond to changes brought about by scientific advances" (Green 1990, p. 375).

Few law schools or legal scholars focused on the intersection of law with science and technology before the later part of the twentieth century. With advances in the computer, the Internet, biotechnology, genomics, telecommunications, and nanotechnology, technology has assumed an ever-increasing role in economic and daily life, and the law has struggled to keep pace. In the words of U.S. Supreme Court Justice Stephen Breyer, "[s]cientific issues [now] permeate the law" (Breyer 1998, p. 537). This has led to a proliferation in the study of law, science and technology interactions, including academic centers, textbooks (Sutton 2001, Areen et al. 1996), courses, specialized journals, conferences, and bar association sections (Merges 1988). There is also a growing awareness of the importance of scientific and technological developments by legal practitioners and scholars, with increased recognition among those outside the legal profession for the central importance of law in mediating the risks, benefits, and ethics of technology.

The field of law, science, and technology is premised on the belief that "[s]cience is a distinctive institution worthy of distinctive treatment by lawyers" (Goldberg 1986, p. 380). Despite increased awareness that science and technology present unique issues for the law, different formulations exist for examining law, science, and technology interactions. Here the field is divided into three primary strands. The first concerns the role of the law in managing the impacts of science and technology, including controlling the risks, promoting the benefits, and addressing ethical implications. The second concerns the institutions of law and science, examining how law affects the practice of scientific research, as well as the reciprocal relationship of how science and technology influence the law. The third involves a more generic inquiry into the problems and tensions that arise from the intersection of law with science and technology.

The Role of Law in Managing the Impacts of Science and Technology

Law plays a primary role in managing the impacts of science and technology. In the words of one prominent jurist, "[l]aw is the only tool that society has to tame and channel science and technology" (Markey 1984, p. 527). The impacts of science and technology that law seeks to manage can be subdivided into (a) risks, (b) benefits, and (c) ethical implications.

CONTROLLING RISKS OF NEW TECHNOLOGIES. New and existing technologies create many known and potential health, safety, environmental, and socioeconomic risks. Law is the principal societal institution for controlling these risks, through legislatures, regulators, and the judiciary (Jasanoff 1995). In developing such controls, the law relies on science to assess the relevant risks. Risk regulation thus involves two levels of science-law interactions: the role of law in regulating risks from science and technology; and the use of science by law to assess risk from new and existing technologies.

Legislation and regulation seek to address and reduce risks *ex ante,* before the risks are imposed. Most industrialized nations have comprehensive statutory and/or regulatory schemes in place to prospectively regulate potential risks from technologies such as pesticides, industrial chemicals, pharmaceuticals, natural resource extraction, genetically modified foods, and automobiles. *Ex ante* legislation and regulation by agencies statutorily empowered to do so presupposes the capability to adequately predict potential harms, a challenging undertaking for most risks. Indeed much of the complexity and controversy in *ex ante* risk regulation relates to uncertainties in the identification and quantification of potential risks. Nevertheless, given the preventive purpose of *ex ante* risk regulation, regulators are generally given considerable leeway in assessing risks, including the use of *conservative* (or plausible worst case) assumptions, requiring only substantial evidence and not necessarily the weight of evidence to support risk findings, and broad judicial deference to regulators' technical expertise.

One ongoing tension in *ex ante* regulation is the respective roles of legislators and regulators. The legislature in most jurisdictions has plenary power, and typically delegates to regulatory agencies the authority to regulate, subject to the substantive and procedural requirements included in the legislation. Regulatory agencies generally have greater technical expertise, available resources, and familiarity to address most risks associated with science and technology, and in that respect are the superior institution to make most risk regulatory decisions.

The legislature may take the lead when distrust between the legislature and regulatory agencies, or an issue itself, becomes so politically controversial that the greater legitimacy and accountability of the legislature is required (Goldberg 1987). A major concern is that legislation is usually more refractory to revision and updating than regulation, and thus inflexible statutory risk requirements can quickly become obsolete in areas of rapid technological change. An example is the so-called Delaney clause (1958) in the United States, which banned all food additives found to cause cancer in animals or humans based on a 1950s-vintage *all or nothing* view of carcinogenicity that had been scientifically outdated for many years before the law was finally repealed in 1996 (Merrill 1988).

Ex ante regulation of risks associated with science and technology thus presents some unique issues and tensions in institutional choice. Given the pace of technological change and the complexity of the subject, legislatures are likely to be at a greater disadvantage compared to regulatory agencies in determining risks associated with science and technology. By contrast the fundamental social, policy, and ethical issues raised by many new scientific and technological advances call for the greater accountability and plenary power elected legislatures offer.

The other major legal mechanism for regulating risks from science and technology is *ex poste* litigation and liability. Individuals injured by technologies may bring tort or product liability lawsuits seeking compensation, and science plays a critical role in providing proof of causation in such cases. Based on concern that such litigation was vulnerable to expert testimony of dubious scientific credibility, courts have focused on ensuring that scientific evidence presented to juries is sound. A leading development in this regard is the U.S. Supreme Court's 1993 decision in *Daubert* v. *Merrell Dow Pharmaceuticals, Inc.* that requires federal courts to perform a *gatekeeping* function to ensure that scientific evidence and testimony is reliable and relevant before it can be admitted. This opinion has resulted in judges being proactive and knowledgeable in screening prospective scientific testimony, and has generated an enormous body of scholarly commentary on how judges should evaluate scientific evidence (Black et al. 1994, Beecher-Monas 2000). It has also stimulated professional scientific organizations such as the American Association for the Advancement of Science (AAAS) to seek to educate judges about science and to provide lists of qualified experts.

Unlike *ex ante* regulation that evaluates whether a particular product, process, or technology may present risks, *ex poste* regulation is directed more specifically at whether the technology caused a specific type of injury in a particular individual or group of individuals. The scientific obstacles and uncertainties in demonstrating *specific causation* are even more complex than those faced in demonstrating general causation in the regulatory context. The judicial system uses presumptions, burdens of proof, and standards of proof in reaching decisions under conditions of uncertainty.

PROMOTING THE BENEFITS OF NEW TECHNOLOGIES. The law also plays a critical role in fostering innovation and promoting the development of new technologies through several legal mechanisms and doctrines. Perhaps the most important of these relates to intellectual property, by which the law gives inventors and creators a time-limited exclusive right to commercially exploit the output of their work. Intellectual property is protected through a number of legal forms, including patents, copyright, trademarks, and trade secrets. The underlying rationale for protecting intellectual property is to promote innovation, by giving researchers and authors economic incentives to create new inventions and works. Intellectual property protection is particularly important in high technology industries such as computer software and biotechnology where ideas and innovations rather than infrastructure and machinery are primary company assets.

New technologies present fundamental challenges to traditional intellectual property doctrines. For example, digital information may not be adequately protected by traditional copyright enforcement procedures, which require the copyright owner to bring a lawsuit alleging infringement. Because unlimited numbers of perfect digital copies can be made at almost zero marginal cost by simply uploading the material onto the Internet, legislatures and courts have extended greater copyright protections for digital data. This is exemplified by the *notice and take-down* provision of the U.S. Digital Millennium Copyright Act (1998) that compels Internet service providers (ISPs) to promptly remove information that copyright holders claim is infringing their copyright.

The rapid growth and use of peer-to-peer file exchange likewise challenges the capability of copyright law to protect copyrighted digital works, and has resulted in a renewed interest in using data protection technologies such as encryption instead of, or in addition to, the law to protect copyright. This trend, in turn, has created the need for legal restrictions on anti-circumvention measures that could be used for unauthorized bypassing of data protection technologies. However restrictions on anti-circumvention technologies have also been criticized for extending copyright beyond its traditional limits, including by undermining the *fair use* of digital data and unduly restricting scientific research (Samuelson 2001).

There are similar challenges in adapting patent law to genetic discoveries. Patenting genes has raised many scientific, legal, ethical, and practical complexities that established patent law is not equipped to address. For example, the traditional distinction between non-patentable products of nature and patentable human inventions and discoveries has been blurred by technology that permits the isolation of genes (often in a slightly different form) from living organisms. How should ethical and moral concerns about patenting genes and living organisms be considered in patent decisions, if at all? Should there be exceptions from patent enforcement for patented genes and organisms used for research or clinical applications? Might gene patents actually impede research and slow innovation, contrary to the very purpose of patenting, due to overlapping and stacked patent rights that make the administrative costs of licensing prohibitive (the so-called *tragedy of the anticommons*) (Heller & Eisenberg 1998)?

In addition to its efforts to protect intellectual property, the law encourages advances in technology through antitrust doctrine. Antitrust law promotes innovation by preventing companies from exercising monopoly power or colluding together to block new market entrants and innovations. Technology industries present unique antitrust issues. On the one hand, increased antitrust concerns and scrutiny may be warranted because of the potential for network effects to result in path dependency. Specifically the positive externalities of having other users with a compatible system may create an entry barrier to new competitors that can result in a de facto monopoly for the early industry leader, because users will be reluctant to adopt a new, better technology if it is not compatible with other users. The high initial costs of creating and introducing a new product combined with the low marginal cost of many knowledge-intensive industries heavily favors superior market power for the already-established player.

On the other hand, there are factors to suggest that antitrust issues might be of less concern in high technology industries. Rapid technological progress in high-technology sectors can result in rapid changes in market position, even for a market leader. For example, WordStar was an early market leader in word processing software, but was quickly replaced by new market entrants with superior attributes. Given these conflicting factors, the role of antitrust law in regulating high technology industries and promoting technological innovation remains a major area of academic and policy debate (Hart 1998–1999, Liebowitz and Margolis 1996).

Antitrust actions brought in the United States and Europe against the Microsoft Corporation in the late 1990s and early 2000s illustrate these conflicting antitrust considerations. Government authorities claimed that Microsoft, by virtue of its Windows computer operating system, had a monopoly power with respect to other such operating systems that allowed Microsoft to suppress innovation in potentially competing products. Microsoft contended that it should be permitted to improve its products to include new functionalities (that is, a web browser), and that the antitrust enforcement actions were restraining such advances.

There are also other legal instruments for promoting innovation and advancing technology. Direct governmental funding of scientific research and development, as well as indirect subsidization through legal mechanisms such as research and development tax credits, are important stimulants. Technology-forcing regulations, such as motor vehicle emission standards, prompt technological progress in specific industries. Other standards that provide for uniformity of new technology formats, such as digital television, likewise are intended to facilitate technological development.

ADDRESSING ETHICAL IMPLICATIONS OF TECHNOLOGY. The law is the primary vehicle by which society seeks to resolve controversies raised by scientific research and new technologies. Whether the issue is surrogate motherhood, voluntary euthanasia, human cloning, genetic engineering, privacy in the workplace, online security, or any other technological advance with potential ethical consequences, society relies on legislatures and courts to develop and apply appropriate legal principles. The bioethicist Daniel Callahan has described this tendency to translate moral problems into legal problems as *legalism,* but he himself identifies a vacuum of societal institutions other than the law to resolve moral issues in a satisfactory manner (Callahan 1996). Indeed the failure to legally proscribe an activity carries an implicit message that the activity is morally acceptable.

In some cases, courts have restricted their own authority to consider the ethical aspects of controversial technological developments. For example, the U.S. Supreme Court held that living, engineered organisms such as the OncoMouse could be patented, and refused to address ethical arguments raised by such patenting, finding that those ethical objections were best addressed to the legislative arm of the government. Even when courts exclude ethical considerations, they often remain the primary motivation for litigation, which is then fought on surrogate legally-cognizable grounds.

Institutional Issues

The second major strand in the study of law-science interactions is the impact of science and technology on the practice of law, and the reciprocal effect of law on the practice of science.

EFFECTS OF SCIENCE AND TECHNOLOGY ON THE PRACTICE OF LAW. Scientific and technological advances have both substantive and procedural effects on the law. On the substantive side, new scientific evidence and techniques can change the way legal claims are resolved, including their outcomes. For example, forensic DNA evidence has fundamentally changed criminal law and paternity disputes by greatly improving the veracity of legal fact finding, while creating a plethora of new legal, ethical, and social issues (Imwinkelried and Kaye 2001). In criminal cases, forensic DNA has helped identify and convict guilty persons who might have otherwise escaped prosecution, and exonerated innocent persons accused or convicted. But this powerful forensic tool raises new issues, such as how and from whom DNA samples should be collected and stored, how genetic information may be used, and when convicted criminals should be permitted to reopen cases based on *new* DNA evidence.

Advances in technology are further revolutionizing the procedural aspects of law. The practice of law has historically been influenced by new technologies, including the printing press, telephone, photocopier, and fax (Loevinger 1985). In the early twenty-first century, digital evidence has improved the quality and availability of trial evidence, while raising concerns about tampering with digital photos and recordings. On-line databases, digital document repositories, electronic discovery, new graphics and presentation technologies, and *digital courtrooms* are changing the ways lawyers research, prepare, and present their arguments (Arkfeld 2001). On-line filing and availability of court records is increasing the convenience and availability of judicial proceedings, yet creating new privacy concerns.

EFFECTS OF LAW ON THE PRACTICE OF SCIENCE. According to Justice Breyer, "science depends on sound law—law that at a minimum supports science by offering the scientist breathing space, within which he or she may search freely for the truth on which all knowledge depends" (Breyer 1998, p. 537). Until recently, law rarely intruded into the inner sanctum of the space it created for science. Beginning in the 1980s, however, the law has steadily intruded into the practice of science. Investigations of claims of science misconduct have become more frequent and legalistic, as government investigators adopt adversarial and formal procedures approaching those used by criminal prosecutors. Individuals claiming to have been aggrieved by scientific misconduct or allegedly false claims of scientific misconduct frequently seek judicial remedies. Attorneys have even served non-party subpoenas on scientists who are doing research potentially relevant to a pending lawsuit, even if the subpoenaed scientists have no relationship to the litigation or any of the parties. This imposes a costly burden on scientists, and exposes them to intrusive searches and disclosures about their research activities.

Legislatures are also subjecting scientists to new legal requirements. Governmentally-funded researchers have long been subject to a number of requirements that are conditions of federal funding, such as requirements for human subject protection. But in 1998, the U.S. Congress passed the so-called Shelby Amendment that subjects researchers funded by the federal government to the Freedom of Information Act (FOIA), under which citizens can request and inspect all relevant documents not protected by limited exemptions. The Office of Management and Budget subsequently narrowed this legislation to federally-funded research directly relied upon in federal rulemaking, but even under such a constricted (and challengeable) interpretation, this legislation represented an unprecedented legal intrusion into the laboratory. In 2000 the U.S. Congress enacted the Data Quality Act, which imposes a series of substantive and procedural requirements on scientific evidence used by regulatory agencies. These developments indicate a trend of growing legal intrusion into the science, which was once perceived as a *self-governing republic* generally impervious to legal interventions (Goldberg 1994).

Tensions Between Law and Science

The third strand of law, science, and technology examines the tensions and conflicts that occur when law and science are juxtaposed in decision making. These tensions and conflicts generally flow from the fact that law and science have different objectives and procedures. One frequently mentioned difference is that the law focuses on process, whereas science is concerned with progress (Goldberg 1994). While both law and science are evidence-based systems for finding the truth (Kaye 1992a, Jasanoff 1995), the law is concerned with normative considerations such as fairness and justice, considerations generally outside the scientific framework. Given this difference, otherwise relevant evidence is inadmissible in law if its use or the way it was obtained is unfair, whereas the concept of excluding pertinent data is foreign to science (Loevinger 1992, Foster and Huber 1997). One U.S. federal judge described science as "mechanical, technical, value-free, and nonhumansitic," while law is "dialectical, idealistic, nontechnical, value-laden and humanistic" (Markey 1984, p. 527). Another difference is that "[c]onclusions in science are always probable and tentative," whereas "[c]onclusions in law are usually certain and dogmatic" (Loevinger 1985, p. 3). Given these and other contrasts, it is not surprising that tensions such as the following have developed.

TECHNICAL COMPETENCE. Most legal decision makers (for example legislators, judges, and juries) have very little scientific training and expertise, and yet are called upon to decide highly complex technological matters (Bazelon 1979, Faigman 1999). The result is that "amateurs end up deciding cases argued by experts" (Merges 1988, p. 324). There is therefore concern that legal decision makers will fail to reach scientifically credible decisions (Angell 1996) and will be improperly misled by *junk science* (Huber 1988).

The legal system has instituted a number of procedural and substantive innovations in an attempt to enhance the scientific merits and credibility of its decisions. One major change has been a systematic shift of decision-making authority from juries to judges, presumably because judges have greater capability and experience in distinguishing valid from invalid scientific testimony. Thus, as previously noted, judges in U.S. federal courts are required to perform a *gatekeeping* function to screen proposed scientific testimony for its reliability and relevance before it can be presented to a jury (*Daubert* v. *Merrell Dow Pharmaceuticals, Inc.* [1993]). Similarly, in patent infringement cases, the critical issue of interpreting the scope of a patent has been taken from juries and given to the trial judge pursuant to a 1996 U.S. Supreme Court decision.

Another innovation is the use of *neutral* or third party experts, appointed by the court rather than the contending parties to assist a judge or jury in understanding the scientific issues in a case. Some jurisdictions have also experimented with specialized courts better able to handle technological disputes, such as the digital court implemented by the State of Michigan. The increased use of pretrial conferences to narrow the scientific issues in dispute and the appointment of specially trained law clerks and *special masters* are other techniques courts employ to better handle complex scientific and technological cases (Breyer 1998).

In the legislative context, there is a growing recognition of the need for legislatures to have their own scientific and technological advisory bodies (Faigman 1999), with some pressures in the United States to replace the Office of Technology Assessment which was abolished in 1995. Most European governments and the European Union have established technology advisory bodies for their legislators.

LEGAL VS. SCIENTIFIC STANDARDS. Another area of dispute is whether the law should apply scientific standards and methods of proof, or apply its own standards to scientific evidence. An example is the concept of statistical significance, where the standard scientific convention is that a result will be considered statistically significant if the probability of the result being observed by chance alone is less than five percent (i.e., $p < 0.05$) (Foster and Huber 1997). Some legal experts argue that the law should apply a more lenient standard, specially in civil litigation where the standard of proof is the preponderance of the evidence (i.e., $p > 0.5$), because while science focuses primarily on preventing false positives, the law is equally if not more concerned about false negatives (Cranor 1995, Shrader-Frechette 1991). Other experts caution against equating the scientific standard of statistical significance with the legal standard of proof, because the two measures perform different functions and are like comparing *apples and oranges* (Kaye 1992b, Kaye 1987).

Judge Howard Markey, while sitting as Chief Judge of the U.S. Court of Appeals for the Federal Circuit, wrote that "[n]o court . . . should base a decision solely on science if doing so would exclude the transcendental ethical values of the law" (Markey 1984, p. 525). He warned that "juriscience might displace jurisprudence" as a result of the tendency to "scientize the law" (Markey 1984, p. 525). In contrast, the U.S. Supreme Court's *Daubert* decision held that courts must ensure that scientific testimony have a "grounding in the methods and procedures of science," that is, be "derived by the scientific method" before it can admitted, which imports scientific standards of evidence into the law (*Daubert* v. *Merrell Dow Pharmaceuticals, Inc.* [1993], p. 590). Similarly Justice Breyer has argued "an increasingly important need for law to reflect sound science" (Breyer 1998, p. 538). Yet "some courts remain in the prescientific age" unless and until they "embrace the scientific culture of empirical testing" (Faigman 2002, p. 340).

TIMING OF DECISIONMAKING. Science and technology are progressing at increasing rates (Carlson 2003). A classic example of the rapid acceleration of technology is Moore's law, which predicts that the number of transistors on microchips will double every two years. The law is much slower to evolve, with case law advancing incrementally and gradually, and legislation advancing only sporadically. Statutes, in particular, can quickly become outdated as legislatures are limited, as a practical matter, to revisiting most issues every few years at best, and for some issues every few decades. Case law is also slow to adapt to advances in science and technology due to the binding effect of past precedents (*stare decisis*), something that does not impede science and technology. The result is that the law is often based on outdated scientific assumptions or fails to adapt to new technologies or scientific knowledge. Many experts argue that more flexible and adaptive legal regimes are needed to keep pace with advancing technological systems (Green 1990).

By contrast, there are situations where the law must address a question prematurely, before adequate scientific data are available (Faigman 1999). Science is in no rush to come to a final decision on any specific issue, and can afford to suspend judgment until *all the evidence is in*, even if that takes decades or centuries. Law does not always have the luxury of waiting (Goldberg 1994, Jasanoff 1995). When a defendant is charged with a crime, or a product manufacturer is sued for allegedly harming a citizen, the court must reach a final decision promptly without waiting for additional research to further clarify the issues. The bounded timeline of the law increases the risk of the legal system reaching decisions that may later be deemed scientifically invalid.

NEW TECHNOLOGIES VS. OLD LAWS. Another issue is whether new technologies require new laws or can be addressed by existing legal frameworks. One colorful articulation of this issue is the debate about whether there is any more need for the *law of cyberspace* than for the *law of the horse* (Easterbrook 1996, Lessig 1999). The analogy refers to the fact that there were no major legal doctrinal changes introduced to address the horse as it became a major part of commerce in earlier times, but rather existing doctrines were applied to the horse with only minor modifications. Thus there is a question about the need for new legal doctrines to address the Internet on issues such as privacy, copyright, pornography, and gambling. The passage of specialized laws such as the Digital Millennium Copyright Act and the Child Online Protection Act (1998) indicate a pattern of adopting new laws to address at least some cyberspace issues.

The same general issue arises in other technological contexts. One major debate in the regulation of genetically modified organisms is whether such products should be governed by existing environmental and food safety laws, or alternatively whether a new statutory regime created specifically for biotechnology products is required (Marchant 1988). Existing laws have generally been applied in the United States, while new enactments have been promulgated in Europe and other jurisdictions.

Another example is patent law, where to date existing patent rules have been applied to new technologies such as genes and other biomedical discoveries. Some commentators have argued that new laws, in particular new approaches that move away from the *one-size-fits-all* approach of current law, are needed to provide optimal patent protection for certain new and emerging technologies (Thurow 1997, Burk and Lemley 2002).

LEGAL INTERVENTION VS. MARKET FORCES. A final recurring issue is the respective roles of law and market in regulating new technologies. Specifically, under what circumstances is legal intervention (in the form of legislation or liability) appropriate, and when should the law pull back and leave the market to operate? Major disagreements on this fundamental issue exist. For example, there are conflicting views on whether government should restrict science funding to basic research, or also fund more applied research and development of new technologies.

This same basic tension between legal intervention and market forces underlay disagreements about whether Microsoft should have been subjected to antitrust enforcement because of its Windows operating system or whether market forces were adequate to prevent the company from unfairly exploiting its near monopoly. Another example is Internet privacy, where some commentators assert that technology and the market can provide adequate assurances of privacy, while others argue that a regulatory approach is needed. A third example is whether the government should set standards for technologies such as digital television and wireless communications, or leave it to the market to develop a de facto standard. These disputes rest on conflicting economic and political perspectives that are unlikely to be resolved in the foreseeable future.

Conclusion

The law interacts with science and technology in diverse ways. These interactions will proliferate in the future with advancing technologies that present novel risk, benefit, and ethical scenarios. The nascent legal field of law, science, and technology seeks to provide a systematic treatment of these actions, and will grow and evolve in parallel and apace with its subject matter.

GARY E. MARCHANT

SEE ALSO *Aviation Regulatory Agencies; Building Codes; Communications Regulatory Agencies; Crime; Death Penalty; Environmental Regulatory Agencies; Expertise; Evidence; Food and Drug Agencies; Human Rights; Information Ethics; Intellectual Property; Internet; Justice; Just War; Misconduct in Science; Natural Law; Police; Regulation.*

BIBLIOGRAPHY

Angell, Marcia. (1996). *Science on Trial.* New York: W. W. Norton & Company. Critical analysis of law's treatment of science by medical researcher and former journal editor.

Areen, Judith; Patricia A. King; Steven Goldberg; et al. (1996). *Law, Science and Medicine,* 2nd edition. Westbury, NY: Foundation Press. Legal casebook for law and science courses.

Arkfeld, Michael R. (2001). *The Digital Practice of Law,* 5th edition. Phoenix, AZ: Law Partner Publishing.

Bazelon, David L. (1979). "Risk and Responsibility." *Science* 205: 277–280. Widely cited.

Beecher-Monas, Erica. (2000). "The Heuristics of Intellectual Due Process: A Primer for Triers of Science." *New York University Law Review* 75: 1563–1657.

Black, Bert; Francisco J. Ayala; and Carol Saffran-Brinks. (1994). "Science and the Law in the Wake of *Daubert*: A New Search for Scientific Knowledge." *Texas Law Review* 72: 715–802.

Breyer, Stephen. (1998). "The Interdependence of Science and Law." *Science* 280: 537–538. Influential analysis by a member of the U.S. Supreme Court.

Burk, Dan L., and Mark A. Lemley. (2002). "Is Patent Law Technology-Specific?" *Berkeley Technology Law Journal* 17: 1155–1206.

Callahan, Daniel. (1996). "Escaping from Legalism: Is It Possible?" *Hastings Center Report* 26, no. 6 (November–December): 34–35.

Carlson, Robert. (2003). "The Pace and Proliferation of Biological Technologies." *Biosecurity and Bioterrorism* 1(3): 1–12.

Cranor, Carl F. (1995). "Learning form the Law for Regulatory Science." *Law and Philosophy* 14: 115–145.

Daubert v. *Merrell Dow Pharmaceuticals, Inc.,* 509 U.S. 579 (1993). U.S. Supreme Court decision adopting new standards for admissibility of scientific evidence.

Diamond v. *Chakrabarty,* 447 U.S. 303 (1980). U.S. Supreme Court decision allowing patenting of living organisms.

Easterbrook, Frank H. (1996). "Cyberspace and the Law of the Horse." *University of Chicago Legal Forum* 1996: 207–216.

Faigman, David L. (1999). *Legal Alchemy: The Use and Misuse of Science in the Law.* New York: W. H. Freeman & Co. Excellent analysis of recent interactions between law and science.

Faigman, David L. (2002). "Is Science Different for Lawyers?" *Science* 297: 339–340.

Foster, Kenneth R., and Peter W. Huber. (1997). *Judging Science: Scientific Knowledge and the Federal Courts*. Cambridge, MA: MIT Press.

Goldberg, Steven. (1986). "The Central Dogmas of Law and Science." *Journal of Legal Education* 36: 371–380.

Goldberg, Steven. (1987). "The Reluctant Embrace: Law and Science in America." *Georgetown Law Journal* 75: 1341–1388.

Goldberg, Steven. (1994). *Culture Clash: Law and Science in America*. New York: New York University Press. Among the best book-length introductions.

Green, Harold P. (1990). "The Law-Science Interface in Public Policy Decisionmaking." *Ohio State Law Journal* 51: 375–405. Extensive, early overview of law-science relationship.

Hart, David M. (1998–1999). "Antitrust and Technological Innovation." *Issues in Science and Technology* Winter: 75–81.

Heller, Michael A., and Rebecca S. Eisenberg. (1998). "Can Patents Deter Innovation? The Anticommons in Biomedical Research." *Science* 280: 698–701. Influential article on how patents might impede innovation.

Huber, Peter W. (1988). *Liability: The Legal Revolution and Its Consequences*. New York: Basic Books, Inc.

Imwinkelried, Edward J., and D. H. Kaye. (2001). "DNA Typing: Emerging or Neglected Issues." *Washington Law Review* 76: 413–474.

Jasanoff, Sheila. (1995). *Science at the Bar: Law, Science, and Technology in America*. Cambridge, MA: Harvard University Press. Important overview of law-science relationship from social studies of science perspective.

Kaye, D. H. (1987). "Apples and Oranges: Confidence Coefficients versus the Burden of Persuasion." *Cornell Law Review* 73: 54–77. Clear, definitive analysis of relationship of legal and scientific standards of proof.

Kaye, D. H. (1992a). "Proof in Law and Science." *Jurimetrics* 32: 313–322.

Kaye, D. H. (1992b). "On *Standards and Sociology*." *Jurimetrics* 32: 535–546.

Lessig, Lawrence. (1999). "The Law of the Horse: What Cyberlaw Might Teach." *Harvard Law Review* 113: L501–549.

Liebowitz, S. J., and Stephen E. Margolis. (1996). "Should Technology Choice Be A Concern of Antitrust Policy?" *Harvard Journal of Law and Technology* 9: 284–318.

Loevinger, Lee. (1985). "Science, Technology and Law in Modern Society." *Jurimetrics* 26: 1–20. A pioneering work on the relationship between law, science and technology.

Loevinger, Lee. (1992). "Standards of Proof in Science and Law." *Jurimetrics* 32: 323–344.

Marchant, Gary E. (1988). "Modified Rules for Modified Bugs: Balancing Safety and Efficiency in the Regulation of Deliberate Release of Genetically Engineered Microorganisms." *Harvard Journal of Law and Technology* 1: 163–208.

Markey, Howard T. (1984). "Jurisprudence or *Juriscience*." *William & Mary Law Review* 25: 525–543. Provocative early critique of law's deference to science.

Markman v. *Westview Instruments*, 517 U.S. 370 (1996).

Merges, Robert P. (1988). "The Nature and Necessity of Law and Science." *Journal of Legal Education* 38: 315–229.

Merrill, Richard. (1988). "FDA's Implementation of the Delaney Clause: Repudiation of Congressional Choice or Reasoned Adaptation to Scientific Progress?" *Yale Journal on Regulation* 5: 1–86.

Samuelson, Pamela. (2001). "Anticircumvention Rules: Threat to Science." *Science* 293: 2028–2031.

Shrader-Frechette, K. S. (1991). *Risk and Rationality*. Berkeley: University of California Press.

Sutton, Victoria. (2001). *Law and Science: Cases and Materials*. Durham, NC: Carolina Academic Press. Legal casebook on law and science.

Thurow, Lester C. (1997). "Needed: A New System of Intellectual Property Rights." *Harvard Business Review* September–October: 95–103.

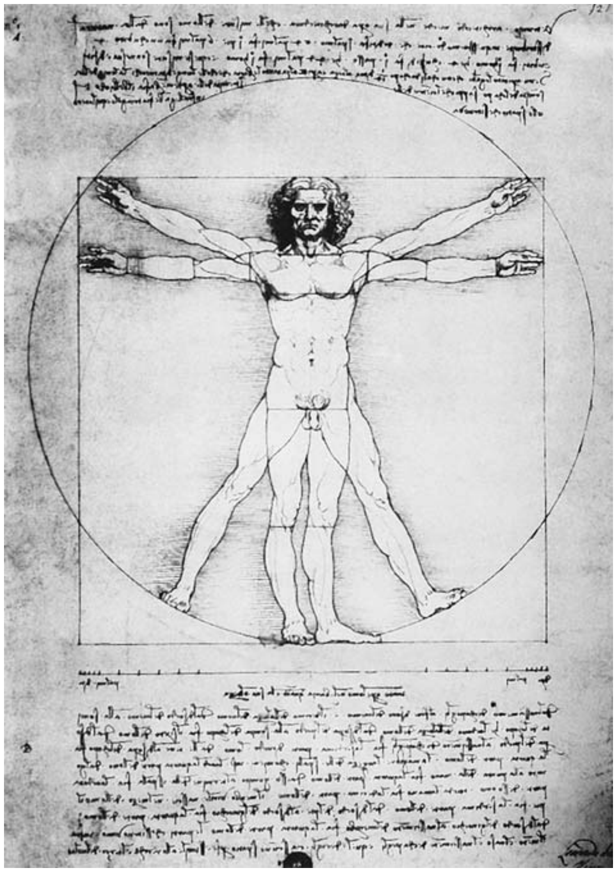
Wessel, Milton R. (1989). "What Is *Law, Science and Technology* Anyway?" *Jurimetrics* 29: 259–266.

SCIENCE, TECHNOLOGY, AND LITERATURE

The ethical implications of science and technology found in literaturre are varied and often implicit as well as explicit. A beginning survey may reasonably include the following non-exhaustive set of topics: the content of narratives that make asseissments of science and technology; orality, writing , printing, and electronic communication as technologies involving certain cultural contexts; and scientific theaories, experiments, and practices as sociocultural influences on literature. (Assessment of the stylistic and rhetorical strategies of science and technology, while also related, are treated in a separate entry.) Scholars in traditional disciplines have often touched on these topics, but only in the 1970s did interdisciplinary fields—the history of the book, science and technology studies, literature and science studies, and cultural studies—begin to give such concerns extensive attention. Tracing ethical aspects of science, technology, and literature calls for examining oratory, writing, printing, and electronic communication as technologies developed in cultural contexts; studying scientific theories, experiments, and practices as sociocultural influences on literature; assessing stylistic and narrative strategies in scientific discourse, including histories and philosophies of science, and elucidating how literary works and theories interpret and reconfigure science and technology as human endeavors. Scholars in traditional disciplines have touched on these topics for many years, but only in since the late 1970s have interdisciplinary fields—the history of the book, science and technology studies (STS), literature and science studies, and cultural studies—flourished to focus on such concerns.

Ancient and Early Modern Myths of Science and Technology

European classical representations of science and technology invoking ethical dilemmas appear in dramatic and didactic poetry. Greek and Roman myths describe Prometheus creating humans with Athena's consent and stealing fire for mortals from Zeus, actions that inspired John Ferguson's characterization of Prometheus as a master inventor and trickster whose rebellious intelligence helps humans rise above animals. Aeschylus's fifth-century *Prometheus Bound* posits that Zeus grew angry at human achievements and at Prometheus's theft, punishing the latter by chaining him to a rock. Hesiod's *Theogony* (c.700 B.C.E.) notes that Prometheus's brother Epimetheus married the beautiful Pandora, who was created as a punishment by Zeus. Pandora opens a container, releasing a host of miseries on humanity; however her curiosity inhibits human progress instead of encouraging innovation and invention. Biblical accounts imputing ethical aspects of science and technology include Genesis 6, which details the building of an ark by Noah, under God's direction, to protect animal species, including Noah's family, from the flood. Genesis 11, in the story of the Tower of Babel, relates how people built a tower and a city, thus prompting God to create different languages in order to constrain human achievement. These classical and Biblical texts represent scientific and technical projects as enhancing human life at the risk of alienating God.



"The Vitruvian Man," 1490 drawing by Leonardo da Vinci. Made as a study of the proportions of the human body, the drawing is often used as an implied symbol of the essential symmetry of the human body, and by extension, to the universe as a whole. *(© Corbis.)*

Modern cautionary tales about Faust and the Sorcerer's Apprentice further consider the dangers of human meddling with science and technology. The Faust Chapbook of 1587 describes Dr. Faust as a master of science and sorcery who conjures the Devil and enters into a pact with him: The Devil promises to serve Faust and in exchange the doctor gives up his soul and renounces his Christian faith. Faust is celebrated for his ability to cast horoscopes but becomes increasingly debauched. The impropriety of Faust's aims and actions has inspired a range of European literary texts, including tragedies, narratives, and poetry by Christopher Marlowe, Johann Wolfgang von Goethe, Heinrich Heine, Paul Valéry, and Thomas Mann, and a number of musical works by Hector Berlioz, Charles Gounod, and Franz Liszt. Goethe's 1779 poem " The Sorcerer's Apprentice" ("*Der Zauberlehrling*") interpreted through Paul Dukas's symphonic scherzo "*L'apprenti sorcier*" (1897) served as a source for the segment of Walt Disney's film *Fantasia* in which Mickey Mouse borrows the Sorcerer's magic broom and causes chaos before he is called to account for the mess. These legends suggest that human desire to know more about the world and control nature might be hubristic and selfish. The narratives imagine how endeavors motivated by extreme ambition inevitably lead to catastrophe. A bug in a computer protocol is commonly known by the term *sorcerer's apprentice mode*, as detailed in a number of websites linked to the Google search engine.

Linking themes of egotism and passion for new knowledge with contemporary theories about electricity in *Frankenstein, or The Modern Prometheus* (1818), Mary Shelley imagined how aspirations to conquer science and ancient alchemy inspire and destroy Dr. Victor Frankenstein. Frankenstein creates life only to turn his back on the creature he belatedly recognizes as a monster. Invoked often in fiction and film, the Frankenstein myth of creation gone awry retains potency for many in the age of bioengineering. Newspapers reporting on deliberations by the U.S. Congress and President's Council on Bioethics to ban cloning and restrict fetal tissue research invoked Shelley's novel (along with Aldous Huxley's *Brave New World*). Activists employ the term *Frankenfood* to denote food modified by processes of genetic transplantation.

Referring to Pygmalion rather than Prometheus, Nathaniel Hawthorne outlines the dangers of scientific ambitions and technological tinkering in stories such as "Rappaccini's Daughter" (1846) and "The Birth-Mark" (1846), whose plots explore how male scientists used their wives or daughters as subjects for their experiments. Villiers de L'Isle-Adam's mechanical fantasy *L'Eve future* (1880) follows a modern Pygmalion character who applies scientific knowledge to engineer a Galatea, only to find that even an artificial woman's needs surpass his scientific and technological ingenuity. Given the saliency of myths pointing up the dangers of science and technology, it is not surprising that themes of hubris, technology run amok, and scientific arrogance are common in science fiction, postmodern realist literature, and expository prose.

Printing and the Reading Revolution

Although the Sumerians created clay books as early as 3000 B.C.E. and the Chinese developed printing techniques in the early-second century C.E., accounts of modern printing technology usually begin with the importation of paper from Asia to Europe (Graff 1991). Early experiments with xylography and metallographic printing were *disappointing* (Havelock 1976). Johannes Gutenberg (1390–1468), who is credited with inventing typography, also is generally understood to be the first printer to use movable type in 1436. Metal type represented an advance on woodcuts, which were time-consuming to produce and of limited use. At the end of the sixteenth century, the printing industry was well established in many European cities even though printing remained a tedious process. While most books dealt with religious subjects, dramas and fictions were also published. Censorship and political restrictions curtailed some printers; in seventeenth-century England the government limited the number of printers.

After the Renaissance, advances in type and the use of paper covers decreased the cost of books while promoting a diversity of written materials. At the end of the eighteenth century, the invention of lithography and innovations in the power press advanced the printing industry, while improvements in papermaking and stereotyping decreased costs in the early-nineteenth century. By then reading had become a necessary part of everyday life for North Americans and Western Europeans in that work, worship, and social relations encouraged the activity and education became a fundamental goal of democracy (Graff 1991). In the United States during the antebellum period, children, prisoners, and freed slaves were taught to read as a means of socialization and economic empowerment, principles enunciated in didactic literature (Colatrella 2002).

Oral-Literacy Transformation

Developing scientific schema and philosophical theories, post-Enlightenment scholars demonstrated wide-ranging interests in linguistic, rhetorical, and narrative forms associated with oral and written texts. Linguists and philologists in the late-eighteenth and nineteenth centuries traced connections among Indo-European languages, studied classical rhetorical modes, and collected folktales from various regions. Romantics, who had an interest in ordinary people and their texts, celebrated the vernacular; James McPherson in Scotland, Thomas Percy in England, Jacob and Wilhelm Grimm in Germany, and Francis James Child in the United States collected examples from the oral traditions of those countries (Ong 1982). The work of these writers influenced twentieth-century formalists and structuralists, who melded textual and cultural analyses in their work on the periphery of the social sciences, notably in the fields of psychology and anthropology.

In the early-twentieth century, Andrew Lang demonstrated that oral folklore offered *sophisticated verbal art forms* (Ong 1982). Lang's work encouraged others to analyze techniques employed in classical poetry, particularly Homer's *Iliad* and *Odyssey*, and reinvigorated a debate begun in the seventeenth century concerning evolution and authorship of these works. In the twentieth century, Milman Parry viewed each Homeric epic as the culmination of orally delivered formulaic phrases used by bards. Building on Parry, Albert Lord hypothesized that "the idea of recording the Homeric poems, and the Cyclic epics [the Epic of Creation and the Epic of Gilgamesh], and the works of Hesiod, came from observations of or hearing about similar activity going on further to the East," specifically early versions of the Old Testament in ninth-century Palestine (Lord 1978, p. 156). Eric Havelock claimed the written versions of the *Iliad* and the *Odyssey* were the first products of the new Greek alphabet developed around 700–650 B.C.E. (Ong 1982).

Parry made phonographic recordings of working poets in 1930s Yugoslavia as a means of studying the composition of oral poems that might shed light on the development of the Homeric epics. After Parry's death, Lord continued the project, publishing *The Singer of Tales* in 1960, a book based on recordings and transcriptions. He argued that the Yugoslavian poets, who were generally illiterate, typically composed their songs during their performances according to mechanisms likely used in formulating the Homeric epics. Novice poets were able to create new songs because they had learned stories and formulaic phrases by watching the performances of others, a prerequisite for developing the special technique of composing by combining well-known formulas. Building on Parry, Lord argued that Homer composed oral narrative poetry through the same method, based on "intricate schematization of formulas" in Greek hexameter (Lord 1978, p. 142).

At the end of the twentieth century, the orality-literacy distinction drew the attention of theorists such as Jacques Derrida, J. L. Austin, John Searle, and Mary Louise Pratt, whose arguments influenced post-structuralist theories about literature. Derrida questioned the privileging of orality over writing, calling the practice phonocentrism and connecting it to logocentrism. He provoked speech act theorists Austin and Searle in pointing out that "the uses of language could not be determined as exclusively either normal or parasitic" (Halion 2003, Internet site). Suggesting the possibility of a unified theory of discourse, Pratt argued against the idea that the discourse of literature is functionally distinct from other verbal expressions.

Media Literacy

Contemporary interest in literacy shifts peaked in the the twentieth century as a transformation from print to new media developed. A number of non-fiction writers, including Marshall McLuhan, Ivan Illich, and Alvin and Heidi Toffler, addressed social issues concerning electronic media. The Tofflers conceived a popular theory of history describing three successive eras—the agricultural age, the age of the Industrial Revolution, and the Information Age, becoming famous as consultants to Newt Gingrich, who served as Speaker of the House in the U.S. Congress in the early 1990s. The Tofflers's work celebrates technological advances as progress. In contrast, Illich's writings question the assumed superiority of industrialized nations, the centralization of political authority, and faith in technology. He analyzed issues in medicine that denaturalize human control for the sake of technology.

Recognizing that consumers are bombarded with hundreds of advertisements, Illich criticized the reversal of the relation of needs and wants by materialist culture and argued that more technology does not produce greater leisure, freedom, or satisfaction; that what many think of as schooling is more properly termed *deschooling*; and that literacy can constrain rather than enable one's prospects in a culture. Some late-twentieth-century writers were inspired to apply Illich's theories in books such as *ABC: The Alphabetization of the Popular Mind* (1988) and *In the Vineyard of the Text* (1993), to projects associating literacy with technological change in the *convivial society*. Illich's concept of the convivial society in which technologies serve individuals rather than managers might have helped convince Lee Felsenstein, a founder of *Community Memory*—regarded by many as the world's first public computerized bulletin board system—to use the computer, which had been primarily promoted as having industrial applications, for artistic expression. English teacher Allan Luke positively characterizes literacy as *a communications technology* engaging individuals with real and fantastic worlds, creating a *simultaneous universe*, akin to McLuhan's *global village*, while Howard Rheingold describes *smart mobs* of individuals linked by electronic technologies.

McLuhan described his argument in *The Gutenberg Galaxy*, published in 1962 as *complementary* to those of Parry and Lord in dealing with cultural shifts affected by changing media; whereas their work accounted for the orality-literacy transformation, his provided trenchant analysis of the transformation from print to digital literacy. McLuhan resisted evaluating cultural change, instead concentrating on delineating connections among sociopolitics, culture, and media. In an interview, he explained how printing influenced nationalism: "Nationalism didn't exist in Europe until the Renaissance, when typography enabled every literate man to *see* his mother tongue analytically as a uniform entity. The printing press, by spreading mass-produced books and printed matter across Europe, turned the vernacular regional languages of the day into uniform closed systems of national languages . . . gave birth to the entire concept of nationalism" (McLuhan 1995, pp. 243–244). McLuhan recognized that while technologies and media inevitably produce changes, such shifts could often be uncomfortable for those experiencing them and ought to be considered critically, as Illich and Neil Postman argue.

McLuhan's work allusively comments on cultures, texts, and media technologies, often through aphorisms attesting to diverse influences. His celebrated statement

"The medium is the message" from *Understanding Media* published in 1964, described technological consequences as continuous: "the personal and social consequences of any medium—that is, of any extension of ourselves—result from the new scale that is introduced into our affairs by each extension of ourselves, or by any new technology" (McLuhan 1995, p. 151). He recognized differences among media, distinguishing *cool* and *hot* media as media requiring engagement (telephone) or passivity (radio) on the part of the user. He described the inevitable constraints associated with technological progress; for example, that the alphabet can "alter the ratio among our senses and change mental processes" as "an aggressive and militant absorber and transformer of cultures" (McLuhan 1995, pp. 119, 144).

Digital Literacy

Many language and technology theorists have developed McLuhan's insights, extending them to other technical developments and evaluating their applicability to revisionist histories of literacy and cognition. Adopting some of McLuhan's ideas about the power of media to influence human perceptions in *Orality and Literacy* (1982), Walter Ong characterizes writing as a technology that changes human consciousness. Investigations in cognition formed the basis for the development of electronic communication media. In *How We Became Posthuman* (1999), Katherine Hayles describes Norbert Wiener's cybernetics, Claude Shannon's information theory, and the fictional contributions of Philip K. Dick to ideas of distributed consciousness and thereby offers a history of disembodiment in cybernetics. Brian Massumi reviews philosophies of perception, including those of Henri Bergson, William James, Gilles Deleuze, Felix Guattari, and Michel Foucault, to argue that new ways of reading are necessary to understand the body and media (film, television, and the Internet) as cultural formations.

Janet Murray argues that late-twentieth-century forms of media changed storytelling conventions to require interactivity. She acknowledges earlier narrative forms and strategies that provide precedents and points of comparison for such media, especially the epic, the picaresque, and the drama of Shakespeare, forcefully arguing that movies, computer games, and hypertext novels are new narrative forms requiring new ways of appreciating a story. Hypertext fiction, poetics, and history, and new media criticism by Michael Joyce, Stuart Moulthrop, George Landow, and Jay Bolter also proffer the argument that hypertextual narrative forms revise notions of interactivity and change perception in representing reality in new, perhaps dangerous, ways. In their joint work, Bolter and Richard Grusin detail changes in Internet media reflecting the remediation of different media forms and their effects on users, particularly in the way that the Internet has become another, albeit more interactive (cool), medium. Greg Ulmer considers electronic communication in teaching composition in universities, arguing that students accustomed to interactive technologies benefit from a constructivist rather than instrumentalist approach.

Authorship, Technology, and Ethics in the Information Age

Post-structuralists theorists Roland Barthes, Derrida, and Foucault questioned traditional notions of authorship. Their critiques suggest that it is impossible for anyone, even another author, to divine a writer's intentions and that readers provide intertextual and contextual information that expands the text. Barthes acknowledges in "The Death of the Author," which first appeared in 1968, that the plurality of voices in the text inevitably produce many possible meanings for readers. Foucault also questioned to what extent biographical information should affect consideration of an author's literary output in "What Is an Author?, first published in 1969, positing *the author function* and emphasizing the value of studying discourse rather than biography. The Internet complicates ideas of authorship. Each search produces a list of sites that could be one person's work, that of a group, or the official page of a company or institution, while many web pages have no identified authors. Contributors to an electronic forum collaborate as multiple authors to a boundless text.

In this way, electronic writing further reduces the distance between reader and text (a shift previously noted by Walter Benjamin), and increases the ephemerality of a text. The fixity of the printed text has transformed into the fluidity of electronic content. Scholars present electronic archives of canonical writers such as Emily Dickinson, Herman Melville, and Walt Whitman that incorporate all versions of particular texts, while hyperlinks organize text to present fluid documents with multiple reading pathways. Electronic sites also recuperate once-popular writers whose works appear on the Internet along with those never-before-published.

Although Internet communication enhances many aspects of social life, its boundlessness also creates ethical problems. Free speech advocates resist filtering information. Satisfactory technical solutions preventing electronic mail spam, plagiarism, identity theft, and pornography aimed at juveniles have not yet been developed. Free electronic distribution of music and film appeals to many users but chips away at intellectual property rights, as is argued by artists and producers in the recording and film industries. Ethical standards regarding authorship, as cases of plagiarism and false documentation of sources suggest, call into question the name on the book or the claims within it, but generally the production process appears to be opaque to a reader, who could easily assume, for instance, that a biography was researched and written by the author noted on the cover or that a reporter whose byline appears on an article witnessed an event, while there may in fact have been contributions from numerous research assistants or virtual research may have substituted for an on the scene account.

Critical Paradigms of Taste and Technology

Literary criticism has a long history of valuing some genres, writers, or works over others for ethical reasons. Plato characterized poetry as too dangerous to exist in the ideal republic because it inspired political critique, and Jonathan Swift satirized the seventeenth-century Battle of the Ancients and the Moderns that provoked many French and English critics to debate the merits of classical versus contemporary literature. Training in modern languages and literatures is a product of the post-Romantic age. Earlier education in liberal arts was dominated by study of classical texts; but by the early-twentieth century, ideas of canonicity transformed to include certain modern texts. Cultural tastes change over time; for example, the novels of Herman Melville gained popular attention in the late 1840s and 1850s, but his critical reputation then diminished before critics in the 1920s rediscovered his work. In the late-twentieth century the literary canon of Great Books expanded to include works from non-European or North American cultures and by women and minorities. Thus, while the high versus popular culture distinction has had particular resiliency, it has been applied to shifting sets of literary works.

The effects of technology on standards of literary taste have primarily concerned issues of reproduction associated with electronic media. In "The Work of Art in the Age of Mechanical Reproduction" (1936), Benjamin argues that advances in printing changed the status of art in making woodcut graphics reproducible in lithography, thereby enabling "graphic art to illustrate everyday life" (Benjamin 1985, p. 219). Benjamin notes the inverse relation of accessibility and quality of works of art that accounts for the popularity of a Chaplin film versus "the reactionary attitude toward a Picasso painting" (p. 234): "The greater the decrease in the social significance of an art form, the sharper the distinction between criticism and enjoyment of the public" (p. 234). His essay ends by suggesting the dangerous capacities of film to support totalitarianism.

Frederick Kittler also analyzes how the functions of literature depend upon contextual shifts of discourse systems and on changing technical capacities of media. Like Foucault, he organizes history into eras based on paradigms of how literature is read in relation to other discourses, and, like Benjamin, he is concerned about determining effects of technology on literature. Saul Ostrow references McLuhan's idea that technology extends the human body in remarking that "Kittler is not stimulated by the notion that we are becoming cyborgs, but instead by the subtler issues of how we conceptually become reflections of our information systems" (Kittler 1997, p. x). In an essay considering Bram Stoker's *Dracula* (1982), as a commentary on the reproducibility of technology, Kittler notes that communication systems determine modern interpretations and forecast the death of literature: "Under the conditions of technology, literature disappears . . ."(Kittler 1997, p. 83).

Building on elements of Jacques Lacan, Foucault, and Derrida, Kittler theorizes about the discourse networks of 1800 and 1900. He identifies the classical romantic discourse network of 1800 according to its fundamental formulation of mothers socializing children through phonetic reading (*universal alphabetization*) and that of the modernist discourse network of 1900 by the influence of technologies such as the typewriter on writing and reading (*technological data storage*). Kittler recalibrates literary works and theories by representing them as media: "literature . . . processes, stores, and transmits data" (Kittler 1990, p. 370). He argues that a transformed literary criticism ought to understand literature as an information network, thereby classifying literary study as a type of media studies. In representing literature as technology, Kittler's theories encourage literary criticism that connects works of art to scientific practices and theories.

Futurism

Agreeing with progressive thinkers who argued the benefits of modern technology, the early-twentieth-century Futurism movement recognized literature to be a form of imaginative anticipation of and stimulation toward scientific and technological change. Futurists reacted against Romantic conceptions of literature as a sentimental retreat from technology. In a 1909 manifesto, Italian futurists such as Filippo Tommaso Marinetti proposed that products of the machine age might be celebrated alongside nature: "We will sing of the vibrant nightly fervour of arsenals and shipyards blazing with violent electric moons; greedy railway stations that devour smoke-plumed serpents; factories hung from clouds by the crooked lines of their smoke; bridges that stride the rivers like giant gymnasts ... adventurous steamers that sniff the horizon; deep-chested locomotives whose wheels paw the tracks like the hooves of enormous steel horses ..." (Tisdall and Bozzola 1978, p. 7). Marinetti excelled in performing manifestoes, designed to incite the crowd, at Futurist evenings; his arguments characterized "man as the conqueror of the universe, destined to impose change with the aid of science" (Tisdall and Bozzolla 1978, p. 89). Futurist painters concentrated on depicting dynamic forces, especially those of urban life. Photographers and filmmakers applied principles of Photodynamism to integrate light and line into action. Futurism encouraged poets, dramatists, and other writers to describe the life of matter without imposing versions of Romantic or pantheistic ego on material conditions.

Composers, architects, and activists were similarly drawn to the utopian promise of futurism. Antonio Gramsci, co-founder of the Italian Communist party, expressed sympathy for the Futurist attempts to destroy the foundations of bourgeois civilization because "they had a precise and clear conception that our era, the era of big industry, of the great workers' cities, of intense and tumultuous life, had to have new forms of art, philosophy, customs, language ..." (Tisdall and Bozzolla 1978, p. 201). In contrast, in "The Work of Art in the Age of Mechanical Reproduction," Benjamin pointed to how such radicalism, encouraged by technological change and promoting self-alienation, aestheticized destruction and contributed to Fascism.

Literature, Science, Technology, and Culture

Matthew Arnold in "Literature and Science" (1882) outlined a distinction between the disciplines later represented by C. P. Snow as *the two cultures* in his 1959 Rede lecture. Literary and cultural critics in the late-twentieth century changed the terms of such classification schemes in interpreting a range of texts—written, dramatized, ritualized, and so on—as cultural products. Clifford Geertz, Raymond Williams, and Victor Turner contributed fundamental concepts supporting the linguistic, or narrative, turn in anthropology and cultural studies. Geertz and Turner unpacked social events as cultural texts affecting individuals as community rituals, while Williams looked at the symbolism of ordinary life that had previously been excluded from scholarly consideration. Sociologists Bruno Latour and Sharon Traweek examined laboratory life and scientists's networks and discourse. Their work, along with that of Stuart Hall and Frederic Jameson, among other cultural critics, effaced previously set boundaries dividing high and low culture, linked art and life, and blurred disciplinary divisions concerning methodologies.

Like writers and artists, scientists and technologists are subject to cultural ideologies and conditions, and they produce literature as well as a body of knowledge. Cultural critics understand literature and science as discursive, epistemological practices with reciprocal influence. Tracing the representations of scientists and scientific ideas in literature can be a critical step in confronting scientific theories and practices because literary genres entertain and educate. Scientific hypotheses and inventions in fictions and ethical issues represented in literature inspire scientists. Given the increasing imbrication of science and technology in everyday life, it is not surprising that many literary and artistic works weave such references into their discourse and offer some ethical commentary on their development and implementation.

Just as science and technology are constructed out of and influence social values, literary works reflect and refract cultural ideas and events, as Maurice Agulhon noted of the Rougon-Macquart novels by Emile Zola and their Darwinian intertexts. But the forms of engagement are not formulaic, with writers using literature to offer ethical arguments about science and technology. Romantic works privilege nature over technology, yet they inspire the individual to become a close observer of the natural world and thereby give some impetus to scientific study. Nineteenth-century campaigns against hunting for leisure and fashion and anti-vivisection movements, along with an appreciation for species developed post-Darwin and support for women's suffrage, inspired British women to write about nature (Gates 2002). U.S. writers such as Ralph Waldo Emerson and Henry David Thoreau promoted scientific observation of nature and reacted against the dehumanizing effects of technology. Melville's *Moby-Dick* (1851) describes the tools and techniques of whaling in telling the story of the doomed Ahab, who is willing to sacrifice his life and his crew to pursue the white whale. In his journals *Household Words* (1850–1859) and *All the Year Round* (1859–1870) and in a number of novels published serially in the mid-nineteenth century, Charles Dickens stimulated ethically inspired social reforms associated with technological changes of the Industrial Revolution; for example, he criticized how utilitarianism associated with factories crushes the human spirit in *Hard Times* (1854), how bureaucratic selfishness results in unjust incarceration in *Little Dorrit* (1855–1857), and how the law inexorably grinds on while ignoring human need in *Bleak House* (1852–1853).

Some feminist tales of science and technology suggest that ethical motivations inspire the creation of scientific knowledge and demonstrate how technology can be applied to effect social improvement. In the short story "Hilda Silfverling: A Fantasy" (1845), Lydia Maria Child depicts a conflict between scientific knowledge and domesticity but optimistically resolves it by technological means when the title character is preserved by a chemist experimenting with cryogenics rather than being executed for a crime she did not commit. Stories by Charlotte Perkins Gilman written between 1890 and 1916 in various magazines celebrate similar examples of women who escape from painful domestic situations by working, often by entrepreneurially employing an innovative management technique or adopting a new technology (Colatrella 2000). Gilman's utopian novel *Herland* (1915) imagines a matriarchal society that can alleviate psychic and social problems for women.

As scientists, particularly defenders of Charles Darwin from T. H. Huxley to Stephen Jay Gould, have appreciated, fiction and non-fiction literature helps people comprehend, digest, and accept scientific principles and applications. Although professional discourse in some fields can be too esoteric for non-scientists to appreciate, essays in newspapers and journals aimed at a broad range of scientists and/or the general public accessibly convey technical information, disseminating new ideas and articulating ethical issues of significance to scientists, technologists, and the public. Literary works of fiction, poetry, and drama also contextualize ethical dilemmas in pointed ways. Recent medical examples of how public understanding can influence scientific and technological processes include efforts to maintain ethical standards in testing AIDS vaccines in Africa, to speed up the drug review process for orphan diseases, and to administer treatment and research studies in a humane manner; in these cases, press reports and literary works (dramas, films, and novels) contributed to informing the public about science in public policy. The fiftieth anniversary of the atomic bombing of Japan inspired a number of books, novels, and films representing the scientific researchers and politicans involved. The fiftieth anniversary of the discovery of DNA also brought historical reconsiderations in film and in print, in this case documenting Rosalind Franklin's contributions to James Watson's and Francis Crick's double helix model. While some considerations of science suggest the limitations of scientists and engineers, others verge on the hagiographical in representing their heroic dimensions. Whether one adopts Gould's ideal of literature as assisting in the process of scientific dissemination or Arnold's assumption that literature has an obligation to criticize science, almost everyone accepts that while researchers pursue knowledge for its own sake, it is impossible to disentangle scientific theory and practice and technological applications from morality and culture.

In conclusion, the interrelationships of ethics, science, and technology have often been represented in literature and other discursive media. Scientific and technical means have also sometimes been utilized to analyze literature, whether as tools of reproduction or as specific cultural circumstances affecting the production and reception of texts. While many literary works explore unpredictable and dangerous outcomes of scientific and technological experimentation, others consider the optimistic potentials of such work. Similarly, the enabling possibilities for humanity offered by computing and information technologies in recent decades have been invoked alongside constraints and problems that harm individuals and society. In studying technologies of representation such as writing, scholars connect humanistic study with scientific and technical research. Some critics and artists bring ethical perspectives to bear on representations of scientific and technology, while cultural historians and critics consider the scientific and technical mechanisms utilized in studying types of language and discourse forms such as the orally composed epic. In the Information Age, we recognize that media forms help structure our understanding and that out culturally constructed assumptions help develop and deploy technologies. Yet as questions concerning fetal tissue research and assisted reproduction testify, we have difficulty in believing that science and technology inevitably lead to progressive outcomes and that they are always ethically motivated and directed. We struggle to make sense of which historical representation of science and technology appears more accurate, while aiming to reduce the risks associated with current technologies and to design new and better ways of doing science and innovating technologies.

CAROL COLATRELLA

SEE ALSO *Asimov, Isaac; Brecht, Bertolt; Brave New World; Communication Ethics; Cybernetics; Foucault,* *Michel; Frankenstein; Huxley, Aldous; Hypertext; Illich, Ivan; Information; Information Ethics; Internet; Levi, Primo; McLuhan, Marshall; Morris, William; Movies; Rhetoric of Science and Technology; Science Fiction; Science, Technology, and Society Studies; Shelley, Mary Wollstonecraft; Thoreau, Henry David; Tolkien, J. R. R.; Utopias and Dystopias; Video Games; Wells, H. G; Zamyatin, Yevgeny Ivanovich.*

BIBLIOGRAPHY

Aeschylus. (1956). "Prometheus Bound." In *Aeschylus II. (The Complete Greek Tragedies)*, ed. David Grene and Richmond Lattimore. Chicago: University of Chicago Press

Arnold, Matthew. (1882). "Literature and Science." *Nineteenth-Century* 12: 216–230. The first published version of Arnold's Cambridge Rede lecture, discussing whether natural science or literature and humanities, which is favored by him, ought to predominate in the curriculum.

Barthes, Roland. (1977). "The Death of the Author." In *Image Music Text*, trans. Stephen Heath. New York: Hill and Wang.

Benjamin, Walter. (1985). "The Work of Art in the Age of Mechanical Reproduction." In his *Illuminations*. New York: Schocken Books.

Bolter, Jay David, and Richard Grusin. (1999). *Remediation: Understanding New Media*. Cambridge, MA: MIT Press.

Child, Lydia Maria. (1997). *The Lydia Maria Child Reader*, ed. Carolyn Karcher. Durham, NC: Duke University Press.

Colatrella, Carol. (2000). "Work for Women: Recuperating Charlotte Perkins Gilman's Reform Fiction." *Research in Science and Technology Studies* 12: 53–76.

Colatrella, Carol. (2002). *Literature and Moral Reform: Melville and the Discipline of Reading*. Gainesville: University Press of Florida.

Dickens, Charles. (1850–1859). *Household Words*. London: Bradbury & Evans.

Dickens, Charles. (2003 [1852–1853]). *Bleak House*, ed. Nicola Bradbury. London and New York: Penguin.

Dickens, Charles. (1859–1870). *All The Year Round*. New York: J. M. Emerson & Co.

Dickens, Charles. (1969 [1854]). *Hard Times*. New York: Penguin.

Dickens, Charles. (1855–1857). *Little Dorrit*. London, Bradbury & Evans.

Ferguson, John. (1972). *A Companion to Greek Tragedy*. Austin: University of Texas Press.

Foucault, Michel. (1984). "What Is an Author?" In *The Foucault Reader*, ed. Paul Rabinow. New York: Pantheon.

Gates, Barbara T., ed. (2002). *In Nature's Name: An Anthology of Women's Writing and Illustration, 1780–1930*. Chicago: University of Chicago Press.

Gilman, Charlotte Perkins. (1979). *Herland*. New York: Pantheon.

Gilman, Charlotte Perkins. (1995). *The Yellow Wallpaper and Other Stories*, ed. Robert Shulman. Oxford: Oxford University Press.

Graff, Harvey. (1991). *The Legacies of Literacy: Continuities and Contradictions in Western Culture and Society*. Bloomington: Indiana University Press. Surveys the history of literacy in Western Europe and America. Examines philosophical, sociological, and anthropological issues associated with its development.

Havelock, Eric. (1963). *Preface to Plato*. Cambridge, MA: Harvard University Press.

Havelock, Eric A. (1976). *Origins of Western Literacy*. Toronto: Ontario Institute for Studies in Education.

Hawthorne, Nathaniel. (1987). *Selected Tales and Sketches*. New York: Penguin.

Hayles, M. Katherine. (1999). *How We Became Posthuman*. Chicago: University of Chicago Press.

Hesiod. (1983). *The Poems of Hesiod*, trans. with introduction and commentary by R. M. Frazer. Norman: University of Oklahoma Press.

Homer. (1963). *Odyssey*, trans. Robert Fitzgerald. New York: Doubleday.

Homer. (1975). *Iliad*, trans. Robert Fitzgerald. New York: Doubleday.

Illich, Ivan. (1978). *Toward a History of Needs*. New York: Pantheon.

Kittler, Friedrich. (1990). *Discourse Networks, 1800/1900*, trans. Michael Metteer, with Chris Cullens. Stanford, CA: Stanford University Press, 1990. Describes nineteenth-century romanticism and early twentieth-century modernism as constituting two discourse networks. Demonstrates that the meanings of literary texts are embedded other contemporaneous discourses.

Kittler, Friedrich. (1997). *Literature, Media, Information Systems: Essays*, ed. John Johnston. Amsterdam, The Netherlands: G & B Arts International.

Kittler, Friedrich (1999). *Gramaphone, Film, Typewriter*, trans. Geoffrey Winthrop-Young and Michael Wutz. Stanford, CA: Stanford University Press. Provides history of three technologies—gramaphone, film, and typewriter—that emerged in the nineteenth century. Analyzes sociopolitical and cultural discourses surrounding them, including contemporaneous appraisals and/or elaborations by Rainer Rilke, Franz Kafka, Martin Heidegger, Thomas Edison, Alexander Graham Bell, and Alan Turing. Considers computational media and information systems in relation to Jacques Lacan's psychological discourse and literary works such as Bram Stoker's *Dracula* and Thomas Pynchon's *Gravity's Rainbow*.

Lord, Albert. (1978). *The Singer of Tales*. New York: Atheneum.

Luke, Allan. (2003). "Literacy Education for a New Ethics of Global Community." *Language Arts* 81(1)(September): 20–22.

Massumi, Brian. (2002). *Parables for the Virtual*. Durham, NC: Duke University Press.

McLuhan, Marshall. (1995). *Essential McLuhan*, ed. Eric McLuhan and Frank Zingrone. New York: Basic Books.

McLuhan, Marshall. (1995). "Excerpt of 'The Gutenberg Galaxy.'" In *Essential McLuhan*, ed. Eric McLuhan and Frank Zingrone. New York: Basic Books.

Melville, Herman. (1988). *Moby-Dick, or The Whale*, ed. Harrison Hayford, Hershel Parker, and G. Thomas Tanselle. Chicago: Northwestern University/Newberry Library.

Murray, Janet H. (1997). *Hamlet on the Holodeck*. Cambridge, MA: MIT Press.

Ong, Walter J. (1982). *Orality and Literacy: The Technologizing of the Word*. New York: Routledge.

Shelley, Mary. (1991). *Frankenstein*. Oxford: Oxford University Press.

Tisdall, Caroline, and Angelo Bozzolla. (1978). *Futurism*. New York: Oxford University Press. A survey account of the development of the movement and the work of its practicioners.

Snow, C. P. (1964). *The Two Cultures; and, A Second Look*. London: Cambridge University Press. A later edition of Snow's 1959 Rede lecture, which argues that there is a divide between scholars in science and the humanities.

Villiers de L'isle Adam, Auguste. (1982). *Tomorrow's Eve*, trans. Robert Martin Adams. Urbana: University Of Illinois Press.

INTERNET RESOURCES

"Faust Legends." University of Pittsburgh. Available from http://www.pitt.edu/~dash/faust.html#15/87.

Goethe, Johann Wolfgang von. *Der Zauberlehrling*. Available from http://german.about.com/library/blgzauberl.htm.

Halion, Kevin. "Deconstruction and Speech Act Theory: A Defence of the Distinction between Normal and Parasitic Speech Acts." e-anglais. com. Available from http://www.e-anglais.com/thesis.html. Ph.D. dissertation.

Pierre de la Mare. "Printing." Dotprint. 6 parts. Available from http://www.dotprint.com/fgen/history1.htm

SCIENCE, TECHNOLOGY, AND SOCIETY STUDIES

Science, Technology, and Society Studies, or STS, is an interdisciplinary field of academic teaching and research, with elements of a social movement, having as its primary focus the explication and analysis of science and technology as complex social constructs with attendant societal influences entailing myriad epistemological, political, and ethical questions. As such it entails four interlinked tenets or concepts that transcend simple disciplinary boundaries and serve as a core body of STS knowledge and practice. Several useful introductions to the STS field are available (Sismondo 2004, Cutcliffe and Mitcham 2001, Volti 2001, Cutcliffe 2000, Hess 1997, Jasanoff, et al. 1995).

Basic Themes

The field of Science, Technology, and Society Studies covers several basic themes.

CONSTRUCTIVISM. First and foremost, STS assumes scientific and technological developments to be socially constructed phenomena. That is, science and technology are inherently human, and hence value-laden, activities that are always approached and understood cognitively. This view does not deny the constraints imposed by nature on the physical reality of technological artifacts, but it does maintain that knowledge and understanding of nature, of science, and of technology are socially mediated processes.

CONTEXTUALISM. As a corollary to the notion of constructivism, it follows that science and technology are historically, politically, and culturally embedded, which means they can only be understood *in context*. To do otherwise would be to deny their socially constructed nature. This does not contradict *reality*, but does suggest that there are different contextualized ways of knowing. Likewise any given technological solution to a problem must be seen as contextualized within the particular socio-political-economic framework that gave rise to it.

PROBLEMATIZATION. A view of scientific knowledge and especially technological development as value-laden, and hence non-neutral, leads to the *problematization* of both. In this view science and technology have societal implications, frequently positive, but some negative, at least for some people. Thus it is not only acceptable, but, indeed, necessary to query the essence of scientific knowledge and the application of technological artifacts and processes with an eye toward evaluative and ethical prescription.

DEMOCRATIZATION. Given the *problematic* natures of science and technology, and accepting their *construction* by society, leads to the notion of enhanced democratic control of technoscience. Due to the inherent societal and ethical implications, there need to be more explicit participatory mechanisms for enhancing public participation in the shaping and control of science and technology, especially early in the decision-making process, when the opportunity for effective input is greatest. The ultimate goal is to structure science and technology in ways that are collectively the most democratically beneficial for society.

In adopting such a theoretical framework for the descriptive analysis and prescriptive evaluation of technoscience, STS serves as a location for discussing key societal and ethical issues of interest and concern to a democratic public. As such STS offers a set of conceptual tools and insights, themselves continually open to reflexive analysis and further evolution as scholars and activists gain ever more experience in understanding science and technology.

Historical Development

STS as an explicit academic field of teaching and research emerged in the United States in the mid-1960s, as scholars and academics alike raised doubts about the theretofore largely unquestioned beneficence of science and technology. Public concerns relating to such areas as consumerism, the environment, nuclear power, and the Vietnam War began to lead to a critique of the idea of technoscientific progress that many people had generally come to believe. Marked by such popular works as Rachel Carson's *Silent Spring* (1962) that raised questions about the hazards associated with chemical insecticides such as DDT and Ralph Nader's automotive industry expose, *Unsafe at Any Speed* (1965), STS reflected a widening activist and public engagement with technoscientific issues and concerns.

At approximately the same time this social movement was emerging, parallel changes within a number of traditional disciplinary academic fields were occurring. Evolving out of the work of scholars such as Thomas Kuhn, whose *The Structure of Scientific Revolutions* (1962), was tremendously influential, traditional philosophers, sociologists, and historians of science and technology, more or less independently of each other, began to move away from internalist positivist-oriented studies to reflect a more complete and nuanced understanding of the societal context of science and technology. Common to the intellectual analysis in each of these fields was criticism of the traditional notions of *objectivity* within scientific and technological knowledge and action, an examination that emphasized the value-laden contingent nature of these activities. As these fields evolved, they increasingly borrowed conceptual models and drew on case examples from each other, such that by the mid-1980s a clearly interdisciplinary academic field of study, replete with formalized departments and programs, professional societies, and scholarly journals, had emerged. Reflecting the more intellectual focus of their work, these scholars and their organizations began to use the term S&TS—Science and Technology Studies—to distinguish themselves from the more activist STS wing.

A third element or subculture within STS involves the more practice-oriented science and technology or engineering management and policy fields. Often referred to by the acronym STPP (Science, Technology and Public Policy) or SEPP (Science, Engineering, and Public Policy), this group is particularly interested in the practical policy issues surrounding science and engineering and in exposing scientific and engineering managers to the broader sociopolitical context they are likely to encounter. It too conducts research and scholarship and offers graduate education programs, but generally as part of a focused mission.

Collectively then this interdisciplinary group of scholars and sub-fields constitutes what has become known as STS or sometimes S&TS Studies. Together they examine the relationships between scientific ideas, technological machines and processes, and values and ethics from a wide range of perspectives. Independent of their specific motivations, approaches, and concerns, however, is a common appreciation for the complexities and contextual nature of science and technology in contemporary (and historical) society. Drawing on a strong base of empirical case studies by academic sociologists and historians of technoscience, more activist STSers and the STTP-oriented policy and management groups have since the 1990s been in a position to take a modest "turn toward practice" (Bijker 1993, p. 129) that should in principle, even if not always in practice, allow a more *democratic* public role in the ethical shaping and control of technoscience.

The STS Controversy

One result of this intellectual theorizing about the socially constructed nature of technoscience has been a strong, often polemical, backlash from certain quarters of the scientific community. This was unfortunate because much of the debate in what became known as the *Science Wars* appeared to miss, or ignore, the central focus and insights of STS, and was often polemical because of comments by participants on both sides. Many scientists hold tightly to the traditional ideal of objective knowledge based on reason and empirical evidence. For such individuals relativist claims that scientific knowledge is *socially constructed* and not to be found in an objective autonomous nature, but rather as the result of a set of historically and culturally elaborated set of conventions, was unsettling and struck more than a discordant note. Combined with widespread evidence of scientific illiteracy among school children and widely held pseudoscientific beliefs on the part of the general public, some scientists came to view much of STS as *anti-science* and indicative of a postmodern cultural decay.

Arguing in support of the objective nature of scientific evidence and science as a special way of knowing, a number of such individuals led by Paul Gross and Norman Levitt (1994) and Alan Sokol (1996a, 1996b,

1998) took issue with some of the more relativist-oriented STS scholars, such as Bruno Latour (1987), and launched a series of sharp attacks in print and at academic conferences. A spirited debate ensued, supposedly over the epistemological nature of scientific knowledge, but it veered into the social dynamics and political implications of science, and by association tended to indiscriminately taint all STS scholars as anti-science and engaged in a *flight from reason*.

Among the skirmishes Sokol, a physicist, wrote an article consisting of complete gibberish, but cast in post-modern constructivist language, that was published in the cultural studies journal, *Social Text* (Sokol 1996a), ironically in an issue intended as a response to the earlier work of Gross and Levitt (1994). Sokol was motivated by what he considered to be the "nonsense and sloppy thinking" that "denies the existence of objective realities" (Sokol 1996b, p. 63) and sought to expose it through his parody article, with the end result of adding fuel to the already hot fire of debate.

Without replaying the whole debate, which also included a bizarre invitation by Sokol for anyone who did not believe in scientific objectivity to come to his upper story office where they could test the law of gravity by stepping out the window, much of the dialog missed the common core of agreement that actually bound the combatants more closely together than perhaps at least science defenders realized. That is to say, most scientists, including Gross, Levitt, and Sokol, readily accept a *moderate constructivism*, one that views scientific knowledge of the natural world and its associated processes, and most certainly technological creations, to be *socially constructed* phenomena. Few moderate STS scholars or members of the public would deny the obdurate reality of nature, nor do they seek to control the underlying scientific epistemology, but it certainly is within reason for them to both understand and seek to control the sociopolitical implications of contemporary technoscientific advances. In the end then, it would appear there was probably more in common between the scientific combatants and that their *war* reflected much ado about little. Yet, at the same time, it does suggest just how difficult it may be for STS, either as a group of investigative scholars or as a social movement, to play an ethically and politically responsible role in the shaping and control of science and technology as the twenty-first century unfolds.

The Problem of Ethics

To say that incorporating an ethical awareness and normative framework into society's control and shaping of contemporary science and technology will be difficult, is not to say that it should not be attempted, nor that such attempts from within the STS community are not already occurring. Indeed that has been much of the raison d'etre of STS right from the beginning, even of those more intellectual scholars most interested in revealing the epistemological underpinnings of scientific knowledge. Thus it has been the case that STS social constructivists have often revealed the underlying values and ethical choice decisions made in scientific research and discovery, while those analyzing technological decision making, such as that surrounding the launch of the space shuttle Challenger (Vaughan 1996), similarly revealed the ethics of the decision to go forward that chilly Florida morning, even in the face of admittedly mixed evidence regarding the viability of O-rings at reduced temperatures. Other more specifically focused philosophers and ethicists have analyzed case studies of technoscientific failures or near failures, ranging from DC-10 aircraft landing gear to the San Francisco BART transportation system to the collapse of the Kansas City Hyatt Regency walkway, for what they reveal about the ethics and values subsumed in such technoscientific endeavors. Other scholars have examined such issues as the siting of toxic waste and hazardous manufacturing facilities because of what they show about environmental justice inequities.

Out of such analyses has come increased attention to the need to make scientists, engineers, and corporate managers much more socially and ethically attuned to the implications of their work. To that end, engineering education programs focus more attention on the ethics of engineering through required coursework, while organizations and groups such as the American Association for the Advancement of Science (AAAS), which established a Committee on Scientific Freedom Responsibility in 1975, and the computer science community, which created the ethics-oriented Computer Professionals for Social Responsibility in 1983, concentrate specific resources toward the effort to raise awareness of ethical issues.

Beyond this institutional level of response, increasing numbers of STS academic scholars have come to recognize and focus on normative concerns as an integral part of their work. In part this has been a response to the gauntlet thrown down by the political philosopher of technology, Langdon Winner (1993), who finds much of the largely *descriptive* constructivist analysis wanting in terms of *human well-being* and the *social consequences of technological choice*. One significant measure of the barometric shift in such matters has been the work of Wiebe Bijker, a leading constructivist scholar and the 2001–2003 President of the Society for the Social Studies of Science. In a number of works, including his 2001 pre-presidential address, Bijker explicitly argued the need for greater *political engagement* in matters technoscientific on the part of citizens and scholars alike, each drawing on the constructivist insights of STS. Such engagement in his view would entail much greater democratic participation in the technoscientific decision-making process on the part of the public and a larger role for STS scholars as *public intellectuals* who, by drawing on their STS insights, might contribute normatively to the civic enhancement of our modern technoscientific culture (Bijker 2001, 2003).

Summary

As the foregoing analysis suggests, STS, as an intellectual area of research and teaching, as applied policy analysis, and as a social movement, is not only a field well suited to explain the nature of science and technology (historically and in the contemporary world), but one that also holds out great promise for the normative and democratic enhancement of today's technoscientific society. STS both provides an analytical framework and serves as a locus of debate. Such is the potential of STS and the greatest opportunity for its application.

STEPHEN H. CUTCLIFFE

SEE ALSO *Interdisciplinarity; Merton, Robert; Scandinavian and Nordic Perspectives; Science, Technology and Law; Science, Technology, and Literature; Sokol Affair.*

BIBLIOGRAPHY

Bijker,Wiebe. (1993). "Do Not Despair: There is Life after Constructivism." *Science, Technology, & Human Values* 18 (Winter): 113–138.

Bijker, Wiebe. (2001). "Understanding Technological Culture through a Constructivist View of Science, Technology, and Society." In *Visions of STS: Counterpoints in Science, Technology, and Society Studies*, eds. Stephen H. Cutcliffe and Carl Mitcham. Albany: State University of New York Press.

Bijker, Wiebe. (2003). "The Need for Public Intellectuals: A Space for STS." *Science, Technology, & Human Values* 28 (Autumn): 443–450.

Carson, Rachel. (1962). *Silent Spring*. Boston: Houghton Mifflin.

Cutcliffe, Stephen H. (2000). *Ideas, Machines, and Values: An Introduction to Science, Technology, and Society Studies*. Lanham, MD: Rowman and Littlefield.

Cutcliffe, Stephen H., and Carl Mitcham, eds. (2001). *Visions of STS: Counterpoints in Science, Technology, and Society*. Albany: State University of New York Press.

Gross, Paul R., and Norman Levitt. (1994). *Higher Superstition: The Academic Left and Its Quarrels with Science*. Baltimore, MD: Johns Hopkins University Press.

Hess, David. (1997). *Science Studies: An Advanced Introduction*. New York: New York University Press.

Jasanoff, Sheila; Gerald E. Markle; James C. Petersen; and Trevor Pinch, eds. (2004). *Handbook of Science and Technology Studies*. Thousand Oaks, CA: Sage.

Kuhn, Thomas. (1962). *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press.

Latour, Bruno. (1987). *Science in Action: How to Follow Scientists and Engineers through Society*. Cambridge, MA: Harvard University Press.

Nader, Ralph. (1965). *Unsafe at Any Speed: The Designed in Dangers of the American Automobile*. New York: Grossman.

Sismondo, Sergio. (2004). *An Introduction to Science and Technology Studies*. Malden, MA: Blackwell.

Sokol, Alan D. (1996a). "Transgressing the Boundaries: Toward a Transformative Hermeneutics of Quantum Gravity." *Social Text* 46/47(Spring/Summer): 217–252.

Sokol, Alan D. (1996b). "A Physicist Experiments with Cultural Studies." *Lingua Franca* 6(May/June): 62–64.

Sokol, Alan D., and Jean Bricmont. (1998). *Fashionable Nonsense: Postmodern Intellectuals' Abuse of Science*. New York: Picador.

Vaughan, Diane. (1996). *The Challenger Launch Decision: Risky Technology, Culture, and Deviance at NASA*. Chicago: University of Chicago Press.

Volti, Rudi. (2001). *Society and Technological Change*. New York: Worth.

Winner, Langdon. (1993). "Upon Opening the Black Box and Finding It Empty: Social Constructivism and the Philosophy of Technology." *Science, Technology, & Human Values* 18(Summer): 362–378.

SCIENTIFIC ETHICS

The term *scientific ethics* may refer to the ethics of doing science (Is one free to inject unwilling subjects with a pathogen so as to gain valuable scientific insights? or What role should animal experimentation play in biology?). In that sense, scientific ethics is a branch of applied ethics. The term may also refer to whether or not the methods and assumptions of science can be applied to the subject matter of ethics. The present entry is concerned with scientific ethics in the second sense—Can there be a science of norms?

Scientific ethics in this sense is often argued to be an oxymoronic term. Science deals in empirical facts, discovering what *is* the case, while ethics deals in normative matters, uncovering what *ought* to be the case. A scientific ethics would thus commit the naturalistic fallacy of confusing what is with what ought to be. Historically speaking, however, this distinction is as much the exception as the rule. Premodern ethical systems, such as the virtue theories of Plato and Aristotle, did not couch the debate about what ought to be done in a way that made facts and norms *non-overlapping magisteria* (Gould 2002). To understand the relationships between science and ethics, it is useful to begin with some working definitions.

Defining Ethics and Science

Ethics is divided into descriptive, normative, and metaethics. *Descriptive* ethics is the study of empirical facts related to morality, such as how people think about norms, use norms in judgment, or how the norms themselves evolve. There is a rich tradition of organizing knowledge about these things scientifically, ranging from the field of moral psychology (focusing on how people reason about norms) to some forms of sociobiology (studying how norms arose on evolutionary timescales).

Normative ethics is an attempt to organize knowledge about what human beings ought to do or intend, or what kind of people they ought to be—it provides guidance and advice. The three major versions of normative ethics are virtue theory, utilitarianism, and deontology. A virtue theoretic approach, such as found in Aristotle, focuses on the nature of persons or agents. Are they flourishing—functioning effectively as human beings—or failing to flourish? Virtue theorists focus on states of character (virtuous or vicious) and how they affect the ability to live the best human life. Utilitarians, such as Jeremy Bentham (1748–1832) or John Stuart Mill (1806–1873), focus instead on the consequences of an action, rather than the character of the person committing it. Specifically they look at the amount of happiness caused (or unhappiness prevented), with the happiness of all counting equally. Deontologists, such as Immanuel Kant (1724–1804), focus on the nature of the action itself rather than its consequences. Certain actions express appreciation for, and are done in accordance with, the demands of duty, respecting that which is the foundation of morality: rationality and autonomy.

Metaethical questions consider the scope and nature of moral terms. Do ethical terms such as good and bad refer to facts about the world, or merely to states of emotion in people making judgments? Does ethics constitute *knowledge* or not; is ethical knowledge illusory? What is the structure of ethical arguments? It is less controversial that science may influence metaethical positions (although that position is also debated) than that there can be a science of normative ethics.

Science likewise comes in three forms. In the weakest sense, a science is an organized body of knowledge. If this is what is meant by science in relation to ethics, then a science of ethics certainly exists. The major moral theories just mentioned are attempts to bring some organization to what is known about morality.

Normally, though, science means something stronger and refers to a set of epistemological canons that guide inquiry. In one form, these canons are called *methodological naturalism:* the methods of inquiry used by an empirical science such as physics or biology. These include observation of the world, hypothesis formation, intervention and experiment, iterative formation and improvement of a theory, and more. Such activities are constitutive of the scientific method. If such methods can produce knowledge about norms, then a science of ethics is possible.

An even stronger form of science is *ontological naturalism:* Only those entities, events, and processes countenanced by the existing sciences may be used in theory construction. Methodological naturalism is a weaker form of science than an ontological naturalism. Consequently the possibility of an ethics grounded in ontological naturalism is more controversial.

In the weakest sense, ethics is a science if it can be organized into a coherent body of knowledge; in the moderate sense, ethics is a science if it can use the traditional epistemological canons of science to gain moral knowledge; and in the strongest sense ethics is a science if in addition to using the methods of science it also makes reference only to the entities and processes accepted by the extant, successful natural sciences. Only nihilists or radical moral particularists (those who contend that moral theory is so situation driven that general principles are impossible) would deny that there could be a science of norms in a weak sense. The moderate position is more controversial. Some would contend that moral knowledge is not gained using the empiricist methodology of the scientific method. For example, Kant's deontological theory does not require that humans reason empirically about morality; rather he maintains that they can know what they must do a priori independent of any particular experience. The strong position is the most controversial: Whether a normative theory can exist that differs neither in scope or content from the empirical sciences is debatable.

Naturalistic Fallacy

The argument offered most often against the possibility of scientific ethics in the moderate or strong senses is the naturalistic fallacy. First articulated by David Hume in *A Treatise of Human Nature* (1739), the naturalistic fallacy occurs when one moves from a list of empirical premises to a conclusion that contains a normative component. Hume is "surprised" when authors writing about ethics who were previously reasoning in the "usual way" suddenly begin to substitute "oughts" in places where before only the copula "is" had been present (Hume, Book III, Part I, Section I, Paragraph 24). Hume appears to point out a flaw in attempts to reason from the empirical to the normative—one will make reference to an unexplained term in a conclusion that was nowhere present in the empirical premises of the argument. Such an argumentative structure is invalid; the truth of the premises does not guarantee the truth of the conclusion. G. E. Moore advanced a similar argument early in the twentieth century when he argued that naturalized ethical systems fall prey to the *open question argument*. After one has identified normativity with a natural property such as avoidance of pain, for example, one can still meaningfully ask whether it is good to avoid pain. This means that utilitarians have not successfully reduced goodness to the natural property *avoiding pain*.

Whether or not the naturalistic fallacy and the open question argument provide *in principle* rationales against a moderate or strong scientific ethic is itself an open question. There are several possible responses. For example, both arguments rely on an analytic/synthetic distinction (a distinction between sentences true by definition and sentences true because of the way the world is), and many philosophers think no such distinction exists (see Casebeer 2003a). In addition, Hume's argument applies only to traditional deductive and inductive arguments. It may well be, though, that the relationship between natural ethical facts and the norms they deliver is *abductive;* one may best explain—abduction is often called *inference to the best explanation*—patterns of certain facts by assuming that they are also natural norms. Finally the open question argument probably does not generalize; it really amounts to saying that the two ethical systems Moore examines (Spencerian evolutionary ethics and hedonism) are not good natural ethical theories, and all but partisans would agree.

Why Scientific Ethics

Given disagreements about whether a scientific ethics in the moderate or strong sense is possible, why might people want such a thing? There are four possibly interrelated reasons. First science seems to some to have undermined traditional ethics, and hence human beings should use science to re-create ethics on firmer foundations. Second scientific ethics might be driven by concerns about the coherence of worldviews. Third scientific knowledge is the only real kind of knowledge. Fourth the sciences provide a prestige model, and in a highly scientific society people always try to imitate that which is of greatest prestige.

The first rationale may reflect a praiseworthy desire to reconsider long-standing issues in ethics from the perspective of contemporary science; for instance, what does contemporary cognitive science say about the existence of a free will, and what impact might this have on the conception of ethics? As another example, sociobiologists sometimes veer towards eliminativist extremes about the subject matter of ethics (morality is an illusion fobbed off on people by their genes). Strong scientific ethics thus might be a path to reconstruct what is purportedly illusory, whether it be a notion of agency compatible with the sciences or a scientific defense of the genuine objectivity of ethics.

The second rationale is closely related: Researchers may hold out hope that human knowledge can be unified. At the very least, they may ask that it be consistent across spheres of inquiry. Concerns about *consilience* can thus drive scientific ethics (Wilson 1975). The third and fourth rationales are strongly linked: If scientific knowledge is on a firmer footing than folk knowledge or nonempirical inquiry, then it is no wonder that funding and prestige would attach to scientific pursuits rather than not. Researchers in ethics may thus be attracted to the epistemic roots of science and the research support flowing from them. Sometimes this attraction leads to pseudoscientific ethics (just as it leads to pseudoscience), as in, for example, the work of Madam Vlabatsky's *theosophical scientific ethics* or in the eugenics movement. A thoughtful scientific ethics rejects pseudoscience and the pseudoethics that might follow.

Of course science advances, changing as time passes. Will attempts to connect science and ethics undermine the certainty some strive for in morality? They may, but this is no objection to the enterprise; it might be that the best one can hope for even in ethics is something like the *best guess hypothesis* offered by the practicing scientist.

Examples of Scientific Ethics

What might a moderate or strong scientific ethics look like? Herbert Spencer (1820–1903) claimed to offer such a theory in his work; he derived an evolutionary account of morality that is basically utilitarian in nature: If humans but allow the mechanisms of nature to do their work, there will be *natural social evolution* toward greater freedom. This will in turn lead to the greatest possible amount of happiness. While widely acclaimed during its time, Spencer's theory was ultimately rejected owing in part to its scientific inaccuracies, and to attacks upon it by Henry Sidgwick, Thomas Huxley, and G. E. Moore. At its worst, Spencer read repugnant norms into evolution; for example, here is what he said about Great Britain's Poor Laws, which mandated food and housing for the impoverished: "... there is an habitual neglect of the fact that the quality of a society is lowered morally and intellectually, by the artificial preservation of those who are least able to take care of themselves ... the effect is to produce, generation after generation, a greater unworthiness" (Spencer 1873 [1961], p. 313).

What might a more plausible scientific ethic look like? Such a theory might resemble that offered by the Greek philosopher Aristotle or the pragmatic philosopher John Dewey (1859–1952).

Aristotelian ethics is prescientific in the sense that the scientific revolution had not yet occurred; nonetheless, his method is empirical. For Aristotle, human flourishing is the *summum bonum* of existence; to say that an action is ethical or that a person is good is just to say that the action or the person contributes to or constitutes proper functioning. Contemporary ethicists have pursued this line of reasoning; for example, Larry Arnhart (1998) argues for a naturalized, Aristotelian ethical framework, and William Casebeer (2003a, b) argues that moral facts can be reduced to functional facts, with functions treated as an evolutionary biologist would (that is, as being fixed by evolutionary history). Leon Kass (1988) raises questions for such approaches; there are things that human passions and gut reactions say about the morality of certain actions that can never be captured with reason or the scientific method alone.

A related merging of science and ethics occurs in the work of the classic American pragmatists, such as Charles Pierce (1839–1914) and Dewey. Pierce argues that science itself is a form of ethics—it expresses respect for the values that underpin effective inquiry, and is subordinate to ethics insofar as it is human concerns about the efficacy of ideas that cause people to pursue science to begin with. Relatedly Dewey argues in his *Ethics* (1932) that the process of regulating ideas effectively—which is what science does in essence—enables human beings to become better able to express values and act upon them. This approach of replacing *preexisting value* with the creation of value and understanding what genuinely follows from that positing of value is called axiology (Casebeer 2003a).

Even if moderate and/or strong versions of scientific ethics seem implausible, almost everyone admits that scientific results may limit the possible space of normative moral theories. Only the most trenchant antinaturalist would think that facts about human beings and how they reason have absolutely no bearing on moral concerns. These facts should, at the very least, constrain moral theorizing. For instance, Owen Flanagan advocates the *principle of minimal psychological realism,* which states that the moral psychologies required by moral theories must be *possible* for humans: "Make sure when constructing a moral theory or projecting a moral ideal that the character, decision processing, and behavior prescribed are possible ... for creatures like us" (Flanagan 1991, p. 32). So the scientific study of the genesis, neurocognitive basis, and evolution of ethical behavior *is* relevant to normative moral theory *even if* the moderate and strong versions of scientific ethics are misguided or fail.

Contemporary Developments and Future Possibilities

There are five general areas in which scientific research has the potential to constrain moral theory: moral psychology, decision theory, social psychology, sociobiology, and artificial modeling of moral reasoning. Moral psychologists focus on the psychological processes involved in moral thought and action. They study such phenomena as *akrasia* (weakness of the will), moral development, the structure of moral reasoning, and the moral emotions. Some of the best known work in this area revolves around moral cognitive development; Lawrence Kohlberg, for example, has formulated an empirically robust theory of moral development whereby people progress through three stages of moral reasoning, each broken into two levels. In the first stage, one reasons by asking, What's in it for me? In the second, one asks, What does culture or society say? In the third, one asks, To what contract would I be a party? What do universal moral principles demand? Progress through these stages or schema is universal and (with some exceptions) invariant. If Kohlberg is right, then perhaps a normative moral theory that takes issues of justice seriously is more viable than one that does not (although his research has been criticized for this very reason; see Lapsley 1996 for a summary).

Other moral psychologists have been exploring the relationship between reason and moral emotions such as guilt or shame. One longstanding debate in moral theory has involved the relationship between having a moral reason to do something and whether that reason necessarily motivates an individual to take action. Internalists (such as Plato or Kant) argue that moral reasons necessarily motivate: If, morally speaking, one ought not to do something then one will, *ceteris paribus*, be motivated not to do that thing. Externalists (such as Aristotle) argue that a moral reason must be accompanied by an appropriate motivational state (such as an emotion) in order to spark action. If certain normative moral theories require either an internalist or externalist psychology in order to be plausible, then results from empirical research may constrain moral theory. For example, Adina Roskies (2003) argues persuasively that neurobiological data about the relationship between emotion and reason rules out internalism and makes a Kantian psychology implausible. Other issues in moral psychology will stand or fall with progress in the cognitive sciences; for instance, moral cognitive development and moral concept development may both be subsumed by research into cognitive and concept development in general.

Decision theorists study the determinants of human choice behavior. Traditional rational actor assumptions (such as possessing unlimited time and computational power, a well-ordered preference set, and indifference to logically equivalent descriptions of alternatives and choice sets) usually inform decision theory. Whether or not these assumptions apply to human reasoning when it is done well may affect whether normative moral theories must be essentially rational and hence whether they must respond to the same norms as those of reason traditionally construed. Much work in decision theory has revolved around either extending the predictive power of traditional rational actor assumptions, or in articulating alternative sets of rational norms to which human cognition should be responsive. For instance, Amos Kahneman and Daniel Tversky's (1982) heuristics and biases research program explores the shortcuts human beings take to achieve a reasonable result when under time pressure or when working with incomplete information. It may very well be that normative moral theories constitute sets of heuristics and biases.

Gerd Gigerenzer and the Adaptive Behavior and Cognition Research Group (2000) focus on ecological rationality, demonstrating that traditional rational canons can actually lead people astray in certain environments. While there is a rearguard action to shore up traditional rational actor driven decision theory, in all likelihood, progress on this front will require articulating a new conception of rationality that is ecologically valid and cognitively realistic. The results of this program may, in turn, affect the structure of normative moral theory in much the same way that the structure of normative rational actor theory has been and will be affected.

Social psychologists study human cognition and emotion in the social domain. Given that moral judgments are paradigmatically about how people ought to treat others, work in this area usefully constrains normative theorizing. One controversy regards whether or not the *fundamental attribution error* (the human tendency to undervalue the situational influences on behavior and overvalue the internal character-driven causes) undermines traditional approaches to virtue theory. If, as some social psychologists argue, there is no such thing as *bravery* as a general trait, but rather only such fragmented virtue-theoretic traits as *brave while standing in the checkout line at the grocery store*, then it may very well be that virtue theory will have to become much more sophisticated if it is to be plausible (see Doris 2002 for a comprehensive discussion, as well as Harman 2000; Doris and Stich 2003 also offer a useful survey). The social nature of moral reasoning means that the latest studies of social psychological behavior can, on the weakest view, usefully constrain normative theorizing, and on a stronger view can usefully coevolve with it.

Sociobiologists such as E. O. Wilson study the origin and evolution of (among other things) moral norms. They argue that genes keep moral culture on some sort of leash: At the very least, the capacities human beings use to reason about morality are evolved capacities and need clear connections to the environments in which these capacities evolved; maximally moral norms may be *nothing more* than norms that have enabled organisms and groups of organisms to increase their genetic fitness. Sociobiological approaches to human social behavior have been controversial, but have nonetheless shed much light on how both the capacity to reason morally and the structure of some moral norms came to be (Boehm 1999, for example, discusses the evolution of egalitarian norms). Game-theoretic work on the evolution of the social contract and other moral norms has illuminated aspects of ethical behavior ranging from the propensity to be altruistic to the temptation to defect on agreements in certain instances. Sociobiological study reinforces the notion that any accepted normative theory should have a describable evolution and a discernable way of maintaining its existence (see Binmore 1994).

Computer models at both the micro and macro level have usefully informed all these fields of research. Changes in technology have influenced what philosophers make of the possibility of scientific impact on ethics. For example, Rene Decartes's inability to reconcile how mental states could be identical to brain states drove, at least in part, his dualism. The advent of in vitro methods for identifying the neural machinery of cognitive activity, such as Positron Emission Tomography (PET) and functional Magnetic Resonance Imaging (MRI), may have headed off dualism at the philosophic pass if such technologies were available during his time. The spread of inexpensive and powerful computing technology has made possible everything from the simulation of artificial societies (and hence has influenced sociobiological approaches) to the simulation of moral reasoning in an individual (and hence has influenced moral psychology). On the social simulation front, promising work by Jason Alexander and Bryan Skyrms (1996) on the evolution of contracts has usefully informed moral theorizing. On the individual level, work by cognitive modelers such as Paul Thagard (2000) and Paul Churchland (2001) has highlighted areas where normative moral theory can intersect with cognitive modeling.

Assessment

Is scientific ethics possible? Appropriately enough, this is an empirical matter. Should the promise held out by the rapidly progressing cognitive, biological, and evolutionary sciences be realized, there is reason to be sanguine about the moderate and strong programs for a scientific ethic. Science could reaffirm some of the prescientific insights into the nature of morality. But even if this very possibility is a misguided hope, scientific insights into human nature and cognition can usefully constrain the possible space of normative moral theory, and in this sense the existence of scientific ethics is a foregone conclusion. Science and ethics are indeed both magisterial, but they are, ultimately, overlapping.

WILLIAM D. CASEBEER

SEE ALSO *Aristotle and Aristotelianism; Berlin, Isaiah; Decision Theory; Deontology; Emotion; Hume, David; Kant, Immanuel; Levi, Primo; Mill, John Stuart; Sociobiology; Spencer, Herbert.*

BIBLIOGRAPHY

Aristotle. (1985). *Nichomachean Ethics*. Indianapolis, IN: Hackett. Aristotle's best-known work in normative ethics. Aristotle was a student of Plato, another foundational figure in virtue ethics.

Arnhart, Larry. (1998). *Darwinian Natural Right: The Biological Ethics of Human Nature*. Albany: State University of New York Press. Defends a contemporary version of Aristotelian ethics using evolutionary biology.

Bacon, Francis. (1605 [2001]). *The Advancement of Learning*, ed. Stephen J. Gould. New York: Modern Library. Arguably the humanities/natural science *split* first occurred with Francis Bacon; a useful introduction to his thought.

Bacon, Francis. (1620 [1994]). *Novum Organum*. Chicago: Open Court Publishing Company. A good statement of the canons of empirical science early in their developmental history.

Binmore, Ken. (1994). *Game Theory and the Social Contract*, Vol. 1: *Playing Fair*. Cambridge, MA: MIT Press. Using assumptions from game theory, argues against the possibility of a Kantian reconstruction of John Rawls's theory of justice.

Boehm, Christopher. (1999). *Hierarchy in the Forest: The Evolution of Egalitarian Behavior*. Cambridge, MA: Harvard University Press. Discusses the evolution of egalitarian tendencies in apes and hominids.

Caplan, Arthur L., ed. (1978). *The Sociobiology Debate: Readings on the Ethical and Scientific Issues Concerning Sociobiology*. New York: Harper and Row. While dated, nonetheless serves as an excellent introduction to the sociobiology debate.

Casebeer, William D. (2003a). *Natural Ethical Facts: Evolution, Connectionism, and Moral Cognition*. Cambridge, MA: MIT Press. Argues for a strong form of scientific ethics, recapitulating a neo-Aristotelian virtue theory using resources from evolutionary biology and cognitive neuroscience.

Casebeer, William D. (2003b). "Moral Cognition and Its Neural Constituents." *Nature Reviews: Neurosciences* 4: 841–847. Discusses the interplay between neuroscience and normative moral theory while reviewing the neural mechanisms of moral cognition.

Churchland, Paul M. (2001). "Toward a Cognitive Neurobiology of the Moral Virtues." In *The Foundations of Cognitive Science*, ed. João Branquinho. Oxford: Oxford University Press. Reprint of Churchland's seminal 1998 article; discusses the affinity between virtue theory and neural network conceptions of cognition.

Dewey, John. (1932 [1989]). *Ethics*. Carbondale: Southern Illinois University Press. Dewey's best known text in moral theory.

Doris, John M. (2002). *Lack of Character: Personality and Moral Behavior*. Cambridge, UK: Cambridge University Press. Surveys results from contemporary social psychology, arguing that they make implausible the kinds of traits required by virtue theory.

Doris, John M., and Stich, Stephen. (2003). "As a Matter of Fact: Empirical Perspectives on Ethics." In *The Oxford Handbook of Contemporary Analytic Philosophy*, eds. Frank Jackson, and Michael Smith. Oxford: Oxford University Press. Offers an excellent introduction to empirical issues in ethics.

Elman, Jeff L., et al. (1996). *Rethinking Innateness: A Connectionist Perspective on Development*. Cambridge, MA: MIT Press. Argues that neural network accounts of cognition can account for multiple facts about the development of language in humans.

Flanagan, Owen. (1991). *Varieties of Moral Personality: Ethics and Psychological Realism*. Cambridge, MA: Harvard University Press. Discusses the relationship between psychology and normative moral theory.

Gigerenzer, Gerd; Peter M. Todd; and the ABC Research Group. (2000). *Simple Heuristics That Make Us Smart*. Oxford: Oxford University Press. Discusses the heuristics and biases at work in human thought, including what impact this has for the human conception of rationality.

Gould, Stephen J. (2002). *Rocks of Ages: Science and Religion in the Fullness of Life*. New York: Ballantine Books. Discusses the relationship between ethics and science, arguing that the two are nonoverlapping magisteria.

Harman, Gilbert. (2000). "Moral Philosophy Meets Social Psychology: Virtue Ethics and the Fundamental Attribution Error." In *Explaining Value and Other Essays in Moral Philosophy*. Oxford: Oxford University Press. Argues that the fundamental attribution error demonstrates that there are no such things as character traits.

Hume, David. (1739 [1985]). *A Treatise of Human Nature*, ed. Lewis A. Selby-Bigge. Oxford: Clarendon Press. Clearly articulates the naturalistic fallacy in this defense of noncognitivism about ethics.

Kant, Immanuel. (1785 [1993]). *Grounding for the Metaphysics of Morals*, trans. James Ellington. Indianapolis, IN: Hackett. A concise summary of Kant's views on ethical issues and one of the best-known works in deontology.

Kahneman, Daniel; Paul Slovic; and Amos Tversky, eds. (1982). *Judgment Under Uncertainty: Heuristics and Biases*. Cambridge, UK: Cambridge University Press. The seminal work in the heuristics and biases research program.

Kass, Leon. (1988). *Toward a More Natural Science: Biology and Human Affairs*. New York: Free Press. Argues that science can go too far if it is not appropriately regulated by the wisdom contained in emotional reactions to certain technological advances.

Lapsley, Daniel K. (1996). *Moral Psychology*. Boulder, CO: Westview Press. An excellent survey of issues in moral psychology.

Moore, G. E. (1902 [1988]). *Principia Ethica*. Amherst, NY: Prometheus Books. Articulates the open question argument against strong scientific ethics.

Roskies, Adina. (2003). "Are Ethical Judgments Intrinsically Motivational?: Lessons from Acquired Sociopathy." *Philosophical Psychology* 16(1): 51–66. Seminal article tackles the internalism/externalism debate (do moral reasons necessarily move people to act?) using neurobiological evidence.

Skyrms, Brian. (1996). *Evolution of the Social Contract*. Cambridge, UK: Cambridge University Press. Brings iterated game theory to bear on the evolution of the norms of justice and exchange; useful work in this area has also been accomplished by Jason Alexander, who studied under Skyrms.

Spencer, Herbert. (1873 [1961]). *Study of Sociology*. Ann Arbor: University of Michigan Press. One of Spencer's best known works in the field of scientific ethics.

Thagard, Paul. (2000). *Coherence in Thought and Action*. Cambridge, MA: MIT Press. Uses computer models to explain how concerns about coherence affect moral reasoning.

Wilson, Edward O. 1975 (2000). *Sociobiology: The New Synthesis*, 25th Anniversary edition. Cambridge, MA: Harvard University Press. Single-handedly established the field of sociobiology (or, in contemporary terms, evolutionary psychology).

SCIENTIFIC INTEGRITY

SEE *Research Integrity*.

SCIENTIFIC REVOLUTION

In the first half of the twentieth century it became a commonplace notion that modern science originated in a seventeenth-century "revolution" in thought precipitated by a new methodology for studying nature. In the last third of the twentieth century, a consensus developed among historians, philosophers, and sociologists of science that the emergence of modern science was more evolutionary than revolutionary. Furthermore, while modern science for 300 years claimed that its methodology generated value-free, objective knowledge, the late-twentieth-century consensus was that, implicitly and explicitly, the practice of science incorporated moral, ethical, and social value judgments.

The Seventeenth-Century Achievement

A fundamentally new approach to the study of nature did indeed emerge in seventeenth-century western Europe. The first herald of this development was Francis Bacon (1561–1626), who argued for a renovation in the human conception of knowledge and of knowledge of nature in particular. Especially in his *Novum Organum* (1620; New instrument [for reasoning]), Bacon formulated a radically empirical, inductive, and experimental-operational methodology for discovering laws of nature that could be put to use to give humankind power over nature. Bacon was primarily a social reformer who believed that knowledge could become an engine of national prosperity and power, improving the quality of life for all. To that end, he championed widespread education for all classes of society, featuring a strong mechanical-technical component that would assure widespread ability to create and maintain technological innovations. (The island of Laputa episode in Jonathan Swift's novel *Gulliver's Travels* (1726) mocks the Baconian faith in science-based innovation as improving the quality of life.)

Bacon was strongly opposed to mathematical accounts of natural phenomena, seeing in them a continuation of Renaissance magical nature philosophy and an erroneous commitment to deductive reasoning. René Descartes (1596–1650) by contrast, especially in his *Rules for the Direction of the Mind* (written 1628, but not published until 1701) and *Discourse on Method* (1637), roughly contemporary with Bacon's *Novum Organum*, articulated a mathematical and rigorously deductive, hence rational methodology for gaining knowledge of nature that employed experiment only to a limited degree and cautiously, because experimental results are ambiguous and subject to multiple interpretations. Descartes's own theory of nature was mechanistic, materialistic, and mathematical, hence deductive and deterministic. It became the basis for the mechanical worldwiew that was incorporated into enlightenment thinking and epitomized the view of nature as a clockwork world. Unlike Bacon, Descartes was a practicing researcher and a mathematician. He introduced analytical geometry—enabling algebraic solution of geometric problems—developed a materialistic cosmology in which the solar system and Earth formed naturally, discovered the reflex arc in his anatomical researches, developed a mechanical theory of life and biological processes, and wrote influentially on mechanics and optics, formulating his own theory of light.

Galileo Galilei (1564–1642), in his *Dialogues Concerning Two New Sciences* (1638), presented a deductive mathematical-experimental methodology that he attributed to Archimedes (c. 287–212 B.C.E.), several of whose treatises were translated into Latin and circulated widely beginning in the second half of the sixteenth century. In this work Galileo founded engineering mechanics and the mathematical theory of strength of materials, and he also extended and corrected earlier contributions to the science of mechanics (while perpetuating the mistaken notion that circular motion was "natural" and hence force-free). This work supplemented his more famous discoveries in astronomy based on his pioneering application of the telescope to the study of the moon and planets, and his defense of Copernicanism, the Sun-centered cosmological theory of Nicolaus Copernicus (1473–1543).

The Newtonian Triumph

Galileo's methodology probably comes closest to what people mean when they refer to "the scientific method" and its invention in the seventeenth century. It reached its mature form in the hands of Isaac Newton (1642–1727) in the last third of the century. In all of his work, but especially in his majestic *Mathematical Principles of Natural Philosophy* (1687), considered the single most influential scientific text ever, and in *Optics* (1704), Newton synthesized induction and deduction, mathematics, and experimentation into a powerful methodology capable of revealing, in his view, the hidden "true causes" responsible for the phenomena of empirical experience. Like Descartes, whose methodology (and theories) he dismissed contemptuously, Newton made major contributions to mathematics, inventing, independently of Gottfried Wilhelm Leibniz (1646–1716), the calculus; to optics, inventing the reflecting telescope, discovering the phenomenon of diffraction and the seven-color composition of sunlight, and formulating a corpuscular, or particle, theory of light that would be dominant until the wave theory of light gained ascendance in the nineteenth century; to mechanics, in his famous three laws of motion; and to a theory of the universe based on his universal theory of gravitation, which provided a full account of the planetary orbits, confirming the validity of the earlier, scattered insights of Johannes Kepler (1571–1630).

Contrary to Descartes, who believed that matter was infinitely divisible, Newton favored an atomic theory of matter, and based physics and chemistry on a variety of forces acting nonmechanically and/or at a distance, rather than basing it only on mechanical contact forces. Newton's scientific style and his accomplishments represent the peak achievement of the seventeenth-century Scientific "Revolution." Until the mid-eighteenth century, many Continental natural philosophers—the term *scientist* was invented only in the 1830s—remained committed to Descartes's strictly mechanical model of scientific explanation while rejecting Descartes's particular theories. After that, Newtonianism effectively defined "modern" scientific study of nature until the early twentieth century and the rise of relativity and quantum theory.

By the end of the seventeenth century, then, modern science was firmly established, not only in mathematical physics and astronomy, but as a comprehensive philosophy of nature that was deterministic and materialistic, though explanations incorporated immaterial forces—such as gravity, electrical and magnetic attraction/repulsion, and selective chemical affinity—that acted according to strictly mathematical laws. This materialistic-deterministic approach to nature was broadly applied to biological and medical phenomena, especially in Italy and at the University of Padua, as reflected in William Harvey's (1578–1657) demonstration in 1628 of the closed circulation of the blood pumped by the heart and by the Galileo-influenced work of Giovanni Borelli (1608–1679) and others on the mechanics of the human skeletal and skeletal-muscular systems.

Even more than the telescope, the mid-seventeenth-century invention of the microscope by Antoni van Leeuwenhoek (1632–1723) revealed the existence of new worlds. The demonstration by Blaise Pascal (1623–1662) and Evangelista Torricelli (1608–1647) of the mechanical pressure exerted by the atmosphere using a simple barometer, which also showed that a vacuum could be created, strongly reinforced the mechanical conception of nature. A critical contribution to the new philosophy of nature was Christiaan Huygens's (1629–1695) midcentury demonstration that circular motion required a force to maintain it, contrary to the previous 2,000 years of Western thought. Descartes and Galileo both misunderstood this fact, which became a cornerstone of modern mechanics in Newton's principle of inertia. By the rise of the enlightenment in the second half of the eighteenth century, an amalgam of Descartes's mechanical worldview Cartesian mechanism and Newtonian deterministic mathematical physics was applied to society and its institutions, for example, by the Baron de Montesquieu (1689–1755), Anne-Robert-Jacques Turgot (1727–1781), and the Marquis de Condorcet (1743–1794) in France, and even to the human mind, for example, by David Hume (1711–1776) and Étienne Bonnot de Condillac (1715–1780).

Newtonianism Dethroned

In the nineteenth century, Newtonianism was severely challenged, and in the twentieth century it was displaced. The relationship between increasingly abstract mathematical models of nature and "reality" became an issue. The models worked empirically, but did they also provide a picture of reality? Meanwhile, the wave theory of light overthrew Newton's corpuscular theory and when incorporated by James Clerk Maxwell (1831–1879) into an electromagnetic field theory of energy led to attributing causal efficacy to space-filling immaterial entities. The introduction of the concept of energy on a par with matter diluted the deterministic materialism of modern science, while the new science of thermodynamics revealed that Newton's conception of time was flawed. Finally, with the kinetic theory of gases, statistical explanations were introduced into physics, which called determinism into question. With relativity and quantum theory, from 1905 on, Newtonian conceptions of space, time, matter, force, cause, and explanation, and Descartes's deductive model of rationality would all be replaced, and a fundamentally new form of science and a new, statistical conception of reality would emerge.

Seventeenth-century nature philosophy had presented itself as a body of impersonal knowledge, as simply descriptive of the way things were "out there," independent of personal, social, and cultural values. Given the religious wars of the first half of the seventeenth century, and the explicitly values-steeped character of Renaissance nature philosophy, this was a major epistemological innovation. The value-free character of the knowledge was guaranteed, it was thought, by a methodology employed in acquiring it that eliminated the influence of the subject on knowledge. However attractive such a conception of knowledge was then and continued to be through the nineteenth century, it created a gulf between facts and values, between knowledge and its applications, that in principle could not be bridged by reason, which increasingly came to be defined as reasoning in the scientific (hence objective) manner.

Bacon tacitly assumed that people would know what to do with the new mastery of nature that scientific knowledge would give them. But already by the mid-seventeenth century, the educational reformer John Amos Comenius (1592–1670) was warning that the new science was as likely to create a hell on Earth as a manmade heaven if application-relevant values were not explicitly linked to knowledge. In fact, right through the twentieth century and into the twenty-first, modernism, first in the West and then globally, has borne witness to the accuracy of Comenius's warning. While the scope and explanatory/predictive power of science in the nineteenth and twentieth centuries increased dramatically and became the basis of life-transforming technological innovations, there was no commensurate increase in conceptual "tools" for identifying which innovations to implement or how to implement them. Elimination of any influence on knowledge of the values held by the subject of knowledge eliminated any influence of knowledge on the values held by subjects!

As a result, even as science and technology became, after 1800, the primary agents of social change around the world, scientists and engineers remained outsiders to the terms of that change, which was driven overwhelmingly by scientifically nonrational political and market values. Both government funding of scientific research, especially in the United States after World War II, and industry dependence on science for technological innovations blurred the distinction between pure and applied science, reinforcing the post-1960s critique of science as in fact a value-laden ideology and not objective knowledge.

STEVEN L. GOLDMAN

SEE ALSO *Enlightenment Social Theory; Industrial Revolution; Moderniation; Secularization.*

BIBLIOGRAPHY

Hankins, Thomas L. (1985). *Science and the Enlightenment.* Cambridge, UK: Cambridge University Press. Outlines the spread of Newtonianism in the eighteenth century.

Harman, P. M. (1982). *Energy, Force, and Matter.* Cambridge, UK: Cambridge University Press. Traces the growing conceptual complexity of nineteenth-century science.

Nye, Mary Jo. (1996). *Before Big Science: The Pursuit of Modern Chemistry and Physics, 1800–1940.* New York: Twayne. Excellent account of physics and chemistry at the dawn of their connection to government.

Shapin, Steven, and Simon Schaffer. (1985). *Leviathan and the Air-Pump.* Princeton, NJ: Princeton University Press. Classic study of the sociocultural context of the seventeenth-century Scientific Revolution.

Webster, Charles. (2002). *The Great Instauration: Science, Medicine, and Reform, 1626–1660,* 2nd edition. Oxford, UK: Peter Lang. Detailed account of the social context of Bacon's ideas and their influence on modern science.

Westfall, Richard S. (1971). *The Construction of Modern Science.* New York: Wiley. Excellent short history of seventeenth-century science.

Westfall, Richard S. (1993). *The Life of Isaac Newton.* Cambridge, UK: Cambridge University Press. Revised version of classic biography.

SCIENTISM

Scientism is a philosophical position that exalts the methods of the natural sciences above all other modes of human inquiry. Scientism embraces only empiricism and reason to explain phenomena of any dimension, whether physical, social, cultural, or psychological. Drawing from the general empiricism of the Enlightenment, scientism is most closely associated with the positivism of Auguste Comte (1798–1857), who held an extreme view of empiricism, insisting that true knowledge of the world arises only from perceptual experience. Comte criticized ungrounded speculations about phenomena that cannot be directly encountered by proper observation, analysis, and experiment. Such a doctrinaire stance associated with science leads to an abuse of reason that transforms a rational philosophy of science into an irrational dogma (Hayek 1952). It is this ideological dimension that is associated with the term *scientism*. In the early twenty-first century the term is used with pejorative intent to dismiss substantive arguments that appeal to scientific authority in contexts in which science might not apply. This overcommitment to science can be seen in epistemological distortions and abuse of public policy.

Epistemological scientism lays claim to an exclusive approach to knowledge. Human inquiry is reduced to matters of material reality. We can know only those things that are ascertained by experimentation through application of *the* scientific method. And because *the method* is emphasized with such great importance, the scientistic tendency is to privilege the expertise of a scientific elite who can properly implement the method. But the science philosopher Susan Haack (2003) contends that the so-called scientific method is largely a myth propped up by scientistic culture. There is no *single* method of scientific inquiry. Instead, Haack explains that "scientific inquiry is contiguous with everyday empirical inquiry" (p. 94). Everyday knowledge is supplemented by evolving aids that emerge throughout the process of honest inquiry. These include the cognitive tools of analogy and metaphor that help to frame the object of inquiry in familiar terms. They include mathematical models that enable the possibility of prediction and simulation. Such aids include crude, impromptu instruments that develop increasing sophistication with each iteration of a problem-solving activity. And everyday aids include social and institutional helps that extend to lay practitioners the distributed knowledge of the larger community. According to Haack, these everyday modes of inquiry open the scientific process to ordinary people and they demystify the epistemological claims of the scientistic gatekeepers.

The abuse of scientism is most pronounced when it finds its way into public policy. A scientistic culture privileges scientific knowledge over all other ways of knowing. It uses jargon, technical language, and technical evidence in public debate as a means to exclude the laity from participation in policy formation. Despite such obvious transgressions of democracy, common citizens yield to the dictates of scientism without a fight. The norms of science abound in popular culture, and the naturalized authority of scientific reasoning can lead, if left unchecked, to a malignancy of cultural norms. The most notorious example of this was seen in Nazi Germany where a noxious combination of scientism and utopianism led to the eugenics excesses of the Third Reich (Arendt 1951). Policy can be informed by science, and the best policies take into account the best available scientific reasoning. Lawmakers are prudent to keep an ear open to science while resisting the rhetoric of the science industry in formulating policy. It is the role of science to serve the primary interests of the polity. But government in a free society is not obliged to serve the interests of science. Jürgen Habermas (1978) warns that positivism and scientism move in where the discourse of science lacks self-reflection and where the spokespersons of science exempt themselves from public scrutiny.

MARTIN RYDER

SEE ALSO *Conservatism; Technicism; Technicization.*

BIBLIOGRAPHY

Arendt, Hannah, (1973 [1951]). The Origins of Totalitarianism. New York: Harcourt Brace. A student of philosopher and Nazi Martin Heidegger, Arendt recounts the social and intellectual conditions that gave rise to totalitarianism in Germany.

Haack, Susan. (2003). *Defending Science—Within Reason: Between Scientism and Cynicism.* Amherst, NY: Prometheus Books. A critical assessment by a logician and philosopher of science.

Habermas, Jürgen. (1978). "The Idea of the Theory of Knowledge as a Social Theory." In his *Knowledge and Human Interests,* 2nd edition, trans. Jeremy J. Shapiro. London: Heinemann Educational.

Hayek, Friedrich A. (1952). *The Counter-Revolution of Science: Studies on the Abuse of Reason.* Glencoe, IL: Free Press.

Midgley, Mary. (1992). *Science as Salvation: A Modern Myth and Its Meaning.* London: Routledge. A general criticism of scientism by a moral philosopher.

SECULARIZATION

Secularization is a concept important to science, technology, and ethics, because it encapsulates influential general theories about how moral influence may be exercised over and by science and technology under different historical and social conditions.

Most societies incorporate practices, beliefs, and institutions that correspond roughly to the domain of religion in modern Western cultures. These religious features presuppose the existence of non-human entities with powers of agency (i.e., gods) or the existence of impersonal powers endowed with moral purposes (i.e., karma). Moreover they generally assume that these non-human agents or powers have an impact upon human affairs. Secularization is a process by which religion comes to have decreasing importance in society along several dimensions.

First there is a decline in the status, prestige, and power of persons, practices and institutions associated primarily with religion. Second there is a decline in the importance of religion for the exercise of non-religious roles and institutions, including those associated with politics and the economy. Third there is a decline in the number of persons who take religion seriously and the degree of seriousness with which those involved in religion continue to take it. Secularization is highly correlated with the extent of industrialization in a society and with the development of scientific practices and institutions. But there is serious disagreement regarding whether secularization is largely a consequence of the growth of science and industry; whether science, industrialization, and secularization are relatively independent features of a more general process of modernization; or whether secularization is a prerequisite rather than a consequence of the growing importance of science in a society.

Three Theories of Secularization

Though he did not use the term, Auguste Comte (1798–1857) offered the first major theory of secularization in articulating what he called his law of three stages in his Positive Philosophy, developed in the 1820s. According to Comte every domain of knowledge passes through three progressive stages—a religious phase in which aspects of the universe are anthropomorphized (that is, human attributes including will and agency are projected onto non-human entities), a metaphysical phase in which impersonal forces (such as gravitational or electrical forces) are presumed to cause effects in the world, and a positive or fully scientific stage in which abstract causal explanations of events are abandoned in favor of general descriptive laws. Within Comte's system the rise of more reliable scientific knowledge drives out inferior religious belief; so secularization is a natural and necessary consequence of the rise of science. Even some sociologists of religion at the end of the twentieth century, such as Rodney Stark, retain a strong element of this positivist vision.

A near mirror image of the positivist view combines elements from the works of Early Modern historians such as Stephen McKnight and modern historians such as Howard Murphy. In their view Christian Humanism in the Renaissance focused Christian concerns on the amelioration of the human condition, encouraging the growth of science for the purpose of manipulating nature to serve human ends. Such views were strongly supported by Tomasso Campanella (1568–1639) in Italy, Johann Andreae 1586–1654> in the Germanies, and by Francis Bacon (1561–1626) in England. Later, when many intellectuals became disillusioned with organized religion because of the religious wars on the continent or because of the failure of institutionalized religion to promote causes of social justice, they turned to science as an alternative source of values that could improve peoples lives. From this perspective, science in Europe was nurtured within a religious context and then became the beneficiary of secularizing trends that emerged first within the Christian community itself.

A third relatively simple explanation of secularization derives from an evolutionary understanding of religion prominent among anthropologists such as Roy Rappaport and David Sloan Wilson. From this perspective religions serve primarily to establish group cohesion and social solidarity by promoting altruistic rather than individualistic behaviors. The growth of commercial economies tended to break down cooperative tendencies within societies, to promote in-group competition and individualism, and simultaneously to encourage inter-group cooperation and culture contact. As a consequence the local authority of religion was undermined both internally, as egoistic, liberal, ideology increasingly governed forms of behavior, and from the outside, as it became clear that many varieties of religion existed in other societies without subverting the functioning of those societies.

Twenty-First Century Perspectives on Secularization

Most social scientists at the beginning of the twenty-first century accept variants of a more complex account of secularization developed by Peter Berger and David Martin that grew out of the ideas of Max Weber (1864–1920). Within this account there are at least three interacting strands. One is a rationalizing trend that seems to emerge in monotheistic religions, especially those which, like Christianity, incorporate a transcendent God and therefore encourage attempts to understand the natural world without reference to specific instances of divine agency, and likewise grant human agency a predominant role in human affairs. Science and technology thus become consequences of the implicit rationality of transcendent monotheism. This rationalizing strand would not necessarily by itself significantly reduce the authority of religion, but interacting with the others it does.

The second strand is a socioeconomic strand that begins from the Weberian claim that the protestant ethic promoted the rise of industrial capitalism. Industrial capitalism in turn encouraged the division of labor and promoted social differentiation into classes, breaking down the social homogeneity of pre-modern society and creating social and cultural diversity. The division of labor also transformed many social roles, which had once had important religious components, into specialized secular roles. Thus educators, health care professionals, government functionaries, and other professional groups developed specialized knowledge and institutions, creating new and non-religious sources of power and authority. Furthermore the breakdown of social homogeneity undermined the sense of communally shared values inculcated by religious practices and institutions.

Finally the Protestant Reformation promoted a sense of individualism that created a tendency for religious schism, the proliferation of competing sects, and a sense of religious relativism that was only exacerbated by culture contact with non-Christian cultures. One consequence of this relativism was the separation of Church and State, which found its most explicit separation in the first amendment to the U. S. Constitution. All of these tendencies—toward rationalization, science, and technological development; toward social differentiation and diversity; and toward religious pluralism—promoted the declining importance of religion relative to secular factors in promoting and controlling human activities. That is they all contributed to secularization.

In spite of such theories of secularization, it is clear that many issues associated with twenty-first century science and technology—from abortion to cloning, from nuclear weapons to internet piracy—are subject, even in such ostensibly secular societies as that of the United States, to religious interest-group influence. Thus the extent to which secularization adequately describes the general trend that shapes the context in which scientific, technological, and ethical interactions occur remains open to debate. There are even some proponents of cultural diversity and advocates of alternatives to modern European and North American industrial culture, who admit the importance of secularization, but who oppose the hegemony of the modern science and technology of those cultures and argue for a *re-enchant-*

ment or re-sacralization of the world. These persons point to such earth-centered spiritual traditions as those of Native Americans, as models that might promote a healthier and ultimately a more sustainable science and technology.

RICHARD OLSON

SEE ALSO *Comte, Auguste; Modernization; Urbanization; Weber, Max.*

BIBLIOGRAPHY

Berger, Peter. (1969). *The Social Reality of Religion*. London: Faber and Faber.

Berman, Morris. (1981). *The Reenchantment of the World*. Ithaca, NY: Cornell University Press. Influential updated Weberian account of secularization.

Bruce, Steve. (2002). *God Is Dead: Secularization in the West*. Oxford: Blackwell. Argues that science is more consequence than a cause of secularization, the chief driving force of which is cultural contact and a consequent awareness of the relativity of values.

Martin, David. (1978). *A General Theory of Secularization*. Oxford: Blackwell.

McKnight, Stephen A. (1989). *Sacralizing the Secular: The Renaissance Origins of Modernity*. Baton Rouge: Louisiana State University Press. Strong argument for the religious sources of modern science and, indirectly, of secularization.

Murphy, Howard. (1955). "The Ethical Revolt Against Christian Orthodoxy in Early Victorian England." *American Historical Review* (July): 800–817. Makes the argument that many nineteenth-century intellectuals turned to science as a source of values only as a consequence of a crisis of religious faith, rather than as a prelude to religious crisis.

Rappaport, Roy A. (1999). *Ritual and Religion in the Making of Humanity*. Cambridge, UK: Cambridge University Press. One of many evolutionary accounts of the survival value of religion. This one emphasizes the role of religion in encouraging in-group truth telling.

Stark, Rodney. (1963). "On the Incompatibility of Religion and Science." *Journal for the Scientific Study of Religion* 3: 3–20. Updated version of the traditional positivist argument that superior scientific knowledge drives out inferior religious faith.

SECURITY

Security has many dimensions, depending on the situation. People secure boats by tying them to a dock, secure loans from financial institutions, or secure promises with a handshake. People feel less secure, or insecure, when they doubt their own abilities, when they lose their privacy, when a thief steals their wallet or purse. Thus, security is a psychological as well as a physical state of feeling—as well as being—protected from loss, breach of trust, attack, or any real or perceived threat.

The word *security* is widespread and appears in many contexts, from the United Nations Security Council and the nuclear and environmental security councils worldwide to national security, social security, and neighborhood security watch groups formed to keep homes safe from burglars. The term has become enshrined as well in the Department of Homeland Security, which describes itself as working "to keep America safe" with one program slogan of "Don't be afraid, be ready." Closely related terms include *safety* and *fear*. Fear is a feeling, not always rational, of agitation and anxiety caused by the perception of danger. In the United States, in 2001, about 1,000 people died from airliner accidents, including those who died in the crashes of September 11, 2001, while in the same year, more than 42,000 people died in automobile crashes. Yet after the September 11 attacks, many people refused to fly and opted to drive. They no longer felt secure in airliners, even though they faced greater risk on the roads.

Pursuing Security

In between self-reliance and the appeal to religion (which places ultimate "security" in the divine), the most general efforts to enhance security involve science, technology, and politics. Many scientists, for instance, argue that insofar as fear arises from ignorance, scientific explanations of phenomena reduce superstition and increase understanding, thus promoting security through knowledge.

From earliest times human beings have also depended for their very existence on the technologies of food gathering, production, and preparation, as well as those that provide clothing and shelter. Technology, especially in the form of medicine, has a long history of combating the insecurity of disease. Virtually all forms of engineering propose to render human productivity and products more secure.

To protect technological gains, however, provisions for political security are a further requirement. The rise of the first civilizations was closely associated with the development of technologies of military security. In order to obtain civil security, people have even given their allegiance and surrendered their rights to emperors, kings, and governments. According to the English philosopher Thomas Hobbes in the *Leviathan* (1651), this compact between people and leaders is necessary because people naturally lack traits that would ensure mutual security. For Hobbes, people are essentially selfish creatures with no concern for or connection to one another. Because humans are largely unsuccessful and constantly warring, they trade away their freedom and individuality in order to gain stability, law and order, a predictable future, leisure, and enjoyment. While other philosophers take a less dim view of human nature, all agree that security is essential for society, production, trade, and culture.

Hobbes and other early modern philosophers also argued that state security would not only protect technological achievement but also promote it, and that security could be enhanced by turning those desires for material welfare that might otherwise lead to warfare between nations to a general warfare against scarcity. Although the pursuit of security thus plays important roles in virtually all modern technologies, the more explicit appeals to security are undoubtedly found in the discussion of computers and the military.

Computer and information professionals are at the front line of ensuring the confidentiality, integrity, operability, and availability of information systems and data. Under the umbrella of those words come physical threats stemming from floods, hurricanes, sandstorms, and other natural disasters, as well as unintentional harm from careless use, and of course intentional harm from thieves, hackers, or terrorist attack. The focus of computer and information security often narrows to the means, such as encryption, passwords, and biometrics, rather than examining the motivations and goals of security. Among the many dimensions of this broader field are various levels of security, false senses of security, intrusive burden of security, and much more.

It is particularly important to differentiate between the *ordinary* and the *national* levels of security (Nissenbaum, Friedman, and Felten Internet article). The ordinary level comprises assurance of safety from the threats mentioned above, such as natural disasters, human error, or unwanted trespass. Computer and information professionals take what measures they can to protect from ordinary threats.

The national level, however, includes more extraordinary measures of action. In the name of national security, nations pursue extreme measures. As Helen Nissenbaum, Batya Friedman, and Edward Felten described it,

> The cause of national security can be parlayed into political measures as well: a lifting of typical restraints on government activities and powers, especially those of security agencies. We may see also a curtailing of certain freedoms (e.g. speech, movement, information), a short-circuiting of certain normal democratic processes (e.g. those in the service of openness and accessibility), and even the overriding of certain principles of justice.

Thus, in some instances, ordinary security is trumped by national security, and the individual is left with fewer rights and feeling less, not more, secure. For example, national identity cards have only limited potential to enhance security but also entail an array of serious risks and other negative characteristics (Weinstein and Neumann 2001). Governments might impose national identity cards and people might agree to them out of fear, rather than out of a rational need.

Specific Issues of Computer and Information Security

In most areas, governments, institutions, and manufacturers give people visual reassurance that they are protected from harm. Security is signified by armed guards standing at a checkpoint, childproof tops on pharmaceutical products, and locks on doors, windows, and cars. Banks are often solid structures, giving depositors the reassurance that their funds are safe. Screen savers can be password protected, although breaking through such protection is trivial. Whether effective or not, these measures calm and reassure people.

In the realm of computers and information, the physical and psychological aspects of security are more elusive, because the digital world is often devoid of the visual cues that lead people to feel secure. How can a user know that a document has not been altered, that no one has eavesdropped on a conversation, that an order comes from a real customer? Challenges include authenticating data and users, maintaining data integrity, and ensuring the confidentiality of communication.

The lack of transparency of technological devices easily renders end users both insecure and dependent. Although this is a problem associated with many technological appliances such as radios, refrigerators, and air conditioners—devices that few can repair or even explain—the lack of "transparency" is peculiarly salient in computers, which are themselves increasingly integrated into other devices—to make the DVD player, car, or toaster "smart," but leaving the users feeling powerless and "dumb." When devices make people feel dumb, they also make them feel less secure.

What about the security threats of private spyware products? Not only do people have to be worried about governments or corporations spying on them, increasingly individuals have available sophisticated technologies for spying (spouses on each other, parents on kids, and so forth).

Another (closely related) issue: False security is provided by deleting computer documents, as some criminals have discovered to their chagrin. Computer professionals can recover many deleted files, even of non-criminals.

Security measures themselves can become burdensome, as when users have too many passwords to remember. Fear focused on one area may leave another more vulnerable. Indeed, professionals who concentrate too narrowly on the machine and wires and airwaves may overlook the danger of a disgruntled employee or an electromagnetic weapon. Research by Rebecca Mercuri into the dangers of electronic voting provides a cautionary tale, for this perceived cure for election errors and interference may result in the potential for even greater fraud.

Thus computer and information security are elusive goals that professionals aim to attain through technological fixes such as encryption, firewalls, and restricted networking. Sometimes these efforts are undertaken because of actual attacks and interference, and sometimes they are applied to allay fear or provide users with a sense of security.

Basic Issues of National and Military Security

The second most common area in which questions of security play a prominent role is that of national and military security. During the Cold War (1945–1990) the primary national security issue was nuclear weapons, and spies were sent into countries to learn more about them. Attempts to enhance nuclear weapons security and safety involved both controlling scientific knowledge that might be of use to an enemy, especially by means of secrecy, and engaging scientists and engineers in the development of technologies thought to enhance national security, technologies that ranged from "fail-safe" command and control techniques to monitoring and surveillance devices. The demand for secrecy in some scientific research was nevertheless often argued to be a distortion of the scientific ideal, insofar as this ideal is committed to the production of shared knowledge. Indeed, some scientists argued that secrecy was actually counterproductive, and that greater security could be had through more openness in science.

As for spies, in the United States there were witch-hunts and other wide-ranging and over-reaching investigations by government that ruined the careers of innocent people and left many feeling insecure and vulnerable. The McCarthy hearings of the early 1950s involved telephone wiretaps and other intrusive acts used on innocent people.

With the end of the Cold War, the promotion of secrecy in science in the name of national security became less pronounced, but was sometimes replaced with the promotion of secrecy in science and technology in the name of corporate security and economic competitiveness. Then, with the advent of the so-called war on terrorism (2001–), needs for secrecy and control in science for national security reasons again became a prominent issue.

One specific example concerns biodefense and the boom in building high-security "hot labs" where the deadliest germs and potential bioterrorist weapons can be studied. Although the need for level 3 and level 4 biosafety labs and associated security measures are real, scientists such as David Ozonoff at the Boston University School of Public Health worry that there may be insufficient safeguards "to prevent work that violates the ethical standards of the scientific community" (Miller 2004). Stanley Falkow of Stanford University has even decided to destroy his own plague cultures rather than work under the new security regulations, pointing out the danger of security driving away talent (Miller 2004).

As these and other examples show, security needs will not abate, for they are deep in the human psyche and are built into the contract between people and their governments. Keeping security measures in balance with other values, such as freedom of speech and the pursuit of knowledge, poses a continuing challenge.

For more extensive discussion of this issue, see "A Difficult Decade: Continuing Freedom of Information Challenges for the United States and its Universities," available at http://www.murdoch.edu.au/elaw/issues/v10n4/woodbury104.html.

MARSHA C. WOODBURY

SEE ALSO *Aviation Regulatory Agencies; Biosecurity; Building Destruction and Collapse; Computer Ethics; Computer Viruses/Infections; Freedom; Hobbes, Thomas; Information Ethics; Police; Privacy; Telephone; Terrorism.*

BIBLIOGRAPHY

Miller, Judith. (2004). "New Biolabs Stir a Debate over Secrecy and Safety." *New York Times*, February 10.

Weinstein, Lauren, and Peter G. Neumann. (2001). "Risks of Panic" (Inside Risks column 137). *Communications of the ACM* 44(11): 152.

INTERNET RESOURCES

Mercuri, Rebecca. "Electronic Voting." Notable Software. Available from http://www.notablesoftware.com/evote.html.

Nissenbaum, Helen; Batya Friedman; and Edward Felten. "Computer Security: Competing Conceptions." Available from http://arxiv.org/html/cs.CY/0110001.

Woodbury, Marsha. "A Difficult Decade: Continuing Freedom of Information Challenges for the United States and its Universities." Available from http://www.murdoch.edu.au/elaw/issues/v10n4/woodbury104.html.

SELFISH GENES

Evolutionary biologists increasingly accept that genes are *selfish*. But what does this mean? Clearly genes do not have personal motivations, and even if they did, they could not achieve their designs without cooperation of the bodies in which they reside. In the most general sense, genes are merely blueprints, or, better, recipes, for the production of proteins. As such they influence the anatomy and physiology of living things including not only structural proteins but also enzymes and other factors that underlie the functioning of organisms. Genes ultimately affect the structure of kidneys, as well as the structure of nervous systems. Genes thus influence kidney function, just as they influence central nervous system function. When the central nervous system functions, behavior results. In this sense, genes are intimately connected to behavior, no less than they are to the physiology and structure of our internal organs.

Organisms are typically rather short-lived. Although they occupy the most obvious stage of the ecological and evolutionary theater, and natural selection appears to act on organisms whenever some reproduce differentially relative to others, the fact remains that natural selection among organisms is only important in the evolutionary sense insofar as it results in the disproportionate replication of some genes relative to others. Individual bodies themselves do not persist in evolutionary time; genes do. In fact genes are potentially immortal whereas bodies are not.

Selfish Genes and Modern Genetics

At the time of Charles Darwin (1809–1882), genetics was unknown, and so the focus of early evolutionary biology was on bodies. With the rise of Mendelian genetics and, subsequently, the field of population genetics, it became possible to trace the consequences of differential reproduction on their ultimate units, the genes themselves. Recognition of DNA as the genetic material, along with identification of its structure and the rise of modern genomic technology, has enhanced our understanding and also clarified the importance of focusing on these crucial units. When a hippo or a human being has a certain fitness, this means that his or her DNA is projected into the future with a given degree of success.

The term selfish, in relation to genes, is no more than a useful verbal short-hand. Selfishness simply refers to success in contributing to a particular gene's own replication. Natural selection rewards those genes that produce a *successful body* by causing more of the genes that influence the production of that body to be projected into the future. In this regard a successful body is one that metabolizes efficiently, that pumps blood successfully, that regulates its internal environment in a way conducive to life, and that also behaves in a manner that maximizes its success in reproducing, and/or in contributing to the reproduction of its component genes in the other major way available to it: by contributing to the success of genetic relatives, with the importance of each relative devalued in proportion as it is more distantly related (i.e., in direct proportion as a gene in a subject individual is likely to be present, by shared descent, in the body of another).

A key event in the development of selfish gene thinking was the recognition by British geneticist William Hamilton (1936–2000) that reproduction itself is only a special case of the more general phenomenon whereby genes contribute to their own replication. In a sexual species, reproduction occurs at some cost to the parent—in time, energy, risk—for which the sole evolutionary payoff is that each of the parent's genes has a 50 percent probability of being present in each offspring, and thereby are given a boost into succeeding generations. Hamilton observed that although reproduction is not normally considered selfish, in fact it is, at the level of genes. Moreover it is only because of the selfish payoff to the genes in question that reproduction is favored by natural selection in the first place!

Unlike the usual, negative implication of the word selfish, when applied to the attributes of genes, the term has no direct ethical implications. Living things are considered to behave in a manner that maximizes their *inclusive fitness*, which is simply the net effect of an act on identical genes present in other bodies. As a result selfish gene theory suggests that behavior that is selfish at the gene level typically involves actions that are *altruistic* at the level of bodies.

Hamilton effectively demonstrated that much seemingly altruistic behavior can be explained by this gene-centered perspective. Individual genes can promote their evolutionary success not only by helping produce offspring—new bodies within which some of these genes will reside—but also by contributing to the success of other individuals that have a probability of containing the genes in question. These other individuals are genetic relatives; indeed, a genetic relative is *defined* as an organism with an above-average probability of containing genes already present in a designated individual. For example, alarm-calling, whereby individuals who sense an approaching predator announce their discovery, that is directed preferentially toward genetic relatives. This can be selected for even if it reduces the likely survival of the alarm-caller so long as it increases the prospects that these relatives—and the alarm-calling genes within them—will survive and reproduce.

British biologist Richard Dawkins has been especially successful in explaining and popularizing this perspective, notably through his highly influential book, *The Selfish Gene* (1989). Dawkins argued that genes are essentially *replicators* whose biological role is to make additional copies of themselves. Those that succeeded in doing so went on to write the continuing history of life. Whereas early in evolutionary history replicators presumably floated freely in an *organic soup*, as natural selection continued, some discovered—quite by chance—that they were more successful by surrounding themselves with cell membranes and eventually, by aggregating together into multicellular bodies. Accordingly these bodies served, and still serve, as mere survival vehicles for the replicators.

This view is counter-intuitive because human beings subjectively experience themselves as the center of their own worlds, and therefore assume that their bodies—and not their genes—are equally the center of evolutionary concern. But bodies do not persist through evolutionary time. Although bodies can be selected for in the very short term, in that certain individuals are more reproductively successful than others, in the long term, these bodies are only vehicles for the differential success of their constituent genes, which replicate by virtue of the actions of the bodies in which they are enclosed.

Selfishness versus Altruism: A False Dichotomy

Critics of sociobiology and evolutionary psychology—both of which disciplines have been strongly influenced by the concept of selfish genes—often assume that this perspective implies that selfishness is more natural than altruism. The assumption has two significant flaws. First it suggests that identifying a trait as natural means that it is necessarily good, a view that was criticized by English philosopher David Hume (1711–1776), and, in the twentieth century, by philosopher George Edward Moore (1873–1958), who emphasized that *is* does not necessarily imply *ought*. Moore called this the *naturalistic fallacy*, and he argued that it is not philosophically or ethically defensible. Although many biologists—including Darwin—have maintained that morality is rooted in a natural moral sense, it is one thing to see morality as somehow deriving from one's biological heritage, quite another to validate behavioral tendencies simply because they are *natural*. It may be natural to respond violently to frustration, or in certain situations of competition, but is debatable whether in such cases, *naturalness* confers any ethical legitimacy.

Second, the suggestion that selfishness is somehow more natural than altruism ignores the crucial recognition that underlies all of selfish gene theory: the biological reality that genes cannot and do not behave in a vacuum, but only in the context of bodies. As such when a gene predisposes its body to behave selfishly (from the perspective of the gene), it often does so by inclining that *self* to act altruistically at the level of bodies. When parents provide food for their offspring, defend them against predators, or invest time and energy in their training, they may well be acting selfishly at the level of shared genes between parent and child, but altruistically insofar as individuals are behaving benevolently toward one another. Accordingly selfish genes need not behave selfishly!

The technology of cloning, stem cell research, and allied genomic sciences—including the identification of the human genome—has made considerations of human genes increasingly real. When developmental geneticists or evolutionary theorists speak of genes, they are increasingly able to speak authoritatively about specific DNA sequences, on identifiable chromosomes. It nonetheless does not seem likely that technology will permit the isolation of specific selfish or altruistic genes because selfish behavior does not exist as such, but rather, as a constituent of other characteristics and tendencies. For example, as discussed above, alarm-calling, which is a common textbook example of animal altruism, enhances the likely survival of others but at some increased risk to the alarm-caller. Alarm-calling need not be a result of generalized altruistic tendencies; rather it could derive from enhanced watchfulness due to anxiety, or even more acute eyesight, or a greater tendency to scan the surroundings for any number of reasons. Neither altruism nor selfishness per se, isolated as a generalized behavior trait, need be involved. The likelihood, therefore, is that advances in genetic technology will continue to elaborate genetic influences on behavior (just as they will with respect to proclivities for disease), without teasing out selfish genes as such. This, however, would not negate the scientific cogency of the concept, or even its genuine reality, because genes are selfish whenever they contribute to their own evolutionary success, without necessarily inducing their bodies to behave in an overtly self-aggrandizing manner.

Ethical Considerations Regarding Selfish Genes

Traditionally selfish behavior is considered unethical and its alternative, altruism, has been lauded as highly ethical. When biologists speak of selfish and altruistic behavior, they are simply defining these actions by their fitness consequences, and are not implying moral judgments. At the same time, one can speculate that the widespread, cross-cultural valuing of altruism and derogation of selfishness may itself derive from recognition that the living world inclines toward selfishness (at least at the level of genes) to a degree that may make exhortations to the contrary especially worthwhile.

Based on this cynics might point out that social and ethical systems may emphasize the desirability of altruism because of the payoff such behavior confers on others: Most people would be better off if others could be persuaded to be more altruistic, while they themselves remain comparatively selfish! Similarly biologists might point out that, as argued above, the boundaries between selfishness and altruism are unclear and often interpenetrating. Ethicists might emphasize that whereas evolutionary phenomena are crucially important to learn *about,* they are not suitable for learning *from*: Insofar as natural selection has produced human beings, along with other organisms, as the survival vehicles for selfish genes, the evolutionary process simply promotes whatever works. It is the responsibility of human beings to decide how they choose to assess such inclinations, and how, if at all, they elect to be influenced by that knowledge.

DAVID P. BARASH

SEE ALSO *Altruism; Dominance; Ethology; Sociobiology.*

BIBLIOGRAPHY

Alcock, John. (2001). *The Triumph of Sociobiology*. New York: Oxford University Press. An explanation of the scientific underpinnings as well as the successes of sociobiology and its selfish genes approach.

Barash, David P. (2001). *Revolutionary Biology: The New, Gene-Centered View of Life*. New Brunswick, NJ: Transaction Publishers. A nontechnical but scientifically accurate account of how a selfish genes perspectives helps illuminate human behavior in particular.

Dawkins, Richard D. (1989). *The Selfish Gene*. New York: Oxford University Press. A modern classic, which first brought the selfish genes perspective to popular attention.

De Waal, Frans B. M. (1996). *Good Natured*. Cambridge, MA: Harvard University Press. An account of various prosocial behaviors in nonhuman primates, showing that a selfish genes perspective is not incompatible with animal benevolence.

Hamilton, William D. (2002). *The Narrow Roads of Gene Land*. New York: Oxford University Press. A compilation of the important technical papers written by the founder of selfish gene thinking, with useful commentary.

Trivers, Robert L. (2003). *Natural Selection and Social Theory*. Cambridge, MA: Harvard University Press. A compilation of the important technical papers by one of the most original practitioners of selfish gene thinking, along with personal commentary.

Williams, George C. (1998). *The Pony Fish's Glow: And Other Clues to Plan and Purpose in Nature*. New York: Basic Books. An exceptionally lucid treatment of the benefits and limits of selfish gene thinking.

Wilson, Edward O. (1975). *Sociobiology: The New Synthesis*. Cambridge, MA: Harvard University Press. The now-classic summarization of sociobiology, which generated much of the controversy, and also brought together many important ideas, previously isolated.

SEMIOTICS

OVERVIEW

Semiotics (from the Greek root *sema* [sign]) proposes to be a science of signs and symbols and how they function in both linguistic (human and culture) and nonlinguistic (natural and artificial) systems of communication. In both instances the science has ethical dimensions. With regard to language and culture, some traditions of semiotics seek to expose what they argue are illegitimate uses of signs and symbols. With regard to nature and machines, questions arise about the legitimacy of conceiving interactions between noncultural phenomena in the same terms as cultural phenomena.

LANGUAGE AND CULTURE

Linguistic and cultural semiotics investigates sign systems and the modes of representation that humans use to convey feelings, thoughts, ideas, and ideologies. Semiotic analysis is rarely considered a field of study in its own right, but is used in a broad range of disciplines, including art, literature, anthropology, sociology, and the mass media. Semiotic analysis looks for the cultural and psychological patterns that underlie language, art, and other cultural expressions. Umberto Eco jokingly suggests that semiotics is a discipline for "studying everything which can be used in order to lie" (1976, p. 7). Whether used as a tool for representing phenomena or for interpreting it, the value of semiotic analysis becomes most pronounced in highly mediated, postmodern environments where encounters with manufactured reality shift humans' grounding senses of normalcy.

Historical Development

That human thought and communication function by means of signs is an idea that runs deep in Western tradition. Prodicus, one of the Greek Sophists of the fifth century B.C.E., founded his teachings on the practical idea that properly chosen words are fundamental to effective communication. Questioning this notion that words possess some universal, objective meaning, Plato (c. 428–347 B.C.E.) explored the arbitrary nature of the linguistic sign. He suggested a separateness between an object and the name that is used to signify that object: "Any name which you give, in my opinion, is the right one, and if you change that and give another, the new name is as correct as the old," (*Cratylus* [384d]). Aristotle (384–322 B.C.E.) recognized the instrumental nature of the linguistic sign, observing that human thought proceeds by the use of signs and that "spoken words are the symbols of mental experience" (*On Interpretation* [1, 16a3]). Six centuries later Augustine of Hippo (354–430 C.E.) elaborated on this instrumental role of signs in the process of human learning. For Augustine, language was the brick and mortar with which human beings construct knowledge. "All instruction is either about things or about signs; but things are learned by means of signs" (*On Christian Doctrine* 1.2).

Semiotic consciousness became well articulated in the Middle Ages, largely because of Roger Bacon (c. 1220–1292). In his extensive tract *De Signis* (c. 1267), Bacon distinguished natural signs (for example, smoke signifies fire) from those involving human communication (both verbal and nonverbal). Bacon introduced a triadic model that describes the relationship between a sign, its object of reference, and the human interpreter. This triad remains a fundamental concept in modern semiotics. John Poinsot (John of St. Thomas, 1589–1644) elaborated on the triad, laying down a fundamental science of signs in his *Tractatus de Signis* (1632). Poinsot observed that signs are relative beings whose existence consists solely in presenting to human awareness that which they themselves are not. It was the British philosopher John Locke (1632–1704) who finally bestowed a name on the study of signs. In his *Essay Concerning Human Understanding* (1690), Locke declared that *semiotike* or doctrine of signs should be one of the three major branches of science, along with natural philosophy and practical ethics.

Modern Semiotics

There are two major traditions in modern semiotic theory. One branch is grounded in a European tradition and was led by the Swiss-French linguist Ferdinand de Saussure (1857–1913). The other branch emerged out of American pragmatic philosophy through its primary founder, Charles Sanders Peirce (1839–1914). Saussure sought to explain how all elements of a language are taken as components of a larger system of language in use. This led to a formal discipline that he called *semiology*. Peirce's interest in logical reasoning led him to investigate different categories of signs and the manner by which humans extract meaning from them. Independently, Saussure and Peirce worked to better understand the triadic relationship.

Saussure laid the foundation for the structuralist school in linguistics and social theory. A structuralist looks at the units of a system and the rules of logic that are applied to the system, without regard to any specific content. The units of human language comprise a limited set of sounds called phonemes, and these comprise an unlimited set of words and sentences, which are put together according to a set of simple rules called grammar. From simple units humans derive more complex units that are applied to new rules to form more complex structures (such as themes, characters, stories, genres, and style). The human mind organizes this structure into cognitive understanding.

The smallest unit of analysis in Saussure's semiology is the *sign*, made up of a *signifier* or sensory pattern, and a *signified*, the concept that is elicited in the mind by the signifier. Saussure emphasized that the signifier does not constitute a sign until it is interpreted. Like Plato, Saussure recognized the arbitrary association between a word and what it stands for. Word selection becomes a matter, not of identity, but of difference. Differences carry signification. A sign *is* what all other signs *are not* (Saussure 1959).

Peirce shared the Saussurian observation that most signs are *symbolic* and arbitrary, but he called attention to *iconic* signs that physically resemble their referent and *indexical* signs that possess a logical connection to their referent (Peirce 1955 [1898]). To Peirce, the relationship of the sign to the object is made in the mind of the interpreter as a mental tool that Peirce called the *interpretant*. As Peirce describes it, *semiosis* (the process of sign interpretation) is an iterative process involving multiple inferences. The signifier elicits in the mind an interpretant that is not the final signified object, but a mediating thought that promotes understanding. In other words, a thought is a sign requiring interpretation by a subsequent thought in order to achieve meaning. This mediating thought might be a schema, a mental model, or a recollection of prior experience that enables the subject to move forward toward understanding. The interpretant itself becomes a sign that can elicit yet another interpretant, leading the way toward an infinite series of *unlimited semioses* (Eco 1979). By this analysis, Peirce shifts the focus of semiotics from a relational view of signs and the objects they represent to an understanding of semiosis as an iterative, mediational process.

Charles Morris (1901–1979) was a semiotician who adapted Peirce's work to a form of behaviorism. For Morris, semiotics involves "goal-seeking behavior in which signs exercise control" (Morris 1971 [1938], p. 85). Morris identified four aspects within the process of semiosis:

(1) the sign vehicle that orients a person toward a goal;

(2) the interpreter, or the subject of the semiotic activity;

(3) the designatium, or the object to which the sign refers;

(4) the interpretant, which is the cognitive reaction elicited in the mind of the interpreter.

Morris attempted to subdivide the field of semiotics into three subfields. *Semantics* studies the affiliations between the world of signs and the world of things. *Syntactics* observes how signs relate to other signs. *Pragmatics* explains the effects of signs on human behavior (Morris 1971).

Russian Influences

Saussure's abstraction of language as a self-contained system of signs became the target of criticism by those who saw language as a socially constituted fabric of human interchange. Language is highly contextual and humans acquire language by assimilating the voices of those around them. Language is not a fixed system but it changes as it is used through interaction with peers in modes of discourse. This philosophy, known as *dialogics*, was the outgrowth of intellectual development in Soviet Russia by a group whose work centered on the writings of Mikhail Bakhtin (1895–1975). The Bakhtin Circle, which included among its members Valantine Voloshinov (1895–1936), addressed the social and cultural issues posed by the Russian Revolution and its degeneration into the Stalin dictatorship. The group dissolved in 1929 after members faced political arrest. Bakhtin himself was not a pure semiotician, but he engaged with others, most notably Voloshinov, in the investigation of how language and understanding emerges in the process of dialogue.

Voloshinov argued that all utterances have an inherently dialogic character. According to Voloshinov, dialogue is the fundamental feature of speech. In his view, signs have no independent existence outside of social practice. Signs are seen as components of human activity, and it is within human activity that signs take on their form and meaning (Voloshinov 1986).

Another Russian, Lev Semenovich Vygotsky (1896–1934), applied the instrumental notion of semiotics toward cognition and learning (the relationship suggested much earlier by Aristotle and Augustine). Vygotsky identified the pivotal role language plays during the exercise of complex mental functions. In *Mind in Society* (1978 [1930]), Vygotsky observes how planning abilities in children are developed through linguistic mediation of action. "[The child] plans how to solve the problem through speech and then carries out the prepared solution through overt activity" (p. 28). He observed the similarity between physical tools and verbal artifacts as instruments of human activity. From his extensive and detailed observations of child development, Vygotsky concluded that higher-order thinking transpires by means of what he called "inner speech," the internalized use of linguistic signs (Vygotsky 1986).

Rhetorical Techniques and Ethical Implications

Roland Barthes (1915–1980) is probably the most significant semiologist to assume the mantle of Saussure. Barthes developed a sophisticated structuralist analysis to deconstruct the excessive rhetorical maneuvers within popular culture that engulfed Europe after World War II. Anything was fair game for Barthes's structuralist critique including literature, media, art, photography, architecture, and even fashion. Barthes's most influential work, *Mythologies* (1972 [1957]) continues to have an influence on critical theory in the early twenty-first century.

Myths are signs that carry with them larger cultural meanings. In *Mythologies*, Barthes describes myth as a well-formed, sophisticated system of communication that serves the ideological aims of a dominant class. Barthes conceived of myth as a socially constructed reality that is passed off as natural. Myth is a mode of signification in which the signifier is stripped of its history, and the form is stripped of its substance and then adorned with a substance that is artificial but appears entirely natural. Through mythologies, deeply partisan meanings are made to seem well established and self-evident. The role of the mythologist is to identify the artificiality of those signs that disguise their historical and social origins.

Barthes was critical of journalistic excesses that justified the French Algerian War (1954–1962). Skillfully, he deconstructed French journalism that had perfected the art of taking sides while pretending airs of neutrality, claiming to express the voice of common sense. Barthes observes that the myth is more understandable and more believable than the story that it supplants because the myth introduces self-evident truths that conform to the dominant historical and cultural position. This naturalization lends power to such myths. They go without saying. They need no further explanation or demystification.

American journalism is no less rich with its own mythical contributions to journalistic history. Examples include the Alamo (1835–1836), the sinkings of the *Maine* (1898) and the *Lusitania* (1915), the Gulf of Tonkin incident (1964), and Iraqi weapons of mass destruction (2003). In each case, the respective signifier was stripped of its own history and replaced with a more "natural" and believable narrative. These examples underscore the ethical implications of mythologies, because each was specifically instrumental in recruiting popular support behind an offensive war by making it appear to be a defensive war.

Mythologies are not limited to the realms of journalism, advertising, and the cinema, but find their way into all aspects of modern society. Science is no exception. The science educator Jay L. Lemke (1990) speaks of a "special mystique of science, a set of harmful myths that favor the interests of a small elite" (p. 129). Lemke believes that airs of objectivity and certainty in scientific discourse lend themselves to an authoritarian culture that serves to undermine student confidence. He describes linguistic practices that place artificial barriers between the pedagogy of science and common experience. He asserts that "a belief in the objectivity and certainty of science is very useful to anyone in power who wants to use science as a justification for imposing the policy decisions they favor. Science is presented as *authoritative*, and from there it is a small step to its becoming authoritarian" (Lemke 1990, p. 31).

George Lakoff and Mark Johnson (1980) describe a "myth of *objectivism*" in science writing that portrays a world of objects possessing inherent properties and fixed relations that are entirely independent of human experience. Objectivist writing emerged in the seventeenth century and now assumes the dominant position in modern discourses of science, law, government, business, and scholarship. Postmodern critics point to objectivism's failure to account for human thoughts, experience, and language, which are largely metaphorical. Metaphors are pervasive and generally unrecognized within a culture of positivism. Highlighting the use of metaphors is a useful key to identifying whose realities are actually privileged in academic writing (Chandler 2002).

Barthes's role as France's supreme social critic has been taken over by the French cultural theorist Jean Baudrillard (b. 1929). Baudrillard argues that postmodern culture, with its rich, exotic media, is a world of signs that have made a fundamental break from reality. Contemporary mass culture experiences a world of *simulation* having lost the capacity to comprehend an unmediated world. Baudrillard coined the term *simulacra* to describe a system of objects in a consumer society distinguished by the existence of multiple copies with no original. People experience manufactured realities—carefully edited war footage, meaningless acts of terrorism, and the destruction of cultural values.

In an age of corporate consolidation in which popular culture is influenced by an elite few with very powerful voices, semiotic analysis is deemed essential for information consumers. Semiotics informs consumers about a text, its underlying assumptions, and its various dimensions of interpretation. Semiotics offers a lens into human communication. It sharpens the consumer's own consciousness surrounding a given text. It informs consumers about the cultural structures and human motivations that underlie perceptual representations. It rejects the possibility that humans can represent the world in a neutral fashion. It unmasks the deep-seated rhetorical forms and underlying codes that fundamentally shape human realities. Semiotic analysis is a critical skill for media literacy in a postmodern world.

MARTIN RYDER

SEE ALSO *Peirce, Charles Sanders; Postmodernism; Rhetoric of Science and Technology.*

BIBLIOGRAPHY

Barthes, Roland. (1972). *Mythologies*, trans. Annette Lavers. New York: Hill and Wang. Originally published 1957. Fifty-four short critical reflections on mass culture in France during early 1950s. A classic work using semiotics to reveal the practices and artifacts of society as signifiers of the surface meanings and deep structures of contemporary life.

Baudrillard, Jean. (1988). *Selected Writings*, ed. Mark Poster. Stanford, CA: Stanford University Press. Provocative and controversial, Baudrillard describes a culture of people disenfranchised by the impotency of politics, media, and the consumer society.

Chandler, Daniel. (2002). *Semiotics: The Basics*. London: Routledge. A comprehensive introduction to semiotic theory for students of popular culture and mass communications.

Eco, Umberto. (1976). *A Theory of Semiotics*. Bloomington: Indiana University Press. In this classic text, Eco offers a theory of sign production that centers on the process of interpretation and the relationship between sign vehicles and the reality they portray. Eco's constructivist philosophy places the interpreter of signs on equal footing with the sign producer in the process of meaning construction.

Eco, Umberto. (1979). *The Role of the Reader: Explorations in the Semiotics of Texts*. Bloomington: Indiana University Press. Nine essays that explore the differences between "open" and "closed" texts, those that hold the reader at bay and those that actively engage the reader in the co-production of meaning.

Lakoff, George, and Mark Johnson. (1980). *Metaphors We Live By*. Chicago: University of Chicago Press. Linguist George Lakoff and philosopher Mark Johnson argue that metaphor is central to language and understanding.

Lemke, Jay L. (1990). *Talking Science: Language, Learning, and Values*. Norwood, NJ: Ablex Publishing. Lemke portrays science as language, suggesting that to learn science, one must learn the language of science; and to learn the language, one must engage with others in active dialog about science.

Morris, Charles. (1971 [1938]). *Foundations of the Theory of Signs*. Chicago: University of Chicago Press. This classic monograph proposed three divisions of semiotic theory: syntactics, semantics, and pragmatics.

Peirce, Charles Sanders. (1955). "Logic as Semiotic: The Theory of Signs." In *Philosophical Writings of Peirce*, ed. Justus Buchler. New York: Dover. Essay originally published in 1898. Considered the founder of pragmatism, Peirce introduced a logical model which he termed "abduction", the iterative process of formulating inferences through the interpretation of signs and testing those inferences with other signs as a means of advancing an investigative inquiry.

Saussure, Ferdinand de. (1959). *Course in General Linguistics*, ed. Charles Bally and Albert Sechehaye; trans. Wade Baskin. New York: Philosophical Library. Originally published 1916. This is a summary of Saussure's lectures at the University of Geneva from 1906 to 1911. In this seminal work, Saussure examines the relationship between speech and the development of language as a structured system of signs.

Voloshinov, V. N. (1986). *Marxism and the Philosophy of Language*, trans. Ladislav Matejka and I. R. Titunik. Cambridge, MA: Harvard University Press. Originally published 1929. Good introduction to the ideas of the Bakhtin Circle. In a series of articles written between 1926 and 1930, Voloshinov emphasizes the social essence of language and he tracks the development of ideology and consciousness at the level of discursive practice.

Vygotsky, L. S. (1978). *Mind in Society*, ed. Michael Cole, Vera John-Steiner, Sylvia Scribner, and Ellen Souberman. Cambridge, MA: Harvard University Press. Originally published 1930. A pioneer in developmental psychology, Vygotsky argued that language is central to learning, and that the workings of the human mind can best be explained in terms of its linguistic and cultural tools.

Vygotsky, L. S. (1986). "The Genetic Roots of Thought and Speech." In *Thought and Language*, trans. and ed. Alex Kozulin. Cambridge, MA: MIT Press. Russian edition originally published 1934, then translated in 1962 to become a classic foundational work in cognitive science. Vygotsky analyzed the role of speech in the development of human consciousness, and the relationship of language to complex thinking in humans.

NATURE AND MACHINE

Semiotics (from the Greek word for sign) is the doctrine and science of signs and their use. It is thus a more comprehensive system than language itself and can therefore be used to understand language in relation to other forms of communication and interpretation such as nonverbal forms. One can trace the development of semiotics starting with its origins in the classical Greek period (from medical symptomatology), through subsequent developments during the Middle Ages (Deely 2001), and up to John Locke's introduction of the term in the seventeenth century. But contemporary semiotics has its real foundations in the nineteenth century with Charles Sanders Peirce (1839–1914) and Ferdinand de Saussure (1857–1913), who, working independently of each other, developed slightly different conceptions of the sign. The development of semiotics as a broad field is nevertheless mostly based on Peirce's framework, which is therefore adopted here.

Ever since Umberto Eco (1976) formulated the problem of the "semiotic threshold" to try to keep semiotics within the cultural sciences, semiotics—especially Peircian semiotics—has developed further into the realm of biology, crossing threshold after threshold into the sciences. Although semiotics emerged in efforts to scientifically investigate how signs function in culture, the twentieth century witnessed efforts to extend semiotic theory into the noncultural realm, primarily in relation to living systems and computers. Because Peirce's semiotics is the only one that deals systematically with nonintentional signs of the body and of nature at large, it has become the main source for semiotic theories of the similarities and differences among signs of inorganic nature, signs of living systems, signs of machines (especially computer semiotics, see Andersen 1990), and the cultural and linguistic signs of humans living together in a society that emphasizes the search for information and knowledge. Resulting developments have then been deployed to change the scope of semiotics from strictly cultural communication to a biosemiotics that encompasses the cognition and communication of all living systems from the inside of cells to the entire biosphere, and a cybersemiotics that in addition includes a theory of information systems.

Biosemiotics and Its Controversies

Semiotics is a transdisciplinary doctrine that studies how signs in general—including codes, media, and language, plus the sign systems used in parallel with language—work to produce interpretation and meaning in human and in nonhuman living systems as prelinguistic communication systems. In the founding semiotic tradition of Peirce, a *sign* is anything that stands for something or somebody in some respect or context.

Taking this further, a sign, or *representamen,* is a medium for communication of a form in a triadic (three-way) relation. The representamen refers (passively) to its object, which determines it, and to its *interpretant,* which it determines, without being itself affected. The interpretant is the interpretation in the form of a more developed sign in the mind of the interpreting and receiving mind or quasi mind. The representamen could be, for example, a moving hand that refers to an object for an interpretant; the interpretation in a person's mind materializes as the more developed sign "waving," which is a cultural convention and therefore a symbol.

All kinds of alphabets are composed of signs. Signs are mostly imbedded in a sign system based on codes, after the manner of alphabets of natural and artificial languages or of ritualized animal behaviors, where fixed action patterns such as feeding the young in gulls take on a sign character when used in the mating game.

Inspired by the work of Margaret Mead, Thomas A. Sebeok extended this last aspect to cover all animal species–specific communication systems and their signifying behaviors under the term *zoösemiotics* (Sebeok 1972). Later Sebeok concluded that zoösemiotics rests on a more comprehensive *biosemiotics* (Sebeok and Umiker-Sebeok 1992). This global conception of semiotics equates life with sign interpretation and mediation, so that semiotics encompasses all living systems including plants (Krampen 1981), bacteria, and cells in the human body (called *endosemiotics* by Uexküll, Geigges, and Herrmann 1993). Although biosemiotics has been pursued since the early 1960s, it remains controversial because many linguistic and cultural semioticians see it as requiring an illegitimate broadening of the concept of code.

A code is a set of transformation rules that convert messages from one form of representation to another. Obvious examples can be found in Morse code and cryptography. Broadly speaking, code thus includes everything of a more systematic nature (rules) that source and receiver must know a priori about a sign for it to correlate processes and structures between two different areas. This is because codes, in contrast to universal laws, work only in specific contexts, and interpretation is based on more or less conventional rules, whether cultural or (by extension) biological.

Exemplifying a biological code is DNA. In the protein production system—which includes the genome in a cell nucleus, the RNA molecules going in and out of the nucleus, and the ribosomes outside the nucleus membrane—triplet base pairs in the DNA have been translated to a messenger RNA molecule, which is then read by the ribosome as a code for amino acids to string together in a specific sequence to make a specific protein. The context is that all the parts have to be brought together in a proper space, temperature, and acidity combined with the right enzymes for the code to work. Naturally this only happens in cells. Sebeok writes of the genetic code as well as of the metabolic, neural, and verbal codes. Living systems are self-organized not only on the basis of natural laws but also using codes developed in the course of evolution. In an overall code there may also exist subcodes grouped in a hierarchy. To view something as encoded is to interpret it as-*sign*-ment (Sebeok 1992).

A symbol is a conventionally and arbitrary defined sign, usually seen as created in language and culture. In common languages it can be a word, but gestures, objects such as flags and presidents, and specific events such as a soccer match can be symbols (for example, of national pride). Biosemioticians claim the concept of symbol extends beyond cultures, because some animals have signs that are "shifters." That is, the meaning of these signs changes with situations, as for instance the head tossing of the herring gull occurs both as a precoital display and when the female is begging for food. Such a transdisciplinary broadening of the concept of a symbol is a challenge for linguists and semioticians working only with human language and culture.

To see how this challenge may be developed, consider seven different examples of signs. A sign stands for something for somebody:

(1) as the word *blue* stands for a certain range of color, but also has come to stand for an emotional state;

(2) as the flag stands for the nation;

(3) as a shaken fist can indicate anger;

(4) as red spots on the skin can be a symptom for German measles;

(5) as the wagging of a dog's tail can be a sign of friendliness for both dogs and humans;

(6) as pheromones can signal heat to the other sex of the species;

(7) as the hormone oxytocin from the pituitary can cause cells in lactating glands of the breast to release the milk.

Linguistic and cultural semioticians in the tradition of Saussure would usually not accept examples 3 to 6 as genuine signs, because they are not self-consciously intentional human acts. But those working in the tradition of Peirce also accept nonconscious intentional signs in humans (3) and between animals (5 and 6) as well as between animals and humans (4), nonintentional signs (4), and signs between organs and cells in the body (7). This last example even takes special form in *immunosemiotics*, which deals with the immunological code, immunological memory, and recognition.

There has been a well-known debate about the concepts of primary and secondary modeling systems (see for example Sebeok and Danesi 2000) in linguistics that has now been changed by biosemiotics. Originally language was seen as the primary modeling system, whereas culture comprised a secondary one. But through biosemiotics Sebeok has argued that there exists a zoösemiotic system, which has to be called primary, as the foundation of human language. From this perspective language thus becomes the secondary and culture tertiary.

Cybersemiotics and Ethics

In the formulation of a transdisciplinary theory of signification and communication in nature, humans, machines, and animals, semiotics is in competition with the information processing paradigm of cognitive science (Gardner 1985) used in computer informatics and psychology (Lindsay and Norman 1977, Fodor 2000), and library and information science (Vickery and Vickery 2004), and worked out in a general renewal of the materialistic evolutionary worldview (for example, Stonier 1997). Søren Brier (1996a, 1996b) has criticized the information processing paradigm and second-order cybernetics, including Niklas Luhmann's communication theory (1995), for not being able to produce a foundational theory of signification and meaning. Thus it is found necessary to add biosemiotics ability to encompass both nature and machine to make a theory of signification, cognition and communication that encompass the sciences, technology as well as the humanities aspect of communication and interpretation.

Life can be understood from a chemical point of view as an autocatalytic, autonomous, autopoietic system, but this does not explain how the individual biological self and awareness appear in the nervous system. In the living system, hormones and transmitters do not function only on a physical causal basis. Not even the chemical pattern fitting formal causation is enough to explain how sign molecules function, because their effect is temporally and individually contextualized. They function also on a basis of final causation to support the survival of the self-organized biological self. As Sebeok (1992) points out, the mutual coding of sign molecules from the nervous, hormone, and immune systems is an important part of the self-organizing of a biological self, which again is in constant recursive interaction with its perceived environment *Umwelt* (Uexkull 1993). This produces a view of nerve cell communication based on a Peircian worldview binding the physical efficient causation described through the concept of energy with the chemical formal causation described through the concept of information—and the final causations in biological systems being described through the concept of semiosis (Brier 2003).

From a cybersemiotic perspective, the *bit* (or basic difference) of information science becomes a sign only when it makes a difference for someone (Bateson 1972). For Pierce, a sign is something standing for something else for someone in a context. Information bits are at most pre- or quasi signs and insofar as they are involved with codes function only like keys in a lock. Information bits in a computer do not depend for their functioning on living systems with final causation to interpret them. They function simply on the basis of formal causation, as interactions dependent on differences and patterns. But when people see information bits as encoding for language in a word processing program, then the bits become signs for them.

To attempt to understand human beings—their communication and attempts through interpretation to make meaning of the world—from frameworks that at their foundation are unable to fathom basic human features such as consciousness, free will, meaning, interpretation, and understanding is unethical. To do so tries to explain away basic human conditions of existence and thereby reduce or even destroy what one is attempting to explain. Humans are not to be fitted and disciplined to work well with computers and information systems. It is the other way round. These systems must be developed with respect for the depth, multidimensional, and contextualizing abilities of human perception, language communication, and interpretation.

Behaviorism, different forms of eliminative materialism, information science, and cognitive science all attempt to explain human communication from outside, without respecting the phenomenological and hermeneutical aspects of existence. Something important about human nature is missing in these systems and the technologies developed on their basis (Fodor 2000). It is unethical to understand human communication only in the light of the computer. Terry Winograd and Fernando Flores (1987), among others, have argued for a more comprehensive framework.

But it is also unethical not to contemplate the material constraints and laws of human existence, as occurs in so many purely humanistic approaches to human cognition, communication, and signification. Life, as human embodiment, is fundamental to the understanding of human understanding, and thereby to ecological and evolutionary perspectives, including cosmology. John Deely (1990), Claus Emmeche (1998), Jesper Hoffmeyer (1996), and Brier (2003) all work with these perspectives in the new view of semiotics inspired by Peirce and Sebeok. Peircian semiotics in its contemporary biosemiotic and cybersemiotic forms is part of an ethical quest for a transdisciplinary framework for understanding humans in nature as well as in culture, in matter as well as in mind.

SØREN BRIER

SEE ALSO *Peirce, Charles Sanders.*

BIBLIOGRAPHY

Andersen, P. B. (1990). *A Theory of Computer Semiotics: Semiotic Approaches to Construction and Assessment of Computer Systems*. Cambridge, UK: Cambridge University Press.

Bateson, Gregory. (1972). *Steps to an Ecology of Mind: Collected Essays in Anthropology, Psychiatry, Evolution, and Epistemology*. San Francisco: Chandler Publishing. Based on Norbert Wiener's classical cybernetics, a foundational work that develops the view toward second-order cybernetics and semiotics.

Brier, Søren. (1996a). "Cybersemiotics: A New Interdisciplinary Development Applied to the Problems of Knowledge Organisation and Document Retrieval in Information Science." *Journal of Documentation* 52(3): 296–344.

Brier, Søren. (1996b). "From Second Order Cybernetics to Cybersemiotics: A Semiotic Re-entry into the Second-Order Cybernetics of Heinz von Foerster." *Systems Research* 13(3): 229–244. Part of a Festschrift for von Foerster.

Brier, Søren. (2003). "The Cybersemiotic Model of Communication: An Evolutionary View on the Threshold between Semiosis and Informational Exchange." *TripleC* 1(1): 71–94. Also available from http://triplec.uti.at/articles.php.

Deely, John. (1990). *Basics of Semiotics*. Bloomington: Indiana University Press.

Deely, John. (2001). *Four Ages of Understanding: The First Postmodern Survey of Philosophy from Ancient Times to the Turn of the Twenty-First Century*. Toronto: University of Toronto Press. Integrates semiotics as a central theme in the development of philosophy, thereby providing a profoundly different view of the history of philosophy.

Eco, Umberto. (1976). *A Theory of Semiotics*. Bloomington: Indiana University Press. Foundational interdisciplinary work of modern semiotics.

Emmeche, Claus. (1998). "Defining Life as a Semiotic Phenomenon." *Cybernetics and Human Knowing* 5(1): 3–17.

Fodor, Jerry. (2000). *The Mind Doesn't Work That Way: The Scope and Limits of Computational Psychology*. Cambridge, MA: MIT Press.

Gardner, Howard. (1985). *The Mind's New Science: A History of the Cognitive Revolution*. New York: Basic.

Hoffmeyer, Jesper. (1996). *Signs of Meaning in the Universe*, trans. Barbara J. Haveland. Bloomington: Indiana University Press. The first and foundational book of modern biosemiotics.

Krampen, Martin. (1981). "Phytosemiotics." *Semiotica* 36(3/4): 187–209.

Lindsay, Peter, and Donald A. Norman. (1977). *Human Information Processing: An Introduction to Psychology*, 2nd edition. New York: Academic Press.

Luhmann, Niklas. (1995). *Social Systems*, trans. John Bednarz Jr. and Dirk Baecker. Stanford, CA: Stanford University Press.

Sebeok, Thomas A. (1972). *Perspectives in Zoosemiotics*. The Hague, Netherlands: Mouton.

Sebeok, Thomas A. (1992). "'Tell Me, Where Is Fancy Bred?' The Biosemiotic Self." In *Biosemiotics: The Semiotic Web, 1991*, ed. Thomas A. Sebeok and Jean Umiker-Sebeok. Berlin: Mouton de Gruyter.

Sebeok, Thomas A., ed. (1994). *Encyclopedic Dictionary of Semiotics*, 2nd edition. 3 vols. Berlin: Mouton de Gruyter. One of the most comprehensive and authoritative works on all aspects of semiotics.

Sebeok, Thomas A., and Marcel Danesi. (2000). *The Forms of Meaning: Modeling Systems Theory and Semiotic Analysis*. Berlin: Mouton de Gruyter.

Sebeok, Thomas A., and Jean Umiker-Sebeok, eds. (1992). *Biosemiotics: The Semiotic Web, 1991*. Berlin: Mouton de Gruyter.

Stonier, Tom. (1997). *Information and Meaning: An Evolutionary Perspective*. Berlin: Springer-Verlag. An important extension of the information processing paradigm, showing its greatness and limitations.

Uexküll, Thure von; Werner Geigges; and Jörg M. Herrmann. (1993). "Endosemiosis." *Semiotica* 96(1/2): 5–51.

Vickery, Brian C., and Alina Vickery. (2004). *Information Science in Theory and Practice*, 3rd edition. Munich: Saur. A comprehensive and important presentation, conceptualization, and use of the information processing paradigm in library and information science.

Winograd, Terry, and Fernando Flores. (1987). *Understanding Computers and Cognition: A New Foundation for Design*. Reading, MA: Addison-Wesley.

SENSITIVITY ANALYSES

Technically, a sensitivity analysis is a calculation or estimation, quantitative or not, in which all variables except one are held constant. This allows for a clear understanding of the effects of changes in that variable on the outcomes of the calculation or estimation. The methodologies of sensitivity analysis are well established in some areas of research, particularly those that employ methods of risk assessment and computer modeling (Satelli, Chan, and Scott 2000). However, the concept of sensitivity analysis has considerable potential for policy research, especially for understanding the role of different types of knowledge as factors contributing to particular value or ethical outcomes related to scientific research or technological change.

Potential use in Policy Making: Some Examples

In the context of research intended to support policy making a sensitivity analysis can help identify and frame the dimensions of a problem and thus clarify the potential efficacy of possible interventions. Consider a hypothetical example. There is a city in a desert that continually faces stress on its water resources. City officials invariably face finite time and budgets but have to make decisions about the community's water use. It is likely that they will hear from advocates proposing the development of new water projects such as dams and reservoirs as well as advocates who call for a reduction in water use in the community. Inevitably a question will arise: To what degree should the city consider limiting the use of water, for example, through conservation, versus increasing supply, for example, by building a new dam?

A sensitivity analysis can help policy makers understand the source of stresses on the community's water resources. Specifically, does stress result primarily from a growing population or from limited storage of water? From drought and climate? From a combination? If so, to what degree? The following idealized example shows how a sensitivity analysis might be organized in this case.

(1) A valued outcome is identified. In this instance the variable is water availability as measured by reservoir storage. Of course, other valued outcomes might be selected, and other measures might be selected.

(2) The existing literature is surveyed to assess the range of factors expected to influence the valued outcome over a period of time that is relevant to the decision context. For water resources the period of concern might be the upcoming decade. The two factors identified to be the most important influences affecting water availability might be rainfall and municipal water usage.

(3) With the two factors identified, the next step is to return to the literature to identify the distribution of views on the effects of rainfall and water use on water availability. The goal here is to identify the range of perspectives on the independent influence of (a) rainfall and (b) municipal water use on water availability.

(4) With a quantitative understanding of 3(a) and 3(b), it will be possible to compare the sensitivity of water availability to each of the two factors, with possible implications for decision making.

For example, if a sensitivity analysis showed that water use was expected to grow faster than variations in existing storage related to climate, policy makers might consider managing water use. Similarly, if a sensitivity analysis showed that reservoir storage was largely insensitive to accumulated rainfall, perhaps because there was far more rainfall than storage capacity, policy makers might consider building new reservoirs. A sensitivity analysis cannot determine what means and ends are worth pursuing, but it can shed some light on the connection of different means and ends.

The point of a sensitivity analysis is to identify factors that may be influenced by decision making in order to make desired outcomes more likely than undesired outcomes. Because the process of framing a problem (for example, using too much water versus not having enough water) necessarily implies some valued outcomes, a sensitivity analysis can help make those values explicit and demonstrate the prospects that different policy interventions might lead to desired outcomes.

More generally, in light of the multicausal nature of most phenomena that are of interest to policy makers (for instance, all the factors implicated in the supply of and demand for water in a large urban setting) and the large uncertainties typically associated with efforts to quantify the relationships between a particular cause (such as the challenges associated with projecting water supply over a period of decades) and an impact (for example, the difficulties of understanding who will be affected the most by water shortages and oversupply decades in the future), one obvious approach to guiding policy decisions is to look for areas of relative strength in relationships between causes and impacts and focus research to support decision making in those areas.

In a somewhat less idealized example Pielke et al. (2000) show that in light of scientific understanding as reported by the Intergovernmental Panel on Climate Change, demographic and socioeconomic change will be twenty to sixty times more important than climate change in contributing to economic losses related to tropical cyclones over the next fifty years. This sensitivity analysis suggests that (1) even if all losses resulting from climate change were prevented, the overall benefit would be dwarfed by increasing losses caused by the growth of populations and economies, and (2) research priorities relevant to the tropical cyclone threat could reflect those relationships by focusing on issues of preparation, planning, infrastructure, development, and resilience. The order-of-magnitude difference between these two sources of tropical cyclone impacts strongly suggests that more research on the sensitivity of tropical cyclones to climate changes is not likely to change the implications for decision making.

In another example one might consider the changing incidence and impacts of tropical diseases such as malaria to understand how predictions of the influence of climate change compare with other causal factors, such as growth in resistance to antibiotics, changes in health-care delivery systems, migration and growth of populations, and annual-to-interannual climate variability.

Goals of Sensitivity Analyses

The goal is not to predict but to provide information about the relative sensitivity of impacts to various causal factors. That information can enhance the bases for effective decision making in the context of values and ethics as well as decisions about science priorities intended to support the generation of knowledge useful in pursuing desired outcomes without additional reduction in or characterization of scientific uncertainty.

In a policy setting sensitivity analysis does not attempt to resolve scientific disputes about causes of societal impacts but to compare and assess existing quantified predictions and observations of the multiple causes of such impacts to identify strong causal links. As the examples of water resources and tropical cyclones show, a sensitivity analysis approach can lessen the perceived need for reduction of uncertainty about future behavior as a prerequisite for decision making and point toward research avenues that can provide knowledge that can be useful in addressing high-priority sources of environmental change and societal vulnerability. Thus, sensitivity analysis can be an important tool for science policy decision makers in their attempt to enhance the societal value of their portfolios.

ROGER A. PIELKE, JR.

SEE ALSO *Science Policy.*

BIBLIOGRAPHY

Pielke, Roger A., Jr., Roberta A. Klein; and Daniel Sarewitz. (2000). "Turning the Big Knob: Energy Policy as a Means to Reduce Weather Impacts." *Energy and Environment* 11(3): 255–276.

Satelli, Andrea; Karen Chan; and E. Marian Scott, eds. (2000). *Sensitivity Analysis.* New York: Wiley. Focuses on the methodologies of sensitivity analysis and with emphasis on computer models. Written for a reader with a high level of expertise.

Saltelli, Andrea; Stefano Tarantola; Francesca Campolongo; and Marco Ratto. (2004). *Sensitivity Analysis in Practice: A Guide to Assessing Scientific Models.* New York: Wiley. Targeted at the non-expert, this book discusses the selection of sensitivity analysis methods and their applications.

SEX AND GENDER

Questions about the degree to which concepts of sex and gender influence science and engineering or are appropriate subjects for scientific research and technological manipulation are fundamental ethical issues. This entry discusses those issues and describes the genesis of the development of sex and gender discussions related to science and technology. The focus then shifts to the role of sex and gender in scientific knowledge and issues of inequity and their implications.

Historical Background

Gayle Rubin (1975) described the sex and gender system, distinguishing the biology of sex from the cultural and social construction of gender and revealing the male-centered social processes and practices that constrain and control women's lives. Rubin extended the implications of *The Second Sex* by Simone de Beauvoir (1947), who initiated the intellectual, theoretical foundations for the second wave of the women's movement, which itself built on the nineteenth-century first wave and took an activist turn in the United States in the context of protests and the civil rights movement of the 1960s. De Beauvoir provided the philosophical basis for existentialist feminism by suggesting that women's "otherness" and the social construction of gender rest on a social interpretation of biological differences (sex).

Rubin articulated the connection between biological sex and the social construction of masculinity and femininity that resulted in superiority being attached to what was labeled masculine and discrimination against what was defined as feminine across various societies. Although the definition of the tasks, roles, and behaviors that were considered masculine or feminine varied among societies, the lower status ascribed to the feminine and to femininity remained consistent. Rubin's articulation of the operation of the sex/gender system in a variety of contexts within a society and across societies provoked ethical questions about unequal treatment based on sex/gender in all arenas, including science and technology. That explication of the sex/gender system led to questions about whether sex/gender biases had permeated science and engineering on a variety of levels.

Sex and Gender in Scientific Knowledge

Inaccurate use of definitions and terms for sex and gender may lead to causal links that go beyond what the data warrant. As Londa Schiebinger (1993) documents, human, particularly male, interest in certain anatomic features, such as mammary glands, has even influenced the taxonomic divisions and biological definitions of animal species. Moreover, aware of the fluidity in biological sex among a variety of species in the animal kingdom, including humans, biologists have explored the definition of biological sex and inappropriate extrapolations from the simplistic binary categories of biological male and female to the gender identities of masculine and feminine as well as inappropriate assumptions of their links with particular sexual orientations.

Indeed, although at the time of birth attendants categorize newborns into the binary category of male or female, numerous clinical examples demonstrate that biological sex can be disaggregated into genetic, hormonal, internal anatomic, and external anatomic components. Typically a genetic male (XY) produces some testosterone prenatally that causes an undifferentiated fetus to develop internal organs such as testes and external structures such as the penis that normally are associated with males. Breakdowns or changes at any level may cause development to take a different path. For example, individuals who are genetic males (XY) with androgen insensitivity (testicular feminization) have testes but have female external genitalia; individuals with Turner's syndrome (genetic X0) at birth have the anatomy of females (although their genitals may remain immature after puberty and they may or may not have ovaries) but do not have the XX sex chromosomes associated with "normal" females.

It once was assumed that after birth an individual categorized as male produces increased levels of testosterone at puberty that lead to the development of secondary sex characteristics such as facial hair and a deep voice, whereas a female develops breasts and begins menstruating in the absence of testosterone and in the presence of estrogen and progesterone. Clinical conditions such as congenital adrenal hyperplasia (CAH) demonstrated further breakdown in the uniformity of biological sex. The absence of the enzyme C-21-hydroxylase in individuals with CAH results in genetic females (XX) with female internal genitalia but male external genitalia.

These breakdowns demonstrating that being a genetic male does not always result in an individual with functioning male anatomy and secondary sex characteristics not only weakened the binary sex categories of male and female but also led scientists to question biologically deterministic models that linked the male sex with male gender identity, male role development, and heterosexuality. Statistical and interview data from the Kinsey Reports, coupled with clinical studies, revealed difficulties with the use of binary categories and assumptions of causality. For example, the studies of John Money and Anke Erhardt (1972) explored so-called ambiguous sex, or babies born with external genitalia "discrepant" with their sex chromosomes and internal genitalia, that is, genetic females (XX) with ovaries but with an elongated "penoclitoris" and genetic males (XY) with testes and androgen insensitivity.

Many of the babies in those studies were genetic females who had ambiguous external genitalia at birth because their mothers had been given synthetic progestins to prevent miscarriage. Money and Erhardt concluded from those studies that operations and hormone treatments that were intended to remove ambiguity would not prevent the "normal" development of gender identity congruent with the assignment of sex based on the construction of external genitalia, regardless of genetic or internal anatomic sex, as long as that reassignment occurred before eighteen months of age. At the time of those studies some ethical questions were raised about surgical attempts to construct "normal, appropriate" external genitalia, especially in the case of male identical twins in whom an accident during circumcision resulted in the amputation of the penis in one of the twins and the surgical reconstruction of genitalia for reassignment of that twin to the female sex.

Some people questioned the assumptions that Money and Erhardt made about appropriate gender identities and roles, such as whether exposure to androgens had resulted in the higher IQ of those genetic females and whether the parents of sexually reassigned individuals treated them in ways that would influence the children to develop an "appropriate" gender identity. In recent years more emphasis has been placed on the ethics of using surgery and hormones to provide conformity between biological sex and socially constructed gender roles. As adults the patients have raised questions about who made the decision to do sexual reassignment, who decided what was appropriate gender identity, and in many cases why they had not been told that those medical and psychological interventions had been performed on them.

Described as a solution for individuals who always felt that they were trapped in a body of the wrong sex, transsexual surgery became popular in the 1970s to make the socially constructed gender identity of individuals congruent with their biological sex. Although large numbers of "dissatisfied" or "problematic cases" of individuals who had undergone transsexual surgery surfaced almost immediately, realization by the broader medical and mainstream community that sex and gender are not the same and that binary categories of male and female, as well as masculinity and femininity, may be too limited and constraining, took longer.

John Money's treatment of Bruce/Brenda Reimer, as analyzed in a study by John Colapinto (2001), was instrumental in casting doubts on Money's social constructionist theories. Although the philosopher Janice Raymond (1979) pointed out that transsexual surgery would not be needed in a society that did not force people to conform to constricted, dichotomous gender roles based on their sex, not until the late 1990s did the transgender movement begin. Leslie Feinberg (1996) discussed how the social construction of gender allows her to assume a male gender role/identity without intending to undergo transsexual surgery; Feinberg understood and wanted to challenge the notion that biological sex determines gender, which is a social construction.

Inequitable Access to Science and Engineering on the Basis of Sex/Gender

Statistical data demonstrate a dearth of women in the physical sciences and engineering, suggesting that the sex/gender system prevents equitable access to education and employment in science and engineering for women and girls. The data document that legal actions in the late 1960s and early 1970s to remove the quotas (usually set at around 7 percent) on qualified women applicants to law, medical, and graduate schools have increased the percentages to parity in most fields. The physical sciences, computing, and engineering are major exceptions.

Although the number of women majoring in scientific and technological fields increased since the 1960s to reach 49 percent in 1998, as Table 1 demonstrates, the percentage of women in computing, the physical sciences, and engineering remains low. The percentage of graduate degrees in these fields earned by women is even lower. The small number of women receiving degrees in the sciences and engineering results in an even smaller percentage of women faculty members in those fields: For example, in 2000 only 19.5 percent of science and engineering professors at four-year colleges and universities were women. Outside academia the percentage of women in the scientific and technical workforce, which includes the social sciences, hovered at approximately 23 percent.

The Dearth of Women and a Gendered Science

Evelyn Fox Keller (1982, 1985) explored whether the dearth of individuals of one sex has led to the construction of a gendered science. Keller coupled work on the

TABLE 1

Women as a Percentage of Degree Recipients in 1996 by Major Discipline and Group

	All Fields	All Science and Engineering	Psychology	Social Sciences	Biology	Physical Sciences	Geosciences	Engineering	Computer Science	Mathematics
Percentage of bachelor's degrees received by women	55.2	47.1	73.0	50.8	50.2	37.0	33.3	17.9	27.6	45.8
Percentage of master's degrees received by women	55.9	39.3	71.9	50.2	49.0	33.2	29.3	17.1	26.9	40.2
Percentage of doctoral degrees received by women	40.0	31.8	66.7	36.5	39.9	21.9	21.7	12.3	15.1	20.6

SOURCE: National Science Foundation. (2000). *Women, Minorities, and Persons with Disabilities in Science and Engineering*. Washington, DC: National Science Foundation, pp. 119, 170, 188.

history of early modern science by David Noble (1992) and Carolyn Merchant (1979), who demonstrated that women were excluded purposely and not permitted to be valid "witnesses" to scientific experiments, with theories of object relations for gender identity development. Keller applied the work of Nancy Chodorow (1978) and Dorothy Dinnerstein (1977) on women as primary caretakers of children during gender role socialization to suggest how that might lead to more men choosing careers in science, resulting in science becoming a masculine province that excludes women and causes women to exclude themselves. Science is a masculine province not only because it is populated mostly by men but because that situation causes men to create science and technology that reflect masculine approaches, interests, and views of the world.

Biases in Research in Science and Technology

The gendered nature of science has led to biases on several levels that are best illustrated by citing examples in science and technology that have led to ethical dilemmas.

EXCLUSION OF FEMALES AS EXPERIMENTAL AND DESIGN SUBJECTS. Cardiovascular diseases are an example of the many diseases that occur in both sexes from which women were excluded from studies until androcentric bias was revealed. Research protocols for large-scale studies of cardiovascular diseases failed to assess sex differences. Women were excluded from clinical trials of drugs because of fear of litigation resulting from possible teratogenic effects on fetuses. Exclusion of women from clinical drug trials was so pervasive that a meta-analysis published in September 1992 in the *Journal of the American Medical Association* that surveyed the literature from 1960 to 1991 on clinical trials of medications used to treat acute myocardial infarction found that women had been included in less than 20 percent and the elderly in less than 40 percent of those studies (Gurwitz, Col and Avorn 1992).

Dominance of men in engineering and the creative design sectors may result in similar bias, especially design and user bias. Shirley Malcom, in a personal communication to this author, suggests that the air bag fiasco in the U.S. auto industry is as an excellent example of gender bias reflected in design. Female engineers on the design team might have prevented the fiasco, recognizing that a bag that implicitly used the larger male body as a norm would be flawed when applied to smaller individuals, killing rather than protecting children and small women.

ANDROCENTRIC BIAS IN THE CHOICE AND DEFINITION OF PROBLEMS. Some subjects that concern women receive less funding and study. Failure to include women in studies of many diseases that occur in both sexes, such as cardiovascular disease, suggested that women's health had become synonymous with reproductive health. After a 1985 U.S. Public Health Service survey recommended that the definition of women's health be expanded beyond reproductive health, in 1990 the General Accounting Office criticized the National Institutes of Health (NIH) for inadequate representation of women and minorities in federally funded studies (Taylor 1994). This resulted in the establishment of the Women's Health Initiative (Healy 1991), which was designed to collect baseline data and look at interventions to prevent cardiovascular disease, breast cancer, colorectal cancer, and osteoporosis.

Having large numbers of male engineers and creators of technologies often results in technologies that are useful from a male perspective in that they fail to address important issues for women users. In addition the military origins for the development and funding of much technology makes its civilian application less useful for women's lives (Cockburn 1983). Men who design technology for the home frequently focus on issues that are less important to women users. For example, an analysis of "smart houses" reveals that those houses do not include new technologies; instead of housework they focus on "integration, centralised control and regulation of all functions in the home" (Berg 1999, p. 306). As Ruth Schwartz Cowan (1981) suggested, the improved household technologies developed in the first half of the twentieth century increased the amount of time housewives spent on housework and reduced their role from general managers of servants, maiden aunts, grandmothers, children, and others to that of individuals who worked alone doing manual labor with the aid of household appliances.

ANDROCENTRIC BIAS IN THE FORMULATION OF SCIENTIFIC THEORIES AND METHODS. Theories and methods that coincide with the male experience of the world become the "objective" theories that define the interpretation of scientific data and the use of technology. A 1996 study that included all prospective treatment and intervention studies published in the *New England Journal of Medicine*, the *Journal of the American Medical Association*, and the *Annals of Internal Medicine* between January and June in 1990 and 1994 revealed that only 19 percent of the 1990 studies and 24 percent of the 1994 studies reported any data analysis by gender despite the fact that 40 percent of the subjects were female (Charney and Morgan 1996).

Excessive focus on male research subjects and definition of cardiovascular diseases as male led to underdiagnosis and undertreatment of those diseases in women. A 1991 study in Massachusetts and Maryland by John Z. Ayanian and Arnold M. Epstein demonstrated that women were significantly less likely than men to undergo coronary angioplasty, angiography, or surgery when admitted to the hospital with a diagnosis of myocardial infarction, angina, chronic ischemic heart disease, or chest pain. A similar study (Steingart et al. 1991) revealed that women had angina before myocardial infarction as frequently as and with more debilitating effects than men, yet women were referred for cardiac catheterization only half as often.

These and other similar studies led Bernadine Healy, a cardiologist and the first woman director of the NIH, to characterize the diagnosis of coronary heart disease in women as the Yentl syndrome: "Once a woman showed that she was just like a man, by having coronary artery disease or a myocardial infarction, then she was treated as a man should be" (Healy 1991, p. 274). The use of the male as norm in research and diagnosis was translated into bias in treatments for women: Women had higher death rates from coronary bypass surgery and angioplasty (Kelsey et al. 1993).

In equally direct ways androcentric bias has excluded women as users of technology. The policy decision by Secretary of Defense Les Aspin (1993) to increase the percentage of women pilots uncovered the gender bias in cockpit design that excluded only 10 percent of male recruits by dimensions as opposed to 70 percent of women recruits. The officers initially assumed that the technology reflected the best or only design possible and that the goal for the percentage of women pilots would have to be lowered and/or the number of tall women recruits would have to be increased. That initial reaction, representing the world viewpoint of men, changed. When political conditions reinforced the policy goal, a new cockpit design emerged that reduced the minimum sitting height from 34 to 32.8 inches, thus increasing the percentage of eligible women (Weber 1999).

Implications of the Social Construction of Gender and of Science and Technology

Awareness and understanding of sex/gender biases raise the fundamental question of the way in which androcentric biases in scientific methods and theories occur. Should biological sex simply be termed essentialist and set aside, leaving the body to be viewed as a "coatrack" on which all that is cultural hangs, as suggested by Linda Nicholson (1994)? This interpretation implies that gender and all aspects of science and technology are socially, culturally constructed and nonobjective. Can scientists and engineers be objective? More important, is good science objective and gender-free? Or, as the title of Londa Schiebinger's 1999 book asks, *Has Feminism Changed Science?*

Most scientists, feminists, and philosophers of science recognize that no individual can be entirely neutral or value-free. To some "objectivity is defined to mean independence from the value judgments of any particular individual" (Jaggar 1983, p. 357). Scientific paradigms also are far from value-free. The values of a culture both in the historical past and in the present society heavily influence the ordering of observable phenomena into a theory. The worldview of a particular society, time, and person limits the questions that can be asked and thus the answers that can be given. Acceptance of a particular paradigm that appears to cause a "scientific revolution" within a society may depend on the congruence of the theory with the institutions and beliefs of the society (Kuhn 1970).

Scholars suggest that Darwin's theory of natural selection ultimately was accepted by his contemporaries, who did not accept similar theories proposed by the naturalist Alfred Russel Wallace (1823–1913) and others, because Darwin emphasized the congruence between the values of his theory and those held by the upper classes in Victorian Britain (Rose and Rose 1980). In this manner Darwin's data and theories reinforced the social construction of both gender and class, making his theories acceptable to the leaders of English society.

The current ideas of Darwinian feminists and feminist sociobiologists such as Patricia Gowaty (1997) and Sarah Blaffer Hrdy (1981) provide a biological explanation for female-female competition, promiscuity, and other behaviors practiced in modern society. Evolutionary psychologists carry this work a step further by positing biological bases for differences in the psychology of men and women. These biological differences, such as the ability of women to experience pregnancy, birth, and lactation, may give women different voices in ethical experiences, as has been suggested by Sara Ruddick (1989).

Not only what is accepted but what is studied and how it is studied have normative features. Helen Longino (1990) has explored the extent to which methods employed by scientists can be objective (not related to individual values) and can lead to repeatable, verifiable results while contributing to hypotheses and theories that are congruent with nonobjective institutions and ideologies, such as gender, race, and class, that are socially constructed in a society: "Background assumptions are the means by which contextual values and ideology are incorporated into scientific inquiry" (Longino 1990, p. 216). The lens of the sex/gender prism reveals how the dominance of men and masculinity in Western society has masked the androcentrism and ethical bias of many scientific experiments, approaches, theories, and conclusions.

SUE V. ROSSER

SEE ALSO *Feminist Ethics; Homosexuality Debate; Sex Selection.*

BIBLIOGRAPHY

Aspin, Les. (1993). *Policy on the Assignment of Women in the Armed Forces*. Washington, DC: U.S. Department of Defense.

Ayanian, John Z., and Arnold M. Epstein. (1991). "Differences in the Use of Procedures between Women and Men Hospitalized for Coronary Heart Disease." *New England Journal of Medicine* 325: 221–225.

Berg, Anne-Jorunn. (1999). "A Gendered Socio-Technical Construction: The 'Smart House.'" In *The Social Shaping of Technology*, 2nd edition, ed. Donald MacKenzie and Judy Wacjman. Philadelphia: Open University Press.

Charney, P., and C. Morgan. (1996). "Do Treatment Recommendations Reported in the Research Literature Consider Differences between Men and Women?" *Journal of Women's Health* 5(6): 579–584.

Chodorow, Nancy. (1978). *The Reproduction of Mothering: Psychoanalysis and the Sociology of Gender*. Berkeley and Los Angeles: University of California Press.

Cockburn, Cynthia. (1983). *Brothers: Male Dominance and Technological Change*. London: Pluto.

Colapinto, John. (2001). *As Nature Made Him: The Boy Who Was Raised as a Girl.* New York: Perennial.

Cowan, Ruth S. (1981). *More Work for Mother: The Ironies of Household Technology from the Open Hearth to the Microwave*. New York: Basic Books.

De Beauvoir, Simone. (1947). *The Second Sex,* ed. and trans. H. M. Parshley. New York: Vintage Books.

Dinnerstein, Dorothy. (1977). *The Mermaid and the Minotaur: Sexual Arrangements and Human Malaise*. New York: Harper Colophon.

Feinberg, Leslie. (1996). *Transgender Warriors: Making History from Joan of Arc to Dennis Rodman*. Boston: Beacon Press.

Gowaty, Patricia, ed. (1997). *Feminism and Evolutionary Biology: Boundaries, Intersections, and Frontiers*. New York: Chapman and Hall.

Gurwitz, Jerry H.; Col, N. F.; and Avorn, J. (1992). "The Exclusion of the Elderly and Women from Clinical Trials in Acute Myocardial Infarction." *Journal of the American Medical Association* 268(8): 1417–1422.

Healy, Bernadine. (1991). "Women's Health, Public Welfare." *Journal of the American Medical Association*. 266: 566–568.

Hrdy, Sarah Blaffer. (1981). *The Woman That Never Evolved*. Cambridge, MA: Harvard University Press.

Jaggar, Alison. (1983). *Feminist Politics and Human Nature*. Totowa, NJ: Rowman & Allanheld.

Keller, Evelyn F. (1982). "Feminism and Science." *Signs* 7(3): 589–602.

Keller, Evelyn F. (1985). *Reflections on Gender and Science*. New Haven, CT: Yale University Press.

Kelsey, S. F., et al. (1993). "Results of Percutaneous Transluminal Coronary Angioplasty in Women: 1985–1986 National Heart, Lung, and Blood Institutes Coronary Angioplasty Registry." *Circulation* 87(3): 720–727.

Kuhn, Thomas S. (1970). *The Structure of Scientific Revolutions*, 2nd edition. Chicago: University of Chicago Press.

Longino, Helen. (1990). *Science as Social Knowledge: Values and Objectivity in Scientific Inquiry*. Princeton, NJ: Princeton University Press.

Malcom, Shirley. Personal Communication, 1998.

Merchant, Carolyn. (1979). *The Death of Nature*. New York: Harper & Row.

Money, John, and Anke Erhardt. (1972). *Man and Woman, Boy and Girl: The Differentiation and Dimorphism of Gender and Identity from Conception to Maturity*. Baltimore: Johns Hopkins University Press.

National Science Foundation. (2000). *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2000*. NSF 00-327. Arlington, VA: National Science Foundation.

Nicholson, Linda. (1994). "Interpreting Gender." *Signs: Journal of Women in Culture and Society* 20(1): 79–105.

Noble, David. (1992). *A World without Women: The Christian Clerical Culture of Western Science*. New York: Knopf.

Raymond, Janice. (1979). *The Transsexual Empire: The Making of the She-Male*. Boston: Beacon Press.

Rose, Hilary, and Stephen Rose. (1980). "The Myth of the Neutrality of Science." In *Science and Liberation*, ed. Rita Arditti, Pat Brennan, and Steve Cavrak. Boston: South End Press.

Rubin, Gayle. (1975). "The Traffic in Women: Notes on the 'Political Economy' of Sex." In *Toward an Anthropology of Women*, ed. Rayna Reiter. New York: Monthly Review Press.

Ruddick, Sarah. (1989). *Maternal Thinking: Toward a Politics of Peace*. Boston: Beacon Press.

Schiebinger, Londa. (1993). *Nature's Body: Gender in the Making of Modern Science*. Boston: Beacon.

Schiebinger, Londa. (1999). *Has Feminism Changed Science?* Cambridge, MA: Harvard University Press.

Steingart, R.M., et al. (1991). "Sex Differences in the Management of Coronary Artery Disease: Survival and Ventricular Enlargement Investigator." *New England Journal of Medicine* 321: 129–135.

Taylor, C. (1994). "Gender Equity in Research." *Journal of Women's Health* 3: 143–153.

Weber, Rachel. (1997). "Manufacturing Gender in Commercial and Military Cockpit Design" *Science, Technology and Human Values* 22: 235–253.

SEX SELECTION

Sex selection is an ancient and persistent practice. At some times and in some places, parents have selected the sex of their children by killing newborns or neglecting babies of the undesired sex, almost always female. In the twenty-first century, technological developments and marketing practices are bringing new attention to sex selection, and raising an array of new concerns about it.

Some bioethicists and others defend sex selection as a matter of parental choice or "procreative liberty" (Robertson 2001). Others are highly critical, arguing that sex selection reflects and reinforces misogyny and gender stereotypes, undermines the wellbeing of children by subjecting them to excessive parental disappointment or expectations, and sets the groundwork for the future accessorizing and commodifying of children. The spread of prenatal screening for sex selection has caused alarm because of increasingly skewed sex ratios in some areas. Newer technologies now being used for sex selection also raise the prospect of a high-tech "consumer eugenics," in which other traits of future children are also chosen or "engineered."

Contemporary Sex Selection Methods

The development during the 1970s of prenatal testing technologies made it possible to reliably determine the sex of a fetus developing in a woman's womb. These procedures were initially intended to detect, and usually to abort, fetuses with Down Syndrome and other genetic anomalies, some of them sex-linked. But the tests were soon being openly promoted and widely used as tools for social sex selection, especially in South and East Asian countries where a cultural preference for sons is widespread. At the turn of the twenty-first century, prenatal screening followed by abortion remained the most common sex selection method around the world.

However, newer methods of sex selection are also coming into use. Unlike prenatal testing, these procedures are applied either before an embryo is implanted in a woman's body, or before an egg is fertilized. They do not require aborting a fetus of the "wrong" sex. In the United States, these pre-pregnancy methods are being promoted for social sex selection, as ways to satisfy parental desires, and are being marketed as forms of "family balancing" or "gender balancing."

EMBRYO SCREENING. Preimplantation genetic diagnosis (PGD), introduced in 1990, is an embryo screening technique. About three days after fertilization, a single cell is removed from each embryo in a batch that has been created using in vitro fertilization (IVF). Technicians test the cells for particular chromosomal arrangements or genetic sequences; then one or more embryos that meet the specified criteria—in the case of sex selection for a boy, those with both X and Y chromosomes—

are implanted in a woman's body. As a sex selection method, PGD is fairly reliable.

Like prenatal screening, PGD was presented as a way for parents to avoid having a child affected by certain genetic conditions (a motivation that has been strongly questioned by disability rights activists, whether involving prenatal tests or PGD). Before long, some assisted reproduction practitioners and bioethicists began suggesting that PGD should be made available to parents who want to fulfill their wish for a boy or a girl.

As of 2005, about 2,000 children have been born worldwide following the use of PGD, but no one knows how many of these procedures were undertaken for purely social sex selection reasons. In fact, the notoriously minimal regulatory environment for assisted reproduction facilities means that there is no firm data on the total number of PGD procedures conducted worldwide, or even on the exact number of clinics offering them. The risks of PGD to women who must undergo the hormone treatments and egg extractions required for all IVF procedures, and to the children born from screened embryos, are likewise unclear, both because of the small numbers involved so far and because of inadequate follow-up studies.

SPERM SORTING. Separating sperm that carry X chromosomes from those with Y chromosomes is the basis for a sex selection method that is less reliable, but that can be used without in vitro fertilization. A sperm sorting technique known as MicroSort® has been available since 1995. It relies on the fact that sperm with X chromosomes contain slightly more DNA than those with Y chromosomes, and uses a process called "flow cytometry," whereby X-chromosome-carrying sperm is separated from Y-chromosome-carrying sperm. The Genetics & IVF Institute (GIVF), the company that markets this technology for the "prevention of X-linked diseases and family balancing," claims that as of 2004, about 500 babies had been born after MicroSort® procedures. The company claims success rates of 88 percent for girls and 73 percent for boys. It reports that about 15 percent of its customers say they are trying to avoid the birth of a child who has inherited a sex-linked disease from the parents; the rest just want a boy or a girl.

Sex Selection as a Global Issue

In 1992 Nobel Prize-winning economist Amartya Sen (b. 1933) estimated the number of "missing women" worldwide—lost to neglect, infanticide, and sex-specific abortions—at one hundred million. Similarly shocking figures were confirmed by others. In areas of the world where sex-selection is most widespread, sex ratios are becoming increasingly skewed. In parts of India, for example, the sex ratio of young children is as low as 766 girls per 1,000 boys.

Some observers in the global North who express distress about the pervasiveness of sex-selective abortions in South and East Asia are untroubled by sex selection in countries without strong traditions of son preference. But politically and ethically, this double standard rests on shaky grounds.

As women's rights and human rights groups point out, an increased use and acceptance of sex selection in the United States would legitimize its practice in other countries, and undermines efforts there to oppose it. A 2001 report in *Fortune* magazine recognized this dynamic, noting that "[it] is hard to overstate the outrage and indignation that MicroSort® prompts in people who spend their lives trying to improve women's lot overseas" (Wadman 2001).

In addition, large numbers of South Asians now live in European and North American countries, and sex selection ads in publications including *India Abroad* and the North American edition of *Indian Express* have specifically targeted them (Sachs 2001). South Asian feminists point to numerous ways in which sex selection reinforces and exacerbates misogyny, including violence against women who fail to give birth to boys.

SOCIAL SEX SELECTION AS CONSUMER CHOICE AND COMMERCIAL ENTERPRISE. In North America and Europe, sex selection seems driven less by preference for boys than by a consumer ideology of "choice." In fact, anecdotal evidence suggests that of North Americans trying to determine the sex of their next child, many are women who want daughters.

However, a preference for girls does not necessarily mean that sex selection and sexism are unrelated. One study found that 81 percent of women and 94 percent of men who say they would use sex selection would want their firstborn to be a boy. Another concern is whether sex selection will reinforce gender stereotyping. Parents who invest large amounts of money and effort in order to "get a girl" are likely to have a particular kind of girl in mind.

The new sex selection methods have also been criticized as a gateway to consumer eugenics, both by public interest groups and by some practitioners in the assisted reproduction field. When the American Society for Reproductive Medicine seemed to endorse using PGD for social sex selection, the *New York Times* reported that this "stunned many leading fertility specialists." One fertility doctor asked, "What's the next step? As we learn more about genetics, do we reject kids who do not have superior intelligence or who don't have the right color hair or eyes?" (Kolata 2001).

Such concerns are exacerbated by the recognition that social sex selection constitutes a potential new profit center for the assisted reproduction industry. It would open up a large new market niche of people who are healthy and fertile, but who nonetheless could be encouraged to sign up for fertility treatments. Since about 2003, several assisted reproduction facilities have begun aggressively going after that market, running ads for social sex selection on the Internet, on radio, and in mainstream publications including the *New York Times* and the in-flight magazines of several airlines. If the parents of 5 percent of the four million babies born each year in the United States were to use MicroSort® sperm sorting at the current rate of $7,500 each, annual revenues would be $1.5 billion.

PROSPECTS FOR POLITICAL AND POLICY ENGAGEMENT. In India women's rights groups have long been at the forefront of efforts to enact laws prohibiting sex-selective abortion. As early as 1986 the Forum Against Sex Determination and Sex Pre-Selection began a campaign to enact legislation to regulate the misuse of embryo screening technology. Though laws have been on the books in India since 1994, they are often not enforced. China banned "non-medical" sex selection in 2004. The Council of Europe's 1997 Convention on Human Rights and Biomedicine also prohibits it, as do a number of European countries including the United Kingdom and Germany, with no adverse impact on the availability or legality of abortion. In 2004 Canada passed comprehensive legislation regulating assisted reproduction that includes a ban on sex selection. The United States currently has no federal regulation of sex selection.

In many parts of the world, even feminists who are deeply uneasy about sex selection have been reluctant to challenge it out of fear that to do so would threaten abortion rights. However, the emergence of pre-pregnancy sex selection methods makes it easier to consider sex selection apart from abortion politics, and may encourage new political and policy thinking about it.

MARCY DARNOVSKY
SUJATHA JESUDASON

SEE ALSO *Assisted Reproduction Technology; Eugenics; Sex and Gender.*

BIBLIOGRAPHY

Belkin, Lisa. (2000). "Getting the Girl." *The New York Times Magazine* July 25. A sympathetic account of women in the United States seeking sex selection techniques in order to have daughters.

Darnovsky, Marcy. (2004). "High-Tech Sex Selection: A New Chapter in the Debate." *GeneWatch* 17(1): 3–6. Also available at http://www.gene-watch.org/genewatch/articles/17-1darnovsky.html

Holmes, Helen Bequaert. (1995). "Choosing Children's Sex: Challenges to Feminist Ethics." In *Reproduction, Ethics, And The Law: Feminist Perspectives*, ed. Joan C. Callahan. Bloomington: Indiana University Press. A co-founder of the International Network Feminist Approaches to Bioethics discusses diverse feminist views on sex selection.

Kolata, Gina. (2001). "Fertility Ethics Authority Approves Sex Selection." *The New York Times* September 28: A16.

Mahowald, Mary. (2001). "Cultural Differences and Sex Selection." In *Globalizing Feminist Bioethics: Crosscultural Perspectives*, ed. Rosemarie Tong, with Gwen Anderson and Aida Santos. Boulder, CO: Westview Press. A philosopher argues that under an egalitarian theory of justice, sex selection is morally objectionable if its impact or intent is sexist.

Paul, Diane. (2001). "Where Libertarian Premises Lead." *American Journal of Bioethics* 1(1): 26–27. A response to John Robertson's defense of sex selection.

Robertson, John A. (2001). "Preconception Gender Selection." *American Journal of Bioethics* 1(1): 2–9. A defense of pre-pregnancy sex selection for social reasons by a bioethicist and legal scholar known for his theory of "procreative liberty."

Sachs, Susan. (2001). "Clinics' Pitch to Indian Émigrés: It's a Boy." *The New York Times* August 15: A1.

Talbot, Margaret. (2002). "Jack or Jill? The Era of Consumer-Driven Eugenics Has Begun." *The Atlantic Monthly* March.

Wadman, Meredith. (2001). "So You Want a Girl?" *Fortune* February.

Warren, Mary Anne. (1985). *Gendercide: The Implications of Sex Selection*. Totowa, NJ: Rowman & Allanheld. Despite her deep misgivings about sex selection, a philosopher argues that the risks of endangering other aspects of reproductive freedom would make any efforts against the practice counter-productive.

Wertz, Dorothy, and John Fletcher. (1992). "Sex Selection through Prenatal Diagnosis: A Feminist Critique." In *Feminist Perspectives in Medical Ethics*, eds. Helen Bequaert Holmes and Laura M. Purdy. Bloomington: Indiana University Press.

INTERNET RESOURCES

Gupte, Manisha. (2003). "A Walk Down Memory Lane: An Insider's Reflections on the Campaign Against Sex-Selective Abortions." An Indian feminist discusses efforts against sex selection and lessons learned. Available at http://www.genetics-and-society.org/resources/background/200308_gupte.pdf.

Human Fertilisation & Embryology Authority. (2003). "Sex Selection: Choice and Responsibility in Human Reproduction." Available from http://www.hfea.gov.uk/AboutHFEA/Consultations.

Mallik, Rupsa. (2002). "A Less Valued Life: Population Policy and Sex Selection in India." *Newsletter for Center for Health and Gender Equity* October. Available from www.genderhealth.org/.

SHELLEY, MARY WOLLSTONECRAFT

Mary Wollstonecraft Godwin Shelley (1797–1851), author of *Frankenstein* (1818), often considered the first science fiction novel and source of the universal modern image of science gone awry, was born in London on August 30 and died there on February 1. Her father, William Godwin (1756–1836), to whom *Frankenstein* is dedicated, was an important liberal reformer now best known for *An Enquiry Concerning Political Justice, and Its Influence on General Virtue and Happiness* (1793). Her mother, Mary Wollstonecraft (1759–1797), who died four days after her daughter's birth, was an important early feminist now best known for *A Vindication of the Rights of Woman* (1792). In 1814 young Mary eloped to the European Continent with Percy Bysshe Shelley (1792–1822), considered one of the greatest Romantic poets. Two years later, having already produced two children and begun *Frankenstein*, Mary married Percy after the suicide of his first wife. They had four children before Percy drowned, but only Percy Florence survived into adulthood. Mary never remarried, devoting herself to motherhood, writing, and editing her husband's works.

Mary treated science less as a solution to practical problems or an intellectual discipline than as a means to "afford a point of view to the imagination for the delineating of human passions more comprehensive and commanding than any which the ordinary relations of existing events can yield" (Shelley 1969, p. 13) Her consistent philosophical position, expressed in science fictions, historical romances, travel books, and essays, was staunchly democratic, based on her belief that while genius must be encouraged, when the discoveries of genius impinge on others, there must be responsibility to the wider community. Frankenstein's murderous monster represents the escape of untempered genius into the world.

Her novel *The Last Man* (1826) is the first in English of the subgenre of works that imagine a global catastrophe. In this case the Percy-like protagonist, Lionel Verney, moves from England to a progressively depopulated Europe, apparently the only human with a natural immunity to a new plague. In this situation science is encouraged to tame rampant Nature. Soon after the deaths begin, a character remarks to Verney that should "this last but twelve months . . . earth will become a Paradise. The energies of man were before directed to the destruction of his species: they now aim at its liberation and preservation" (Shelley 1965, p. 159).

Mary Wollstonecraft Shelley, 1797–1851. Shelley is best known for her novel *Frankenstein; or, The Modern Prometheus*, which has transcended the Gothic and horror genres and is now recognized as a work of philosophical and psychological resonance. *(Source unknown.)*

Science always raises social and moral problems in Mary Shelley's writing. In her philosophical satire "Roger Dodsworth: The Reanimated Englishman" (1826), the fact that someone is brought back from frozen suspended animation to live out a 209 year life span, raises fundamental questions of authenticity. Was he *alive* while frozen? Is his even one *life*?

In her fiction Mary Shelley consistently articulates ethical issues related to science and technology that have since become major themes of public discussion. In Percy Bysshe Shelley's poem "Queen Mab" (1813), we see the cleft stick implicit in the progress of science: "Power, like a desolating pestilence, / Pollutes whate'er it touches; and [yet] obedience, / Bane of all genius, virtue, freedom, truth, / Makes slaves of men, and, of the human frame, / A mechanized automaton." Mary Shelley contributes to ethical thinking about science and technology by calling on society to consider how the power of scientific genius might be limited by the moral claims of the human community. Mary Shelley asks humans, by pursuing science within a community, to do better than they—and her characters—have.

ERIC S. RABKIN

SEE ALSO *Enlightenment Social Theory; Frankenstein; Science, Technology, and Literature.*

BIBLIOGRAPHY

Bennett, Betty T., and Charles E. Robinson, eds. (1990). *The Mary Shelley Reader.* New York: Oxford University Press..

Muriel Spark. (1987). *Mary Shelley.* New York: Dutton.

Shelley, Mary. (1965). *The Last Man,* ed. Hugh J. Luke, Jr. Lincoln: The University Press of Nebraska. Text originally published in 1826.

Shelley, Mary. (1969). *Frankenstein, or The Modern Prometheus,.* ed. M. K. Joseph. New York: Oxford University Press. M. K. Text originally published in 1818 and 1831.

SHINTŌ PERSPECTIVES

The indigenous religion of Japan, Shintō describes human existence much like the popular singer, Sting: as spirituality in the material world. This worldview is the foundation of Japanese civilization and has endured and adapted for centuries. While Shintō recognizes spirit over materiality as the basis of life, it shares something compelling with the perspective of science: the human propensity to identify that which is most powerful in nature and to harness that power for a comfortable and happy human life. Both are able to channel the raw potential of nature toward specific human aims on all levels of society, from the domestic to the national, and both regulate human control over nature through ethical standards that rely on an unquestioning belief in the value system upon which they are built.

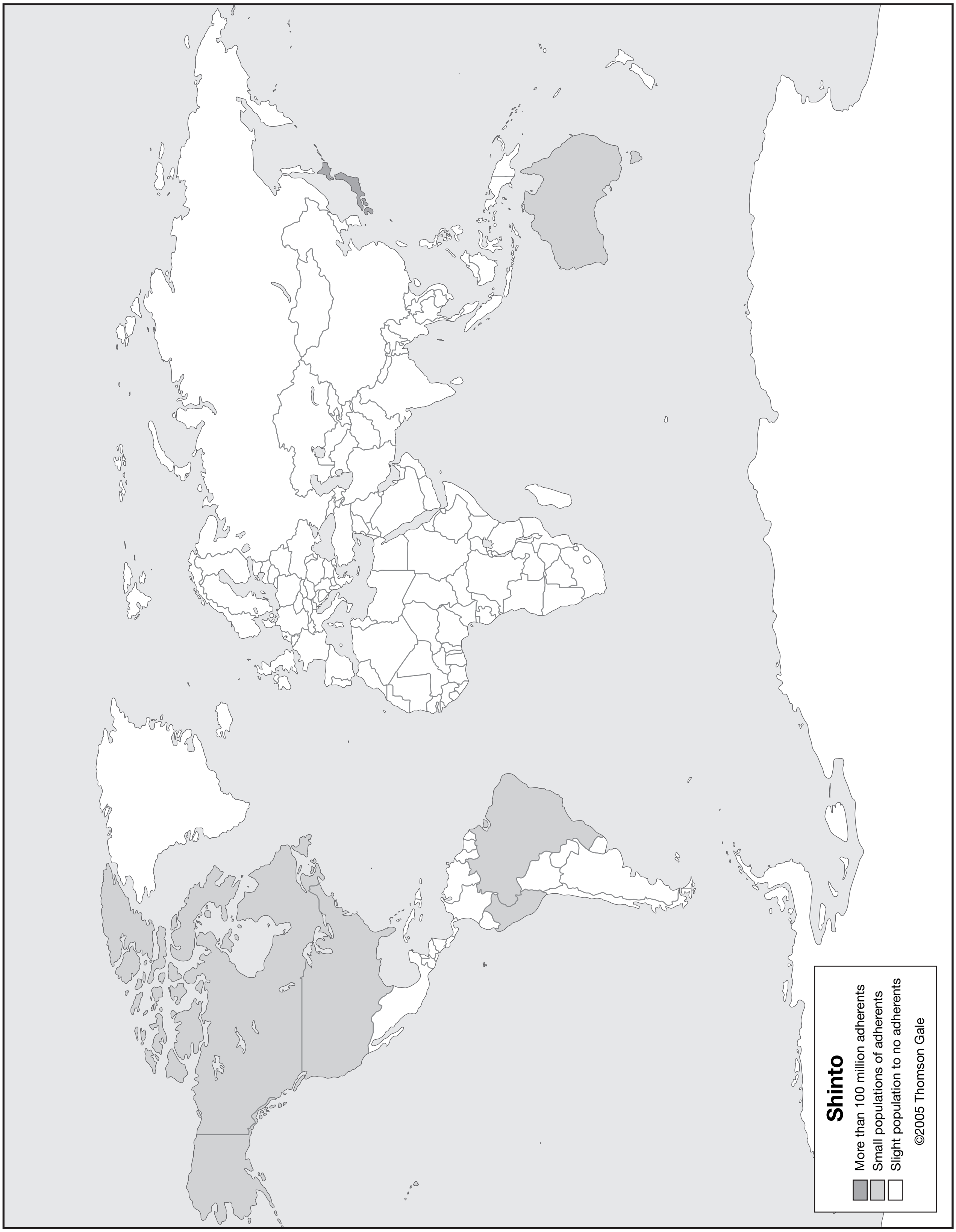
Traditional Teachings

Some of the earliest forms of science and religion sought to answer the question of the origins of living things. Practitioners of both looked to the sun for clues and based their theories and myths on its primordial role in sustaining life on Earth. The sun is the most reliable source of technology. It regulates time. Its proximity to the Earth allows life to flourish. The sun is the gravitational center of the solar system and causes all the planets to orbit it in precise yearly progressions. Hence many ancient cultures regarded the sun as a great celestial king, embodied as a human sovereign on earth.

Shintō, similarly, reveres the sun as the source of all forms of power in the world, both divine and temporal, and as the animating life force behind objective reality. The ancient Japanese personified the sun as a goddess, Amaterasu, who provided life-sustaining technologies—the cultivation of rice and wheat, the knowledge of harvesting silk from silkworms, and the invention of weaving. The goddess also allowed her grandson, Jimmu Tenno, to incarnate as the first historical mikado (emperor) of Japan. His descent to the sacred Japanese islands in 660 B.C.E. began an unbroken line in a divine solar dynasty. The mikado's chief role was to administer the life-giving force of the sun and its associated technologies within the conduct of Japanese life and ethics.

Shintō acknowledges the connection between fundamental natural processes, such as the live-giving, maintaining, and destructive nature of the sun, and the smooth function of human life lived in harmony with them. Nature is tangible power. Certain natural occurrences and objects possess more potency than others, such as the celestial bodies, mountains, rivers, fields, oceans, rain, and wind. These centralized embodiments of natural power, including also special people such as heroes and leaders, were divinized as *kami* (nature spirits) and worshipped.

Nature is very delicate; it can be disrupted easily. Of all living creatures, human beings have the unique propensity to consciously become disjointed from the balanced flow of nature. Its creative and destructive powers (*musubi*) and those objects (*kami*), both active and inert, that harness it rest on a fragile hinge. If nature's power is unleashed without a conduit, its destructive force can inhibit human happiness and survival. If the objects that house nature's power become contaminated, the creative functions of life stall or halt. The ancient Japanese regarded such obstructions as *pollution* (*tsumi*), overcome only through ritual ablution and lustration (*misogi harai*), likened to the polishing of tarnished silver. To overcome obstructions to nature's inherent balance caused by pollution, Shintō presents a threefold solution: conscious invocation of the power within a *kami,* ritual cleansing as the manner in which


Shinto
More than 100 million adherents
Small populations of adherents
Slight population to no adherents
©2005 Thomson Gale

to remove the pollution, and ethical conduct to prevent such pollution in the first place.

The Shintō tradition of the divine emperor together with the living presence of *kami* relies on the complete integration of politics, science, and religion, with Shintō, the *shen* (spirit) *tao* (the way of), as the unbroken thread connecting these three societal divisions. Even after shogun temporal authority resigned the *tenno*, the *heavenly god-king*, to symbolic status, the divinity of the emperor remained powerful in the cultural mind of Japan. The emperor would always be regarded as the true ruler of Japan, so much so that the tradition was reinstituted in 1868, ending the feudal rule of the shogun and beginning the *taikyo* (great teaching) movement of 1870 to 1884.

Modern Shintō

The Great Teaching Movement (1870–1884) brought Shintō into the modern world in the same manner as many other neoreligious and political movements—in the guise of an ancient tradition. Even though the divinity of the emperor was considered the basis of all civic and devotional duty, the ideology of the modern Western nation-state was beginning to take shape in Japan. Shintō became synonymous with the Japanese nation. The notion that Shintō, specifically with its concept of the divine emperor, was the exclusive religion of Japan made the Japanese a unique race, a belief successfully promoted through the national education system. It remained Japan's guiding ethos until the end of World War II.

Japan's entrance into the modern world involved much more than the reassertion of traditional values in a foreign governmental model. For the first time, Japan was exposed to Western technology, which led to its own industrial revolution beginning in the nineteenth century. At the same time that Japan was adopting new technologies, the emperor was restored to temporal power—achieving the modern-ancient blend that characterizes all non-Western nation-states.

Before Japan's contact with the West, Shintō did not have a code of ethics comparable to those of Western religions. Humans were regarded as fundamentally good because positive forces of nature, the gods, had created them. There is no original sin in Shintō. Salvation is deliverance from the troubles of the world, which often means the malfunction of the world. Evil is simply the lack of harmony between spirit and matter, which can be restored through ritual appeasement of the disturbed *kami*. Ethics based on the strict division between good and evil did not emerge in Shintō until the seventeenth century with the influence of Confucian dualism expressed in the war code of Bushido. The samurai who followed this code contributed the qualities of loyalty, gratitude, courage, justice, truthfulness, politeness, reserve, and honor to Shintō's system of natural ethics. From the Confucian Teachings of Kogzi, Shintō acquired its three central insignia: the mirror to symbolize wisdom, the sword to symbolize courage, and the jewel to symbolize benevolence.

By the 1890s observance of Shintō's reverence to the emperor became the secular obligation of every Japanese citizen and not a matter of personal piety. As a result, a threefold code of ethics distinguished Japan's national identity: loyalty to the country; harmony within the family; and, by extension, harmony within society as a whole through modesty, fraternity, and intellectual development. After World War II, Shintō influence was no longer part of the Japanese national identity because the post-war constitution provided for strict separation of religion and state. There is no official government support for Shintō in early twenty-first century Japan.

Contemporary Issues

Shintō beliefs continue to undergird Japanese popular culture, particularly in its relation to technology, a field that Japan has dominated since the end of World War II. Because Shintō recognizes an unseen force behind the machinery of the world, its application to the numerous human-made devices that provide conveniences to humankind is obvious. The most notable example of Shintō's interaction with modern technology was in connection with the Apollo 11 moon mission. Before the launch of Apollo 11, Shintō purification rites were offered to placate a potentially restive *kami*, the moon-brother of the sun, Amaterasu. The rites aimed to secure two goals: to avert the imbalance of the moon's natural rhythms affected by human-made machinery landing on its virgin soil, and to assure a successful journey for the spacecraft and its crew.

In the early-twenty-first century, the Japanese increasingly rely on machines to make life easier. However many unseen factors can cause mechanical malfunction. With computer viruses and their consequences rampant, Japanese high-tech businesses often invoke the favor of Shintō *kami* to prevent the damage caused by hackers. The nation's computer network sustains 35,000 cyber attacks each month and many companies believe that antiviral software will not solve the problem. From playing a role in the development of technology and the resolution of its associated problems to averting domestic disharmony by presiding over wedding unions, Shintō continues to maintain the spirit behind the material world.

KATHERINE J. KOMENDA POOLE

SEE ALSO *Environmental Ethics; Japanese Perspectives.*

BIBLIOGRAPHY

Breen, John and Mark Teeuwen, eds. (2002). *Shintō in History: Ways of the Kami.* Honolulu: University of Hawaii Press.

Hardacre, Helen. (1989). *Shintō and the State: 1868–1988.* Princeton, NJ: Princeton University Press.

Holtom, D. C. (1943). *Modern Japan and Shintō Nationalism: A Study of Present-Day Trends in Japanese Religions.* Chicago: University of Chicago Press, 1943.

Littleton, C. Scott. (2002). *Shintō: Origins, Rituals, Festivals, Spirits, Sacred Places.* New York: Oxford University Press.

Muraoka Tsunetsugu. (1988). *Studies in Shintō Thought,* trans. Delmer M. Brown, and James T. Araki. New York: Greenwood Press.

Ono Sokyo. (1999). *Shintō: The Kami Way.* Singapore: Tuttle Publishing.

Philippi, Donald L. (1990). *Norito: A Translation of the Ancient Japanese Ritual Prayers.* Princeton, NJ: Princeton University Press.

SHIPS

Ships were invented before the beginning of recorded history. The Egyptians developed true sails by 3500 B.C.E., and the first sail-only boats were being used by 2000 B.C.E. For almost 4,000 years the leading technological developments involved refinements in sails and the design of larger and more powerful ships. The nineteenth century brought the development of steam power; after that time ships driven by electricity, fossil fuels, and even nuclear energy were developed.

Humans have used ships in warfare for almost the entire period of their development, first as a means of transporting soldiers and supplies, later as tactical vehicles for raids and looting expeditions, and then for strategic control of the seas. During the cold war era nuclear-equipped ships and submarines that were dispersed across the oceans to render them less vulnerable played a significant role in the nuclear deterrence strategy known as mutually assured destruction (Till 1984). Today, in a world where loose aggregations of terrorist organizations are considered the enemy, the role of a navy is being redefined again in light of incidents such as the 2000 suicide attack on the U.S.S. *Cole* by men in a small, innocuous motorboat packed with explosives.

Commerce

Throughout history ships have served as unifying forces, promoting multilateralism and cultural diversity through trade. However, ships also were used as tools of colonialism and exploitation. Some analysts have observed that the more contact Europeans made with African culture, the more contempt they manifested and the more violence they committed (Scammell 1995). Ships also served as unwitting vectors of diseases such as smallpox, which decimated the native population of the Americas. Chartered shipping companies often acted as proxies of government, carrying out policies of ruthless exploitation that went well beyond what governments could do in the face of public opinion (Jackson and Williamson).

Safety

The most common type of ship collision involves two ships heading toward each other on a course that would lead them to pass each other without incident. At the last moment one of the ships turns into and collides with the other. These accidents always involve a classic misinterpretation of visual data: The captain of one ship assumes that the other ship is going away from his or her vessel and is turning to set a course landward of the first ship (Perrow 1984).

Technology, usually improperly used, can make captains complacent and careless. Studies of ship groundings have revealed that officers did not take soundings even though they knew they were in shoal water, failed to monitor the tide and current, did not keep a proper record of bearings, did not recheck the radar, and failed to adjust a magnetic compass, which in one disastrous case deviated 20 percent from true north (Moody 1948).

Design Issues

Huge ships, like skyscrapers, present safety issues that are implicit in their design. "[L]uxury passenger liners constitute the most serious fire risk afloat. Superimpose a hotel, a cinema, and a pleasure pier onto a very large cargo vessel…" with all of the possibilities for chaos that would entail (Sullivan 1943).

After the *Titanic* disaster in 1912 it was revealed that the ship did not carry enough lifeboats to accommodate every passenger and crew member. The *Titanic* had twenty boats that could carry only a third of its total passenger and crew capacity (Jim's Titanic Website 2004). When the *Andrea Doria* sank in 1956, it listed an angle greater than that envisioned by the designers, and so the lifeboats on the uphill (port) side could not be launched ("Andrea Doria: The Life Boats" 2004).

The Environment

Ships have a significant environmental impact. They act as a vector for invasive species such as hydrilla weed and zebra mussels, which arrive attached to a ship's hull or in the ballast and are released into local environment, where they drive out native species. Ships sometimes accidentally hit and damage fragile coral reefs such as those in Pennekamp State Park, Florida, and marine mammals such as whales, dolphins, and manatees frequently are maimed or killed after colliding with ships' propellers.

The public consciousness long retains the names of ill-fated oil tankers that dump their cargoes into the marine environment. On the evening of March 23, 1989, the *Exxon Valdez,* as a result of navigational errors, grounded in Prince William Sound, Alaska, with more than 53 million gallons of oil aboard. Approximately 11 million gallons of oil were spilled, resulting in the deaths of 250,000 seabirds, 2,800 sea otters, 300 harbor seals, 250 bald eagles, up to 22 killer whales, and billions of salmon and herring eggs (Exxon Valdez Oil Spill Trustees Council 2004).

However, the quiet dumping of engine oil during normal operations accounts for a majority of the oil that pollutes marine environments (Boczek 1992). A variety of treaties provide an international regime that governs dumping and oil spills. Those treaties include the United Nations Convention on the Law of the Sea, four 1958 Geneva conventions, the 1969 Brussels Convention passed in response to the Torrey Canyon disaster, another 1969 Convention on Civil Liability for oil spills, and a December 1988 annex to the Marpol agreement that established strict controls over garbage disposal from ships at sea (Boczek 1992).

Dangerous cargoes sometimes explode in port, as occurred in the July 17, 1944, incident in Port Chicago, California, when a Pacific-bound navy ship being loaded with explosives by a work crew consisting mostly of black sailors exploded, killing 320 men. Concerned about another explosion, 258 black sailors refused an order to load ammunition on another ship and were court-martialed ("A Chronology of African-American Military Service" 2004). Later large-scale peacetime ship explosions include the April 16, 1947, explosion of the S.S. *Grandcamp* at the pier in Texas City, Texas, killing 576 people (Galvan 2004), and the May 26, 1954, explosion aboard the carrier U.S.S. *Bennington* at sea, which killed 100 sailors (Hauser 1954).

Status of Seafarers

Contrary to popular belief as reflected in movies such as *Ben Hur,* most oared ships in antiquity were not operated by slaves. Citizen rowers were less expensive because they were paid only when aboard ship and their deaths did not cost the state anything. However, Athens turned to the use of slaves at a point in the Peloponnesian War when it ran out of available citizens (Casson 1994).

In 1598 the chronicler Hakluyt wrote of sailors: "No kinde of man of any profession in the commonwealth passe their yeres in so great and continuall hazard . . . and . . . of so many so few grow to gray haires" (quoted in Scammell 1995, p. 131). Sailors faced a high mortality rate from disease, accidents, and combat. Unable to recruit enough sailors, the British government began the impressment, and essentially enslavement, of unwilling agricultural and industrial workers in the 1500s, a policy that would continue for almost three centuries (Scammell 1995). However, the sea was one of the few careers that allowed people of humble rank to move up to positions of status and power (Scammell 1995). A significant path out of the working class was blazed by engineers (Dixon 1996).

Today the lives of itinerant seamen on cargo ships are still dangerous, grindingly hard, and poorly compensated (Kummerman and Jacquinet 1979).

JONATHAN WALLACE
ELIZABETH C. MCNIE

SEE ALSO *Roads and Highways.*

BIBLIOGRAPHY

Boczek, Boleslaw A. (1992). "Global and Regional Approaches to the Protection of the Marine Environment." In *Maritime Issues in the 1990's: Antarctica, Law of the Sea and the Marine Environment,* ed. Dalchoong Kim. Seoul: Institute of East and West Studies. Summary of international law pertaining to the marine environment and shipping.

Casson, Lionel, (1994). *Ships and Seafaring in Ancient Times*. London: British Museum Press. Overview of ships in antiquity.

Dixon, Conrad. (1996). "The Rise of the Engineer in the 19th Century." In *Shipping, Technology and Imperialism*, ed. Gordon Jackson and David Williams. Hants, UK: Scolar Press. An account of the engineering profession as a pathway out of the working class.

Kummerman, Henri, and Robert Jacquinet. (1979). *Ship's Cargo, Cargo Ships*. London: McGregor Press. An overview of issues pertaining to modern cargo shipping.

Moody, Lieutenant Alton P. (1948). *Why Ships Ground*. Address to the fourth annual meeting of the Institute of Navigation. In the collection of the New York Public Library. An interesting brief analysis of the reasons why ships hit obstacles at sea.

Perrow, Charles. (1984). *Normal Accidents: Living with High Risk Technologies*. New York: Basic Books. Fascinating analysis of the elements of human error which contribute to high technology accidents.

Scammell, G. V. (1995). *Ships, Oceans and Empire: Studies in European Maritime and Colonial History, 1400–1750*. Brookfield, VT: Ashgate. Includes essays on ships as tools of colonialism.

Sullivan, A. P. L. (1943). *Ships and Fire: Suggested in Outline by the Deputy Chief of Fire Staff*. Liverpool and London: C. Birchall & Sons. In the collection of the New York Public Library. A brief summary of the reasons ships catch fire.

Till, Geoffrey. (1984). *Maritime Strategy and the Nuclear Age*, 2nd edition. London: Macmillan. The continuing relevance of warships in the age of nuclear weapons.

INTERNET RESOURCES

"Andrea Doria: The Life Boats." (2004). Available at http://www.andreadoria.org/TheLifeboats/Default.htm. Why half the Andrea Doria lifeboats weren't available after the collision.

"A Chronology of African-American Military Service from WWI through WWII." (2004). Available at http://www.africanamericans.com/MilitaryChronology4.htm. Includes a summary of the port Chicago incident.

Hauser, Don. "A Personal Account of Explosion Aboard *U.S.S. Bennington*, May 26, 1954." Available on the Crew Stories website, http://www.uss-bennington.org/stz-explosion-dhauser54.html.

Exxon Valdez Oil Spill Trustees Council. (2004). "Exxon Valdez Q&A." Available at http://www.evostc.state.ak.us/facts/qanda.htm. Useful summary of facts relating to the causes and impact of the Exxon Valdez grounding..

Galvan, Jose. (2004). "The Texas City Disaster." Available at http://www.useless-knowledge.com/articles/apr/july107.html.

Jim's Titanic Website. (2004). "Titanic Facts and Figures." Available at http://www.keyflux.com/titanic/facts.htm. Contains a description of the inadequacy of the Titanic lifeboats.

SIERRA CLUB

The Sierra Club is one of the leading non-governmental organizations that influence science, technology, and ethics relations from the environmental perspective.

Origins

The oldest environmental organization in the United States, the Sierra Club was founded in 1892 by a Scotsman, John Muir (1838–1914), who did not become a U.S. citizen until 1903. By 1892, however, he was already known to presidents and writers (including Ralph Waldo Emerson (1803–1882) as one of the country's most passionate advocates for the protection of wilderness.

Muir arrived in San Francisco, California, from Wisconsin in 1868 and headed to Yosemite Valley in the Sierra Nevada Mountains, which the avid outdoorsman had read about in a magazine. He spent the next seven years there, exploring, collecting plants, writing about his discoveries, and urging others to visit the high country. Those writings helped convince President Benjamin Harrison to create the Yosemite National Park in 1890.

In 1892 Muir became the first president of The Sierra Club, an association whose purpose as listed in its Articles of Incorporation was "To explore, enjoy, and render accessible the mountain regions of the Pacific Coast; to publish authentic information concerning them; and to enlist the support and cooperation of the people and government in preserving the forests and other natural features of the Sierra Nevada Mountains."

The Sierra Club-sponsored hiking and camping outings, called High Trips, that were fun but also meant to make members aware of and articulate about the preservation challenges facing the Sierra Nevadas. The education of such *activists* was important, for almost as soon as Yosemite National Park was established, efforts began to shrink it, strip it of federal protection, build a private railroad through it, and drown its beautiful Hetch Hetchy Valley behind a dam.

The park was shrunk and the proposal to build the dam passed in 1913, but all these fights—and especially the tragedy of the Hetch Hetchy defeat—helped transform the Sierra Club from a politically naive hiking club into a formidable and politically astute environmental organization. Its leaders now understood how the government worked and how important it was to win over public opinion to its causes. Outings and conservation were still integral to the Sierra Club, but so was political clout.

Contemporary Work

In the early twenty-first century, the Sierra Club is headquartered in San Francisco. With more than 750,000 members, it has lobbyists in Washington, DC, and a nationwide volunteer grassroots network striving to influence public policy on a variety of environmental issues.

Over the years, the club focus widened as environmental threats increased. Air and water pollution, urban sprawl, unsustainable logging, and the promotion of renewable energy—in addition to the protection of wilderness areas such as those in Yosemite—have emerged as some of the organization's top priorities. In recent years scientific pursuits in the areas of biotechnology—particularly as this new science relates to genetically modified organisms in agriculture and forestry—have been challenged by the club.

With regard to genetically engineered organisms, the club subscribes to a hard version of the Precautionary Principle and calls for a moratorium on the planting of all genetically engineered crops and the release of all genetically engineered organisms (GEOs) into the environment. It urges that where there are safer alternatives to the use of GEOs, these technologies should be given preference. On this topic the Sierra Club represents citizen science in action. Its biotechnology committee is all-volunteer. Some of its members are scientists but others are merely concerned citizens, worried about an unproven technology, who have researched the issue and feel compelled to act. Sierra Club committees make recommendations to the board of directors, which then formulates the club's *official* stand.

In the areas of energy conservation and renewables, the Sierra Club advocates for public transportation systems, energy efficient buildings and fuel efficient automobiles, and the use of renewable energy sources such as solar, wind, and geothermal power. The club has urged the U.S. Congress to provide for the expenditure of at least 2 billion dollars per year for at least five years for federal research and development—with emphasis on geothermal, solar, and fusion power; energy conservation and more efficient utilization of energy; and strip-mining reclamation. In 2001, when the U.S. government announced an energy plan that privileged oil, gas, and nuclear power interests, the Sierra Club sued to gain access to Vice President Dick Cheney's notes of meetings in which the energy policy was developed.

Following founder John Muir's statement that "Everybody needs beauty as well as bread, places to play in and pray in, where nature may heal and give strength to body and soul alike" (Muir 1912, p. 260), the Sierra Club has made an effort to broaden its preservation ethic to include what have come to be called *environmental justice* issues. Whether it is the threat to the Gwichin people's subsistence hunting from drilling in the Arctic National Wildlife Refuge or dioxin-spewing power plants in poor neighborhoods of Detroit or San Francisco, the Sierra Club attempts to reach out to communities not usually associated with the environmental movement and assist them in their struggles.

In the early 2000s the Sierra Club continues to promote outings, where hikers can explore and enjoy the wild places of the earth. But in a political and corporate environment that increasingly compromises the quality of water, air, and soil in pursuit of economic gain, organizations such as the Sierra Club have become essential advocates for the responsible use of the earth's ecosystems and resources. The Sierra Club's catalog of coffee table nature books and environmental literature can be accessed at http://www.sierraclub.org/books.

MARILYN BERLIN SNELL

SEE ALSO *Alternative Energy; Deforestation and Desertification; Ecological Restoration; Ecology; Environmental Ethics; Environmental Justice; Environmentalism; Genetically Modified Foods; Nature; Nongovernmental Organizations; Rain Forest; Sustainability and Sustainable Development; Water.*

BIBLIOGRAPHY

Muir, John. (1912). *The Yosemite*. New York: Century.

Turner, Tom. (1991). *The Sierra Club: 100 Years of Protecting Nature*. New York: Harry N. Abrams in association with the Sierra Club.

INTERNET RESOURCE

Sierra Club. Home page at http://www.sierraclub.org.

SIMON, HERBERT A.

Herbert Alexander Simon (1916–2001) was born in Milwaukee, Wisconsin, on June 15. He received his

Herbert Simon, 1916-2001. The study of decision-making behavior, especially in large organizations, led Simon to develop new theories in economics, psychology, business administration, and other fields. He was awarded the Nobel Prize in economics in 1978. He was also the first social scientist elected to the National Academy of Sciences. *(AP/Wide World Photos.)*

Ph.D. in political science from the University of Chicago in 1943, and taught at the Illinois Institute of Technology (1942–1949) before going to Carnegie Mellon University in 1949, where he remained until his death on February 9. Simon received major awards from many scientific communities, including the A.M. Turing Award (with Allen Newell; 1975), the Nobel Prize in Economics (1978), and the National Medal of Science (1986). During his career, Simon also served on the National Academy of Science's Committee on Science and Public Policy and as a member of the President's Science Advisory Committee. Simon made important contributions to economics, psychology, political science, sociology, administrative theory, public administration, organization theory, cognitive science, computer science, and philosophy. His best known books include *Administrative Behavior* (1947), *Organizations* (with James G. March 1958), *The Sciences of the Artificial* (1969), *Human Problem Solving* (with Newell 1972), and his autobiography, *Models of My Life* (1991). Having advanced the scientific analysis of decision-making, Simon's thought also has evident implications for bringing ethics to bear on science and technology.

A New Theory of Decision-Making

Decision-making was the core of Simon's work. It was the heart of his dissertation, later published as *Administrative Behavior,* and it became the basis of his other contributions to organization theory, economics, psychology, and computer science. Decision-making, as Simon saw it, is purposeful, yet not rational, because rational decision-making would involve a complete specification of all possible outcomes conditional on possible actions in order to choose the single best among alternative possible actions. In challenging neoclassical economics, Simon found that such complex calculation is not possible. As a result, Simon wanted to replace the economic assumption of global rationality with an assumption that was more in correspondence with how humans actually make decisions, their computational limitations, and how they access information in a current environment (Simon 1955), thereby introducing the concepts of *bounded rationality* and *satisficing.*

Satisficing is the idea that decision makers interpret outcomes as either satisfactory or unsatisfactory, with an aspiration level constituting the boundary between the two. In neoclassical rational choice theory decision makers would list all possible outcomes evaluated in terms of their expected utilities, and then chose the one that is rational and maximizes utility. According to Simon's model, decision makers face only two possible outcomes, and look for a satisfying solution, continuing to search only until they have found a solution that is good enough. The ideas of bounded rationality and satisficing became important for subsequent developments in economics.

Simon used this view of decision-making to create (together with March and Harold Guetzkow) a propositional inventory of organization theory, which led to the book *Organizations* (1958). The book was intended to provide the inventory of knowledge of the (then almost nonexistent) field of organization theory, and also a more proactive role in defining the field. Results and insights from studies of organizations in political science, sociology, economics, and social psychology were summarized and codified. The book expanded and elaborated ideas on behavioral decision-making, search and aspiration levels, and the significance of organizations as social institutions in society. "The basic features of organization structure and function," March and Simon wrote,

> derive from the characteristics of rational human choice. Because of the limits of human intellective capacities in comparison with the complexities of the problems that individuals and organizations face, rational behavior calls for simplified models that capture the main features of a problem without capturing all its complexities." (p. 151)

The book is now considered a classic and pioneering work in organization theory.

Interdisciplinary Contributions

Simon also incorporated these views into his contributions to psychology, computer science, and artificial intelligence. For example, in his work with Newell, Simon attempted to develop a general theory of human problem solving that conceptualized both humans and computers as symbolic information processing systems (Newell and Simon 1972). Their theory was built around the concept of an information processing system, defined by the existence of symbols, elements of which are connected by relations into structures of symbols. The book became as influential in cognitive science and artificial intelligence as Simon's earlier work had been in economics and organization theory.

During his amazingly productive intellectual life, Simon worked on many projects, yet essentially pursued one vision—understanding how human beings make decisions. He contributed significantly to many scientific disciplines, yet found scientific boundaries themselves to be less important, even unimportant, *vis-à-vis* solving the questions he was working on. Even as Simon sought to develop the idea that one could simulate the psychological process of thinking, he tied his interest in economics and decision-making closely to computer science and psychology. He used computer science to model human problem solving in a way that was consistent with his approach to rationality. He implemented his early ideas of bounded rationality and means–ends analysis into the heart of his work on artificial intelligence.

MIE-SOPHIA AUGIER

SEE ALSO *Economics and Ethics; Management.*

BIBLIOGRAPHY

Augier, Mie-Sophia, and James G. March. (2002). "A Model Scholar." *Journal of Economic Behavior and Organization* 49(1): 1–17.

March, James G., and Herbert A. Simon. (1958). *Organizations*. New York: Wiley; 2nd edition, Cambridge, MA: Blackwell, 1993.

Newell, Allen, and Herbert A. Simon. (1972). *Human Problem Solving*. Englewood Cliffs, NJ: Prentice-Hall.

Simon, Herbert A. (1947). *Administrative Behavior*. New York: Macmillan; 4th edition, New York: Free Press, 1997.

Simon, Herbert A. (1955). "A Behavioral Model of Rational Choice." *Quarterly Journal of Economics* 69(1): 99–118.

Simon, Herbert A. (1969). *The Sciences of the Artificial*. Cambridge, MA: MIT Press; 3rd edition, 1996.

Simon, Herbert A. (1991). *Models of My Life*. New York: Basic.

SIMON, JULIAN

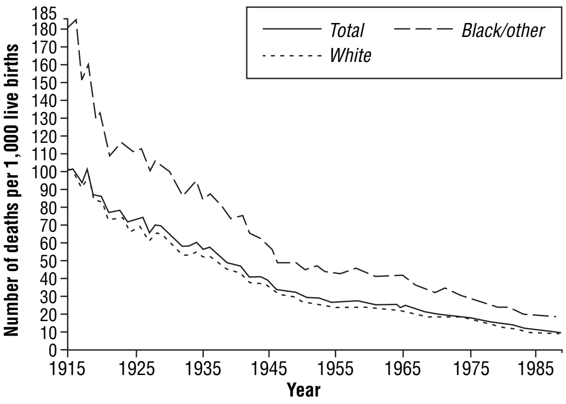
An economist who brought reams of evidence to bear against the conventional wisdom about the dangers of population growth and resource consumption, Julian Lincoln Simon (1932–1998) was born in Newark, New Jersey, on February 12; he attended Harvard University. After service in the Navy and work in advertising, Simon earned an MBA in 1959 and a Ph.D. in business economics in 1961, both from the University of Chicago. Although initially adopting the conventional Malthusian view that rapid population growth was a primary obstacle to economic prosperity in both the developed and developing worlds, his own research soon convinced him otherwise. Instead, science and technology, products of inexhaustible human ingenuity, have improved human welfare in nearly every measurable way and will continue to do so indefinitely into the future. He served as professor of business administration at the University of Maryland and distinguished senior fellow at the libertarian Cato Institute until his death from a heart attack in Maryland on February 8.

Against the Doomsayers

Simon had been fairly successful in the business and marketing fields during the mid-1960s. He operated a mail-order firm that was so lucrative he wrote the popular *How to Start and Operate a Mail-Order Business* (1965). But economic research led him to become critical of the grim Malthusian outlook on resource use and population growth popularized by Paul Ehrlich's *The Population Bomb* (1968) and *The End of Affluence* (1974), which argued that population growth was threatening human and environmental health. Simon replied that data from economists such as Simon Kuznets

FIGURE 1

Infant Mortality Rate, Total and by Race, United States, 1915–1989



SOURCE: *Historical Statistics of the US, Colonial Times to 1970,* Series B 136–147; *Statistical Abstract of the US, 1982–92*, table 111; *Statistical Abstract of the US, 1992*, table 109. In Simon (1995), p. 5.

(1901–1985) and Richard Easterlin (b. 1926) showed there was no general negative correlation between population growth and living standards (Regis 1997).

Simon began his much maligned public crusade against the conventional wisdom "doomsayers" with a 1980 article in *Science,* which declared that false bad news about resources, population, and the environment was being widely published in the face of contrary evidence. Tellingly, the article was written in the form of a statement followed by facts, because Simon believed that sound science revealed unequivocal facts about the state of the world. As he wrote in the preface to *The Ultimate Resource 2* (1996), "Indeed, the facts and my new conclusions about population economics altered my wider set of beliefs, rather than the converse" (p. xxxi). Here he implies that his adversaries are poor scientists because they allow preconceptions to trump empirical evidence. His major books and articles elaborating a positive view of the state of humanity are notoriously crammed with trend data in hopes that the weight of the facts will persuade readers of the doomsayers' errors.

Two trends that he saw as most convincing are declines in infant mortality and rises in life expectancy (see Figures 1 and 2). He also presented data on decreasing pollution, rising agricultural productivity, increasing standards of living, and the declining prices of natural resources and commodities. All of these figures detail the overarching story of human progress and affluence made possible by the ultimate resource, the human mind. Indeed, his central premise was that human ingenuity is boundless, creating unlimited resources to "free humanity from the bonds in which nature has kept us shackled" (Simon 1995, p. 23).

The Dialectic of Scarcity and Abundance

For Simon, the problems of scarcity and the achievements of abundance are not so much fundamental opposites as they are different moments in an ongoing process.

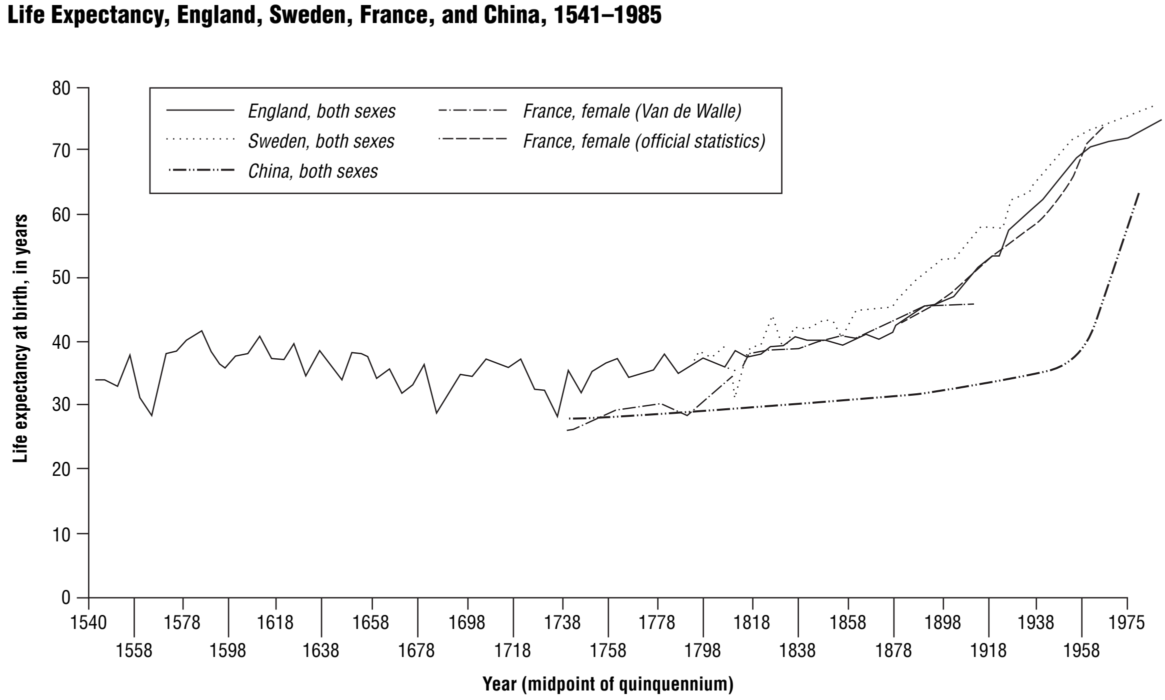
> The process goes like this: More people and increased income cause problems in the short run. These problems present opportunity, and prompt the search for solutions. In a free society, solutions are eventually found, though many people fail along the way at cost to themselves. In the long run the new developments leave us better off than if the problems had not arisen. [Indeed, human beings now have in their hands] the technology to feed, clothe, and supply energy to an ever-growing population for the next seven billion years. (Myers and Simon 1994, p. 65).

The evident hyperbole of this rhetoric should not be used to portray Simon as a Pollyanna. Problems do arise, people are harmed, and people often fail in trying to solve them. But the larger perspective reveals that the process produces ultimate benefits for human welfare, which Simon insists are best measured by long-run trends. There is a sense of theodicy in Simon's vision.

With regard to long-run measurements, absolute trends comparing present and past states of affairs are more important than relative trends comparing two contemporary variables. Simon also argues that broad aggregate measures should emphasize effects on people rather than phenomena themselves. For example, he measures life expectancy rather than occurrences of AIDS, or agricultural productivity rather than global warming.

Moreover, the dialectic between scarcity prediction and abundance production highlights Simon's core belief that liberty is the most important precondition for progress. Free markets, free institutions, and even the free flow of immigrants are necessary for long-term material progress. Most centrally, people ought to be free to have as many children as they desire, in part because children, through their own inventiveness, will add to human welfare. A better future does not happen automatically, but requires free and well-informed decisions.

FIGURE 2



SOURCE: Simon (1995), p. 9.

Finally, warnings about scarcities have a role to play in human welfare production. Unlike his opponents, who find his position detrimental, Simon actually grants critics an important if limited role in progressive developments. Simon's worldview partially depends on doomsayers to spark the impetus that steers humanity toward a better future.

Nonetheless, Simon believed that the "false bad news" of doomsayers is often overstated and can become counterproductive if not shamelessly self-promotional. With Herman Kahn (1922–1983) he co-edited *The Resourceful Earth* (1984) to discredit one such pessimistic volume, the *Global 2000 Report to the President* issued by the Global 2000 Study in 1980. More famously, Simon engaged in a highly publicized bet with Paul Ehrlich (b. 1932) in 1980. Ehrlich wagered that at least five of ten non-renewable resources (of his choosing) would be more expensive ten years later. Simon won the bet. In 1990, every one of the resources had declined in price by an average of forty percent. (When offered an opportunity to renew the wager for the next ten-year period, Ehrlich declined.)

As a result of his advocacy, Simon's ideas have won many converts to the idea that the status quo with some modest incremental adjustments will be sufficient for continued improvement in human well-being (e.g., Bailey 1993, Wildavsky 1995). His last major book, *The State of Humanity* (1995), was written with more than sixty collaborators. But despite the increased respectability accorded to Simon's views, they remain contentious and do not represent the mainstream in resource and population economics.

Science, Values, and the Hermeneutics of Data

From his very first article, Simon has been attacked by those who disagree with his views. Ehrlich called him an "imbecile," others considered his ideas simpleminded and dangerous, while most in the mainstream tried to refute the validity of his statistics (Regis 1997). But if the facts tell an unequivocal story, why is there so much disagreement? And if the facts corroborate Simon's analysis, why were his views so unpopular? Simon often felt that he was being ignored due to "a vast Malthusian population-environment-resources conspiracy of crisis" (1999, p. vii). In the posthumously published *Hoodwinking the Nation* (1999), he took up the question of why so much "false bad news" persists. He cited academic and media incentives and vested interests, psychological factors, strategies of change based on the assumption that crises mobilize action, racism, the non-intuitive nature of some of Simon's arguments, and widespread misunderstanding of resource creation and population economics. In all cases, he argued that what is at issue is the discrepancy between dominant, misguided beliefs and the facts of the matter.

On this level of psychological and sociological analysis, Simon undoubtedly presents some accurate findings. Yet a deeper level of analysis opens up beyond this limited argument that Simon has the true science and the absolutely correct data while others are just misled or willfully distorting the truth. For example, a graph may demonstrate that forest cover is increasing, but the reason for this may be the rise in forest plantations rather than recovery of more natural systems. Thus, the fact of increased forest cover leaves room for interpretation about its meaning and whether it is a good or a bad sign. Furthermore, some may find fault in Simon's anthropocentric view. They may regard global climate change as a problem even if humans are able to adapt to it, or they may object to his idea that genetic engineering and seed storage are reasonable responses to species extinction (1995, p. 15). Finally, some may argue that his categories miss the most important trends as he substitutes "what can be easily counted" for "what really counts." For example, in *The State of Humanity,* Simon admits that his trends describe only material and economic welfare but not emotional or spiritual welfare.

Unfortunately the underlying values differences between Simon and his adversaries are not often explicitly addressed. This held true of a similar controversy surrounding one of Simon's protégés, Bjørn Lomborg (b. 1965), author of *The Skeptical Environmentalist* (1998). Like Simon, Lomborg attacked the conventional wisdom and was in turn rebuked in a passionate series of exchanges with other scientists. Although disputants often claimed to be debating the facts, in reality the issues were much larger.

Despite his often zealous reliance on facts, Simon was perhaps aware of this dynamic to a greater extent than Lomborg. Whereas Lomborg concludes that we need to base decisions "not on fear but on facts" (p. 327), Simon concludes *The Ultimate Resource 2* with a section titled "Beyond the Data," including a subsection titled "Ultimately—What Are Your Values?" In this latter section he argued: "Whether population is now too large or too small, or is growing too fast or too slowly, cannot be decided on scientific grounds alone. Such judgments depend upon our values, a matter on which science does not bear" (p. 548). Measuring the real state of humanity or the world involves normative as well as scientific considerations.

CARL MITCHAM
ADAM BRIGGLE

SEE ALSO *Environmental Ethics; Science Policy.*

BIBLIOGRAPHY

Bailey, Ronald. (1993). *Ecoscam: The False Prophets of the Environmental Apocalypse*. New York: St. Martin's Press. Deconstructs the conventional wisdom about resources and population growth in much the same way as Simon.

Ehrlich, Paul R. (1968). *The Population Bomb*. New York: Ballantine.

Ehrlich, Paul R., and Anne H. Ehrlich. (1974). *The End of Affluence: A Blueprint for Your Future*. New York: Ballantine.

Lomborg, Bjørn. (2001). *The Skeptical Environmentalist: Measuring the Real State of the World*. New York: Cambridge University Press. Full of trend data to support Simon's basic position that problems are mostly getting smaller rather than larger.

Myers, Norman, and Julian L. Simon. (1994). *Scarcity or Abundance? A Debate on the Environment*. New York: Norton.

Simon, Julian. (1965). *How to Start and Operate a Mail-Order Business*. New York: McGraw-Hill.

Simon, Julian. (1980). "Resource, Population, Environment: An Oversupply of False Bad News." *Science* 208(4451): 1431–1437.

Simon, Julian. (1996). *The Ultimate Resource 2,* rev. edition. Princeton, NJ: Princeton University Press.

Simon, Julian. (1999). *Hoodwinking the Nation*. New Brunswick, NJ: Transaction Books. Explains why the false litany of environmental bad news persists despite evidence to the contrary.

Simon, Julian, ed. (1995). *The State of Humanity*. Cambridge, MA: Blackwell.

Simon, Julian L., and Herman Kahn, eds. (1984). *The Resourceful Earth: A Response to Global 2000*. Oxford, UK: Basil Blackwell.

Wildavsky, Aaron. (1995). *But is it True? A Citizen's Guide to Environmental Health and Safety Issues*. Cambridge, MA: Harvard University Press. Case studies explore relationships between knowledge and action in environmental policy to argue that informed participation is a possible and necessary part of democratic citizenship. Concludes by rejecting the precautionary principle.

INTERNET RESOURCE

Regis, Ed. (1997). "The Doomslayer." *Wired Magazine* vol. 5, no. 2, pp. 136-140 and 193-198. Available from http://www.wired.com/wired/archive/5.02/ffsimon_pr.html. Recounts the confrontations between Ehrlich and Simon and clarifies Simon's basic points.

SIMPLICITY AND SIMPLE LIVING

The term *simple living* is generally used to refer to a voluntarily chosen way of life that is significantly less frenetic, and significantly less focused on "getting and spending," than life in the mainstream. Simple living traditions exist in a wide array of cultures, and date back thousands of years. But they take on special salience in highly affluent societies dependent on science and technology for their patterns of production and consumption.

The term *simplicity* is sometimes used synonymously with *simple living,* but this can lead to confusion as one of the potential uses of high levels of income is to purchase solutions to the burdens of everyday life. Thus, the very wealthy can afford to have personal assistants to take care of their finances, assist in childrearing, and manage the household, vastly simplifying their existence.

Basic Arguments

A theme common to many diverse simple living traditions is that too great an involvement with money is deeply problematic. A classic presentation of this thesis is found in Aristotle's *Politics* (4th century B.C.E.), which opens with a critique of excessively commercialized civilization. Aristotle (384–322 B.C.E.) distinguishes between what he terms natural and unnatural ways of life. Among the natural ways are hunting, fishing, and farming. What is distinctly unnatural is commerce, whose hallmark is that the pursuit of money takes on a life of its own, knowing no bounds.

Aristotle offers two critiques. The first anticipates the economic theorists of the nineteenth century: Aristotle argues for the diminishing marginal utility of money, maintaining that beyond a limited sufficiency, additional money does not contribute to human happiness. His second thesis is yet more radical, arguing that the unbridled absorption in attaining money results in the misuse of human capabilities and the distortion of the personality. When elevated to the social level, this produces a society in which all social roles have been corrupted. Doctors no longer pursue the health of the patient; jurists no longer seek justice. All activities are ultimately undertaken in pursuit of financial gain.

The two issues Aristotle raises, distortion of the personality and corruption of social roles, are two of a number of concerns that have motivated proponents of simple living. An example of the first is Henry David Thoreau (1817–1862), who wrote in *Walden* (1854) that wealth is a curse because it enslaves us. "I see young men, my townsmen, whose misfortune it is to have inherited farms, houses, barns, cattle and farming tools; for these are more easily acquired than got rid of." And, "The finest qualities of our nature, like the bloom on fruits, can be preserved only by the most delicate handling. Yet we do not treat ourselves nor one another thus tenderly" (Thoreau 1965, p. 4 and p. 6).

An example of the second concern, the health of the society, can be found in what has been called *Republican Simplicity* by historian David Shi. In the mid 1700s prior to the American Revolution, many of the leaders of that Revolution looked to the history of ancient Rome and Greece for guidance in their democratic venture. The lesson that they drew was that public virtue was necessary for the success of a republic, and that it could be undermined by excessive commercialism. John Adams (1734–1826) and Thomas Jefferson (1743–1826) corresponded about how to build a non-materialist society, and Jefferson looked to state-supported schools and value education as a foundation.

In the writings of the Quaker theorist John Woolman (1720–1772), one finds two lines of thought, both of interest. First, in contrast to the Puritans, Woolman suggested that the simple life also involved limitations on the amount of work one would do. This would later be expanded on by Thoreau, who suggested that we should have one day of work and six days of Sabbath. Secondly, Woolman argued that most of the ills of the world—poverty, slavery, war—could be traced to luxurious desires. He urged that we examine our own lives and see whether, unwittingly, we are part of the problem. He said we should "look upon our treasures, and the furniture of our houses, and the garments in which we array ourselves, and try whether the seeds of war have nourishment in these our possessions or not." The contemporary application of this outlook is the suggestion that war in the Middle East, and perhaps terrorism as well, have their roots in our excessive consumption of oil.

Benjamin Franklin (1706–1790), another American advocate of simple living, came to it from a rather different direction. Franklin argued the importance of the individual's liberation from the demands of onerous labor. "Employ thy time well, if thou meanest to gain Leisure." But Franklin argued for sharply limiting our consumption, so that we may save. His message was that we could all become wealthy if we learned to discipline ourselves, limited our desires, and earned more than we consumed.

Assessment and Application

These various examples make clear that simple living can be advocated for a wide variety of reasons. It represents no single philosophy of life. And while there are some exceptions—perhaps Franklin is one—what they have in common is the view that the good life, both individually and socially, is to be found largely outside the economic realm. Human happiness is obtained not by consuming more and more of what the economy has to offer, but by satisfying core economic needs, and then turning away from the economic to other realms of importance, whether they be religion, science, literature, service to others, or friends and family.

While much of the simple living literature is directed at the individual, offering advice and suggestions for how to live, simple living at times emerges as a politics of simplicity. Here it looks to social policy to offer the framework within which it becomes feasible for the average person to opt for a simple life. Such a politics offers a different paradigm for understanding the relationship between a technological economy and the good life. Economic performance is assessed not in terms of growth, but in terms of success in meeting core needs of the entire population. Technological and economic progress is measured more in terms of the expansion of leisure than the growth of gross domestic product (GDP). And work, rather than being seen as one productive input within the production process, is seen, potentially, as a realm within which personal growth and meaning can be achieved.

JEROME M. SEGAL

SEE ALSO *Consumerism.*

BIBLIOGRAPHY

Shi, David. (2001). *The Simple Life: Plain Living and High Thinking in American Culture.* Athens: University of Georgia Press. Shi provides a comprehensive and highly readable account of the different forms that simple living has taken, in practice and thought, throughout the American experience.

Segal, Jerome M. (2003). *Graceful Simplicity: The Philosophy and Politics of the Alternative American Dream.* Berkeley: University of California Press. Segal challenges the standard view within the simple living literature that, except for pockets of poverty, Americans have sufficient income to meet core economic needs. Rather than a "how to" book on simple living, he calls for a new approach to social and economic policy. He emphasizes the importance of beauty within the good life.

Thoreau, Henry David. (1965). *Walden and Other Writings,* ed. Brooks Atkinson. New York: The Modern Library.

SINGAPORE

Small states, like small businesses, often serve as the incubators of new forms of government. Perhaps no state has been so carefully and deliberately managed as Singapore, a multi-ethnic island city-state of 4 million inhabitants in an area of 250 square miles, or about the size of Guam. Because of the ways its management has sought to utilize science and technology to achieve certain social values, which has itself influenced some of these values, Singapore provides a useful case study in the possible relations between science, technology, and ethics.

Background

Located on the southern tip of the Malay Peninsula and separated from Indonesia, the largest Muslim country in the world, by the Straits of Malacca, Singapore was colonized by the British in the early 1820s due to its strategic location (for the British, it was the Gibraltar of the East). Important because it served as both a submarine port and had a major airfield, the Japanese captured Singapore during World War II. After the war it evolved toward independence in phases: It elected its first legislature in 1955 and was granted internal self-government in 1959. In 1963 Singapore joined the Federation of Malaysia, but separated in 1965 and has been fully independent since.

The People's Action Party (PAP), founded and dominated by Lee Kuan Yew (b. 1923), a British-educated lawyer, has led the country since the mid-1950s, creating a single-party state dedicated to the pursuit of economic growth through social order and efficiency under the guidance of a technocratic ideology. The result has been one of the most globalized entities in the world, measured in terms of foreign trade, investment, information inflows, and immigration. Between 1971 and 2003, Singapore's economy expanded at an average annual gross domestic product (GDP) growth rate of 7.2 percent. It enjoys one of the highest standards of living in Asia and was ranked sixth in the Growth Competitive Index conducted by the World Economic Forum in 2003.

From Stability to Creativity

Constant technological upgrading has been vital to the economic ascendancy of Singapore, and social policies have been reflexively monitored and implemented—whether in the streaming policies of the educational system, the level of civil liberties, or the value system of society—to ensure Singapore's global economic relevance. The political elite's Hobbesian view of national and international politics underpins Singapore's broad ethical approach to economic and technological development. The dominant image widely propagated in Singapore is that of a vulnerable city-state, lacking both natural resources and the cultural homogeneity of a Japan or a Korea (Singapore's ethnic composition is 76.8 percent Chinese, 14 percent Malay Muslim, and 8 percent Indian), and surrounded by potentially volatile Malay Muslim neighbors. The Singaporean leadership has used "survival" to justify the hierarchical management of society. The resulting political system has been dubbed by Chan Heng Chee (1989) as "the administrative state," a term that captures the depoliticization of the citizenry and the central place of a powerful bureaucracy in managing society. The political elite sees itself as practicing a pragmatic style of governance, understood as the ability to act rationally in the interest of the collective good without getting bogged down by moral and democratic excesses (Chua 1995).

The value framework has varied with the technological challenges facing Singapore. From the mid-1960s to the mid-1990s, technocratic planners invited multinationals from around the world to invest and manufacture consumer goods, and later highly sophisticated engineering components, for the global market. Founding leader Lee Kuan Yew, with strong eugenics views (Barr 2000), did not believe that Singapore's small population could produce a critical mass of creative individuals doing cutting-edge research. Instead, science and technology policies focused on producing highly competent citizens who could absorb and perhaps re-engineer products and processes from existing technology. Huge investments were made in tertiary education to supply technicians and engineers for the multinational sector at cheaper costs than in Western countries. Generous tax incentives, a highly controlled labor movement, and the sheer predictability of politics attracted some 7,000 well-known global companies to invest in the economy. These included such names as Philips, Honeywell, Hewlett-Packard, Seagate, Motorola, Exxon-Mobile, NEC, Siemens, and Sony.

In this phase, the ethical framework laid out by the government for technology development was a broad, society-wide one rather than a set of specific policies applied to particular industries or sectors. Singaporeans were expected to be socially disciplined, to comply with the technocratic goals of the government, and to refrain from excessive individualism and political expression (Quah 1983). They were asked to subscribe to a stereotypical notion of Asian values, which the leaders believed would help the population ward off pernicious Western practices, such as weak commitment to the family, a propensity for contention over consensus, and a disrespectful youth culture. Singapore became famous for harsh punishments for behaviors such as littering, failing to flush public toilets, and small-scale drug dealing. The government expected conformity and in turn promised order, prosperity, integrity, and dedication to the collective good.

In the 1990s, however, new competitive pressures led to a major shift in the government's approach to technological development, and in almost cybernetic fashion, adjustments in social regulation policies. Countries previously outside the global capitalist system, such as China, India, and Central Europe, were now entering the global market. The Asian crisis that began in 1997 saw multinationals changing locations in the region. Gripped by concerns of national survival, planners saw the need to go beyond using multinationals for economic development and technology transfer, and undertook to produce original knowledge and technology. The planners hoped to build on existing educational and scientific infrastructures, such as the Institute of Molecular and Cell Biology (IMCB), which had been set up in 1987, to embark on original research.

The sectors targeted to spearhead the knowledge-based economy were bioscience and biomedical research, with foci in tissue engineering, stem cell research, immunology, and cancer research. Through these efforts, Singapore hoped to become a major player in pharmaceuticals, medical equipment, and health services. More than a billion U.S. dollars was committed toward creating an integrated medical and biotechnological park, Biopolis, and huge funds were earmarked for strategic investments in local and foreign biotechnology companies.

Framework for Policy and Ethics

The key question was how Singapore, without a long history of broad-based original research, would make the transition from being a technology-recipient to technological innovator. This challenge was met with a two-pronged approach. The planners mapped out a research process in which innovation would be carried out and directed by global research stars drawn to Singapore by alluring financial terms, including generous research funding. The other tack, and an important further inducement for researchers, was the creation of a stable and predictable milieu for long-term research, particularly in the biomedical area, unencumbered by moral and religious obstacles. Some technologically sophisticated nations, especially the United States, were putting restrictions on research involving living embryos, so Singapore's ability to provide a liberal moral climate allowing for such research would place it in a comparative advantage. Singapore's technocrats now had to use skills that had provided the high degree of economic, social, and political predictability during the technology-receiving phase to lay the requisite financial and ethical predictability for these new research and technological goals.

The challenge in creating a liberal moral climate involved coming to terms with local religious groups, particularly those from the growing Christian population among the upper stratum of Singaporeans. In addition, to gain legitimacy from the international community of researchers and regulators, Singapore had to demonstrate that it was not a morally renegade society but was committed to socially responsible research. This led the government to set up the Bioethics Advisory Council (BAC) in late 2000 to make recommendations for bioscience and biomedical research in Singapore. The committee, which was chaired by the former Vice-Chancellor of the National University of Singapore, stated that it would consult civil society groups, professional associations, and religious organizations in carrying out its charge, and promised to proceed with caution "so our findings and recommendations will be acceptable to society" (*Straits Times*, February 7, 2001).

Civil society in Singapore was generally quiescent (Tamney 1996), but on this morally sensitive issue involving the use of human embryos for research, religious groups freely gave their opinion. (Singapore is 42.5 percent Buddhist, 15 percent Muslim, 14.5 percent Christian, 8.5 percent Daoist, 4 percent Hindu, and 15 percent claiming no religion.) Most professional groups went along with embryonic stem cell research, but there was consternation among the religious representatives. Muslim representatives, believing that ensoulment of the human being begins forty days after conception, were amenable to early stage embryonic research. The same was true of the Buddhist groups, which view genetic research as helping humankind. By contrast, Protestant and Catholic bodies, as well as Hindu and Daoist representatives, objected to any destruction of embryos to obtain stem cells. Daoists argue it was against nature's way, Christians define life as beginning at conception, and Hindus see the destruction of the embryo as short-circuiting the karmic cycle. The deontological ethical position of these groups was at variance with the BAC, whose desire was to see bioscience development in Singapore. As far as the BAC had an ethical position, it was a consequentialist one, proffering the benefit to humankind of finding cures to terrible diseases as a result of bioscience research. The Council subsequently ruled that its recommendations would not be dictated by religious positions, and argued, in typical pragmatic language, that research had to move ahead because "Singapore is a small place" (*Straits Times*, December 28, 2001).

Its recommendations, which were incorporated in the Biomedical Research Act of 2003, allowed for stem cells to be obtained from human embryos less than fourteen days old, the age just before the neurological system developed (Bioethics Advisory Committee 2002). Embryos less than fourteen days could be cloned but there would be no cloning of embryos for reproductive purposes. As if to underscore its ethical concerns, the Council stressed that all researchers and doctors required the consent of patients and embryo donors. In addition, the BAC was keen to point out that its recommendations were no more lax than legislation in other democracies such as the United Kingdom, Australia, Japan, and Sweden. In short, it was acting well within international norms. Despite some religious misgivings, resulting legislation is likely to preempt any future religious or moral objections, because both the government and the regulatory bodies can claim that society had been fully consulted in the decision-making process, and most groups went along with the final recommendations.

Singapore's liberal moral climate and weak civil society has earned the praise of many top scientists. A number of U.S. scientists, responding to the Bush administration's banning of embryonic research and its strict control over the use of existing stem cell lines, have found Singapore to be a more hospitable climate for their research. Dr. Philippe Taupin, a renowned biologist previously at the Salk Institute, gave the following reason for his move to Singapore in 2003: "I came here because I want to jumpstart my career. There are fewer ethical and political minefields than in the West, and Singapore has pledged a strong commitment to stem cell biology" (*Straits Times*, February 17, 2004).

Prospects

Singapore's strategy of bringing in experts from abroad has been impressive. Generous funding, which makes it unnecessary to apply constantly for research grants, and an uncritical climate, which extends to the plentiful supplies of laboratory mice undisturbed by animal rights activists, have been major draws. An influx of high-profile researchers would help both to leapfrog into cutting edge research and attract younger scientists the world over by establishing a prestigious and reputable climate. In 2003, 30 percent of the 3,600 Ph.D.s working in the biomedical sector were foreigners. Global stars such as Edison Liu, formerly at the National Cancer Institute in the United States, Alan Colman of "Dolly the sheep" fame, and Yoshiaki Ito from Kyoto University have given Singapore overnight attention as a global research center. Whole research teams from Japan and France have immigrated and been generously funded. The administrative coordination of education, immigration, and the health sector to support the advancement of bioscience has greatly impressed foreign researchers. Liu, who came to Singapore in 2001 to head the Genome Institute of Singapore (GIS), marveled at the integrative approach of the leaders and planners: "They are strategic thinkers, and are smart enough to view this as a whole. It is the most astounding social engineering I have seen in my life" (*Far Eastern Economic Review*, October 9, 2003).

The top-down control of society has not prevented the pragmatic relaxation of social controls from helping to realize the leaders' economic goals. Departing selectively from its previous preoccupation with social discipline and conformity, the government now asks Singaporeans to become creative individuals willing to take entrepreneurial risks. Activities such as bungee jumping, bar-top dancing, and street busking, once banned and frowned upon, are now being permitted to foster an adventurous spirit among the population. The most dramatic reversal has been to allow the lesbian and gay population to join the civil service. The tolerance of homosexuality, once derided as contrary to Asian values, is now seen as consistent with the pursuit of creativity—as argued by Richard Florida (2004).

Ethical Ambiguity

It would not be surprising if the urgency of meeting national economic goals in conjunction with the pragmatic design of the ethical framework for research should leave some ambiguity about the moral boundaries of research. A test case occurred in 2002, involving a world-famous British researcher, Dr. Simon Shorvon, a neurologist who had done pioneering work in epilepsy and Parkinson's disease. After being courted by Singapore authorities, he took up the position of Director of the National Neuroscience Institute. Shorvon's research into the role of genetic mutations in Parkinson's required patients to go off their medications while he studied the effects of administering various doses of L-Dopa and traditional Chinese herbs. The research design required 1,500 Parkinson patients, but only twelve volunteers were available as of July 2002.

To secure more subjects, Shorvon retrieved records from the databases of pharmacies, deliberately bypassing the patient's doctors, and then led patients to believe that they had their physicians' approval for their research participation. In his experiments, Shorvon and his co-workers sometimes administered drugs at dangerously high levels, causing a few serious complications. When Singapore neurologists learned of his research and complained, he dismissed their concerns by saying that his methods were sensible and efficient, and claimed he had the backing of the various hospital review boards. Many of the Singapore doctors, including established professors, were torn between their commitment to patient rights and research ethics and the presumed importance of Shorvon's research. None of his peers and fellow neurologists made an official complaint.

Consistent with the top-down system of control in Singapore, it took a member of the inner circle of the elite to highlight and publicize the wrongdoing. Dr. Lee Wei Ling, a neurologist and (then) Deputy Director of the National Neuroscience Institute, is also the daughter of Lee Kuan Yew and sister to the current prime minister. When she was hospitalized for a neurological problem, her fellow neurologists mentioned the activities of Dr. Shorvon (*Straits Times*, April 4, 2003). Dr. Lee then reported him to the relevant authorities, leading to his removal. The interesting point about this case is not the lack of ethical standards in Singapore's research setting, but the fact that individual doctors and researchers did not feel sufficiently empowered by the hierarchical ethical system to take it upon themselves to expose wrongdoing. It took a member of the elite, who fortuitously happened to personally object to the egregious activities, to give weight to the ethical framework already in place.

JAMES V. JESUDASON
HABIBUL H. KHONDKER

SEE ALSO *Modernization; Political Economy; Political Risk Assessment; Science Policy.*

BIBLIOGRAPHY

Barr, Michael D. (2000). *Lee Kuan Yew: The Beliefs Behind the Man*. Washington, DC: Georgetown University Press. An informative book on the ideas behind Singapore's social engineering policies.

Bioethics Advisory Committee of Singapore (BAC). (2002). *Report on Ethical, Legal, and Social Issues in Human Stem Cell Research, Reproductive and Therapeutic Cloning*. Singapore: Author.

Chan Heng Chee. (1989). "The PAP and the Structuring of the Political System." In *Management of Success: The Moulding of Modern Singapore,* ed. Kernial Singh Sandhu and Paul Wheatley. Singapore: Institute of Southeast Asian Studies. A good distillation of this prominent author's works on Singapore politics.

Chua, Beng Huat. (1995). *Communitarian Ideology and Democracy in Singapore*. London: Routledge. An influential book on Singapore's political ideology.

Florida, Richard. (2004). *The Rise of the Creative Class*. New York: Basic Books. A controversial book arguing that a culture of diversity and tolerance in cities accounts for high economic growth.

Quah, Stella R. (1983). "Social Discipline in Singapore." *Journal of Southeast Asian Studies* 14(2): 266–289.

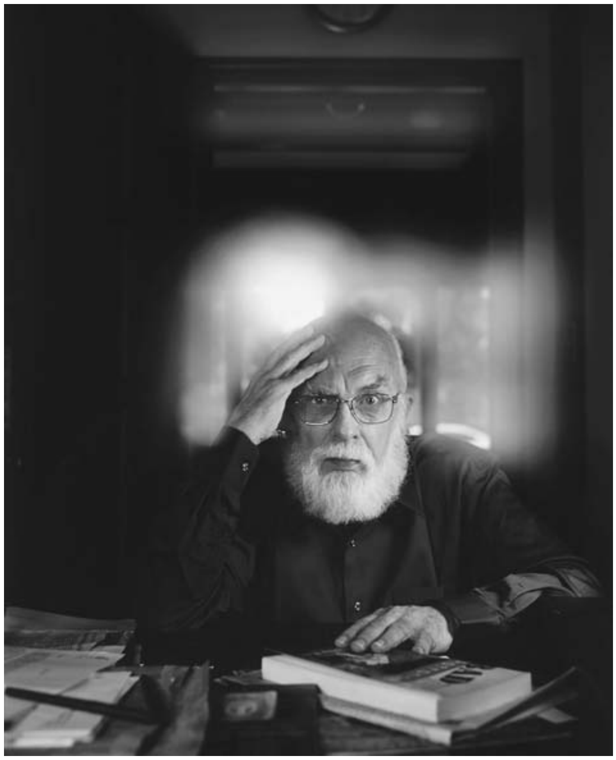
Tamney, Joseph B. (1996). *The Struggle Over Singapore's Soul: Western Modernization and Asian Culture*. Berlin: W. de Gruyter. A careful survey of Singapore's blend of Asian and Western values.

SKEPTICISM

Skepticism has a long history that includes multiple meanings and in the early twenty-first century has complex ethical implications for science and technology. It plays an important role *within* science and technology but also can be *applied to* the same areas. In the former case skepticism may serve as a means to reject mistaken or false claims, limit fraud and misconduct, and produce evaluations of engineering designs and the safety of technologies. In the latter case skepticism may help the public place the benefits of science and technology in a larger perspective, although it also may deprive the public of certain real benefits.

Antecedents

The roots of skepticism can be traced back at least 2,500 years to the ancient Greeks. The historian of skepticism Richard Popkin states: "Academic scepticism, so-called because it was formulated in the Platonic Academy in the third century, B.C.E., developed from the Socratic observation, 'All I know is that I know nothing'" (Popkin 1979, p. xiii). In fact, the philosopher Pyrrho and his followers doubted the possibility of real knowledge of any kind, a viewpoint that led to a form of nihilism. Skepticism in this sense is a positive assertion about knowledge and thus cannot be held seriously if it is turned on itself: If one is skeptical about everything, one also has to be skeptical about one's own skepticism. Like a decaying subatomic particle pure skepticism uncoils and spins off the viewing screen of the mind's intellectual cloud chamber.



Magician James "the Amazing" Randi. Randi's media presence has brought the skeptical movement into the public consciousness. *(© Jeffery Allan Salter/Corbis.)*

A more pragmatic meaning of the word *skeptic* can be found in the Greek word *skepsis,* which means "examination, inquiry, consideration." The *Oxford English Dictionary* gives this historical usage: "One who doubts the validity of what claims to be knowledge in some particular department of inquiry; one who maintains a doubting attitude with reference to some particular question or statement," along with "a seeker after truth; an inquirer who has not yet arrived at definite convictions." Skepticism is not "seek and ye shall find" but "seek and keep an open mind." In this context having an open mind means finding the essential balance between orthodoxy and heresy, between a total commitment to the status quo and the blind pursuit of new ideas, between being open-minded enough to accept radical new ideas and being so open-minded that one's brain cannot function.

Since the time of the ancient Greeks skepticism has evolved along with other epistemologies. On one level the Enlightenment was a century-long skeptical movement because there were few beliefs or institutions that did not come under the critical scrutiny of thinkers such as Voltaire (1694–1778), Denis Diderot (1713–1784), Jean-Jacques Rousseau (1712–1778), John Locke (1632–1704), and Thomas Jefferson (1743–1826). David Hume (1711–1776) in Scotland and Immanuel Kant (1724–1804) in Germany were skeptics' skeptics in an age of skepticism, and their influence continues to be felt in the early 2000s. In the twentieth century Bertrand Russell (1872–1970) and Harry Houdini (1874–1926) stood out as representatives of skeptical intellectuals and activists, respectively. Martin Gardner's *Fads and Fallacies in the Name of Science* (1952) launched the contemporary skeptical movement.

The Contemporary Skeptical Movement

Starting in the 1970s, the magician James "the Amazing" Randi's psychic challenges and media appearances pushed the skeptical movement to the forefront of public consciousness. In 1976 the philosopher Paul Kurtz (born 1925) founded an international skeptical organization called the Committee for the Scientific Investigation of Claims of the Paranormal (CSICOP), and in 1991 Michael Shermer cofounded the Skeptics Society and *Skeptic* magazine. This has led to the formation of a burgeoning group of people calling themselves skeptics who conduct investigations, hold monthly meetings and annual conferences, and provide the media and the general public with natural explanations for apparently supernatural phenomena.

Although intellectual skepticism flourishes in academia, skeptical activism has emerged as a powerful force in the application of science to all claims. In fact modern skepticism is embodied in the scientific method, which involves gathering data to formulate and test naturalistic explanations for natural phenomena. A claim becomes factual when it is confirmed to an extent where it would be reasonable to offer temporary agreement. However, all facts in science are provisional and subject to challenge, and skepticism thus is a method that leads to provisional conclusions.

Some claims, such as water dowsing, extrasensory perception (ESP), and creationism, have been tested and have failed the tests often enough that they may be rejected provisionally as false. Other claims, such as hypnosis, near-death experiences, and neurological correlates of consciousness, also have been tested, but the results have been inconclusive. Finally, there are claims, such as string theory, inflationary cosmology, and multiple or parallel universes, that are theoretically possible but have not been tested empirically. The key to skepticism is to apply the methods of science continuously and vigorously to make it possible to navigate the straits between "know nothing" skepticism and "anything goes" credulity. In this sense skepticism is the ethical component of science. It is the attitude that keeps the scientific method honest, the canary in the scientist's mine.

Ethical Issues

In regard to ethical concerns it is important to recognize the fallibility of science and skepticism. Although scientific skepticism is well suited for identifying certain kinds of mistakes and errors in thinking, such as what are called type I errors, or false positives, its standards are so high that it occasionally leads to the commission of a type II error, or false negative, failing to identify, for example, potential lifesaving medicines.

However, within this fallibility there are opportunities for self-correction. Whether mistakes are made honestly or dishonestly, whether a fraud is perpetrated unknowingly or knowingly, in time it will be recognized. The cold fusion fiasco in the late 1980s was a classic example of how organized skepticism can identify hype and error. Because of the importance of this self-correcting feature, there is in the profession what the Nobel laureate physicist Richard Feynman called "a principle of scientific thought that corresponds to a kind of utter honesty—a kind of leaning over backwards." As Feynman explained: "If you're doing an experiment, you should report everything that you think might make it invalid—not only what you think is right about it: other causes that could possibly explain your results" (1988, p. 247). Of course, not all scientists live up to this ideal.

What separates skepticism and science from other human activities is the tentative nature of all conclusions: There are no final absolutes, only varying degrees of probability. Skepticism is not the affirmation of a set of beliefs but a process of inquiry that leads to the building of a testable body of knowledge that is open to rejection or confirmation. In skepticism, knowledge is fluid and certainty is fleeting. That is the heart of its limitation and its greatest strength.

MICHAEL SHERMER

SEE ALSO *Libertarianism; Locke, John; Merton, Robert; Pseudoscience; Tocqueville, Alexis de; Wittgenstein, Ludwig.*

BIBLIOGRAPHY

Feynman, Richard P. (1988). *What Do YOU Care What Other People Think?* New York: Norton. A collection of first-person accounts by a Nobel laureate on how science is done, including his investigation into the Space Shuttle *Challenger* disaster.

Gardner, Martin. (1982 [1952]). *Fads and Fallacies in the Name of Science*. New York: Dover. The book that launched the skeptical movement. Still current after fifty years, it covers unidentified flying objects, scientology, alternative medical claims, and ways to detect pseudoscience.

Hecht, Jennifer Michael. (2003). *Doubt: A History: The Great Doubters and Their Legacy of Motivation, from Socrates and Jesus to Thomas Jefferson and Emily Dickinson*. San Francisco: Harper. A comprehensive history of skepticism from the ancient Greeks to modern atheists; includes both intellectuals and activists.

Popkin, Richard H. (1979). *The History of Scepticism from Erasmus to Spinoza*. Berkeley: University of California Press. An excellent history of intellectual skepticism by a philosopher and skeptic.

Randi, James. (1985). *Flim Flam! Psychics, ESP, Unicorns and Other Delusions*. Buffalo, NY: Prometheus Books. The classic work of a master investigator of psychics and scam artists; includes his many personal investigations into the world of the paranormal.

Shermer, Michael. (1997). *Why People Believe Weird Things: Pseudoscience, Superstition, and Other Confusions of Our Time*. New York: Freeman. A skeptical and scientific manifesto that includes analyses of creationism, Holocaust denial, immortality, near-death experiences, cults, and the nature of pseudoscience and superstition.

SKINNER, B. F.

The reinventor and foremost champion of behaviorist psychology, Burrhus Frederic Skinner (1904–1990) was born in Susquehanna, Pennsylvania on March 20, and died at age 86 in Cambridge, Massachusetts on August 18. Building on the work of Ivan Pavlov (1849–1936), Edward Thorndike (1874–1949), and J. B. Watson (1878–1958), B. F. Skinner made unique contributions to the science of human behavior and intended for his work to serve as the basis for technologies by which human beings could control themselves and others for the benefit of all.

Life and Achievements

Graduating from Hamilton College, New York, with a bachelor's degree in English, Skinner initially wanted to become a writer. This vocation eluded him, and after a period of time in Greenwich Village he enrolled for graduate studies at Harvard University, where he earned his doctorate in psychology in 1931. In 1936 he went to teach at the University of Minnesota, where he met and married Yvonne Blue. In 1945 he became chair of the psychology department at Indiana University, but three years later returned to Harvard as a professor, where he remained for the rest of his academic career.

B. F. Skinner, 1904–1990. The American experimental psychologist became the chief exponent of that form of behaviorism known as operationism, or operant behaviorism. *(The Library of Congress.)*

Skinner's work centered on the idea of *operant conditioning*. Unlike classical behaviorism, operant conditioning is the idea that as living organisms move about in their environments, behaviors that meet with reinforcing stimuli will be promoted, and other behaviors will not. Imagine saying "Hello" to associates at work, to which they give cheerful and friendly replies, leading to increased greetings; in the absence of any response, greetings will likely diminish or cease. Skinner elaborated this insight into diverse schedules of reinforcement (fixed and variable ratio and interval schedules) in order to investigate empirically their various degrees of effectiveness in behavior modification. Anthony Burgess's novel, *A Clockwork Orange* (1962) and the Stanley Kubrick film of the same title (1972) misrepresent behavior modification as using aversive reinforcement or stimuli (punishment) to discourage behavior, which Skinner regarded as ineffective.

Skinner was a fervent advocate of the application of operant conditioning. He even publicized that he applied his theories to his children, especially his younger daughter, who was in part raised in an air crib designed by Skinner. As a result of Skinner's work, operant conditioning became popular among therapists; some remained devotees into the twenty-first century.

But some problems with operant conditioning have led to skepticism. Among these are the underlying assumption of determinism and the dismissal of human consciousness. Skinner also proposed awkward ways for understanding emotions and thinking—the latter he dubbed "probability of verbal behavior"—so they would conform to the requirement of being observable (in Skinner's mind, a general requirement for all experimental sciences).

It is also unclear how some reinforcing stimuli become reinforcing in the first place. Suppose one hopes that saying "Hello" will encourage associates to leave one alone. Instead, they become intrusively friendly. The condition thus backfires. Ordinarily it is not difficult to tell a welcome response, but with complex actions this is no longer simple. Some critics argue that Skinner was openly ambivalent about whether human conscious life exists (Baars 2003), but others find in Skinner the most advanced way to apply modern science to human life and human society (Woodward and Smith 1996).

Controversies

Skinner thought that his insights into the technology of behavior ought to be used to cure sociopolitical problems. His presentation of this view in a utopian novel, *Walden II* (1948), and in such applications as *The Technology of Teaching* (1968), drew extensive criticism. Many charged him with proposing an anti-democratic technocracy that would extinguish human liberty and morality.

His response to this criticism was his most famous book, *Beyond Freedom and Dignity* (1971). Here he argued that "freedom" and "dignity" are pre-scientific concepts, and shifting to scientific terminology and applications would advance human life and society better than rhetoric. For Skinner, the scientific approach is the most dependable, reliable way to understand the world, and the implications of this approach are so significant as to render it imperative to follow it in all spheres of human concern. Religion, morality, free will, and even feelings are to be purged from an objective (that is to say, empirical) scientific conception of relationships to the world and each other. Indeed, Skinner thought that the more humans adopted his recommendations, the more likely they would be to achieve the goal of peace.

As to the overall success of Skinner's ideas, on some fronts his views have triumphed. His ideas that humans and other animals are pretty much the same have been well received in the burgeoning animal rights or liberation movement, for example. In applied psychology, however, Skinner has lost much appeal. Cognitive psychology, for example, has eclipsed his behaviorism. Skinner remains, however, one of the twentieth century's most prominent theorists about human behavior, next, perhaps, only to Sigmund Freud.

TIBOR R. MACHAN

SEE ALSO *Genetics and Behavior; Psychology; Utopia and Dystopia.*

BIBLIOGRAPHY

Baars, Bernard J. (2003). "The Double Life of B.F. Skinner: Inner Conflict, Dissociation and the Scientific Taboo Against Consciousness." *Journal of Consciousness Studies* 10(1): 5–25(21). This issue of the journal contains the lead essay by Baars and several replies, including one from Skinner's daughter, Julie S. Vargas.

Bjork, Daniel W. (1993). *B. F. Skinner: A Life*. New York: Basic Books. This is a comprehensive guide to B. F. Skinner's life.

Skinner, B. F. (1948). *Walden Two*. New York: Macmillan. Skinner's novel is his illustration of the kind of society his technology of behavior would produce.

Skinner, B. F. (1953). *Science and Human Behavior*. New York: Macmillan. Skinner's most accessible scientific book.

Skinner, B. F. (1968). *The Technology of Teaching*. New York: Appleton-Century-Crofts. The focus here is the deployment of Skinner's technique for teaching.

Skinner, B. F. (1971). *Beyond Freedom and Dignity*. New York: Viking. Skinner's most popular book on his understanding of human life and society.

Skinner, B. F. (1974). *About Behaviorism*. New York: Knopf. Skinner's explanation of his work in the later stages of his career.

Woodward, William R., and Laurence D. Smith, eds. (1996). *B. F. Skinner and Behaviorism in American Culture*. Bethlehem, PA: Lehigh University Press. A good collection of reflections on Skinner's work.

SLIPPERY SLOPE ARGUMENTS

"*Partial-birth abortion* bans are not themselves that bad. But you should oppose them because, if they are enacted, much broader bans on abortion will become more likely." "Letting dying people cut off their lifesaving treatment may seem proper on its own. But if we allow that, it may lead to dying people getting help in actively killing themselves, and then over time to involuntary killing of the comatose or even of the disabled." "Embryonic stem cell research might be OK in itself, but it may lead to people getting pregnant just to get abortions." Such arguments are commonplace in debates on many ethical topics: abortion, euthanasia, genetic engineering, gun control, free speech, privacy, and more.

All these arguments express concern about the *slippery slope:* the risk that implementing a seemingly modest and worthwhile decision A now will increase the likelihood of a much broader and more harmful decision B later. The arguments are sometimes made by political liberals and sometimes by political conservatives. They sometimes relate to judicial decisions and sometimes to legislative ones. But they are all prudential arguments about long-term consequences.

The slippery slope is not just a form of argument. It is also an asserted real-world phenomenon—the tendency of one decision to increase the likelihood of others. If this phenomenon is real, people may want to consider it when deciding where to stand on policy questions: After all, if a decision today does make likelier other decisions tomorrow, it is prudent to consider this risk when making the first decision.

Analyzing Slippery Slope Arguments

There is no well-established definition for what constitutes a slippery slope. Some limit it to situations where A and B are separated by a long series of incremental steps: first one restriction on gun ownership, then another, then a third, and eventually all guns are banned. Others limit slippery slopes to situations where A and B cannot be easily logically distinguished. Some philosophers define the slippery slope as a form of purely logical argument, that enacting A will logically require the enactment of B.

Still others look to the reason that people worry about slippery slopes. Voters, legislators, judges, and others often face the question, Should I support proposal A, or should I oppose it for fear that it might help bring about B? To answer this, one must consider all the possible ways that A can help lead to B—whether sudden or gradual, logical or political. This entry will therefore use this broad definition: A slippery slope happens whenever one narrow judicial or political decision now (for instance, banning Nazi or Communist speech) increases the likelihood that another, broader decision will be enacted later (for instance, censorship of more speech).

Not *We,* but *They*

Why would slippery slopes ever happen? Say that we think gun registration (A) is good but gun confiscation (B) is bad. Why would decision A make decision B more likely? If we dislike gun confiscation now, would we not dislike it as much even after gun registration is enacted?

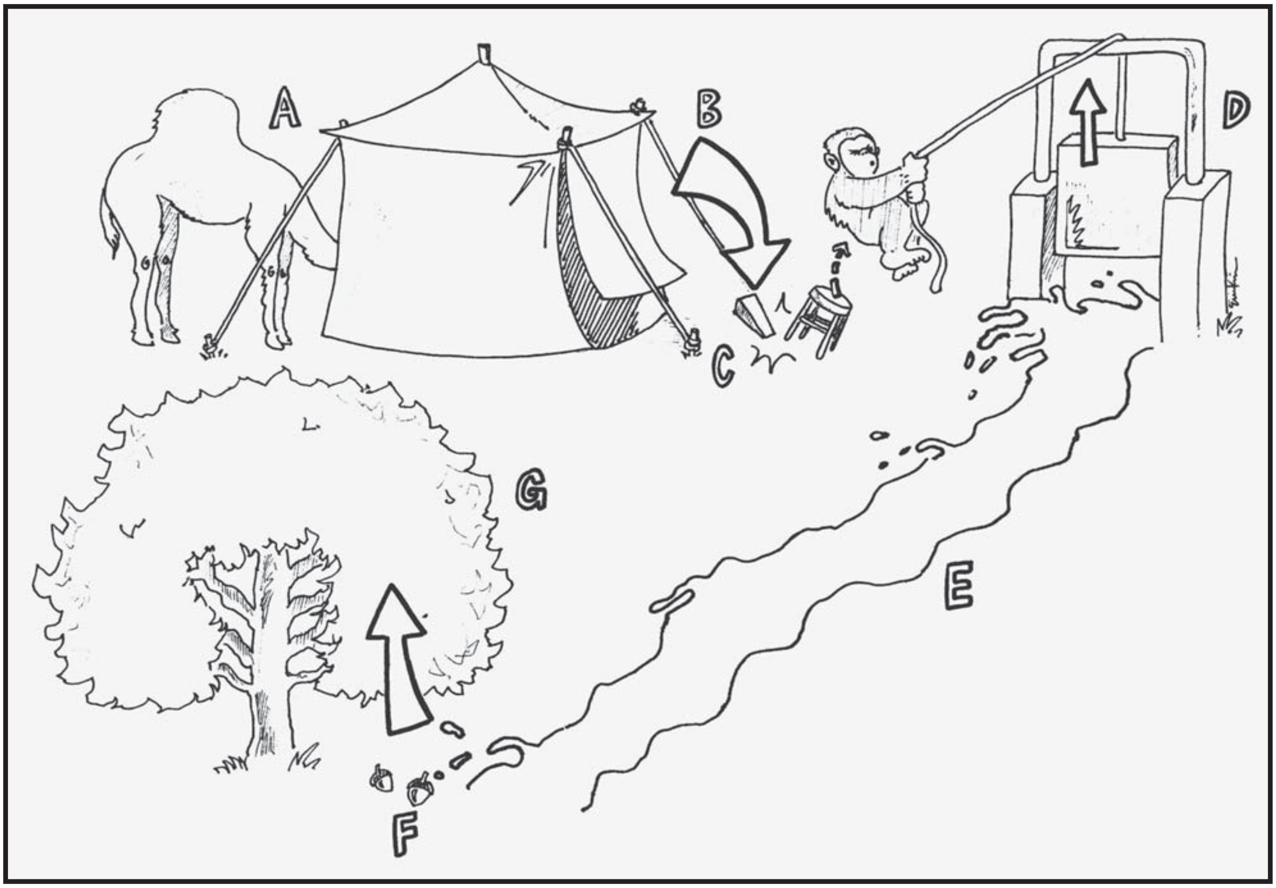
Social decisions are made by groups composed of individuals—voters, legislators, judges, and so on—who have different views. The slippery slope concern is that our support for decision A today will lead *other* people to support decision B tomorrow.

For instance, gun registration may make gun confiscation easier because the police will know where the guns are. It may also make confiscation more defensible legally because the police will be able to get warrants to search the homes of those people who have the guns. The cheaper a policy is, the more likely people are to support it. This year a swing group of voters may help enact gun registration because they like registration but not confiscation. But next year the same group might find itself outvoted by another group of voters who conclude that, because guns are now registered, confiscation is cheaper and thus more appealing.

The first group of voters will have fallen victim to the slippery slope: They voted for a modest step A, which they liked, but as a result got outcome B, which they loathe. They may then wish that they had considered the slippery slope dangers before making the first decision.

Different Slippery Slope Mechanisms

How can one evaluate the likelihood that supporting A will indeed lead others to support B? The metaphor of the slippery slope, unfortunately, will not help, precisely because it is just a metaphor. It is necessary to identify the mechanism behind it: How exactly will the first decision change the conditions under which others will evaluate the second proposal? There are several such mechanisms, all of which can be called slippery slopes,



Drawing illustrating the concept of a slippery slope argument. Camel (A) sticks his nose under the tent (B), which collapses, driving the thin end of the wedge (C) to cause monkey to open floodgates (D), letting water flow down the slippery slope (E) to irrigate acorn (F) which grows into oak (G). *(Drawing by Eric Kim. Courtesy of Eugene Volokh.)*

but which are analytically different. Here are just a few examples.

COST-LOWERING SLIPPERY SLOPES. The gun registration example is one scenario. If decision A makes decision B cheaper, then it makes B more likely.

EQUALITY SLIPPERY SLOPES. Decision A may lead some people to feel that decision B must be enacted as well for equality reasons. For instance, some people argue that it is unfair to allow the dying to commit assisted suicide while refusing to permit the same release to those who are in great psychological pain but are not dying. The first step A may push some voters, legislators, or judges to support B, not because they like B as such, but because they oppose discrimination between A and B.

ENFORCEMENT NEED SLIPPERY SLOPES. When a modest restriction A—for instance, a mildly enforced prohibition on some drug—is often violated, some people may come to support a much more severe restriction B (for instance, a war on drugs, with harsh punishments and intrusive searches) because they do not like to see the law being flouted. The intermediate position A thus becomes politically unstable, and slippage to B more likely.

ATTITUDE-ALTERING SLIPPERY SLOPES. Thus far this entry has discussed slippery slopes that operate without changing anyone's underlying attitudes. People might have the same attitudes about equality or cost as they did before A—but once A is enacted, those very attitudes lead them to support B, because of changed real-world circumstances.

Some slippery slopes, though, do operate by changing people's attitudes. Many voters, and even some legislators and judges, feel that they know little about certain issues. For instance, if they are asked whether they support some restriction on privacy, they might realize that privacy questions are very difficult, and that they have no good theory about which restrictions are good and which are not. Because they are thus *rationally ignorant*—they know the necessary limitations of their own knowledge—they may defer to the judgment of other authoritative institutions, such as courts and legislators. So if some kind of surveillance is legally permitted, many voters may therefore conclude that it is also morally proper.

This means that when proposal A is being considered, one must try to predict not only what A will do on its own terms, but also how it will change public attitudes. Will it, for instance, lead voters to alter their views to the point that they will also start supporting broader proposals like B? Will stem cell research on human embryos, for instance, change people's attitudes about the propriety of harvesting older fetuses or even babies for medical purposes? Would it lead people to think of abortions as a good rather than a necessary evil, and thus legitimize (for instance) people's getting pregnant just to harvest the resulting embryos? This sort of psychological prognostication is difficult, but it often has to be done if people are to decide whether the benefits of A indeed exceed its costs.

LEGISLATIVE-LEGISLATIVE, LEGISLATIVE-JUDICIAL, JUDICIAL-LEGISLATIVE, AND JUDICIAL-JUDICIAL SLIPPERY SLOPES. All these slippery slopes may in some measure operate whether decisions A and B are legislative decisions or judicial ones. Slippery slopes are often associated with judicial decision making, in which the doctrine of precedent helps accelerate the slide chiefly by strengthening the equality slippery slope and the attitude-altering slippery slope. But as some of these examples show, slippery slopes can operate even without any formal rule of precedent.

The Slippery Slope Inefficiency

None of these arguments, of course, always carry the day—nor should they. Sometimes we must make decisions even if there is a risk that the decisions will lead others to enact laws of which we disapprove. And yet some policy proposals that may be good on their own do end up being blocked because of eminently reasonable slippery slope concerns; one might call this the *slippery slope inefficiency*. Some people think this is true of gun registration, which has been blocked by concerns over a slippery slope to gun confiscation. Others think it is true of moderate assisted suicide proposals, which may be blocked by concerns that assisted suicide will become the norm for more and more patients.

Identifying this inefficiency suggests, perhaps surprisingly, that constitutional rights might sometimes *enable* modest regulation even while they *disable* broader prohibition. If gun right supporters feel that their right to own guns is constitutionally secure and, thus, that gun confiscation would be struck down by the courts, many of them might well drop their opposition to gun registration—an opposition that may be largely driven by slippery slope risks. If a trustworthy barrier against slippage is erected, then people may be more willing to take the first step out onto the slope.

EUGENE VOLOKH

SEE ALSO *Choice Behavior; Decision Theory.*

BIBLIOGRAPHY

Rizzo, Mario J., and Douglas Glen Whitman. (2003). "The Camel's Nose Is in the Tent: Rules, Theories, and Slippery Slopes." *UCLA Law Review* 51(2): 539–592.

Schauer, Frederick. (1985). "Slippery Slopes." *Harvard Law Review* 99(2): 361–383.

Volokh, Eugene. (2003). "Mechanisms of the Slippery Slope." *Harvard Law Review* 116(4): 1026–1137.

Walton, Douglas. (1992). *Slippery Slope Arguments*. New York: Oxford University Press.

SMITH, ADAM

Although Adam Smith (1723–1790) was not the originator of many of the ideas that became modern economics, his synthesizing treatise, *An Inquiry into the Nature and Causes of the Wealth of Nations* (1776), was so influential that he is generally considered the founder of the discipline. He effectively elaborated the concept of unplanned, spontaneous order, a feature of his economics that later played a part in other sciences such as evolutionary biology and cybernetics. Smith treated economic behavior as part of an entire ethical system, which he set out in his other major work, *The Theory of Moral Sentiments* (1759). Born in Kirkcaldy, Scotland, and baptized on June 5, he attended Glasgow and Oxford Universities and then returned to Glasgow as professor of moral philosophy. He died in Edinburgh on July 17.

Self Interest and Public Benefit

For Smith and contemporary practitioners, economics is in large measure the study of the outcome for society of

Adam Smith, 1723–1790. The Scottish economist and moral philosopher believed that in a laissez-faire economy the impulse of self-interest would work toward the public welfare. *(The Library of Congress.)*

individuals acting in their own interest without a view to public benefit. Smith thought the outcome was generally good. Unregulated, self-interested behavior could produce greater material wealth for society than could a system of policies designed by authorities to achieve wealth. Economists, historians, philosophers, and ethicists have debated his argument from his day to the present.

In support of his notion that beneficial order, not destructive chaos, can result from persons acting in their own interest, Smith repeatedly shows how desirable features of society are the unintended outcome of actions taken for other reasons. For example the division of labor, to which he attributed national wealth, was not the effect of human wisdom that intended the resulting material well being. Smith argues that humans, unlike animals that fawn to obtain favors, learn to divide tasks and specialize in producing goods and services that they can exchange for what they want. The division of labor, therefore, was the effect of the tendency of humans to barter in order to get what they want from others. It produces wealth because it saves time, develops specialized skills, and prompts workers to invent technologies to ease their tasks.

Being aware of the productive advantages of specialization, authorities may presume that they can plan the division of labor. Smith traces the steps involved in producing a simple item and makes it clear that a planner would be incapable of assessing people's desires, devising tasks to satisfy them, and assigning the tasks to various workers. Even if people made their desires known in any one place, no person or group could imagine the skills and resources required to provide for any one desire. The division of labor functions most effectively if individuals learn from market prices the best way to employ their own time and abilities to satisfy the desires of others, thereby offering productive resources of which a planner would be unaware. When entrepreneurs seek the most profitable employment of their capital and workers go where wages are highest, the result, which neither intended, is that they unintentionally supply the desires of others in the cheapest way. Individuals do not have to have benevolent motives to produce social benefits.

Smith, who did not romanticize business, thought that employers always try to conspire to keep wages down and that sellers in the same trade always conspire to raise prices. Accordingly he admonished governments never to take actions that would make it easier for members of the same trade to cooperate. Self-interest leads to public benefit, but only if competition prevails.

Unregulated markets, when competitive, harness self-interested behavior to produce public benefit. Smith understood, however, that the authorities did not deliberately institute a market system to achieve this end. On the contrary, history taught him that the system emerged when landlords used the produce of their agricultural estates to buy luxuries rather than to maintain hundreds of tenants, soldiers, and servants. When they were no longer bound to their landlords, these individuals became freer to exchange their services for market-determined wages.

Smith's understanding of how the pursuit of individual interest produces the wealth of all led him to advocate the system of *natural liberty* in which the government's role, while indispensable, is confined to providing national defense, law and order, and goods that are unprofitable for private persons to produce, even though their benefits exceed their costs. Attempts by government to fix prices, encourage particular technologies, or subsidize certain industries for the benefit of society would be useless if not pernicious.

The Moral Basis of Markets

Smith devotes much of *The Wealth of Nations* to working out the implications of individuals being able to pursue their own interests, but he was aware that his system of natural liberty had a moral foundation. Markets not only had to be free from improper government interference and monopoly; legal and moral rules also had to protect them from injustice—murder, theft, and broken promises. In *The Theory of Moral Sentiments* (1759), Smith contended that orderly society was possible because the Author of Nature endowed humans with resentment of injustice and a desire to see it punished. For Smith society is possible because people passionately desire to punish injustice, not because they reason that their group will suffer if crimes against its members go unpunished. In his treatment of the social support for justice, as in his explanation of the emergence and functioning of markets, Smith emphasizes unintended outcomes. Individuals do not seek a wealthy society; they pursue their own interest and national wealth results. Similarly individuals do not strongly desire orderly society; their resentment of malice provides the basis for order.

It is easy enough to see that humans would resent malice toward themselves, but what of hurtful actions toward others? Humans are self-interested, but, as Smith claims in the opening line of *The Theory of Moral Sentiments*, they also care about the fortunes of others. By imagining what they themselves would feel in a similar situation, humans sympathize with the resentment of sufferers of injustice.

Smith does not limit the role of sympathy to ensuring that members of society will punish perpetrators of injustice. He uses the term sympathy to mean the human capacity to experience, to some degree, all the passions of others. When people share the passions that prompt others to act in ways they themselves would act in similar circumstances, they consider the acts of others just and proper. Similarly people approve of their own conduct if they feel that an *impartial spectator* would sympathize with the passions that influenced it. The impartial spectator acts as a constraint on self-interest. It approves of such self-regarding virtues as prudence, industry, and temperance, but recoils at *malevolence or sordid selfishness*.

Thus although Smith recognized the power of self-interestedness, he understood and celebrated other motives as well. According to his figure of speech, if the pillar of justice prevails, a society of the merely self-interested can exist, but without the ornaments of friendship, generosity, gratitude, and charity, people live a less happy, agreeable, and comfortable life. In his words, "to restrain our selfish, and to indulge our benevolent, affections, constitutes the perfection of human nature" (Smith 1969, p. 71).

Relevance to Current Policy

Smith's system of natural liberty does not provide guides for policies for the contemporary problems of poverty, environmental degradation, or for the alleviation of the stultifying effects of specialization. In these areas, later developments in specialized fields of economics have surpassed Smith's approach. At the same time, his understanding of human behavior and the sources of national wealth is still pertinent. The human tendency to regard first self-interest and that of family and friends has a basis in nature and is not entirely the consequence of education or culture. Therefore persons who make laws and policies must acknowledge it. It is fruitless to hope that authorities can persuade humans to provide for each other's needs out of benevolence. Self-interested individuals, however, will serve each other as they pursue their own interests, if competition exists and there are rules that punish violators of personal and property rights. Moreover authorities, as compared with the public, are no less self-interested and no more able to judge which industries or technologies will provide the greatest future social benefits. One lesson from Smith, then, is that governments should forgo planning and concentrate on promoting wealth and happiness by having legal systems that protect property rights and by encouraging ethical standards that honor following the rules of justice.

Another lesson is that markets do not become free because of the vision of some well-meaning and enlightened group. In the case of England, Smith observed that the market system resulted when landlords lost power. This historical observation is in keeping with his understanding of the limited effect of beneficial intent.

The twentieth-century failure of planned economies relative to those with freer markets lends support to Smith's free-market policies for the growth of national wealth. Even so, international agencies and national governments should be careful about promoting free markets by financially supporting authorities that promise to create them. Smith's historical perspective suggests that markets become freer when power changes hands, not when powerful leaders purport to make them free.

WILLIAM O. SHROPSHIRE

SEE ALSO *Capitalism; Cybernetics; Enlightenment Social Theory; Libertarianism; Market Theory; Political Economy.*

BIBLIOGRAPHY

Hayek, Friedrich. (1988). *The Fatal Conceit.* Chicago: University of Chicago Press. Includes an exposition of Smith's contribution to the concept of spontaneous order and references to his influence on Darwin and cybernetics.

Heilbroner, Robert. (1986). *The Essential Adam Smith.* New York: W. W. Norton, Inc. Excerpts from most of Smith's works, an excellent introduction to each of them, and a brief biography.

Marx, Karl. (1963). "Economic and Philosophical Manuscripts." In *Karl Marx: Early Writings*, ed. and trans. Tom B. Bottomore. New York: McGraw-Hill Book Company. Marx's view of the damage done to humanity by Smith's market-dominated society.

McCloskey, Deirdre. (1998). "Bourgeois Virtue and the History of P and S." *Journal of Economic History* 58: 297–317. An explanation of Smith's system of ethics as a combination of the prudent and social virtues.

Niebuhr, Reinhold. (1953). "The Christian Faith and the Economic Life of Liberal Society." In *Goals of Economic Life,* ed. A. Dudley Ward. New York: Harper Brothers. The perspective of a Christian theologian who came to a more moderate view of market society after being a socialist critic in his earlier years.

Samuels, Warren. (1977). "The Political Economy of Adam Smith." *Ethics* 87:189–207. An interpretation of Smith as a synthesizer of natural theology, ethics, jurisprudence, and expediency.

Schumpeter, Joseph. (1954). *History of Economic Analysis.* New York: Oxford University Press. A monumental history of economic thought that assesses Smith's importance and traces the background of many of his ideas, including the concept of spontaneous order.

Smith, Adam. (1969 [1759]). *The Theory of Moral Sentiments.* Indianapolis, IN: Liberty Classics Fund, Inc. Liberty Classics edition with introduction by Edwin G. West.

Smith, Adam. (1981 [1776]). *An Inquiry into the Nature and Causes of the Wealth of Nations,* eds. Russell Campbell and Andrew Skinner. Indianapolis, IN: Liberty Fund, Inc. Introduction by R. Campbell and A. Skinner.

West, Edwin. (1976). *Adam Smith: The Man and His Works.* Indianapolis, IN: Liberty Press. An accessible and sympathetic biography.

SOCIAL CONSTRUCTION OF SCIENTIFIC KNOWLEDGE

The leading research orientation in contemporary science and technology studies—the social construction of scientific knowledge (SSK, or social constructivism)—has been controversial since its inception in the 1970s. It primarily consists of a set of methodological imperatives for the study of science and technology that focus on the means by which people, ideas, interests, and things are organized in specific places and times to produce knowledge that has authority throughout society, especially among those not originally involved in the process of knowledge production. Thus, social constructivists tend to stress the diversity of interpretations and applications of knowledge across social contexts. However, in areas where philosophers and scientists might interpret that diversity as different representations or instantiations of an already established form of knowledge, social constructivists treat that variety as part of the ongoing core process of knowledge production.

Social constructivists therefore do not recognize a sharp distinction between the production and the consumption of knowledge. Thus, social constructivism has a "democratizing" effect on epistemology by leveling traditional differences in the authority granted to differently placed knowers. To a social constructivist a technologist using a scientific formula is "constructing" that formula as knowledge in exactly the same sense as did the scientist who originated the formula. Each depends on the other to strengthen their common "cycle of credibility" or "actor-network," in the words of Bruno Latour, perhaps the leading social constructivist. In contrast, most philosophers and scientists would raise the epistemic status of the original scientist to that of a "discoverer" and lower the status of the technologist to that of an "applier."

Basic Attitudes and Origins

In philosophical terms social constructivism is a form of antirealism: Social constructivists do not presuppose the existence of a reality independent of the procedures available to the examined agents for deciding the truth value of their assertions. In this respect social constructivism has affinities with idealism, pragmatism, phenomenology, and even logical positivism. The proponents of all those movements agree that aspects of the world that traditionally have been cited as evidence for "external reality" are in significant respects the intended and unintended products of human practices. However, this common insight has led to rather different philosophical responses. For example, positivists and phenomenologists strive to design criteria that can command universal assent, whereas idealists and pragmatists regard the resolution of conflict in the application of such procedures as the basis of future epistemic developments.

Social constructivists differ from earlier antirealists by challenging their common fundamental assumption of a centralized decision-making environment, whether it is a unified self or society.

In contrast, social constructivists presuppose that the social world in which construction occurs is highly dispersed. This implies that different decisions are taken across many places and times. This often is considered a "postmodern" feature of social constructivism. However, despite the lip service paid to French poststructuralist thinkers such as Michel Foucault (1926–1984) and Gilles Deleuze (1925–1995), social constructivists originally derived this characterization from the social phenomenologist Peter Berger (Berger and Luckmann 1967), from his Viennese teacher Alfred Schutz (1899–1959), and ultimately from Schutz's mentor, the neoliberal political economist Friedrich Hayek (1899–1992).

Just as Hayek had argued in the 1930s, against the socialists, that no central planner can determine fair prices more efficiently than can the spontaneous self-organization of buyers and sellers, social constructivists deny that a single philosophical method can determine the course of science more efficiently than can the spontaneous self-organization of scientific practitioners. Hayek grounded his argument on the unique knowledge possessed by people differently placed in the market. Thus, the social construction of scientific knowledge can be seen historically as an extension of a market mentality into an aspect of social life—science—that for much of the twentieth century tied its legitimacy to the control mechanisms of the state.

Despite often being portrayed as antiscientific, social constructivism has precedents in the history of science, starting with Aristotle's view of matter as an indeterminate potential that is given form through human intervention. In the nineteenth and early twentieth centuries the constructivist position was represented most clearly by chemists who contested the idea of an ultimate form of physical reality as defined by, say, "atoms." Instead, chemists appealed to "energy" as an updated version of Aristotelian potential. Current versions of constructivism further "socialize" this perspective by invoking concepts such as work and practice as the media through which scientific objects are brought in and out of existence. According to its proponents, social constructivism is the spontaneous philosophy of the working scientist, who is concerned more with making things happen in the laboratory, as well as in society at large, than with completing a philosophically inspired picture of ultimate reality. Not surprisingly, Latour and other leading social constructivists have flourished in engineering schools rather than in pure science faculties.

The Trajectory of Social Constructivist Research

The social construction of scientific knowledge normally is described in terms of its opposition to two familiar, although extreme, views that might be called philosophical rationalism and sociological determinism. Philosophical rationalism implies that science ultimately is driven by a concern for the truth, perhaps even a desire to provide a comprehensive and unified picture of reality. From that standpoint the social dimension of science functions as either a facilitator or an inhibitor of this quest. Sociological determinism implies that the science of a particular time and place is an ideological reflection of the social conditions that sustain it. From that standpoint the development of science is dependent on its larger societal functions. Social constructivism differs from those two perspectives by denying a strong ontological distinction between the "cognitive" (or "natural") and "social" (or "cultural") dimensions of science. Both dimensions are coproduced in any episode of scientific activity. As a result social constructivists see science as much more subject to agency and contingency than either philosophical rationalism or sociological determinism allowed.

David Bloor's *Knowledge and Social Imagery* (1976) was the first book to put forward the social constructivist case against both philosophers and sociologists. Bloor, a mathematician and psychologist, was influenced by Ludwig Wittgenstein's (1889–1951) later writings on rule following. Wittgenstein implied that there is no correct way to continue a number series (for example, 2, 4, 6 . . .) except to abide by the judgement of the community engaged in the counting because any arithmetic series is open to an indefinite number of continuations (such as 8, 10, 12 . . . or 7, 8, 9 and then 10, 12, 14 . . .), depending on what is taken to be the rule underlying the number series. Bloor generalized that insight in the name of a thoroughly naturalistic approach to the study of knowledge that he called the "Strong Programme in the Sociology of Scientific Knowledge." That approach involved suspending all external normative judgements about the validity or rationality of knowledge claims. (In contrast, the "Weak Programme" would use sociology only to explain episodes of scientific dysfunction, because the canons of rationality were presumed to explain science's normal operation.) Bloor would look only to the standards of reasoning and evidence available to those who must live with the consequences of what they do. That approach encouraged what Bloor called a "symmetrical" attitude toward the various competing beliefs or courses of action in a particular situation. In other words the inquirer is to treat those beliefs or actions as seriously as the situated agents treat them, suspending any knowledge the inquirer might have about their likely or, in the case of historical cases, actual consequences. The import of this approach was to neutralize specifically philosophical appraisals of knowledge claims, which typically appeal to standards of rationality and validity that transcend the interests or even competence of the involved agents.

Whereas Bloor, along with his Edinburgh colleague Barry Barnes (1975), mapped out the conceptual terrain defined by social constructivism, the 1980s and 1990s brought a plethora of historical and sociological case studies inspired by that position. Constructivist historical studies characteristically reinterpret landmark scientific debates so that what traditionally was seen as an instance of truth clearly triumphing over falsehood came to appear as a more equally balanced contest in which victory was secured at considerable cost and by means that were specific to the contest. Attached to these reinterpretations is a view, traceable to Thomas Kuhn (1922–1996), in which every scientific success entails a rewriting of history to make it appear inevitable. In this respect social constructivist history of science aims to "deconstruct" the narratives of scientific progress typically found in science textbooks and works of science popularization.

Stephen Shapin and Simon Schaffer's *Leviathan and the Air-Pump* (1985) is perhaps the most influential work of this sort. It deals with Robert Boyle's (1627–1691) successful blocking of Thomas Hobbes's (1588–1679) candidacy for membership in the Royal Society. This episode normally is told in terms of Hobbes's persistent metaphysical objections to the existence of a vacuum long after it was found to be scientifically reasonable. However, it turns out that Hobbes was defending the general principle that experimental demonstrations are always open to philosophical criticism even if the philosopher could not have designed such an experiment. Hobbes's failure on this score set a precedent for the competence required for judging experiments that began to insulate science from public scrutiny.

Constructivist case studies typically draw on the sociological method of grounded theory, according to which the inquirer introduces a theoretical concept or perspective only if the agents under study also do so. Grounded theory originally was used to oppose structural functionalism, the leading school of U.S. sociology, which was associated with Talcott Parsons (1902–1979) and Robert Merton (1910–2003). Proponents of that school postulated that deviance is a well-defined role that performs specific functions in the social system. In contrast, for grounded theorists the deviant role, say, in the context of asylums and hospitals, had to be constructed from moment to moment because generally speaking there was no clear observable difference between the behavior of so-called normals and that of deviants.

Achievements and Weaknesses

The groundbreaking, albeit perverse, insight of Latour and Steve Woolgar (Latour and Woolgar 1986), Karin Knorr-Cetina (1981), and the other early constructivist sociologists was to imagine that "deviance" may apply to people on the positive extreme as well as the negative extreme of a normal distribution curve. Thus, in their daily laboratory tasks scientists do not sound or look especially different from people working in an industrial environment subject to an intensive division of labor. Nevertheless, scientists are socially constructed as exceptionally rational, producing knowledge that commands authority throughout society. How is this possible? For a constructivist sociologist the answer lies in the "made for export" language scientists use to describe their activities and the specific distribution channels in which that language, as expressed in journal articles, preprints, and press releases, circulates. This produces a forward momentum, involving many other people, laboratories, interests, and so forth, that eventually turns a unique set of events into a universally recognizable fact.

There is little doubt that social constructivism has provided an important challenge to standard historical, philosophical, and sociological accounts of science. The question is its implications for science itself. The steadfast adherence of constructivism to the symmetry principle has been both a strength and a weakness.

The strengths of constructivism extend beyond intellectual insight to the ease with which it can be used in science policy research, especially in a time when constrained budgets and skeptical publics demand that science be evaluated in terms of its actual consequences rather than its professed norms. In this respect social constructivism has been a success in the marketplace, proving especially attractive to the increasing proportion of academic researchers who depend on external contracts for their livelihood. However, beneath that success lies a weakness: Constructivism lacks a clear normative perspective of its own. This lack largely reflects its decentralized vision of social life. Although constructivists excel in revealing the multiple directions in which science policy may go, they refuse to pass judgment on any of them or even on the means by which their differences might be resolved. In this respect social constructivism is indifferent to the future of science and the role of science as the vanguard of rationality and progress in society at large.

The program of "social epistemology" has attempted to redress this imbalance in social constructivism. It argues that social constructivism can provide the basis for a science policy that is both genuinely democratic and experimental. Conventional science policy tends to be problem-centered without evaluating the relevant discipline-based knowledge. Indeed, science policy analysts rarely think of themselves as *constructing* problems the problems they address—they are simply treated as given. In contrast, social epistemology moves science policy toward constructivism by critically examining the maintenance of institutional inertia: Why don't research priorities change more often and more radically? Why do problems arise in certain contexts and not others? These questions are addressed on the basis of three presumptions that take seriously the normative implications of the social constructivism (from Fuller and Collier 2003):

- *The Dialectical Presumption:* The scientific study of science will probably serve to alter the conduct of science in the long run, insofar as science has reached its current state largely through an absence of such reflexive scrutiny.
- *The Conventionality Presumption:* Research methodologies and disciplinary differences continue to be maintained only because no concerted effort is made to change them—not because they are underwritten by the laws of reason or nature.
- *The Democratic Presumption:* The fact that science can be studied scientifically by people who are themselves not credentialed in the science under study suggests that science can be scrutinized and evaluated by an appropriately informed lay public.

STEVE FULLER

SEE ALSO *Science, Technology, and Society Studies; Sokal Affair.*

BIBLIOGRAPHY

Barnes, Barry. (1975). *Scientific Knowledge and Sociological Theory*. London: Routledge & Kegan Paul.

Berger, Peter, and Thomas Luckmann. (1967). *The Social Construction of Reality*. Garden City, NY: Anchor Doubleday.

Bloor, David. (1976). *Knowledge and Social Imagery*. London: Routledge & Kegan Paul.

Collins, Harry, and Trevor Pinch. (1993). *The Golem: What Everyone Needs to Know about Science*. Cambridge, UK: Cambridge University Press.

Fuller, Steve. (1988). *Social Epistemology*. Indianapolis: Indiana University Press.

Fuller, Steve, and James Collier. (2003). *Philosophy, Rhetoric, and the End of Knowledge,* 2nd edition. Hillsdale, NJ: Erlbaum. (Originally published in 1993.)

Gilbert, Nigel, and Michael Mulkay. (1984). *Opening Pandora's Box*. Cambridge, UK: Cambridge University Press.

Glaser, Barney, and Anselm Strauss. (1967). *The Discovery of Grounded Theory*. Chicago: Aldine.

Golinski, Jan. (1998). *Making Natural Knowledge: Constructivism and the History of Science*. Cambridge, UK: Cambridge University Press.

Knorr-Cetina, Karin. (1981). *The Manufacture of Knowledge*. Oxford: Pergamon.

Latour, Bruno. (1987). *Science in Action*. Cambridge, MA: Harvard University Press.

Latour, Bruno, and Steve Woolgar. (1986). *Laboratory Life: The Social Construction of Scientific Facts*, 2nd edition. Princeton, NJ: Princeton University Press. (Originally published in 1979.)

Shapin, Steven, and Simon Schaffer. (1985). *Leviathan and the Air-Pump*. Princeton, NJ: Princeton University Press.

SOCIAL CONSTRUCTION OF TECHNOLOGY

The phrase *the social construction of technology* is used in at least two different, though overlapping, ways. Broadly it refers to a theory about how a variety of social factors and forces shape technological development, technological change, and the meanings associated with technology. More narrowly, the phrase refers to a specific account of the social construction of technology; the acronym SCOT is used to refer to this version of the broader theory (Pinch and Bijker 1987). According to Ronald Kline and Trevor Pinch (1999), SCOT uses the notions of *relevant social groups*, *interpretive flexibility*, *closure* and *stabilization;* the concept of interpretive flexibility is its distinguishing feature. To claim that technology has interpretive flexibility is to claim that artifacts are open to radically different interpretations by various social groups; that is, artifacts are conceived and understood to be different *things* to different groups.

Contra Technological Determinism

The starting point for understanding both the broad theory of the social construction of technology and the

SCOT version of that theory is to compare them with another view of technology referred to as *technological determinism*. Technological determinism has two basic tenets: (1) that technology develops independently from society; and (2) that when a technology is taken up and used, it has powerful effects on the character of society. According to the first tenet, technological development either follows scientific discoveries—as inventors and engineers *apply* science—or it follows a logic of its own, with new inventions deriving directly from previous inventions. Either way, technological development is considered to be separate from social forces; engineers and inventors work in an isolated domain in which all that matters is discovering and manipulating nature.

According to the second tenet of technological determinism, when technologies are adopted by societies or particular social groups, the adoption brings about—determines—social change and patterns of social behavior. In one formulation, technological change is said to create a *cultural lag* until culture catches up. One specific determinist argument proposed by historian Lynn White (1962) is that feudal society evolved from the invention of the stirrup. Another example is Langdon Winner's (1986) claim that society cannot have nuclear power without hierarchical organization. Winner's broader claim is that technologies necessitate particular forms of political organization. This principle of technological determinism leads to the commonly held view that technology determines society; that is, when technologies are adopted and used, they change the character of society.

The broad theory on the social construction of technology denies the first tenet of technological determinism entirely but makes a more nuanced response to the second tenet. In denying the claim that technology develops independently from society and follows science or its own logic of development, social constructivists argue that technological development is shaped by a wide variety of social, cultural, economic, and political factors. Nature does not reveal itself in some necessary or logical order. Scientists and engineers look at nature through lenses of human interests, theories, and concepts; engineers invent and build things that fit into particular social and cultural contexts. Technologies are successful not by some objective measure of their goodness or efficiency; rather, technologies are taken up and used because they are perceived to achieve particular human purposes and to improve a particular social world or to further the interests of individuals and social groups.

Broad theory proponents respond similarly to the second tenet of technological determinism: They claim the theory misses the fact that technology is being shaped by social factors and forces. But here the social constructivist does not wholly deny the technological determinist claim that technology affects society; rather, constructivists argue that forces may move in both directions. Technology shapes society *and* society shapes technology. Social constructivists claim that the theory of technological determinism gives an inadequate and misleading picture of the technology-society relationship in leaving out the powerful social forces at work in shaping the development, adoption, use, and meanings associated with technology. Social constructivists have also gone further in claiming that shaping does not just work in both directions but that technology and society are mutually constitutive; they cocreate one another.

Specific Theories of Social Construction

The critique of technological determinism and the emergence of the theory of the social construction of technology began and gained momentum in the 1980s along with other activities contributing to the development of a new field of study sometimes labeled *science and technology studies* (STS) and other times *science, technology, and society* (also STS). Within this field of study, two theoretical approaches are often distinguished: the version of social constructivism referred to as SCOT and actor-network theory (ANT). Both theories seek to explain why and how particular technologies are adopted while others are rejected or never developed. Both SCOT and ANT are concerned with how technological designs are adopted and become embedded in social practices and social institutions.

Actor-network theory takes as its unit of analysis the systems of behavior and social practices that are intertwined with material objects. This is the *network* part of actor-network theory. The *actor* part of actor-network theory emphasizes the presence of many actors, human and nonhuman. For instance, nature plays an important role in determining which technologies come to be adopted, and nature can be described as one of the actors in shaping the technologies that succeed in becoming embedded in the social world. Technologies and artifacts can themselves also be actors. Humans, nature, and artifacts collectively are referred to in actor-network theory as actants.

Resistance to Social Constructivism

Two issues often get in the way of understanding social constructivism in the broad sense. The first is an issue about which social constructivists disagree, the extent to which nature is real or *merely* socially constructed. *Realists* claim that nature is real and has an inherent or fixed character that scientists and engineers must manipulate to succeed. The hard character of nature shapes what engineers can do and what technologies are developed. Nevertheless while constructivist-realists claim that there is something real or *hard* about nature, they generally acknowledge that the only way humans have access to nature is through human meaning, human constructs, and human theories, all of which are social. Thus nature can be represented in different ways, in different knowledge systems. At the same time, *anti-realists* claim that there is nothing hard or real about nature around which ideas and meanings can be constructed; at least, there is nothing real to which people have access. There are only ideas and meanings constructed by humans, and ideas and meanings are social.

While the chasm between realists and antirealists is wide, many social constructivists simply sidestep or bracket the issue without taking sides. For many social constructivists who seek to understand the cocreation of technology and society, it does not make a difference whether nature is real, because all concede that nature is viewed through the lenses of human beings, which are interested and social.

The second issue is the principle that new technologies build on older technologies. Technological determinists contend, for example, that computers could not have been developed if electricity and transistors and many other devices had not already been developed. Thus technology influences technology; later technology builds on prior technology. Social constructivists agree. What social constructivists reject, however, is that technological change and development follows a predetermined, linear path, a path necessitated by some nonhuman reality. Social constructivists argue that social factors influence the pace and direction of technological development and that development is often nonlinear.

How Social Construction Works

What does it mean to say that technology is socially constructed? As already mentioned, the theory referred to as SCOT makes use of the notions of relevant social groups, interpretative flexibility, stabilization, and closure.

THE BICYCLE STORY. Wiebe Bijker (1995) and Pinch and Bijker (1987) give an account of the development of the design of the bicycle—the design that has been used since the early-twentieth century. They argue that the path of development was complex, with various designs being tested and rejected by various groups in a nonlinear order. Relevant social groups—including sports enthusiasts, men and women who spent leisure time in public parks, bicycle makers, bicycle repair people, and more—responded to various models differently and found different advantages and disadvantages as well as meaning in them.

Development moved in many directions aimed at solving a variety of problems for riders, manufacturers, and those who repaired the bicycles; the problems included safety, ease of manufacture and repair, speed, ability to manage the roughness of roads, and so on. Designs had varying cultural meanings (was the bicycle macho or ladylike?), facilitated or constrained various social activities in public parks, and served the interests of various groups, including sports enthusiasts and manufacturers.

Design of the bicycle first took hold when the relevant social groups coalesced around one design because it solved problems for each group. This is the point Bijker refers to as stabilization. Once this happens small design changes may continue to be made, but tend to presume the overall design; designers tinker within that framework. In this way, Bijker shows that the design of the bicycle was socially constructed in the sense that the design that succeeded (that is, was adopted and pervasively used) was not the *best* in some objective sense, such as most efficient or elegant; rather, it was the one that the relevant social groups agreed upon because they were convinced it fit their needs.

The broader theory of the social construction of technology does not refute the SCOT theoretical apparatus; rather, the broader theory remains open to the use of alternative concepts, frameworks, and tools to study the cocreation of technology and society. Because social constructivism emphasizes the social shaping of technology, it may be useful to consider a few areas where social factors have a powerful influence on the technologies that are developed and what those technologies look like.

ECONOMICS. Perhaps the most obvious place to see the workings of society is in funding for the development of new technologies. Companies and government agencies invest large amounts of money, space, time, and effort in technological endeavors that seem promising. When enormous resources are put into an area of scientific or technological development, that area is much more likely to yield results. Thus, contrary to the inherent logic of development suggested by technological determinism, technology develops, at least in part, in an order that is determined by investment choices and other human decisions, and not by logic alone.

REGULATION. While governments often invest heavily in technological development, funding is not the only aspect of government that shapes technology. Governments often regulate technological domains and when they do so, the regulation affects future development. Consider, for example, the vast array of regulatory standards that automobiles must meet. Whether they are aimed at safety or clean air or decreasing dependence on fossil fuels, when governments set standards for automobiles, automobile manufacturers must design within the confines of those specifications. Hence regulation promotes development in a certain direction and forecloses development in other directions.

CULTURE. Yet another way that technological development is socially shaped is by the cultural meanings that influence the design of artifacts. Perhaps the best place to see this is in cross-cultural studies of technology. Such studies reveal how cultural meanings strongly influence technological development. Think, for example, of the lack of development in rail transportation in the United States where individualism and many other historical factors promote the use of automobiles, whereas in many European countries, this mode of public transportation has been successfully developed and enhanced for more than a century.

Ethics and Social Construction

Technological determinist theories such as that of Jacques Ellul (1964) seem to imply that technological development is autonomous and unstoppable; that is, individuals and even social movements can do nothing to change the pace or direction of development. Social constructivism can be seen as, at least in part, a response to the pessimism of technological determinism. Many social constructivist scholars see themselves as providing an account of technological development and change that opens up the possibility of intervention, the possibility for more deliberate social control of technology. Wiebe Bijker (1993), for example, describes the field as being rooted in critical studies. He claims that science and technology studies of the 1980s were "an academic detour to collect ammunition for struggles with political, scientific, and technological authorities" (Bijker 1993, p. 116). Thus, social constructivist theories might be seen as having an implicitly critical, and perhaps even a moral, perspective. However, social constructivist theories have been developed primarily by historians and social scientists, and scholars in these fields have traditionally understood the task of their scholarship to be that of description, not prescription. Hence, social constructivist theorists generally deny that their perspective is ethical.

Nevertheless, in bringing to light many of the otherwise invisible forces at work in shaping technology and society, social constructivist analysis often reveals the ways in which particular social groups wield power over others through technology. Knowledge of this aspect of technology opens up the possibility of deliberate action to counter the unfair use of power and the undesirable social patterns being created and reinforced through technology. A good example here is the work on gender and technology by such scholars as Judy Wajcman (1991) and Cynthia Cockburn and Susan Omrud (1993). By drawing attention to the ways in which technology reinforces gender stereotypes and more broadly, how gender and technology are co-created, these scholars make it possible for those involved with technological development to avoid reinforcing prevailing stereotypes or patterns of gender inequality. In this respect social constructivism has important ethical implications.

While social constructivism has significantly furthered the social analysis of science and technology, social constructivism is still relatively new. Perhaps the most serious criticism of social constructivism is that it consists only of a few theoretical concepts and a wide-ranging set of case studies. Hence, it still needs a more comprehensive theoretical foundation. Nevertheless, social constructivism has been influential and is likely to continue to be important in understanding the relationships among science, technology, and society.

DEBORAH G. JOHNSON

SEE ALSO *Science, Technology, and Society Studies.*

BIBLIOGRAPHY

Bijker, Wiebe E. (1993). "Do Not Despair: There is Life after Social-Constructivism." *Science, Technology, & Human Values* 18: 113–138. Bijker reviews four problems surrounding socio-historical technology studies: relativism, reflexivity, theory, and practice. He argues for scholars to break away from overly academic perspectives and to return to political issues.

Bijker, Wiebe E. (1995). *Of Bicycles, Bakelites, and Bulbs.* Cambridge, MA: MIT Press. Bijker provides three detailed case studies of the development of a technology. His sociological analysis of these cases makes use of and illustrates a theoretical, social constructivist framework.

Cockburn, Cynthia and Susan Omrud. (1993). *Gender and Technology in the Making.* London: Sage Publications.

Explains the evolution of "microwave technology" that became the "microwave oven." It is a story of a technology that begins as masculine and eventually becomes a feminine kitchen appliance.

Ellul, Jacques. (1964). *The Technological Society*, trans. John Wilkinson. New York: Knopf. This book is considered a classic. Ellul argues that the internal logic of technological development, that is, instrumental rationality and efficiency, transforms domains of human life and is not in control of humans.

Kline, Ronald, and Trevor J. Pinch. (1999). "The Social Construction of Technology." In *The Social Shaping of Technology*, 2nd edition, ed. Donald MacKenzie and Judy Wajcman. Buckingham, UK, and Philadelphia: Open University Press. This is an excerpt from a longer piece that appeared in 1996 in *Technology and Culture* 37: 763–795. Kline and Pinch concisely present the advantages and weaknesses of the specific version of the social construction of technology known as SCOT and developed by Bijker and Pinch.

Pinch, Trevor J., and Wiebe E. Bijker. (1987). "The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other." In *The Social Construction of Technological Systems*, ed. Wiebe E. Bijker, Thomas P. Hughes, and Trevor J. Pinch. Cambridge, MA: The MIT Press. Using the conceptual apparatus of the SCOT model, this piece provides a historical account of the development of the bicycle.

Wajcman, Judy. (1991). *Feminism Confronts Technology*. University Park: Pennsylvania State University Press. Explores the relationship between technology and gender in western society. Wajcman uses the lens of feminism to examine the traditional association of technology with masculinity. She argues that this relationship is not natural but intertwined with socially and cultural processes. Notions of gender and technology social reinforce one another.

White, Lynn T. (1962). *Medieval Technology and Social Change*. New York: Oxford University Press. White examines the effects of technology on societies of medieval Europe. He attributes the collapse of feudalism to the development of machines and tools.

Winner, Langdon. (1986). *The Whale and the Reactor*. Chicago: University of Chicago Press. Consists of essays by Langdon Winner, which together constitute his unique perspective as a political scientist examining technology. As a whole the essays can be thought of as a critical philosophy of technology. Several of the essays had been published earlier and are seminal pieces in the field.

SOCIAL CONTRACT FOR SCIENCE

The social contract for science is an evocative ideological construct used to describe the relationship between the political and scientific communities. Participants in science policy debates often invoke the social contract for science uncritically and flexibly, ritually referring to Vannevar Bush as its author and *Science, The Endless Frontier* (1945) as its text. The term, however, has no explicit connection to Bush, but explaining its history and usage is enlightening.

Historical Origins and Decline

There are two helpful hypotheses for origin of the phrase. One focuses on what Don K. Price called the "master contract" that formed the "basic charter" of the postwar relationship between the U.S. government and the scientific community (Price 1954, p. 70). This relationship "gives support to scientific institutions that yet retain their basic independence" (Price 1954, p. 67–68). A second hypothesis holds that the social contract for science is related to a social contract for scientists, which describes how the profession of science is bound as a community to uphold behavioral norms and to "rely on the trustworthiness" of each other (Zuckerman 1977, p. 113).

Harvey Brooks polished the promise of the social contract for science as "widely diffused benefits to society and the economy in return for according an unusual degree of intellectual autonomy and internal self-governance to the recipients of federal support" (Brooks 1990, p. 12). Brooks's definition takes into account both hypotheses of origination by relying on the overall structure of Price's formulation and on the rationale of Zuckerman's formulation as why the *unusual degree* of autonomy and self-governance could be offered to science. That is, science could be granted autonomy because its members maintain their integrity by upholding group norms (Merton 1973).

In addition to evoking the contractual nature of the relationship between the public patron and the scientific community and the tacit trustworthiness of scientists to one another, the social contract for science has additional descriptive power. As with more formal social contracts from political philosophy, it offers an account of the provision of a public good, and it suggests the conditions of an original consensus against which change can be measured and evaluated (Guston 2000). Some scholars and policy makers, relying on a tacit understanding of the social contract for science, argue variously that science has been faithful to it but politics not particularly so (Press 1988); that the contract died in the late 1960s with a decline in research funding, only to be resuscitated in the 1980s (Smith 1994); and that the contract crumbled in the 1990s through various policy changes (Stokes 1997).

Using the Social Contract in Policy and Ethics

Guston (2000), however, argues that to serve as a baseline for historical change, the social contract for science must have its tenets elaborated in clear historical detail and have criteria for change derived from there. Thus although there is a consensus that any such agreement dates to the immediate post-World War II period, *Science, The Endless Frontier* is not the sole articulation of postwar science, and John Steelman's report, *Science and Public Policy* (Steelman 1947) must also be taken into account. Although these two analyses differed on how they imagined the organization and funding of postwar science, they both held—along with much theoretical writing of the period—that the political community would provide resources to the scientific community and allow the scientific community to retain its decision-making mechanisms and in return expects forthcoming but unspecified technological benefits. Such a contract was premised on the automatic provision of scientific integrity and productivity, which thus becomes the central criterion against which to measure change.

There were many potential challenges to the social contract for science, thus specified, over the postwar period in the United States, including inquiries into the loyalty of scientists in the 1950s, the changes in financial arrangements and funding in the 1960s, and greater emphasis on applied research and questions about the limits of scientific inquiry in the 1980s. But no challenges altered the presumption of the automatic provision of scientific integrity and productivity until the conflicts over scientific (or research) misconduct and over technology transfer in the late 1970s and early 1980s. Political perceptions in this period held that scientists might have broken the contract through the failure to control misconduct and to produce sufficient economic benefits. But scientific perceptions held that politicians might have broken the contract through meddling. Neither perspective is completely right (or wrong), but it was through their instigation of organizational innovation—the creation of the Office of Research Integrity and of offices of technology transfer—that these issues marked the end of the social contract for science and its assumption of the automatic provision of scientific integrity and productivity. The political and scientific communities collaborated over the creation of these institutions, and they ushered in a new era in which the political and scientific communities engage in a *collaborative assurance* of integrity and productivity instead. Scholars have traced similar transitions in science policies in European nations as well.

DAVID H. GUSTON

SEE ALSO *Research Integrity; Science Policy.*

BIBLIOGRAPHY

Brooks, Harvey. (1990). "Lessons of History: Successive Challenges to Science Policy." In *The Research System in Transition,* eds. Susan E. Cozeens; Peter Healey; Arie Rip; and John Ziman. Boston: Kluwer Academic Publishers.

Guston, David H. (2000). *Between Politics and Science: Assuring the Integrity and Productivity of Research.* New York: Cambridge University Press.

Merton, Robert K. (1973 [1942]). "The Normative Structure of Science." In *The Sociology of Science: Theoretical and Empirical Investigations,* ed. Norman W. Storer. Chicago: University of Chicago Press.

Press, Frank (1988). "The Dilemma of the Golden Age." In *The Presidency and Science Advising,* Vol. 6, ed. Kenneth W. Thompson. New York: University Press of America.

Price, Don K. (1954). *Government and Science: Their Dynamic Relation in American Democracy.* New York: New York University Press.

Smith, Bruce L. R. (1994). "The United States: The Formation and Breakdown of the Postwar Government-Science Compact." In *Scientists and the State: Domestic Structures and the International Context,* ed. Etel Solingen. Ann Arbor: University of Michigan Press.

Steelman, John R. (1947). *Science and Public Policy.* 5 Vols. The President's Scientific Research Board. Washington, DC: U.S. Government Printing Office.

Stokes, Donald E. (1997). *Pasteur's Quadrant: Basic Science and Technological Innovation.* Washington, DC: Brookings Institution Press.

Zuckerman, Harriet. (1977). "Deviant Behavior and Social Control in Science." In *Deviance and Social Change,* ed. Edward Sagarin. Beverly Hills, CA: Sage.

SOCIAL CONTRACT THEORY

The idea of a social contract can have broad and narrow meanings. In the broad sense a social contract can simply be short hand for expectations in relations between individuals or groups. In the narrow, more technical sense social contract theory has a long and venerable history that in the present has been rhetorically adapted to assess general expectations between science and society. A review of various theoretical perspectives nevertheless raises questions about the adequacy of such adaptations.

Social Contracts in General

Contracts in the strict sense are agreements between two parties that establish mutual obligations and are enforceable by law. The idea of a social contract is more fundamental, and argues that society comes into existence as a kind of contract. In the classical or premodern views that are sometimes identified as anticipations of social contract theory, the social contract is not so much an originating action as one that implicitly exists between a preestablished order and individuals within it. This is, for instance, the view argued by Socrates in Plato's *Crito*. The modern view, by contrast, is that individuals come first, and through their agreement establish a new phenomenon called the state.

For most modern theorists this contract is not a historical event, much less an actual legal document, but an ideal construct to aid in postulating how things should be. It depends on two key assumptions: (a) that human beings as individuals are in some sense prior to any established social order, so that their obedience to the state has to be justified; and (b) that the condition of human beings outside the socially constructed state, or in what is called the *state of nature*, is ultimately unsatisfactory, thus providing humans a reason to escape such a condition by social contract. From these assumptions Thomas Hobbes (1588–1679) and John Locke (1632–1704), without using the term, developed social contract theory to examine the status of a monarch. When Jean-Jacques Rousseau (1712–1778) subsequently coined the term *social contract*, he used the same kind of theory to defend a notion of democratic equality. Later John Rawls (1921–2004) adapted social contract theory to defend a system of distributive justice.

From Hobbes through Kant

Early modern versions of social contract theory were justifications for overthrowing tyrants who had overstepped the bounds allotted them, failing therefore to meet their obligations. Manegold of Lautenbach (c. 1030–c. 1112), Englebert of Volkersdorf (fl. c. 1310), Mario Salamonio (c. 1450–1532), and Junius Brutus (fl. 1572) all argued that a sovereign was bound by an implicit contract to act in the interest of his subjects. If he abused these obligations, the population had the right to take up arms.

Hobbes used contract theory for the exact opposite reason than most of his predecessors when he argued that a ruler should never be overthrown. Heavily influenced by the destruction of the English Civil War (1639–1651) and the resulting social upheaval, his version presented an appeal against such atrocities. In his *Leviathan* (1651), Hobbes pictured the original state of nature for prepolitical humans was one of constant war, which he argued any rational person would want to end. In their desire for peace, individuals would forfeit their natural liberty. Hobbes's contract between individuals rather than between subjects and sovereign establishes an obligation on all to obey the sovereign as a *rule of reason*, which he also calls a *law of nature*. Thus, for Hobbes, subjects never have the right to oppose their sovereign. Likewise Hobbes sees no contractual constraint on the sovereign, because only the sovereign can preserve a state of peace.

Unlike Hobbes, Locke in his *Two Treatises of Government* and *A Letter Concerning Toleration* (both 1689) argued that an absolute monarchy is inconsistent with civil society. For Locke, the prepolitical state of nature is a peaceful yet moral society where humans are bound by divinely commanded natural law. Social problems develop insofar as they lack a common judge with authority over all. In the absence of this common judge, individuals strive for power to exert wills and attempt to seize each other's property. This situation calls for someone with the authority to act as judge in order to protect life, liberty, and estate. The lack of a state prevents enforcement of the laws of nature, so citizens create one. As with Hobbes, the contract is between individuals rather than between governed and ruler. But citizens who institute a government to prevent people from occasionally violating natural law and showing partiality do not give up their liberty in the contract. They simply grant the state the right to judge and punish offenders of natural law. The state, therefore, has very limited authority based on its contractual powers. Its primary duty is to protect property. The contract is dissolved and resistance is justified if the government commits any breach of trust.

During the eighteenth century, a time of monarchial excess in much of Europe, social contract theory moved away from just overthrowing the king to arguing for a more equitable political system. The most notable theorist in this regard was Rousseau, whose treatise on *The Social Contract* (1762) foreshadowed both the American and French revolutions. These theories were no longer concerned with the status of a monarch, but with the idea that monarchy was itself a suspect political system. The social contract was no longer between the people and a sovereign; now the people have become sovereign.

Rousseau discussed the idea of social contract on two separate occasions. In neither case did he claim that the contract was an actual historical event. Instead he offered a theoretically ideal contract concerned with the origin of government. He did not write about how it actually happened but how it ought to have happened. He believed that the state of nature was one of individual liberty where each person was free and equal and none had by nature any legitimate authority over any other. The prepolitical state was also a presocial state. The result of the establishment of social relations was the rise of inequalities in social and economic forums. It is this that leads to conflict between individuals, because only social individuals could begin to acquire wealth and hence have reasons for war. The rich end up controlling the masses because they manipulate society in order to protect it from the ravages of war. Hence there is a need for an ideal contract that should be established to preserve equality. This contract between citizens establishes a government that is ruled by the general will or what is best for all. Rousseau's ideal contract creates not a sovereign person but a sovereign people. The government can only be an agent of the people's will. It is an exchange of natural liberty for civil liberty, where each member has an equal share in the expression of a general will.

More systematically than Rousseau, Immanuel Kant (1724–1804) extended social contract theory by presenting the contract as a regulatory ideal. Kant's contract was not so much what people would have agreed to as what they should have agreed to in such a hypothetical situation. For Kant, the social contract was that ideal to which individuals would agree if they were ideal moral beings. In his view all laws should be framed so that everyone would consent to them if given the choice.

The social contract theories of the eighteenth century provide a justification for a political system based on the equality of all citizens. The emergence of republican democracies at the same time is no coincidence. The idea that citizens were equal was not particularly novel, because earlier contract theory began with a prepolitical state of nature in which all were equal. But the idea that individuals in the political state should retain their equality creates a whole new conception of government.

It is important to note that social contract theory not only arose in historical association with the rise of modern democracy, but also in association with the rise of modern science and technology. Indeed the theories of the state of nature in both Hobbes and Locke provide justifications for the pursuit of technology. With Hobbes the justification is one of necessity, in order to escape the oppression of nature. With Locke the justification is more that of seizing opportunities for advancement. Moreover the social order within science is not unlike that elaborated by Rousseau and Kant: one of free and equal members in a well-ordered body politic. Indeed the scientists of the Enlightenment often referred to the *republic of letters* and the *republic of science*—and saw this democracy in science as a model for that to be established outside science. The term republic of science has continued to be used by such defenders of science as Michael Polanyi (1962) and Ian Jarvie (2001).

John Rawls and a Theory of Justice

Interest in social contract theory declined in the nineteenth century and was displaced by utilitarianism, the theory that actions are right when they produce more benefit than harm for society. But in the mid-twentieth century, social contract theory reemerged as a theory for justice, first in economics and then in philosophy.

Economist James Buchanan, for instance, has developed an argument derived out of rational choice theory dealing with the distribution of wealth in society. Like others, Buchanan is not talking about a historical event but rather suggests a contract theory that could be used to propose changes in political institutions. For him, the optimum decision making rule is to minimize the cost of collective action and promote what is advantageous to utility-maximizing citizens.

Philosopher Rawls, however, has altered the overall emphasis of the social contract by using it to promote a theory of justice. The social contract ensures that all people's interests are properly protected. The problem of justice arises because individuals make competing claims to the same goods produced through social cooperation. Unlike earlier versions of contract theory, Rawls sees social contract theory as a means for addressing this problem of conflicting interests. The distribution of social goods is just if and only if it would be acceptable to all parties prior to any party knowing which goods he or she might receive. In order to meet this requirement Rawls imagines a *veil of ignorance* behind which "no one knows his place in society, his class position or social status" (Rawls 1971, p. 12), a condition from which any social order could be constructed.

Michael Lessnoff's *Social Contract* (1986) argues that Rawls's theory of justice is the culmination of social contract theory. Although he believes that the problem of justice is the correct subject for contract theory, he nevertheless proposes a reformulation of Rawls. First, all must enjoy equal basic liberties unless an unequal distribution would improve the total basic liberty of those with less. Second, a fair and equitable opportunity must exist for all to achieve their desired social and economic positions, unless the inequality improves the lives of those with fewer opportunities. Third, inequalities of various social and economic goods must be to the benefit of those who have less of them.

Thus in the twentieth century social contract theory moved from a theory of governance to one of distributive justice. As such it has been used to question some of the situations brought about by science and technology. For instance, there are questions of justice regarding the practices of the United States that, with about 4 percent of the world's population, uses more than 20 percent of the world's resources. Distributive justice questions also come into play in assessing access to science and science education on the basis of economic class, gender, or ethnicity. Finally from the perspective of Rawls' veil of ignorance, one can ask whether the contemporary distribution of governmental funding for science is just. Instead of defending particular governmental funding policies for science from the perspective of particular scientific interest group politics, would it not be more just to ask how physicists, chemists, and biologists would distribute societal support for science, before knowing which kind of scientists they were going to become?

Science, Technology, and the Social Contract

The idea of a social contract has appeared in a number of different forms when discussing science and science policy. Classic sociology of science, such as that found in the work of Robert Merton (1973) and Joseph Ben-David (1984), although they do not use the term, might well be read as describing how a social contract among scientists leads to the creation of a distinctive scientific ethos. Studies of the history of engineering as a profession (Layton 1971) point in the same direction: that engineering as a profession was self-defined in part by means of a social contract among engineers. (It might also be interesting to note the special situation among social scientists, who both study and are constituted by such contracts.) In the broad sense, a social contract between science, technology, and society may also simply refer to common expectations in the relations between professional representatives in each of these three sectors: scientists, engineers and technologists, and politicians, respectively.

In this second sense of a social contract between scientists and the body politic, discussions have been at once more explicit and less well-grounded in social contract theory. As with social contract theory, a social contract for science need not refer to any specific historical agreement in a prepolitical period between the scientific community and the state or government. Instead it may be argued to be a logical extension of a desire on the part of individuals to better their condition, insofar as any such desire can itself be argued to benefit from scientific progress.

The whole concept of government spending on items such as science, technology, and medicine can thus be derived both from the original idea of individuals giving up their freedom to secure life, liberty, and property and from Rawls's idea of justice as directing resources to science and technology so as to increase benefits for all. Because the government is obligated by the social contract to improve its citizens' welfare, and insofar as science and technology are seen as having the potential to improve citizens' lives, the government invests in science, technology, and medicine.

Most explicitly science policy analysts in the United States have argued that Vannevar Bush's *Science—The Endless Frontier* (1945) established a social contract between the scientific community and government. In this case the public was left out of the agreement or at best represented by the government. In this contract, scientists promised to eliminate disease, feed the world, increase national security, and increase jobs in return for government funding and the right to maintain their autonomy. One description of this contract as a military-industrial complex became a focus for liberal political criticism during the 1960s. Antitechnology criticism of science as the cause of environmental pollution was a further spur to such criticism. In the 1980s and early 1990s with the downturn in the U.S. economy and the end of the Cold War, policy analysts began to question this social contract as well. They argued that the scientific community had failed to live up to its end of the bargain or was no longer as crucial to national welfare as it had been previously, and that public funding of science should be reexamined. With the reemergence of the U.S. economy in the mid-1990s and the rise of global terrorism in the 2000s such concerns tended to disappear.

The previous analysis assumes a kind of symbiosis between science and technology in what is often called technoscience. But in fact it can be argued that the situation with technology, especially that form of technology known as engineering, needs to be distinguished. For engineers, at least in the United States, any presumed social contract is mostly manifested in the marketplace. Industrial or market success substitutes for the social contract. When it comes to engineering, the problem is that there is no social contract—and yet the technologies that are developed and commercialized often have a social impact that consumers are not able intelligently to anticipate and governmental regulation is not sufficient to control.

The idea of a social agreement or contract continues to be invoked by politicians. For instance, in 1974 the British Labor Party proposed to save the United Kingdom by means of a social contract with the trade union movement. In 1994 the Republican Party in the United States ran its political campaign based on a *Contract with America*. The usefulness of social contract theory is its ability to ask what rational individuals would do if given a choice, and then to critique a system based on an argument about what is best for everyone. Even in Hobbes's defense of the monarchy, he begins with the assumption of what is best for all and not just a minority. Rawls extends this idea to justice and the distribution of resources to criticize any historical situation. Both approaches have been indirectly appealed to in discussions of a social contract for science, but it remains to be shown that such rhetoric has drawn at all deeply on the social contract theory tradition.

FRANZ ALLEN FOLTZ

SEE ALSO *Hobbes, Thomas; Kant, Immanual; Locke, John; Rousseau, Jean-Jacques; Social Contract for Science.*

BIBLIOGRAPHY

Ben-David, Joseph. (1984). *The Scientist's Role in Society: A Comparative Study,* with a new introduction. Chicago: University of Chicago Press. First published 1971.

Buchanan, James M. (1975). *The Limits of Liberty*. Chicago: University of Chicago Press.

Bush, Vannevar. (1945). *Science—The Endless Frontier*. Washington, DC: Government Printing Office.

Cozzens, Susan E.; Peter Healey; Arie Rip; and John Ziman. (1989). *The Research System in Transition*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Hobbes, Thomas. (1968). *Leviathan*. Harmondsworth, UK: Penguin.

Jarvie, Ian C. (2001). *The Republic of Science: The Emergence of Popper's Social View of Science*. Amsterdam: Rodopi.

Kant, Immanuel. (1977). *Kant's Political Writings*, ed. Hans Reiss. Cambridge, UK: Cambridge University Press.

Layton, Edwin T., Jr. (1971). *The Revolt of the Engineers: Social Responsibility and the American Engineering Profession*. Cleveland, OH: Press of Case Western Reserve University.

Lessnoff, Michael. (1986). *Social Contract*. London: Macmillan. A collection of edited selections from eleven of the most influential writings on social contract theory.

Lessnoff, Michael. (1990). *Social Contract Theory*. New York: New York University Press.

Locke, John. (1966). *Two Treatises of Government* and *A Letter Concerning Toleration*. Oxford: Blackwell.

Merton, Robert K. (1973). *The Sociology of Science: Theoretical and Empirical Investigations*, ed. Norman W. Storer. Chicago: University of Chicago Press. A collection of more than twenty important papers, from 1935 to 1972, by the founder of the sociology of science.

Nozick, Robert. (1974). *Anarchy, State, and Utopia*. Oxford: Basil Blackwell.

Polanyi, Michael. (1962). "The Republic of Science." *Minerva* 1: 54–74.

Rawls, John. (1971). *A Theory of Justice*. Cambridge, MA: Harvard University Press.

Rousseau, Jean-Jacques. (1968). *The Social Contract and Discourses*. London: Penguin Books.

SOCIAL DARWINISM

Social Darwinism was a prominent ideology in the late-nineteenth and early-twentieth centuries that emerged when biologists and social thinkers tried to apply the biological theories of Charles Darwin (1809–1882) to human society. Social Darwinists believed that humans were subject to scientific laws, including Darwinian natural selection and the struggle for existence. They viewed human competition as a beneficent force bringing progress. However serious differences emerged among those who tried to formulate social theories based on Darwinism. One of the most controversial disputes among social Darwinists was whether humans should model their societies on nature or use scientific knowledge to vanquish nature. Specifically the question was whether humans should sharpen or soften the struggle for existence. Though most social Darwinists never admitted it, this fundamental question was not tractable scientifically, but depended on one's ethical perspective, because Darwinian processes could not predict future outcomes nor provide moral guidance. Not all Darwinists embraced social Darwinism, of course, and some promoted eugenics as a way to evade the human struggle for existence.

From Malthus to Darwin

Tracing the origins of social Darwinism is complicated, because many ideas associated with social Darwinism—such as laissez-faire economics, militarism, and racism—predated Darwin and influenced the formulation of his biological theory. Probably the most important of the forerunners of social Darwinism was Thomas Robert Malthus (1766—1834), whose population principle claimed that human populations tend to expand faster than the food supply. This population imbalance, according to Malthus, inevitably produces human misery, famine, and death. Darwin forthrightly incorporated Malthus's ideas, along with other concepts from nineteenth-century economics, into his biological theory. However he also gave a new twist to Malthus that would be important in the rise of social Darwinism. While Malthus considered the human misery caused by overpopulation entirely harmful and lamentable (though inevitable), Darwin construed it as beneficial and progressive, because it drove the evolutionary process, producing new species. The rise of Darwinian theory in the late-nineteenth century gave greater currency to Malthus's ideas, which became prominent in social Darwinist circles.

Darwin was clearly a social Darwinist, because he believed that the Malthusian population principle demonstrated the necessity of a struggle for existence among humans, leading to competition both within and between human societies. However these two levels of competition could work at cross-purposes, presenting Darwin (and other social Darwinists) with a dilemma. Which was more important: individual or group competition? Most social Darwinists—including Darwin—insisted that both operated simultaneously, though they did not always agree on which was more important. Darwin believed that individual competition among humans manifested itself primarily as peaceful economic competition, while group competition often brought warfare and racial conflict.

Another important plank of social Darwinism that Darwin propagated was human inequality. Natural selection could only function if there were significant differences between organisms. Also, in order to make their theory of human evolution more plausible, Darwinists had to emphasize the tremendous diversity within the human species, while showing the proximity of humans to other species. This led them to stress the differences between races, and the proximity of "primitive" races to primates. Darwin specifically claimed that "savage" races were biologically inferior to Europeans. He believed their intellectual prowess was far below that of Europeans, and because he considered moral character a hereditary trait, he also accused them of being biologically inferior in their moral character.

In most of his writings Darwin confined himself to *describing* the process of human evolution. However at times he became *prescriptive,* proposing public policy based on his theory. He generally supported laissez-faire economics, because it would promote competition among individuals, allowing the "fittest" to succeed. In a private letter he expressed concern that labor unions were deleterious, because they opposed individual competition. He also used his theory to justify national and racial competition, which was reflected in British and other European attempts to dominate the globe through imperialism. In *The Descent of Man* Darwin stated, "At some future period, not very distant as measured by centuries, the civilised races of man will almost certainly exterminate and replace throughout the world the savage races" (Darwin 1981, vol. 1, p. 201). Darwin, however, did make it clear that despite his view that wars have played a crucial role in human evolution, he hoped they would cease in the future.

Classic Social Darwinism

While justifying and supporting human competition as biologically beneficial, Darwin did not believe that the human struggle for existence was completely ruthless. He thought that human morality—which he explained as a product of the struggle for existence—tempered the struggle, at least within societies. Herbert Spencer (1820–1903), whom Darwin and many of his contemporaries considered a great philosopher, but whose star has waned since, likewise argued that ethics was the pinnacle of human evolution. However, like Darwin, he thought that too much altruism would be detrimental to humanity, because it would diminish human competition.

Spencer's role in the development of social Darwinism has been hotly debated, because before Darwin published his theory, Spencer already believed in biological evolution and embraced a competitive ethos and laissez-faire economics. However Spencer's pre-Darwinian ideas about evolution were shaped by Lamarckism, which taught that organisms passed acquired traits on to their offspring. Spencer's pre-Darwinian view of competition was not really social Darwinism. After 1859 Spencer integrated natural selection and the struggle for existence into his social views, thus espousing a form of social Darwinism. Like Darwin, he did not think the human struggle for existence had to be violent. On the contrary, he thought the struggle was becoming more and more peaceful as society progressed.

Not all social Darwinists thought warfare was becoming obsolete, as Spencer did. William Graham Sumner (1840–1910), a prominent American sociologist who pioneered social applications of Darwinism, claimed that Darwinism proved the inevitability of war. He even stated that "nothing but might has ever made right" (Hawkins 1997, p. 117), a position that Darwin rejected, but that several social Darwinists embraced. Even so, Sumner advised avoiding war if possible, so he was far from being a rabid militarist. However some social Darwinists, including the German general Friedrich von Bernhardi (1849–1930), author of the best-selling book, *Germany and the Coming War* (1912), used social Darwinism to promote militarism.

Racial competition was an even more prominent and widespread theme in social Darwinist thought than was national competition. Ernst Haeckel (1834–1919), the leading Darwinian biologist in Germany in the late-nineteenth century, was even more racist than Darwin. He argued that the distinctions between the human races were so great that humans should be divided into twelve separate species, which he placed in four separate genera. These races, he claimed, were in a competitive conflict that would only end with the extermination of the least fit races. Ludwig Gumplowicz (1838–1909), a law professor at the University of Graz in Austria, published one of the most extensive treatments of this theory in *The Racial Struggle* (1883), a term that became popular among social Darwinists in the 1890s and first decades of the twentieth century. Gumplowicz did not consider races a biological entity at all, however, as did most later racial thinkers, but rather he stressed their cultural construction. Nonetheless he argued that races are locked in an ineluctable Darwinian struggle for existence, and he believed that the ethnic conflicts within the Austro-Hungarian Empire were part of this universal struggle.

Another influential social Darwinist in the late-nineteenth and early-twentieth centuries who emphasized the racial struggle for existence was Georges Vacher de Lapouge (1854–1936), who exerted greater influence in Germany than in his native France. Lapouge was worried that certain "inferior" European races were displacing the "superior" forms. He wanted to supplement the racial struggle with eugenics. He hoped to replace the slogan of the French Revolution—liberty, equality, fraternity—with a more "scientific" triad—determinism, inequality, and selection. He warned in 1887, "In the next century people will be slaughtered by the millions for the sake of one or two degrees on the cephalic index [i.e., cranial measurements]. . . . the superior races will substitute themselves by force for the human groups retarded in evolution, and the last sentimentalists will witness the copious extermination of entire peoples" (Hecht 2000, p. 287).

Social Darwinist racism also found much support in Britain and the United States. Walter Bagehot (1826–1877), one of the first writers in Britain to apply Darwinism to politics, thought racial competition was a blessing to the human race, stimulating progress. He asserted that even though some races may not accept the superiority of the European race, "we need not take account of the mistaken ideas of unfit men and beaten races" (Hawkins 1997, p. 70). Karl Pearson (1857–1936), a leading British biologist, wanted to mitigate individual competition to increase national and racial vitality. He promoted eugenics as a way to give the British a competitive advantage in the racial struggle, and he supported the extermination of other races to make room for British settlement. In 1916 Madison Grant (1865–1937), a well-connected lawyer who served as president of the New York Zoological Society, published *The Passing of the Great White Race*. The preface to his book was written by one of the leading scientists of his time, Henry Fairfield Osborn (1857–1935), who was both a professor at Columbia University and president of the American Museum of Natural History. In his book Grant proposed using immigration restrictions and eugenics to restore the vitality of the "Great White Race," which was threatened with biological decline. Pearson and Grant were by no means idiosyncratic in supporting eugenics within their countries to strengthen their nation or race to compete successfully in the wider national or racial struggle for existence.

Conflicting Perspectives

One of the striking things about nineteenth-century social Darwinism was the variety of political positions that could use social Darwinist arguments to buttress their positions. British liberals—like Darwin—could use the theory to support laissez-faire economics and imperialism. But some non-Marxian socialists thought social Darwinism was on their side. For example, the physician Ludwig Büchner (1824–1899), one of the earliest and most famous Darwinian popularizers in Germany, argued that individual competition was essential for human advancement. However, he denied that the capitalist system was best in promoting competition. Capitalism, he thought, skewed the struggle for existence, because those who inherited capital would have an unfair advantage over those from poor families. Büchner suggested eliminating the inheritance of capital to level the playing field, so one's biological traits and abilities would be the only factors determining success or failure. Similar arguments were advanced by prominent Fabian socialists in Britain, such as Sidney Webb (1859–1947), and by the Labour Party leader, Ramsey MacDonald (1866–1937), who both promoted their socialist ideas as the logical outcome of Darwinian theory.

Though appropriated by scholars and politicians embracing a wide variety of political positions, social Darwinism would have its greatest impact on the world stage through the political power exerted by a fanatical social Darwinist whose racist brand of social Darwinism would drive him to unleash World War II in Europe. In *Mein Kampf* (1925–1927) Adolf Hitler argued that racial competition was a part of the universal struggle for existence, which destroys the weak and unfit. Hitler believed that morality consisted in cooperating with nature in destroying the weak, so the healthy, "superior" individuals could triumph.

Social Darwinism declined in popularity in the mid-twentieth century, and not only because of its association with the Nazis. Biological explanations for human behavior gave way in the mid-twentieth century to environmental explanations. Behaviorism dominated psychology in the 1950s, cultural relativism dominated anthropology, and Marxism and other non-Marxist forms of economic and environmental determinism displaced biological determinism in the social sciences. By the 1960s biological determinism had almost completely disappeared from serious scholarly work. After Richard Hofstadter wrote the first major historical work titled *Social Darwinism in American Thought* (1944), the term social Darwinism was generally used disparagingly.

In the 1970s a new movement within the scientific community emerged that reinvigorated biological determinism. Edward O. Wilson provoked intense controversy with the publication of his book, *Sociobiology* (1975). Many accused Wilson of resurrecting social Darwinism, but he and supporting colleagues denied the charge. Indeed Wilson did embrace some of the positions of earlier social Darwinists (for example, his stress on biological determinism, the importance of Darwinian selection on human behavior, and so on), but he did not embrace the crude nationalism and racialism that Hofstadter identified as leading characteristics of social Darwinism.

RICHARD WEIKART

SEE ALSO *Christian Perspectives; Darwin, Charles; Dominance; Eugenics; Holocaust; Population; Race; Sociobiology; Spencer, Herbert.*

BIBLIOGRAPHY

Bannister, Robert. (1979). *Social Darwinism: Science and Myth in Anglo-American Social Thought*. Philadelphia: Temple University Press. Bannister challenges Hofstadter's thesis by claiming that the influence of social Darwinism was minimal. His unconvincing argument is that social Darwinism was merely a straw man created by progressives who opposed a competitive ethos.

Clark, Linda. (1984). *Social Darwinism in France*. Tuscaloosa: University of Alabama Press. Clark's work shows the varieties of social Darwinism in France, especially emphasizing what she calls reform Darwinism.

Darwin, Charles. (1981). *Descent Of Man*. 2 Vols. Princeton, NJ: Princeton University Press.

Degler, Carl N. (1991). *In Search of Human Nature: The Decline and Revival of Darwinism in American Social Thought*. New York: Oxford University Press. Degler provides an excellent survey of the nature-nurture debate in the human sciences in the twentieth-century United States, focusing especially on the role of Darwinism in this debate. He is sympathetic to the rise of sociobiology.

Hawkins, Mike. (1997). *Social Darwinism in European and American Thought, 1860–1945*. Cambridge, UK: Cambridge University Press. This is the best single volume on social Darwinism available. Hawkins provides in-depth analysis of key social Darwinist thinkers in various countries.

Hecht, Jennifer Michael. (2000). "Vacher De Lapouge and the Rise of Nazi Science." *Journal of the History of Ideas* 61 (2000): 285–304.

Hofstadter, Richard. (1955). *Social Darwinism in American Thought*, revised edition. Boston: Beacon Press. This is the pioneering work that introduced the term social Darwinism into historical discourse. While providing excellent explanations and examples of social Darwinism, he wrongly equated it with conservative political thought.

Jones, Greta. (1980). *Social Darwinism and English Thought: The Interaction between Biological and Social Theory*. Sussex, UK: Harvester. Jones shows the prominence (and variety) of social Darwinist thought in Britain during the late-nineteenth and early-twentieth centuries.

Weikart, Richard. (2004). *From Darwin to Hitler: Evolutionary Ethics, Eugenics, and Racism in Germany*. New York: Palgrave Macmillan. This work shows the impact of Darwinism on ethical and moral thought in Germany during the late-nineteenth and early-twentieth centuries. It explores eugenics, euthanasia, racism, militarism, and the impact of Darwinism on Hitler's thought.

Wilson, Edward O. (1975). *Sociobiology: The New Synthesis*. Cambridge, MA: Belknap Press of Harvard University Press. This is the classic work by a Harvard biologist that brought sociobiology into prominence in the late twentieth century.

Weindling, Paul. (1989). *Health, Race and German Politics between National Unification and Nazism, 1870–1945*. Cambridge, UK: Cambridge University Press. A long chapter on social Darwinism in Germany shows the predominance of political liberalism in social Darwinist discourse. Much of the rest of the book examines eugenics.

Young, Robert. (1985). "Darwinism *Is* Social." In *The Darwinian Heritage*, ed. David Kohn. Princeton, NJ: Princeton University Press. Young cogently explains how social thought impacted Darwin and influenced the formulation and expression of his theory.

SOCIAL ENGINEERING

Social engineering occurs in two forms: large scale and small scale. The debate surrounding these two approaches to the design of social institutions constitutes a fundamental issue in the ethics of science and technology. To what extent is it possible and legitimate for scientific expertise to serve as the basis for social policy and action? Can humans use science to rationally design and successfully implement an enduring society? Different concepts of scientific knowledge and technological action supply different answers to these questions and variously support large scale versus small scale engineering efforts.

Large Scale Social Engineering

Large scale efforts to improve the human condition are a modern phenomenon. Such endeavors require technical knowledge, political muscle, and economic resources. In supporting these claims, James Scott (1998) characterizes the rise of high modernism in social-political, agricultural, industrial, and architectural contexts during the last two centuries. High modernism encompasses a quest for authoritarian control of both human and nonhuman nature, a belief that carefully crafted social order surpasses happenstance, and a confidence in science as a means to social progress. Once the improvement of humanity becomes a plausible state goal, the convergence of rising social science, state bureaucracy, and mass media undergirds five-year collectivist plans, colonial development schemes, revolutionary agricultural programs, and the like, often under the control of a single planning entity.

In urban planning, for example, Scott details the designs of the Swiss architect, Charles-Edouard Jeanneret, (1887–1965), known professionally as Le Corbusier. For Le Corbusier, urban design expresses universal scientific truths. His geometric symmetries often structured human activity, as inhabitants conformed to the design rather than vice versa. This approach applied to entire cities as well as individual homes ("machines for living"). Le Corbusier's formulaic concatenation of single function components produced simplicity via widely separated spaces for living, working, shopping, and recreating. Defining the good of the people, often the working poor, in terms of detached, scientific principles and their authoritarian imposition is, according to Scott, emblematic of high modernist, large scale attempts at social engineering.

Small Scale Social Engineering

In conceiving the perfect, nondecaying state, Plato envisions a radical departure from existing society. Marxists, too, as self-described social engineers, use historical interpretation in aiming for revolutionary, holistic change. The Anglo-Austrian Philosopher, Karl Popper (1902–1994) contrasts these utopian endeavors with "piecemeal social engineering." When society needs reforming, the piecemeal engineer

> does not believe in the method of re-designing it as a whole. Whatever his ends, he tries to achieve them by small adjustments and re-adjustments which can be continually improved upon. . . . The piecemeal engineer knows, like Socrates, how little he knows. He knows that we can learn only from our mistakes. Accordingly, he will make his way, step by step, carefully comparing the results expected with the results achieved, and always on the look-out for the unavoidable unwanted consequences of any reform; and he will avoid undertaking reforms of a complexity and scope which make it impossible for him to disentangle causes and effects, and to know what he is really doing. (Popper 1957, pp. 66–67)

These claims resonate with Camus's (1956) distrust of ideologically calculated revolution and his preference for limited but inspired rebellion. In Popper's view, mistakes are inevitable, and more radical innovations produce more mistakes. Because foolproof social forms are unattainable, some mechanism for identifying needed improvements must be an integral part of a necessarily gradual implementation process. This view contrasts with that of large scale social engineering on several dimensions and highlights multiple points of contention.

Spontaneous versus Consciously Controlled Change

Popper's (1972) concept of evolutionary epistemology supports not only the idea that advances are slow and piecemeal but also that they are guided by no overarching plan. This view resembles that of the twentieth-century British economist Friedrich Hayek (Nishiyama and Leube 1984). Hayek (1967) emphasizes the view that significant social phenomena emerge spontaneously via the unintended effects of individual actions, and he finds support for the benefits of this process in the ideas of the British political economist, Josiah Tucker (1711–1799), and especially the Austrian economist Karl Menger (1840–1921), that social institutions compete with one another in a kind of survival of the fittest. Because knowledge required for large-scale planning is widely distributed among many minds and cannot be narrowly concentrated, Hayek rejects centralized planning. Popper (1963a) advocates "negative utilitarianism," the view that proposals for reform should be judged by how little suffering is caused. Government should thereby ameliorate enduring social ills (such as poverty and unemployment) and leave efforts to increase happiness to individual enterprise. These views shape the method (monitored, incremental change) and the goals (amelioration) of social engineering.

The nature of social reform is also examined by the American philosopher and educator John Dewey (1859–1952). But when Dewey speaks about the need for liberalism to advance beyond its early gains in securing individual freedom, his vision is incongruent with that of Hayek and Popper. For Dewey, liberalism should advance a social order that "cannot be established by an unplanned and external convergence of the actions of separate individuals, each of whom is bent on personal private advantage" (Dewey 1963 [1935], p. 54). This social reform must be thoroughgoing in its quest for institutional change.

> For the gulf between what the actual situation makes possible and the actual state itself is so great that it *cannot be bridged by piecemeal policies undertaken ad hoc*. The process of producing the changes will be, in any case, a gradual one. But "reforms" that deal now with this abuse and now with that without having a *social goal based upon an inclusive plan*, differ entirely from efforts at re-forming, in its literal sense, the institutional scheme of things. (p. 62)

Dewey sees the necessity of early planning in his thinking about social reform (Geiger 1971 [1939]), and while it is clear that Popper restricts not planning per se but only its scope and method, Dewey projects a wider, more vibrant use of planning in achieving social renovation. Education, science (the method of intelligence), and well-designed government policy are keys to social improvement.

The Nature of Scientific Knowledge

Any call for social engineering requires some clarification of the relationship between science and engineering. Popper differentiates natural and social science in ways that Dewey does not. In natural science, Popper's realist perspective dictates that theories make claims about unobservable realities responsible for observed regularities. These claims are tested by means of controlled experiments. In contrast, Popper construes social science as producing low-level empirical laws of a negative sort ("you cannot have full employment without inflation"), which are tested through practice in social engineering. This amounts to a narrow view of social science and contributes to the contrast between his scientific radicalism, which focuses on natural science, and his engineering conservatism, which is linked to social science. The contrast between Dewey the pragmatist and Popper the realist is instructive here. From Dewey's pragmatic perspective, "the ultimate objects of science are guided processes of change" (Dewey 1958 [1929], p. 160). Both natural science and social science provide an illustration of this concept (Dewey 1947). Popper's general aversion to abstract theories in social science may be linked to his desire to reject certain theories, such as that of the Austrian psychiatrist Sigmund Freud, on the basis of unfalsifiabilty. Dewey's acceptance of a wider range of theory plus empirical law in social science allows for testing to occur in a greater range of circumstances, not only in practice (which is often problematic: even piecemeal change simultaneously introduces multiple causal factors) but also in controlled, even laboratory, settings. Contemporary studies in social science embrace such methods, including those of simulation (Liebrand, Nowak, and Hegselmann 1998; Ilgen and Hulin 2000). Moreover, when guided by theory and experimental tests, changes introduced into practice need not be small scale. Large-scale changes may be introduced for larger scale problems (such the Great Depression or disease epidemics). Linking Science to Practice Popper and Dewey differ when relating science to social engineering. In disputes with the American philosopher Thomas Kuhn (1922–1996), Popper emphasizes the value of critical and revolutionary action (bold conjectures and severe tests) over and above the uncritical plodding of normal science (Popper 1970). This contrasts with his recommendations for social engineering where action should be piecemeal. This contrast, acknowledged by Popper (1976) himself, may arise from the use of the scientific community as a model for society at large. Nevertheless, the degree of openness and fruitfulness of criticism differs significantly within these two realms (Burke 1983). Robert Ackermann proposes that an explanation "of the relative isolation of theoretical scientific knowledge from practical concerns is required to explain how a form of social conservatism can be held consistently with a form of theoretical radicalism" (Ackermann 1976, p. 174).

Such concerns are related to Scott's analysis of why large scale schemes have often failed to improve the human condition. Scott sees knowledge of how to attain worthwhile, sustainable solutions as being derived not from scientific theory, nor from the low level empirical laws cited by Popper, but by a form of know how (*metis*, from the ancient Greek) rooted in localized, cultivated practice. Like Dewey's conception, which builds an inherent normative element ("*guided* processes") into knowledge itself, there is no need to search for means of effective "application." The implication is that useful knowledge springs from contextualized activities, not from using local conditions to fill in the variables of general principles. This view raises serious doubts about the practical relevance of scientific expertise, in the modern sense, and its ability to produce sustainable solutions to social problems. Indeed, some have suggested that such limitations exist not only in large scale enterprises but also in small scale efforts involving more narrowly focused problems (Hamlett 1992, Winner 1992). A narrow focus can undermine the need to address larger issues and long run concerns and can mire the political process in gridlock. From these considerations, it should be clear that small scale engineering offers no panacea and that different concepts of small scale enterprise point the way in somewhat different directions.

Impact of the Social Engineering Issues

Questions concerning appropriate scale and the interaction of social science and social engineering have wide impact. An entire school of social scientists use Popper as a guide in trying to design effective social policy. The works of the incrementalist Charles Lindblom (*The Intelligence of Democracy*; *Usable Knowledge: Social Science and Social Problem Solving*; *Inquiry and Change: The Troubled Attempt to Understand and Shape Society*; etc.) provide, by title alone, some measure of the impact of Popper and Dewey and of social scientists' pursuit of social engineering. Moreover, differences between planned, rule-governed (top-down) versus unplanned, evolutionary (bottom-up) approaches inform methodologically diverse explorations within social science itself (Banathy 1996, Read and Miller 1998). Whether or not humans can effectively design social systems is essentially a question concerning human intelligence, and efforts to build automated intelligent systems confront the same methodological controversy concerning rule-governed versus connectionist, evolutionary designs ("Sackler Colloquium" 2002). Finally, controversies over the promises of planned societies continue to echo the dispute between Popper and Marxists over the true nature of social engineering (Cornforth 1968, Marquand 2000, Notturno 2000, Postrel 2001).

MARVIN J. CROY

SEE ALSO *Dewey, John; Incrementalism; Popper, Karl; Plato.*

BIBLIOGRAPHY

Ackermann, Robert. (1976). *The Philosophy of Karl Popper*. Amherst: University of Massachusetts Press. Provides analyses of several central concepts, including Popper's account of the social sciences.

Banathy, Bela. (1996). *Designing Social Systems in a Changing World*. New York: Plenum. Explains design as a collective human activity and system design as a process for addressing a wide variety of problems from a holistic, large scale perspective.

Burke, T. E. (1983). *The Philosophy of Popper*. Dover, NH: Manchester University Press. Critically assesses Popper's connection of epistemological concepts to issues of freedom and values.

Cornforth, Maurice. (1968). *The Open Philosophy and the Open Society: A Reply to Dr. Karl Popper's Refutations of Marxism*. New York: International Publishers.

Camus, Albert. (1956). *The Rebel: An Essay on Man in Revolt*. New York: Alfred A. Knopf. Articulate and inspired statement of Camus's rejection of ideology, including Marxism, and his view of where that leaves any effort to improve the human condition.

Dewey, John. (1947). "Liberating the Social Scientist: A Plea to Unshackle the Study of Man." *Commentary* 4: 378–385.

Dewey, John. (1958 [1929]). *Experience and Nature*, 2nd edition. New York: Dover Publications.

Dewey, John. (1963 [1935]). *Liberalism and Social Action*. New York: Capricorn Books. Classic statement on the nature of Liberalism and its promise for an improved social order.

Geiger, George. (1971 [1939]). "Dewey's Social and Political Philosophy." In *The Philosophy of John Dewey*, ed. Paul Arthur Schilpp. La Salle, IL: Open Court.

Hamlett, Patrick. (1992). *Understanding Technological Politics: A Decision Making Approach*. Englewood Cliffs: Prentice Hall. Combines the strengths of theoretical and empirical approaches by analyzing the framework and consequences of particular decisions concerning technology development and implementation.

Hayek, Friedrich. (1967). *Studies in Philosophy, Politics, and Economics*. Chicago: University of Chicago Press. Impressive collection of twenty five articles authored in two decades that illustrate the range and genius of Hayek's thinking.

Ilgen, Daniel, and Charles Hulin. (2000). *Computational Modeling of Behavior in Organizations: The Third Scientific Discipline*. Washington, DC: American Psychological Association.

Liebrand, Wim B. G.; Andezej Nowak; and Rainer Hegselmann, eds. (1998). *Computer Modeling of Social Processes*. Thousand Oaks, CA: Sage. This collection explores simulations, neural networks, and data analysis methods in explaining and predicting complex social processes.

Marquand, David. (2000). "A Tale of Three Karls: Marx, Popper, Polanyi, and Post-Socialist Europe." In *Philosophy and Public Affairs,* ed. John Haldane. Cambridge, UK: Cambridge University Press.

Nishiyama, Chiaki, and Kurt R. Leube, eds. (1984). *The Essence of Hayek*. Stanford, CA: Hoover Institution Press, Stanford University.

Notturno, Mark Amadeus. (2000). *Science and the Open Society: The Future of Karl Popper's Philosophy*. New York: Central European University Press.

Popper, Karl. (1957). *The Poverty of Historicism*. New York: Basic. Contains the kernel of Popper's argument against large scale social engineering, particularly the Marxist variety, plus the characterization of piecemeal social engineering that stimulated decades of incrementalist thinking in the social science.

Popper, Karl. (1963a). *Conjectures and Refutations: The Growth of Scientific Knowledge*. New York: Harper and Row.

Popper, Karl. (1963b). *The Open Society and Its Enemies,* 4th edition. Princeton, NJ: Princeton University Press.

Popper, Karl. (1970). "Normal Science and Its Dangers." In *Criticism and the Growth of Knowledge,* ed. Imre Lakatos and Alan Musgrave. Cambridge, UK: Cambridge University Press.

Popper, Karl. (1972). *Objective Knowledge: An Evolutionary Approach*. Oxford, UK: Oxford University Press.

Popper, Karl. (1976). "Reason or Revolution." In *The Positivist Dispute in German Sociology,* ed. Theodor W. Adorno et al. London: Heinemann.

Popper, Karl. (1983 [1956]). *Realism and the Aim of Science*. Totowa, NJ: Rowman and Littlefield.

Postrel, Virginia. (2001). "The Future and Its Enemies: Dynamism versus Stasis." In *Competition or Compulsion? The Market Economy versus the New Social Engineering,* ed. Richard Ebeling. Hillsdale, MI: Hillsdale College Press.

Read, Stephen, and Lynn Miller. (1998). *Connectionist Models of Social Reasoning and Social Behavior*. Mahwah, NJ: Erlbaum.

"Sackler Colloquium on Adaptive Agents, Intelligence, and Emergent Human Organization: Capturing Complexity through Agent-Based Modeling." (2002). *Proceedings of the National Academy of Sciences* 99(suppl. 3): 7187–7316.

Schilpp, Paul Arthur, ed. (1974). *The Philosophy of Karl Popper*. La Salle, IL: Open Court.

Scott, James C. (1998). *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed*. New Haven, CT: Yale University Press. Clearly delineates the differences between small scale and large scale social engineering, with accessible examples of each, and provides helpful analyses of the differences.

Winner, Langdon, ed. (1992). *Democracy in a Technological Society*. Dordrecht: Kluwer Academic Publishers.

SOCIAL INDICATORS

The historical tradition of social indicators may be traced back to Jeremy Bentham's (1789) ideas about a *felicific calculus* that would allow decision makers to calculate the net pleasure or pain connected to everyone affected by an action, with evidence-based public policy choices made to get the greatest net pleasure or least net pain for the greatest number of people. From a consequentialist moral point of view, the aim of government should be to increase the pleasure or happiness, broadly construed, of the maximum number of persons.

This approach is similar to the naturalist tradition in American pragmatism as argued in work by William James (1909), Ralph Barton Perry (1926, 1954), John Dewey (1939), and C. I. Lewis (1946), but more complicated. It is similar in the sense that pragmatism, like Bentham, naturalizes ethics by basing it in subjective preferences. It is more complicated in that most early-twenty-first century social indicators researchers believe the relatively objective circumstances of people's lives merit at least as much attention as how people assess those lives. The argument is that a morally complete assessment of people's lives, or a full assessment of people's lives from a moral point of view, requires a thorough examination of the nature or being as well as the value or good of those lives. In philosophical jargon, social indicators rest on an ontological answer to the question, What is its nature?, and an axiological answer to the question, What is its value?

Basic Concepts

The term *social indicator* denotes a statistic that has significance for measuring the quality of life. The term *social report* designates an organized collection of social indicators, and *social accounts* names a balance sheet in which costs and benefits are assigned to the indicators in a social report. Briefly the main difference between social reports and accounts is that the former answers the question, How are we doing?, and the latter answers the question, At what price?—where price may be measured in dollars, energy, personal satisfaction or dissatisfaction, or some other applicable metric.

From a linguistic perspective, social indicators usually consist of a term denoting a subject class and a term denoting some *indicator property*. For example, the second term of the phrase *infant mortality* denotes the indicator property mortality and the first term denotes a particular class of things, namely infants that may possess that property. By replacing the subject term infant by *one-year-old, two-year-old,* or more, one can routinely generate (social) mortality indicators for as many age groups as desired. Similarly by replacing the subject term by *male, Indian,*or others, one can routinely generate mortality indicators for as many kinds of groups as one likes.

Social indicator phrases are like variable names in logic and mathematics, and social indicators are like the variables themselves. Furthermore just as one speaks of the values of variables in logic and math, one may speak of the indicator-values of social indicators. For example, the annual percent of undergraduate degrees awarded to females in engineering in the United States in the 1990s was about 16 percent. So one may say that this variable (annual percent of undergraduate degrees awarded to females in engineering in the United States in the 1990s) had an indicator-value of 16 percent.

Social indicators that refer to personal feelings, attitudes, preferences, opinions, judgments, or beliefs of some sort are called *subjective indicators*, for example, satisfaction with one's health, attitudes toward science or scientists, and beliefs about the dangers of some new technology. Social indicators that refer to things that are observable and measurable are called *objective indicators,* for instance, the height and weight of people, numbers of automobiles manufactured or sold each year, and numbers of people employed in research and development.

Positive indicators are those for which most people equate an indicator-values increase with quality of life improvement, such as elderly citizens incomes and minority-group educational attainment. The female engineering degrees indicator mentioned above would be regarded as positive by those who think that the quality of women's lives tends to improve as their access to the full range of professional occupations improves. *Negative indicators* are those for which most people equate an indicator-values increase with quality of life deterioration, namely, infant mortality rates and murder rates. (Notice that an indicator is regarded as positive or negative not in virtue of whether or not its values in fact increase or decrease, but only in virtue of whether or not most people would like its values to increase or decrease. What is relevant is not the *fact* but the *desirability* of an increase or decrease in its values.)

Unclear indicators are such that either (a) most people will not be willing or able to say whether higher indicator-values indicate a better or worse state of affairs, for instance, welfare payments, or (b) there is serious disagreement about whether higher indicator-values indicate a better or worse state of affairs, namely, divorce rates. In the case of welfare payments, it is difficult to say, because as the values increase there may be an increase of people in need of such assistance, which is bad; while, at the same time, there is an increase in the amount of assistance given, which is good. In the case of divorce rates, many people know exactly what they want to say, and they happen to disagree with what some other people want to say.

Input indicators indicate some sort of inputs into a process or product, such as numbers of people engaged in research and development. *Output indicators* indicate some sort of output of a process or product, such as numbers of articles published or patents awarded per 1,000 people employed in research and development. Unlike the previous indicator classifications, what counts as an input or output indicator depends on the purposes of the classification. For example, from the point of view of a teacher, the amount of time a student spends studying could be regarded as an output indicator measuring the effects of a student's own need for achievement as well as from advice, admonitions, and threats given to the student. However from the point of view of a student, time spent studying could be regarded as an input indicator measuring the necessary investment made in the interest of obtaining such important measurable outputs as university degrees, good jobs, and higher income. In some contexts it is useful to talk about *intermediate output indicators* (for example, that count the machines that make consumer products), *throughput indicators* (for instance, that assess choices people make for certain consumer goods) and *outcome indicators* (such as those that measure longer-term net results of inputs).

When people use the phrase *quality of life,* they sometimes intend to contrast it with quantities or numbers of something. There are, then, two different things that one might reference when using the phrase *quality of life*. First, one might want to refer to sorts, types, or kinds of things, rather than to mere numbers of things. For example, one might want to know not merely how many people received bachelors degrees majoring in mathematics, but also something about who they were, male or female, in public or private institutions, with or without scholarship aid, and so on. When the term *qual-*

ity in the phrase *quality of life* is used in this sense, one may say that it and the phrase in which it occurs is are intended to be primarily *descriptive*.

Second, one might want to refer to the value or worth of things when using the term quality in the phrase *quality of life*. For example, one frequently hears of people making a trade-off between a high salary and better working or living conditions. Presumably the exchange here involves monetary and some other value. That is, one exchanges the value of a certain amount of money for the value of a certain set of working or living conditions. When the term *quality* in the phrase *quality of life* is used in this sense, one may say that it and the phrase in which it occurs is intended to be primarily *evaluative*.

Both senses of the phrase *quality of life* are important. It is important to be able to describe human existence in a fairly reliable and valid fashion, and it is important to be able to evaluate human existence in the same way. In the early years (1960s) of social indicators research, people asked, Should researchers measure the nature and value of life with objective or subjective indicators, or both? In the early twenty-first century, nearly everyone agrees that both kinds of measures should be used.

Uses and Abuses

It cannot be emphasized too strongly that social reporting is an essentially political exercise and that its ultimate success or failure depends on the negotiations involved in creating and disseminating the reports. Every opportunity to use social indicators is equally an opportunity to abuse their use. For examples, indicators:

(1) provide convenient numerical summaries of important features of society, but also encourage commission of The Number-Crunchers' Fallacy, which is this: Anything that cannot be counted is unimportant and anything that can be counted is important.

(2) can be used to predict and alter future behavior, for better or worse depending on the nature of the behavior and the alterations.

(3) can give visibility to problems, and also create them by focusing attention on them, or by hiding some in the interest of emphasizing others.

(4) can help obtain balanced assessments of conditions against mere economic assessments, and can distort appropriate assessments by assuming that everything valuable can be given a price in monetary terms.

(5) can help in the evaluation of current public policy and programs, and also contribute to perverse evaluations because the statistics routinely collected may not allow decision makers to control for important contaminating variables when they are trying to decide what has caused what.

(6) can help determine alternatives and priorities, but also allow an elite corps of statisticians and other experts to unduly influence the public agenda by providing the *official version* of the state of the world.

(7) can facilitate comparisons among nations, regions, and cities, and service providers, but also encourage invidious comparisons, raising aspirations and hopes too high or not high enough.

(8) can suggest areas for research to produce new scientific theories and more knowledge about the structures and functions of systems, but also retard action because people may be unwilling to act in the absence of a perfect theory or model.

(9) can provide an orderly and common framework for thinking about social systems and social change, perhaps so orderly and common that alternatives from different points of view might be perceived as unrealistic, unthinkable, totally radical, and incredible merely because they are different.

(10) can stimulate thinking about new polices and programs, or stifle such thought as a result of massive *group-thinking*.

Critical Issues

Anyone constructing social indicators with the aim of integrating them into a social reporting or accounting system to monitor changes in the quality of people's lives will have to address the following thirteen issues, which collectively yield more than 200,000 possible combinations representing at least that many different kinds of systems.

1. *Settlement/aggregation area sizes:* For example, best size to understand air pollution may be different from best size to understand crime.
2. *Time frames:* For example, optimal duration to understand resource depletion may be different from optimal duration to understand impact of sanitation changes.

3. *Population composition:* For example, analyses by language, gender, age, education, ethnic background, and income, among others, may reveal or conceal different things.
4. *Domains of life composition:* For example, different domains such as health, job, family life, and housing give different views and suggest different agendas for action.
5. *Objective versus subjective indicators:* For example, relatively subjective appraisals of housing and neighborhoods by actual dwellers may be very different from relatively objective appraisals by experts.
6. *Input versus output indicators:* For example, expenditures on teachers and school facilities may give a very different view of the quality of an education system from that based on student performance on standardized tests.
7. *Measurement scales:* For example, different measures of perceived subjective well-being provide different views of people's well-being and relate differently to other measures.
8. *Report writers:* For example, different stakeholders often have very different views about what is important to monitor and how to evaluate whatever is monitored.
9. *Report readers:* For example, different target audiences need different reporting media and/or formats.
10. *Quality-of-life model:* For example, once indicators are selected, they must be combined or aggregated somehow in order to get a coherent story or view.
11. *Distributions:* For example, because average figures can conceal extraordinary and perhaps unacceptable variation, choices must be made about appropriate representations of distributions.
12. *Distance impacts:* For example, people living in one place may access facilities (hospitals, schools, theatres, museums, and libraries) in many other places at varying distances from their place of residence.
13. *Causal relations:* Prior to intervention, one must know what causes what, which requires relatively mainstream scientific research, which may not be available yet.

In the presence of the potential abuses and the great variety of reports that might be produced as people make different choices regarding the thirteen critical issues, the general rule to be used is to try to have a development process that is maximally inclusive and transparent. William James came close to capturing the appropriate aim in 1891.

> That act must be the best act . . . which makes for the *best whole,* in the sense of awakening the least sum of dissatisfactions. In the casuistic scale, therefore, those ideals must be written highest which prevail at the least cost, or by whose realization the least possible number of other ideals are destroyed. . . . The course of history is nothing but the story of men's struggles from generation to generation to find the more and more inclusive order. (James 1977, p. 623)

ALEX C. MICHALOS

SEE ALSO *Science and Engineering Indicators.*

BIBLIOGRAPHY

Berger-Schmitt, Regina, and B. Jankowitsch. (1999). *Systems of Social Indicators and Social Reporting: The State of the Art.* Mannheim, Germany: Centre for Survey Research and Methodology (ZUMA).

Dewey, John. (1939). *Theory of Valuation.* Chicago: University of Chicago Press.

Hagerty, Michael R., et al. (2001). "Quality of Life Indexes for National Policy: Review and Agenda for Research." *Social Indicators Research* 55(1): 1–96.

James, William. (1909). *The Meaning of Truth: A Sequel to Pragmatism.* New York: Longmans, Green and Co.

James, William. (1977). "The Moral Philosopher and the Moral Life." In *The Writings of William James: A Comprehensive Edition,* ed. J. J. McDermott. Chicago: University of Chicago Press. Originally published in 1891.

Lewis, Clarence I. (1946). *Analysis of Knowledge and Valuation.* LaSalle, IL: Open Court.

Michalos, Alex C. (1997). "Combining Social, Economic and Environmental Indicators to Measure Sustainable Human Well-Being." *Social Indicators Research* 40(1–2): 221–258.

Michalos, Alex C. (1980–1983). *North American Social Report,* 5 vols. Dordrecht, The Netherlands: D. Reidel.

National Science Board. (2002). *Science and Engineering Indicators.* Washington, DC: Government Printing Office.

Nordhaus, William D., and E. C. Kokkelenberg, eds. (1999). *Nature's Numbers: Expanding the National Economic Accounts to Include the Environment.* Washington, DC: National Academy Press.

Perry, Ralph Barton. (1926). *General Theory of Value.* Cambridge, MA.: Harvard University Press.

Perry, Ralph Barton. (1954). *Realms of Value.* Cambridge, MA: Harvard University Press.

INTERNET RESOURCES

Bentham, Jeremy. (1907 [1789]). *An Introduction to the Principles of Morals and Legislation*. Oxford: Clarendon Press. Available from http://www.econlib.org/library/Bentham/bnthPML.html

London Group of Environmental Accountants. (2002). "SEEA 2000 Revision." Available from http://www4.statcan.ca/citygrp/london/publicrev/pubrev.htm.

SOCIAL INSTITUTIONS: OVERVIEW

Ethics is involved not only with personal decisions and the assessments of individual behavior but also with social institutions, especially, in the contemporary world, with those institutions constituted by scientific and technical professions as well. Classic sociology—as developed by social scientists considered in entries on "Durkheim, Émile," "Marx, Karl," and "Weber, Max," among others—identified a number of basic social institutions such as the family, religion, state, economy, and education. Social institutions in this sense are defined by persons acting in concert to address distinctive human interests; as such they are characterized by social roles that people accept when acting, for instance, in relation with those to whom they have biological links (the family), in relation to that which is seen as sacred (religion), in relation to the exercise of group power (state), and so on. Each social institution is thus defined by and defines a sphere of human behavior, and the roles woven into these institutions traditionally constitute both descriptive or empirical (and in this sense scientific) and prescriptive or normative (and thus ethical) phenomena. Roles both describe and prescribe human behavior within the contexts of social institutions.

Science and technology, while acquiring the status of social institutions, have likewise influenced and altered other social institutions and social roles in at least three overlapping ways. First, technological change over the long sweep of human history has shifted the relative weights or balances between different roles. For thousands of years, during the preliterate period of human history, when humans were primarily hunters and gatherers, the institution of the family occupied the dominant position with only the most modest autonomy granted to religion and even less to those activities now associated with the state, economy, and education. With the domestication of plants and animals, however, divisions of labor arose that in turn gave rise and increasing prominence to religion, state, economy, and education, while also transforming the institution of family (as is considered, for example, in the entry on "Family").

Second, over the course of written history science or the systematic pursuit of knowledge in its various permutations altered fundamental ideas about these basic social institutions and their justifications. Mythical narratives of the gods and relations between gods and humans as the original behavior patterns to be differentially imitated by different social institutions were supplemented by accounts that appealed to patterns in nature. The science of nature slowly introduced alternative understandings of social institutions and social roles, as can be seen, for instance, in Plato's *Republic*, with its rational account of the need for myths or likely stories about the differences between the social roles of the three basic classes (or social institutions) of artisans, soldiers, and rulers.

Finally, in the modern period, new unifications of science and technology in both the "Scientific Revolution" (sixteenth century) and the "Industrial Revolution" (eighteenth century) intensified the proliferation of social institutions and social roles through the development of scientific disciplines and industrial divisions of labor. These historical changes altered anew the balances between institutions (giving both science and economy, for instance, a weight previously unknown in human history), granted each institution more autonomy or independence, and ultimately relativized the power of particular social roles through their very proliferation. Beginning in the second half of the twentieth century, the growing multiplicity and complexity of roles began to be linked and networked in synchronic hybrids of interdisciplinarity and diachronic career changes. (Entries on "Education" and "Interdisciplinarity" are especially relevant in regard to such changes.)

Beyond entries already mentioned, others in the *Encyclopedia of Science, Technology, and Ethics* break out social institution–related issues in different ways. The perspective of the basic institution of religion finds expression in a series of entries on "Buddhist Perspectives," "Christian Perspectives," "Hindu Perspectives," and more. The basic institution of the state is engaged with entries on "International Affairs," "Military Ethics," "Police," "Science Policy," and "Science, Technology, and Law." Entries on such basic social institutions are complemented by ones on more fine-grained social organizations and agencies (professional societies such as the "American Association for the

Advancement of Science"), on related processes (such the emergence of "Professions and Professionalization"), and on ethical questions that repeatedly challenge and are challenged by social institutions (such as "Justice").

CARL MITCHAM

SEE ALSO *Aristotle and Aristotelianism; Bell, Daniel; Civil Society; Ethics: Overview; Modernization; Nongovernmental Organizations; Plato; Polanyi, Karl; Professional Engineering Organizations; Regulation and Regulatory Agencies; Science, Technology, and Society Studies; Work.*

SOCIALISM

Socialism has been one of the most popular political ideas in history, rivaling in some ways even the great religions. By the late 1970s, a mere 150 years from the time the term *socialism* was coined, roughly 60 percent of the world population was living under governments that called themselves "socialist," although these varied widely in their institutions and were often violently at odds with one another.

Socialism drew impetus from the rise of industry in Europe in the nineteenth century. The new wealth generated by new methods of production encouraged the belief that now it would be possible to assure a comfortable standard of living for every member of society. The uneven distribution of this new wealth was seen to pose ethical questions that were less often asked about long-entrenched class disparities prevalent in the countryside. Socialism was seen by many of its advocates as not only an ethical but also a scientific response to these new circumstances. Drawing on the Enlightenment critique of religion, socialism offered an image of the ideal life as something to be achieved in the here and now rather than in the great beyond.

Five Types of Socialism

The myriad forms of socialism that were actually put into practice might be grouped into five broad categories: communism, social democracy, Third World socialism, fascism, and communal socialism. (There were others, such as anarcho-syndicalism, that remained forever in the realm of speculative thought.) Each of these five requires a note of explication.

In the early decades of socialist thought the terms *socialism* and *communism* were often used interchangeably, and while some writers attempted to define the distinction between the two, no such distinction ever achieved widespread acceptance. When Vladimir Ilich Lenin (1870–1924) led his group of Bolsheviks to power in Russia in 1917, he announced that they would henceforth call themselves communists. Until then, they had been merely the *bolshevik* (meaning majority) segment of Russia's Social-Democratic movement. (This had been a single party, at least formally, until 1912, when Lenin's faction announced it was a party in itself. Still they were all social democrats.)

In the years following 1917, as parties modeled after Lenin's appeared in dozens of countries, a clear distinction emerged between social democracy and communism. There were countless points of dispute and differences, but probably the most profound was that social democrats sought parliamentary means to power and adhered to the principle that political systems should have multiple parties, whereas communists envisioned a revolutionary path to power and believed that communist parties, as the only true representatives of the working class, were the only legitimate ones. This made for such a wide gulf that thereafter social democrats never called themselves communists, and communists never called themselves social democrats. The distinction, however, continued to be clouded by the fact that both sides claimed the term *socialism* for themselves. Thus the country Lenin created was called the Union of Soviet Socialist Republics, and at the same time the international federation that brought together the world's social democratic parties (the British Labour Party, the German Social Democrats, etc.) called itself the Socialist International.

Third World socialism is a loose category comprising "African socialism," "Arab socialism," and various cognate forms that appeared elsewhere in poorer countries after World War II. These were usually dictatorial in their political practice (although not in all cases: India offers a dramatic counterexample), but rarely was the state as all controlling as in communist systems. Some of these states (for example, Tanzania under Julius Nyerere [1922–1999]) elaborated complex blueprints of economic development, whereas in others "socialism" probably served as little more than a popular label for a hodgepodge of policies of a military dictator or a rationalization for strengthening the power of the central government (for example, Somalia under Mohammed Siad Barre [c. 1919–1995]).

To include fascism as a subset of socialism invites controversy because fascist movements often made their appeal on the promise to protect society from socialists or communists, because they were almost always part of the Right (whatever that may mean) rather than the Left, and because their inclusion may be taken as a polemical device to tar socialism with the odium attached to fascism. Yet the historical basis for their inclusion is strong. Adolf Hitler's party called itself National Socialist (as did some similar groupings in other countries, such as Hungary, some of which thought up the name independently of, and even prior to, Hitler). In Italy, Benito Mussolini formed his fascist movement as a leftist pro-war breakaway from the Socialist Party, of which he was a top leader. Each of these movements attempted to retain some of the elements of socialism while substituting the nation (or in Hitler's case the German *volk*) for the working class that had been seen as the main engine and beneficiary of socialism in traditional theory. Once in power, both Mussolini's party and Hitler's continued to preserve some of the accouterments of their socialist heritage. Mussolini himself probably captured best the relationship between these isms when he declared that fascism was a "heresy" of socialism, suggesting something that had sprung from the same premise but turned to challenge some of socialism's integral tenets.

Communal socialists differ from all the others in that they do not focus on trying to gain power (whether by vote or violence) in order to establish a socialist system over an entire country. Rather they are groups of individuals whose primary goal is to live a socialist life themselves by organizing communities operating on socialist principles. (No doubt many commune members also hope that their example might inspire emulation.) Usually such communities have numbered a few hundred members, although some have measured only in the tens and others in the low thousands. In the United States, a few hundred such societies were founded over the course of the nineteenth century, some by people whose driving belief was socialism, per se, others by devotees of religious sects, such as Shakers, for whom sharing property was but a facet of their sense of spirituality. Israeli kibbutzim are another important example of this form.

Historical Origins

Except for the communal, all of these forms grew from the same acorn: the French Revolution of 1789, with its ethos of "liberty, equality, fraternity." Although the Revolution itself did not aim for socialism, and although the term socialism was not coined until decades later, it was in pursuit of this inspiring triad of goals that socialism came to be conceived and then popularized. How can there be equality, it was asked, with vast disparities between rich and poor? How can there be brotherhood in a context of heartless economic competition? How can there be liberty if most people are enslaved to material necessity?

These questions presented themselves with greater urgency as the Industrial Revolution took hold. Although the poor of the factories were not poorer than the poor of the farms, their poverty, concentrated in urban slums, was more visible. Moreover, the Industrial Revolution entailed new ills such as industrial accidents and work environments devastating to human health. The labor of young children in factories offered a spectacle more heartbreaking than work of children on farms, which seemed a natural part of rural life from time immemorial.

The solution, it was argued, was to be found in collective ownership of property and the egalitarian distribution of the goods of society. These twin principles were to remain at the heart of socialism, although each of them, as well as many lesser points of doctrine, were to be disputed, refined, and amended repeatedly. Collective ownership in an individual commune was easy to envision. Collective ownership of the economic assets of an entire society was more difficult to conceptualize. It might mean ownership by the central government, but in other versions it might mean something less centralized—for example, that individual enterprises would be owned by the people who worked in them or by local communities. Egalitarian distribution did not necessarily mean exactly equal shares. The most fetching socialist slogan was "from each according to his abilities; to each according to his needs," which implied a measure of inequality but raised the question of how such needs would be determined. In Israeli kibbutzim, one place where an earnest effort was made to implement this principle, special committees existed to which kibbutz members could bring their special needs or abilities (a medical condition, an artistic calling, a family emergency abroad that required travel, and the like), and these committees were empowered to distribute resources accordingly.

Relation to Science and Technology

The connection between socialism and science originates in the claim of Karl Marx (1818–1883) and Friedrich Engels (1820–1895), the most influential of all socialist thinkers, to have discovered "scientific socialism." By this they meant to distinguish themselves from such early-nineteenth- (or in a few cases, late-eighteenth-) century visionaries as Henri de Saint-Simon

(1760–1825), Robert Owen (1771–1858), Charles Fourier (1772–1837), and Étienne Cabet (1788–1856), who had inspired the founding of various communes. Marx and Engels ridiculed the idea that a group of individuals could move the world toward socialism by creating model communities to demonstrate socialism's benefits. They saw this as naive because they doubted that political forms or even political ideas emerged simply from the free play of the human mind. To believe this, they said, is to be "utopian."

This term *utopian* itself is misleading because Marx and Engels were not objecting to the fancifulness of some of the early socialist visions. (Fourier's socialism, for example, envisioned that lions and whales would be tamed so as to free humans from physical labor and that each citizen would be entitled not only to a "social minimum" of economic rewards but also a "sexual minimum" of carnal satisfaction.) The fleeting glimpses Marx and Engels offered of life under socialism were pretty idyllic in themselves: People would do only those activities that they find intrinsically gratifying, say, hunting in the morning, fishing in the afternoon, writing poetry in the evening. Rather, what Marx and Engels found unrealistic, hence "utopian," about the earlier thinkers were their ideas about how socialism could be brought about. "Life is not determined by consciousness but consciousness by life," they wrote (*The German Ideology* part 1A,1845).

What they meant by this was that socialism could not come about until the objective conditions—which meant a certain level of wealth and technology—were right. Nor would it be brought about by individuals who happened upon the idea of socialism through reading or contemplation; rather its engineers would be people impelled to fight for socialism by the very conditions of their daily lives. Specifically, they held that socialism had not been possible in rural society but that the advent of industrialization laid open a new era. For one thing, the new technologies generated unprecedented abundance, making it possible for every member of society to enjoy a high standard of living. (Of course, what seemed a high standard in 1850 would be considered quite low by twenty-first-century standards, a wry comment perhaps on the elasticity of human need.) Moreover, the character of industrial production, depending on highly collective human effort, was conducive to collective ownership, making socialism a natural choice.

For the first time, because of this change, socialism had become a realistic possibility. Indeed its appearance had become likely, perhaps even inevitable. This was because industrialization brought the flowering of capitalism. Capitalist competition forced manufacturers to cut costs, including labor costs, thus driving down rates of pay. As a result, the very individuals whose sweat was providing the new abundance were left with too little income to share in it themselves. Eventually, driven in part by a sense of injustice but even more by the whip of destitution, they would rise up to abolish the system of private capitalism and replace it with socialism. This would not be because anyone had persuaded or taught them to do so but because bitter circumstances would impel them to do it.

In sum, Marx and Engels believed that they had discovered the processes that drive social and political change, and that these were rooted in the march of technology rather than in anything as arbitrary as individual will or cognition. They believed that this revelation of the laws of social evolution was analogous to the recent sensational revelation of the principle of the evolution of species. As Engels put it in his graveside eulogy to Marx in 1883: "Just as Darwin discovered the law of development of organic nature, so Marx discovered the law of development of human history."

Relation to Science and Ethics

Science, itself, as it is now understood, was not as clearly demarcated in their time, and from the perspective of the early twenty-first century it is easy to see the flaws in Marx and Engels's claims to science. To start with, they did an injustice to those they invidiously compared to themselves as "utopian." Owen among others also considered himself a man of science. Like Marx and Engels, Owen sought to draw generalizations about human behavior from his observations. His most cherished belief was that persons' characters are formed by the circumstances of their lives rather than by inner moral convictions or any other factors that they can control themselves. This notion, that one's thoughts and actions are shaped by forces larger than oneself, is very akin to Marx and Engels's central scientific claim and anticipated them by a full generation.

Moreover, in their approach to socialism, a good case can be made that the "utopians" were more scientific than Marx and Engels. Having hit on the idea that socialism would furnish a cure for society's ills, they set out to demonstrate its efficacy by attempting socialist experiments. Insofar as experimentation lies at the heart of the scientific method, the "utopians" were more genuinely "scientific socialists" than Marx and Engels, who discounted any such attempt. The latter duo claimed they could see where history was heading, but it is hard to imagine how this counts as more scientific than any other exercise in prophecy.

Beyond the absence of experimental method, Marx and Engels never stated any testable proposition nor did they betray any doubts inspired by the failure of specific details of their prophesies. Tellingly, they never treated their own forecasts as if they did amount to "science," at least as the term has come to be understood. As the decades passed they poured forth an endless stream of commentary, much of it arresting, on unfolding political events. But they rarely displayed any sense of needing to examine whether and in what way these new events comported with their larger theories. That is, they conducted themselves as what today are sometimes called "public intellectuals" or as activists, not as people who thought of themselves as scientists.

Still, it is difficult to dismiss Marx and Engels's claim to "science" without conceding that their method of attempting to distill systematic generalizations from the study of contemporary history constitutes a main building block of contemporary social science. There may be room to debate about how "scientific" social science is, falling as short as it does from the methodological rigor of "hard science," but insofar as its scientific legitimacy is accepted, then Marx and Engels must be given credit as pioneers, however imperfect their methodology.

In terms of its relationship to ethics, socialism presents an ambiguous picture. By claiming that they were doing no more than divining historical laws that showed that socialism was due to triumph, Marx and Engels shifted the argument in favor of socialism from the realm of "ought" to "is" (or, more precisely, to "will be"). And they specifically denied the possibility of absolute or universal moral principles, as opposed to principles that merely served the interests of a particular class. "Law, morality, religion are to [the proletarian] so many bourgeois prejudices, behind which lurk in ambush just as many bourgeois interests," wrote Marx and Engels in *The Communist Manifesto* (1848).

At the same time, it would be hard to deny that the force of Marx and Engels's indictment of capitalism is the sense of moral indignation that flows through it. Despite their own militant atheism, they decried capitalism as a system under which "all that is holy is profaned." A similar ambiguity can be found in various non-Marxist socialists. To take Owen, his fervent assertions that people's characters were molded for them seemed to negate any sense of moral responsibility. Yet he was very interested in discovering methods to mold characters to some kind of proper moral standard. He was for this reason a pioneer in early childhood education, and the organization of his followers in the 1830s called itself the Society for the New Moral World.

Owen, like Marx and Engels, was a vituperative opponent of revealed religion. (They called it an "opiate"; he called it one of the "three great evils" afflicting humanity.) In contrast, however, there have always been some religious socialists. As already mentioned, various socialist communes rested on religious bases, and a broader movement of Christian socialism made a strong appearance during the twentieth century. These adherents saw socialism as an expression of the biblical precept to love thy neighbor as thyself and of the Christian emphasis on spiritual rather than material values.

This points toward another aspect of the ambiguity of the relationship between socialism and ethics. On the one hand, socialist ideas aim to create a society that will fulfill certain moral goals, such as liberty, equality, and brotherhood. On the other hand, the emphasis on politics and policy has meant that many socialists have made little use of traditional notions of individual moral agency. The socialists who have most fully avoided this dilemma are the communal socialists who aim to carry out socialism in their own lives rather than to engineer larger political changes.

Their great emphasis on improving the world through political and economic changes rather than uplifting individual behavior has also brought socialists into a fraught confrontation with the question of whether, or to what extent, ends justify means. In the main, communists (as well, of course, as fascists, if one counts them under the socialist umbrella) have been ruthless in their means and ruthless in justifying this. As Leon Trotsky (1879–1940) once put it: "Only that which prepares the complete and final overthrow of imperialist bestiality is moral, and nothing else. The welfare of the revolution—that is the supreme law!" ("The Moralists and Sycophants Against Marxism," essay in his *Their Morals and Ours* [1936])

Social democrats and other noncommunist socialists have ordinarily rejected such claims, and they have often chastised the communists on moral grounds for their deceptive or violent tactics. Yet the force of such condemnations in intrasocialist debates was often vitiated by the emphasis on social change as the preeminent path to improving the world. If social change bulks so much larger than individual behavior, then might not unsavory tactics be justified in pursuit of the necessary policies?

The Legacy of Socialism

By the twenty-first century, much of the body of socialism has wasted away. Fascism, if it ever deserved to be counted here, is little more than a grim memory—although the term continues to be applied to various violent authoritarian movements. Communism has disappeared from the large majority of once-communist states. The remaining communist states all seem either to be following China in gradually shedding their distinctly communist features or to be living on borrowed time, awaiting the demise of a powerful dictator. Communal socialist societies are few and far between. Even their most triumphant exemplars, the kibbutzim, have mostly transformed themselves into miniature market economies.

What remains strong, however, is the legacy of social democracy. Social democratic parties justly claim most of the credit for various forms of worker protection and a wide variety of services and benefits that every developed democratic society provides. And these parties continue as powerful forces throughout the democratic world. None of them aim any longer to displace capitalism; rather their program is to continue to tame or modify it. Although markets have, to most minds, proven their superiority over the socialist dream of "economic planning," there still are social values—protection of the weak or of the environment or the provision of certain public services, for example—that unfettered markets do not serve. Social democracy has found an enduring niche as the advocate of these values—which have been put into practice through such programs as social security and socialized medicine.

If this is a dilute residue of socialism, so, too, do the scientific and ethical issues that have long surrounded socialism endure in dilute form. Contemporary protests against "globalization" echo earlier ones against capitalism itself. While there are few remaining believers in "scientific socialism" or in Marx and Engels's economic determinism, the question of the degree to which individual behavior should be attributed to free will as opposed to external or biological influences continues to be hotly debated in such policy areas as criminal justice and the rights of homosexuals. And the deep discourse over whether it is more efficacious to improve society by uplifting individuals or to improve individuals by reforming the society seems certain to endure.

JOSHUA MURAVCHIK

SEE ALSO *Arendt, Hannah; Communism; Critical Social Theory; Fascism; Marxism; Marx, Karl; Mondragón Cooperative Corporation; Morris, William.*

BIBLIOGRAPHY

Harrington, Michael. (1970). *Socialism.* New York: Bantam. A brief for socialism by the leading American socialist writer of the late twentieth century, who was both a social democrat and a Marxist.

Kolakowski, Leszek. (1978). *Main Currents of Marxism,* trans. P. S. Falla. 3 vols. Oxford: Clarendon Press. A comprehensive account of the many varieties of thought flowing from socialism's most influential thinker. Includes also Marx's antecedents.

Lichtheim, George. (1970). *A Short History of Socialism.* New York: Praeger. A concise history of Western socialism by a leading European intellectual of socialist bent.

Muravchik, Joshua. (2002). *Heaven on Earth: The Rise and Fall of Socialism.* San Francisco: Encounter Books. An overview history of socialism in all its forms told through biographical sketches of its key figures.

SOCIAL THEORY OF SCIENCE AND TECHNOLOGY

The idea of social theories of science and technology initially seems counterintuitive, because commonsense notions of science and technology separate them from the social world, and place them instead into the world of nature and fact. But closer scrutiny reveals a number of relevant aspects of social theory that can assist in understanding the development of science and technology, and the ethical and political aspects of such changes.

Social Theory: Scale, Structure, Agency, and Critique

Social theory is a body of scholarly work that describes and explains the social world. While ordinary people use workable models of social interaction and causality to get through the day, these folk sociologies, psychologies, and economic theories are not carefully articulated as testable models, and are often limited in scale and scope.

The idea of scale—or the size, duration, and level of complexity at which phenomena occur—is one of the first dimensions of variation in all social theory. One expects, and finds, different mechanisms and patterns to explain the behavior of small groups in comparison with large, complex societies. The disciplines themselves mirror this issue of scale, in which psychology, for example, is mostly concerned with individuals and small-group processes while sociology, anthropology, or economics examine the behaviors of whole populations or cultures. Moreover within each discipline of the social sciences and humanities are specialties that focus on different scales or levels of analysis. In sociology, this is the distinction between micro- and macro-sociologies, between models of small-group interactions and explanations of whole social systems.

With distinctions based on issues of scale, questions arise concerning scope—to articulate models appropriate at one scale with those of a larger or smaller level of analysis, or of a longer or shorter duration in time. What are the relationships among small groups and larger social institutions? How do social forces, historical trends, and cultural formations impact individuals? This remains a challenge for interdisciplinary social theory, and points to a related set of questions regarding the relationship between individual agency and social structure as well as relations between ethics and politics. How, and in what ways, are individual thoughts and actions, including ethical assessments, influenced by preexisting cultural, social, and economic conditions? If individual actions are strongly determined by social structure, where does social, scientific, or technological innovation come from—not to mention ethical criticism? If individuals freely innovate and criticize, why do social structures and belief systems persist over time? Issues of scale, structure, and agency link very closely to long-standing issues in the study of science and technology, particularly concerning questions about the balance between society determining technology (social constructivism) and technology determining society (technological determination)

The issue of social criticism is particularly important to science, technology, and ethics. Much social theory includes some assessment (positive or negative) of the social world. For example, Karl Marx (1818–1883) articulated his theory of the means of production determining the social structure and belief system of a society, while witnessing the devastating poverty of rapid industrialization and urbanization in Manchester, England in the mid-nineteenth century. Twenty-first-century authors are concerned with an array of issues, such as explaining new technologies and their effects on indigenous cultures, often with an implied concern that these societies are threatened by technological change. Others focus on the way common work and language practices of science shape how experiments are conceived and interpreted, or how social power influences what research is prioritized for funding. Focusing on how technology affects work and employment often leads to concern with systems of wealth and social stratification, with the unequal distribution of goods and harms. Social theory, then, always intersects with the political and ethical sides of science and technology because it is concerned ultimately with the human dimensions, both causes and consequences, of change.

Approaches to Science and Technology Studies

Science and technology studies, like economic theory, can be read as an argument with the ghost of Marx. In his voluminous writings, Marx articulated a model of the constitution of society literally from the ground up. In this model, the productive relationships of a society, meaning economy and agriculture, determined the basic social organization, in terms of classes and the structure of the state. Society then determined the cultural formations and basic ideologies, including science as an explanatory system. This model implies a degree of technological determinism in which social relations are determined by technology. The first generations of scholars concerned with science and technology wrestled with this issue, with Lewis Mumford (1895–1990), Jaques Ellul (1912–1994), and Ivan Illich (1926–2002) leading the way in developing critical theories of contemporary society adopting and criticizing Marx's insights. In the early-twenty-first century, Langdon Winner (1986, 1977) continued this tradition.

Focused on science, Robert Merton was also influenced by another founding social scientist, Max Weber (1864–1920), to formulate a theory of science as a modern institution based on the Protestant work ethic and the development of capitalist economic systems. Merton's *normative structure of science* articulated formally what had been a set of assumptions and values governing science as it emerged in sixteenth-century Europe. The values of *communalism*, in which knowledge is to be shared; *disinterestedness*, against personal or economic gain from knowledge acquisition; *universalism*, in which the identity of the author of scientific statements is not to be taken into account; and *organized skepticism* to provide the mechanisms for self-correction in science continue to be upheld and are presented to science and technology students as the primal values governing good science. Writing in the mid-twentieth century, Merton was concerned with demonstrating that democracy needed science, and science needed democracy, to avoid the distortions of Stalinist and Nazi influence he saw occurring early in his career.

Scholarship on science and technology struggled, however, with whether or not the social structure affected merely the social organization of these activities or the content and details of scientific and technological change as well. Within historical scholarship on technology this led to two major streams of thought: the internalist, which focused on the internal logic of development, seeing it as resistant to all social influences, and the externalist, which focused on the pervasiveness of social influences and impacts on scientific and technological change. This parallels questions of whether internal professional ethics or external political pressures should be granted priority in the governing of science and engineering.

Toward the latter third of the twentieth century the opposition between social and technological determinism was partially resolved with the development of the social construction conjecture. Social construction is based, in part, on insights derived from Thomas Kuhn's (1962) work in the history and philosophy of science, especially his notion of paradigm and paradigm shift, which spread quickly through the scholarly world, influencing studies of both science and technology. Focus on moments of change and controversy allowed scholars to see how both the social and natural are always present in shaping science and technology. The first generation of scholarship (Mulkay and Knorr-Cetina 1983) articulated what would come to be called the empirical program of relativism that generated the *symmetry principle,* which proposes that both true and false beliefs should be amenable to the same kind of social analysis. (In the past, true propositions were explained as reflecting the way nature is, false ones as reflecting the distorting interests of scientists or society.) Symmetry models have been further refined over time, for example by scholars such as Bruno Latour, who with colleague Steve Woolgar articulated the term *technoscience* to represent the confluence of technology and science as organized ways of interacting with the material world.

Technology studies applied these insights in its own way, and the editors of *The Social Construction of Technological Systems* (1989) presented a collection of works for what would become the *SCOT* model. This model describes how the *working* of a technology is primarily dependent on the social processes leading to its manufacture and the decisions of various end user groups as to whether or not it meets their needs as they decide how to employ the new technology. A technology whose material parts are in functioning order may still, and is often, deemed to be *not working* or a failure because it does not meet people's needs. In effect this appeared to constitute an ethical and political assessment of the adequacy of the status quo, a position criticized by Winner (1993) and generating further scholarly discussion.

What the initial constructivist studies of science and technology focused on was the microsocial processes of laboratory and workbench activities, such as the socially-grounded work of the interpretation of experiments. Negotiations among different groups in the design processes followed quickly, eventually moving up in scale to study organizational and bureaucratic contexts for generating models of change. Studies of cultural ideas, language, and values can generate explanations for the general trends of development in science and technology, but not the strong causal explanations aspired to by prior generations of scholars. Despite the advantages of having concrete artifacts and well-defined scientific ideas to trace, the shift from context to context and across different scales of social action remains challenging for social theorists of science and technology.

Similarly the question of determinism and the relationship between individual agency and social structure still challenge explanatory models. Rather than strong causal laws, heuristics outlining the applicability of models and propositions guide social studies of science and technology. For example, while a strongly deterministic model of the origins of new science and technology cannot be true, because that would be to ignore all evidence of the work, politics, and economic choice leading up to the new technoscience, it often *feels* true to consumers of science and technology to whom all of those prior social relations are invisible. Wiebe Bijker (1997) has developed a theory that helps to explain this by noting that people with low inclusion in the construction process often face a *take-it-or-leave-it* choice with new science and technology. Technoscience seems determined, to them, while those with high inclusion in the process see much of the construction. This interpretation of the construction of technoscience raises important ethical and political issues related to levels of participation in scientific and technological processes.

Indeed the roles of end users and stakeholders in science and technology have gained increased attention, in research on the public understanding of science, vernacular design, and consumer analyses. In the first instance, it has been pointed out that users are strongly dependent on technological *scripts*—that is, cultural and behavioral frameworks for understanding and interacting with technologies (Bijker and Law 1992). But users also create opportunities to rewrite scripts, and to modify not only the meaning, but the materiality and affordances of new technologies. End users can be creative appropriators of technology: "Low-riders" are transformations of automobile suspension systems by Hispanic urban culture for cultural self-expression; artisans use old tools in new ways to produce new effects; cell phones can be used to organize "smart mobs" and synchronize political action.

Contemporary Issues and Elaborations of the State of the Art

John Staudenmaier (1989) has cataloged the major historical themes in the history of technology since the inception of the Society for the History of Technology (1958), such as work and labor, military, aerospace, and gender. Recent scholarship on science and technology continues and expands these topics. For example, technology, labor, and work receive attention from sociologists such as Steven Vallas (2001), particularly in the roles that information technology and computerization have in different kinds of industries and organizations. Older models of technology, as always deskilling workers and centralizing power in organizational leadership, have given way to more nuanced models of context- and work-dependent implementations of new technology.

Computerization has become a major topic in social theories of technology. Much work is focused on the emergence of information and telecommunication technologies, their contexts of production, and the impacts of their use and adoption. A second, also revolutionary area of inquiry is the transformation of the life sciences, producing the emerging biotechnology industry, in which distinctions between pure and applied research or fundamental understanding of life processes and product development are increasingly blurred. These two areas come together in interesting ways in *cyborg theory*. Developed by Donna Haraway (1991), this is the treatment of human beings and the material world as interconnected and interdependent, with humans seen as biological, social, and information-based beings that obscure traditional boundaries between nature and culture, human and machine.

Some level of constructivism in both science and technology is well-argued consensus within the field, although its counter-intuitive elements often provoke commentary and criticism from those outside the social studies of science and technology. Finer distinctions among models and theories have been generated, for example between SCOT and its sibling, actor-network-theory (Law and Hassard 1999). Actor-network theory analyzes the networks of humans and material objects to generate specific explanations for the success or failure of ideas or artifacts. It is perhaps a methodology rather than a theory, per se, but nonetheless has value in generating detailed analysis of the various components of technoscientific projects. Such a method may also offer resources for analyzing the influence or failure of various ethical or political responses to technoscience.

Various social movements have picked up insights from social theories of science and technology. A first heuristic derived from constructivism is that things might have been otherwise. Designs could have turned out differently; the pursuit of scientific knowledge prioritized on different values would lead in new directions.

A second heuristic is that scientific and technological change generally follows the lines of power and resources already prevalent within a society. This does not mean that technoscience cannot have revolutionary effects on social relations, but that it is more likely that people will use technoscience to attempt to preserve power and privilege that already exists.

From these insights, environmentalists, social justice organizations such as feminist and anti-racist groups, and critics of development and globalization can make better informed interventions in the formulation, conduct, and effects of scientific and technological change. Feminists and racial or ethnic minorities, for example, point to the potential benefits of increasing the diversity of formal scientific and technological involvement because diverse backgrounds can be resources for new ideas, and for different values to motivate practice. They also point to the inventive and problem-solving activities of ordinary people, and take into account the moral and cultural values that might have bearing on the products of technoscience and their consequences for diverse communities.

Environmentalists point to the unequal distribution of the harms of technoscience, for example that poor communities and nations often face far greater harm from industrial pollution, and conduct research to help ameliorate those problems. There is also an evident tension between improving the economic and health circumstances of people in non-industrialized countries and preserving important ecological and cultural configurations. Social theories of science and technology may help anticipate the related consequences of technological change, and design interventions to minimize their negative outcomes.

Formal policy-making has taken up social theories of science and technology unevenly. One of the most concise models of science and society from a policy perspective is indirectly informed by social theories of technoscience. Backing away from a traditional linear model that privileges basic research leading directly to development and application, Donald Stokes (1997) proposes a more complex model in which different kinds of technoscientific problem formulation and research processes are supported and managed in different ways.

Whether broadly or narrowly defined, social theories of science and technology are as dynamic as technoscientific change itself. The connection is both strength and weakness. There is always a lot to do; new questions emerge daily. But there are too few resources or people to do all the work. Cutting edge analysis of technoscience easily becomes a quaint historical account of a forgotten technology or discredited science. More seriously, with rapid change and diverse topics, it is often difficult to see commonalities across fields of inquiry, and to develop generalizations about scientific and technological processes that are independent of specific contexts and thus subject to general ethical assessment. Integrating research across different scales of interaction, from individuals and identity formation processes to macroeconomic changes in global economic activity, remains a daunting task for all forms of social theory.

The final challenge for social theories of science and technology is one faced by all disciplines: to remain relevant to a diverse public audience and policy professionals. All disciplines face the possibility of becoming too focused on internal, scholastic issues, rather than seeking to develop broad heuristics that can be of benefit to those seeking to understand the important questions all social theories engage: How do I know? Why did this happen? Is it a good thing? What can be done about it?

JENNIFER L. CROISSANT

SEE ALSO *Autonomous Technology; Ellul, Jacques; Illich, Ivan; Kuhn, Thomas; Marx, Karl; Merton, Robert; Mumford, Lewis.*

BIBLIOGRAPHY

Bijker, Wiebe. (1997). *Of Bicycles, Bakelites and Bulbs: Toward a Theory of Technological Change*. Cambridge, MA: MIT Press.

Bijker, Wiebe, and John Law, eds. (1992). *Shaping Technology, Building Society: Studies in Sociotechnical Change*. Cambridge, MA: MIT Press.

Bijker, Wiebe; Thomas P. Hughes; and Trevor Pinch, eds. (1989). *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Cambridge, MA: MIT Press.

Haraway, Donna. (1991). *Simians, Cyborgs, and Women: The Reinvention of Nature*. New York: Routledge.

Kuhn, Thomas. (1962). *The Structure of Scientific Revolution*. Chicago: University of Chicago Press.

Latour, Bruno, and Steve Woolgar. (1986). *Laboratory Life: The Construction of Scientific Facts*. Princeton, NJ: Princeton University Press.

Law, John, and John Hassard, eds. (1999). *Actor-Network Theory and After*. London: Blackwell.

Mulkay, Michael, and Karin Knorr-Cetina, eds. (1983). *Science Observed: Perspectives on the Social Study of Science*. Thousand Oaks, CA: Sage Publications.

Staudenmaier, John. (1989). *Technology's Storytellers: Reweaving the Human Fabric*. Cambridge, MA: MIT Press. A basic history of the history of technology as represented by the Society for the History of Technology and its journal *Technology and Culture*.

Stokes, Donald. (1997). *Pasteur's Quadrant: Basic Science and Technological Innovation*. New York: The Brookings Institute.

Vallas, Steven. (2001). *The Transformation of Work*. Greenwich, CT: JAI Press.

Winner, Langdon. (1977). *Autonomous Technology: Technics-out-of-Control as a Theme in Political Thought*. Cambridge, MA: MIT. Press.

Winner, Langdon. (1986). *The Whale and the Reactor: A Search for Limits in an Age of High Technology*. Chicago: University of Chicago Press.

Winner, Landgon. (1993). "Upon Opening the Black Box and Finding it Empty: Social Constructivism and the Philosophy of Technology." *Science, Technology and Human Values* 18(3): 362–378.

SOCIOBIOLOGY

Sociobiology denotes the attempt to provide a biological explanation for the social behavior of animals, including humans, although the focus is more often on social insects such as ants and honey bees. Because ethics is also concerned with social behavior among human beings, achievements in sociobiology may also have implications for a possible science of ethics.

The Darwinian Background

As a term the word sociobiology first appears in *Principles of Animal Ecology* (1949) by Warder C. Allee, Alfred E. Emerson, et al., but the subject matter is much older. In *On the Origin of Species* (1859), Charles Darwin argued that there is constant population pressure brought on by the fact that numbers of organisms always outstrip food and other resources. There is therefore a constant struggle for existence. Some organisms have features enabling them to better succeed in the struggle, and thus there is a natural selection of the winners over the losers. This leads to evolution, but evolution of a special kind. Selection produces and perfects features useful in the struggle—organisms have adaptations such as the hand and the eye that aid them in survival (and, even more importantly, to reproduce).

Darwin realized that behavior is as much part of an animal's repertoire in the struggle for existence as are any physical adaptations. He was particularly interested in social behavior such as that of the hymenoptera (the ants, bees, and wasps). His interest was spurred not only by the phenomenon itself but because (in Darwin's opinion) such behavior seems to go against the workings of selection. Darwin believed that the struggle for existence pits every organism against every other organism, and hence selection can only promote adaptations that are valuable to the individual. (In contemporary language, Darwin was an individual selectionist rather than a group selectionist.) How then do organisms develop social features that seem to help the nest, perhaps even at the cost of total sacrifice of the interests of the individual? Sterile workers apparently spend their whole lives looking to the needs of their mothers and siblings. Eventually Darwin came to believe that the nests of social insects should be regarded as one large superorganism, rather than a group of individuals working together. In that way, the individuals in a nest are more parts of the whole (like the heart and liver are parts of the human body) rather than organisms existing in their own right with their own interests.

For a number of reasons, in the century after *On the Origin of Species* was published, the study of behavior by biologists lagged behind other areas of evolution. First behavior is much more difficult to record and measure than are physical characteristics. Experimentation is particularly difficult, for it is notoriously true that animals change their behaviors in artificial conditions. Secondly practitioners of the new social sciences thought that they exclusively should examine behavior, and that biology had no place in their endeavors. Unfortunately there existed a strong ideology that experience and training are the cause of most, if not all, behavior, and hence evolutionary factors tended to be discounted before any research was done. Continental students of behavior known as ethologists were a notable exception to this indifference to evolutionary theory, although their work was (as judged by twenty-first century standards) hampered by unjustified assumptions about the significance of group selection.

Breakthroughs in the 1960s

Major breakthroughs occurred in the 1960s, due, in large part, to the work of William Hamilton (1936–2000) in England. Promoting the theory now known as *kin selection,* Hamilton, then a graduate student, pointed out that in modern terms, selection is equivalent to passing on a particular individual's genes (or rather copies of those genes) more effectively than competitors. However when a person's close relatives reproduce, because they share copies of that person's genes, they also pass on those same copies: reproduction by proxy as it were. Normally it is biologically most efficient to reproduce oneself because (except for identical twins) an individual cannot be genetically more closely related to any other being. Hamilton argued there are some exceptions to this general rule. The hymenoptera particularly have an unusual reproductive system, with females having both mothers and fathers and males having only mothers. Queens get all the sperm they will ever use on the nuptial flight. To produce a female, the queen releases a sperm; in contrast, in producing male offspring, no sperm is released. Thus sisters (50% ♂ + 50% ♀ x ½ = 75%) are more closely related than mothers and daughters (50% ♀ x ½ + 50% ♂ x ½ = 50%), and so, from an evolutionary perspective, a nest member is better off raising fertile sisters than fertile daughters. From an individual selection perspective, sociality is advantageous.

After Hamilton others proposed theories using an individualistic perspective. One important contribution was Robert Trivers's notion of *reciprocal altruism,* based on the *you scratch my back and I'll scratch yours* principle, which holds that some forms of sociality succeed because organisms gain more through cooperation than through conflict. Also significant were insights based on the use of game theory, particularly the idea of an Evolutionarily Stable Strategy (ESS). A whole group is sometimes less well adapted than it could be because self-interest is paramount. Sex ratios are a case in point. Females do not need a large number of males for fertilization. But because 50:50 seems to be a more stable balance in the population, the group maintains a surplus of males, instead of a more efficient 10:90 male to female ratio. Building on ideas like this, the study of evolution started to change dramatically, and by the 1970s the study of social behavior, in theory and in practice, became one of the most advanced and exciting areas of evolutionary inquiry. The ideas were presented in popular form by British biologist Richard Dawkins in his *The Selfish Gene* (1976), and in what became the bible of the movement and gave the field its name, *Sociobiology: The New Synthesis* (1975), by the American scholar of the study of social insects, Edward O Wilson.

Controversies

These works, Wilson's in particular, were highly controversial, mainly (although not exclusively) because they extended to humans. Much like Darwin himself, having surveyed social behavior in the animal world from the most primitive forms to the primates, Wilson argued that Homo Sapiens is part of the evolutionary world in its behavior and culture. Although he did allow that experience and training can have some effects, Wilson believed that genes are the real key to understanding human thought and behavior. In male-female relationships, in parent-child interactions, in morality, in religious yearnings (a very important phenomenon for Wilson, a Southerner), in warfare, in language, and in much else, biology matters crucially.

Social scientists and left-leaning biologists (especially Richard Lewontin and Stephen Jay Gould), and philosophers (especially Philip Kitcher in a witty attack, *Vaulting Ambition*), accused sociobiologists—particularly human sociobiologists—of a multitude of sins. Epistemologically these detractors judged the work of sociobiologists to be false, and then (not entirely consistently) charged them with producing ideas and theories that are not falsifiable. One particularly effective rhetorical charge was that sociobiologists's claims are akin to the *Just So* stories by Rudyard Kipling, in which a fantastical tale is created (i.e., that of how the elephant's nose is long because it was pulled by a crocodile) and then is alleged to be fact. Sociobiologists were also found to be wanting ethically. Their work was attacked as sexist, racist, homophobic, capitalist, and in short, guilty of every possible transgression that exists in a patriarchal, unjust society. They were accused of supporting the status quo in Western societies, and of pretending to give genuine scientific answers to bolster what were really ideological convictions.

There was undoubtedly some truth to all of these claims. Yet some change can be progress, and there is little doubt—at the animal level particularly—that evolutionists have taken full note of critics' complaints and worked hard to address them. Modern techniques, particularly those that employ the insights of molecular biology, have been of great help here. For instance many sociobiological claims concern parenthood. If males are competing for females, for instance, and (as in birds) males are also contributing to childcare, one expects efforts to be tied to reproductive access and success. But while it is difficult if not impossible to determine paternity with traditional methods, that Gordian Knot is cut as soon as one starts using genetic fingerprints. Not only are the scientific claims testable but in many cases they have been found to be correct. Animal sociobiology is no more tentative than other scientific fields. It can be persuasively argued that in science bold conjectures are needed in abundance. However when those conjectures are accepted as fact without being tested, there is a problem. Science requires continual, rigorous challenge.

Human sociobiologists argue that they too have theories that can be, and are, put to the test, such as theories about infanticide, showing that this occurs when and generally only when it is in the biological interests of parents not to have all of the children to which they (or sometimes, rivals) have produced. One well-known theorem (with much support in the animal realm) asserts that females who are more fit will tend to skew birth rates toward males, and less fit females toward females. The reason for this is that even unfit females generally get impregnated, whereas if there is competition among males—and there usually is—the fitter male tends to get the prize. Hence because fit mothers are more likely than unfit mothers to have fit offspring, for fit mothers having males is a good strategy, whereas for unfit mothers having females is a good strategy. There is incidentally no necessary presumption that this always requires conscious intention—fluctuating hormones, for instance, might be the proximate causes. Human sociobiologists argue that this also occurs in human societies, with the members of upper classes tending to dispose of daughters, either physically by allowing them to die or giving them away shortly after birth, or through other methods that effectively prevent reproduction even without killing (for instance, by forcing daughters into religious orders that require celibacy thereby effectively preventing them from reproducing). In recent years, human sociobiology has changed into what is now called *evolutionary psychology*. The emphasis is less on behavior and more on the mental traits that lead to behavior. This view is still philosophically controversial, with much debate about how and whether one can talk of psychological characteristics as being *innate* (and how one would test the theory).

Sociobiologists have countered vigorously against the social and ethical charges levied against them. Almost without exception, human sociobiologists have not had significant social agendas and are greatly concerned by the misuse that can (and sometimes is) made of their work. They repudiate strongly the charge that they are crypto-nazis or subscribers to other vile doctrines, and deplore the fact that sometimes people favorable to these ideas invoke the authority of sociobiology in support. They stress that differences between races, for instance, are far less than similarities, and in any case differences in themselves do not necessarily spell superiority or inferiority. Although their work has been much criticized by feminists, human sociobiologists respond that pointing out differences between males and females is not in itself sexist. Indeed one might argue that not to recognize differences can be morally wrong. If boys and girls mature at different rates, insisting that they all be taught in the same ways could be detrimental to both sexes. In more specific issues also sociobiology is not necessarily erroneous or promoting an immoral agenda. To hypothesize that something such as sexual orientation is dictated by an individual's genes (and that there is a pertinent underlying evolutionary history to explain it) could be a move toward recognizing that all people are equally worthy of moral tolerance and respect.

There is ongoing philosophical debate over all of these issues. In the early twenty-first century there is renewed interest in the possible evolutionary underpinnings of religion. It is clear that sociobiology—animal and human, and by whatever name the field is known—is not about to disappear, and is in fact a thriving area of inquiry.

MICHAEL RUSE

SEE ALSO *Aggression; Animal Tools; Darwin, Charles; Ethology; Evolutionary Ethics; Game Theory; Nature versus Nurture; Scientific Ethics; Selfish Genes; Social Darwinism; Sociological Ethics.*

BIBLIOGRAPHY

Darwin, Charles. (1859). *On the Origin of Species*. London: John Murray.

Dawkins, Richard. (1976). *The Selfish Gene*. Oxford: Oxford University Press.

Hamilton, William D. (1996). *Narrow Roads of Gene Land: The Collected Papers of W. D. Hamilton*. New York: W.H. Freeman/Spektrum.

Kitcher, Philip. (1985). *Vaulting Ambition*. Cambridge, MA: MIT Press.

Ruse, Michael. (1979). *Sociobiology: Sense or Nonsense?* Dordrecht, The Netherlands: Reidel.

Trivers, Robert L. (1971). "The Evolution of Reciprocal Altruism." *Quarterly Review of Biology* 46: 35–57.

Wilson, Edward O. (1975). *Sociobiology: The New Synthesis*. Cambridge, MA: Harvard University Press.

Wilson, Edward O. (1978). *On Human Nature*. Cambridge, MA: Cambridge University Press.

SOCIOLOGICAL ETHICS

Sociology, or the scientific study of society, social institutions, and social relationships, is one of the most important social sciences and may include in its concerns anthropology, economics, history, political science, and psychology. As a field of study it is inherently intertwined with ethics. Because any society is dependent on common assumptions about what is acceptable and unacceptable behavior among its members, sociological analysis has to include descriptions of those ethical beliefs and practices. Indeed, the society constituted by sociologists may be defined by its internal ethical commitments. At the same time, insofar as sociologists do research in and on society, they produce knowledge about moral values and their social functions, and questions arise about the proper guidelines for their work, especially when that work may conflict in various ways with accepted social norms.

The Sociology of Ethics

Early in the formation of sociology morals and values entered into the picture and influenced sociological thought and practice. A specific concentration such as a "sociology of moral values" may not exist (Durkheim 1993, p. 14), but morality has played a central role in the prevailing concepts that have shaped and molded sociology. This ideology can be seen in the works of individuals such as Karl Marx (1818–1883), Max Weber (1864–1920), and Emile Durkheim (1858–1917). These classical sociologists agreed on issues surrounding industrial capitalism and how values and morals worked to keep a society together; however, they nonetheless differed in their views of the function these elements have and how they change over time.

Although Marx is credited for playing a key role in establishing the field, Weber is the one considered to be the father of sociology. Marx's challenging social criticism was replaced by Weber's value-neutral sociology, which nevertheless stressed, as in *The Protestant Ethic and the Spirit of Capitalism* (1904), the ethical foundations of social orders. Marx was intrigued by the interaction between science and society, whereas Weber examined social structure and focused more on the notion of value-free science. Weber believed people acted on their own accord and emphasized the importance of the individual rather than the role of society as a collective whole. He also emphasized the notion that people should not expect science to tell them how to live their lives.

Durkheim's theories are considered by some sociologists to be even more applicable today than they were at the time he formulated them (Turner 1993). His primary contribution to sociology was his stance on social solidarity, social roles, and the division of labor. Morality and the connection between science and society also influenced Durkeim's work on professional ethics. Durkheim touted the importance of moral education on everyday life and emphasized its inclusion in the study of sociology. Marx, Weber, and Durkheim may have developed their theories in a different academic era, but they continue to influence and impact the field of sociology today.

Works by Weber and Durkheim were the precursors to those by Robert Merton, the first sociologist to win the National Medal of Science and the founder of the sociology of science. Merton's focus was on the functional analysis of social structures, and he discounted subjective dispositions, such a motives and aims. Things Merton is best known for are coining the terms "self-fulfilling prophecy," "deviant behavior," and implementing the focus group concept in a research setting.

The Ethics of Sociology

The first attempt to promote international cooperation and professionalize the field of sociology can be seen in the formation of the International de Sociologie by Rene Worm in 1893. In 1905 a number of well-known sociologists across the United States met to create an entity to promote the professionalization of the field of sociology. This organization was called the American Sociological Society and later evolved into what is known today as the American Sociological Association. Today, the ASA is the largest organization of sociologists and its membership is not only made up of students and faculty, but 20% of its membership is comprised of individuals who represent government, business, and non-profit groups. In the spring of 1997, the ASA membership approved its current version of the Code of Ethics. It includes an introduction, a preamble, five general principles, and specific ethical standards. Rules and procedures for handling and investigating complaints are also noted.

As time went on, more organizations such as the International Sociological Association were formed to support sociologists and advance knowledge about this field of study. Like ASA, these entities have also developed and established codes of ethics for their membership to follow. ISA, an organization founded in 1949, drafted its own code of ethics and the current version was approved by their Executive Committee in the fall of 2001. Other groups, such as the North Central Sociological Association, have preferred to base their codes on those outlined by ASA.

New and exciting research opportunities often bring unforeseen scenarios, many of which revolve around the sociologist's relationship with subjects. Dilemmas involving the applicability of informed consent, the use of deception, and the protection of privacy and confidentiality are common in social science research. A conflict between the desire to protect human subjects and the goal of obtaining data may not be easy to rectify even if guidelines are followed.

Research misconduct and authorship violations are also concerns that face social scientists. Abuses vary in severity and may encompass plagiarism, data fabrication, and falsification of data and results. The ethical dilemmas encountered in sociology are not unique. As science and technology become intertwined further with society, these ethical questions will become even more complex.

Sociological Issues Related to Science and Technology

Problems that occurred during the 1960s and 1970s, such as the thalidomide drug tests (1962) and the Tuskegee syphilis study (1932–1972) emphasized the fallibility and injustices of scientific research and added momentum to appeals for more regulations and guidelines. Scientific investigations, especially those in biomedicine, often are considered high-risk and life-threatening, but the social sciences also have encountered less obvious but not necessarily less dangerous situations. One case that is discussed frequently in social science circles is Stanley Milgram's work on obedience to authority in 1963. Milgram found that a majority of the individuals participating in this series of studies were willing to administer what they believed to be harmful electrical shocks to their victims. Laud Humphreys's tearoom trade in 1970 also sparked controversy. Humphreys studied homosexual encounters in a St. Louis park restroom without revealing the true nature and intention of his research. Philip Zimbardo's Stanford prison experiment in 1973 is another example of an infraction that sent up red flags to those involved in protecting human subjects (Sieber 1982). Zimbardo's study, which ended early due to concerns about its effects on the subjects, used role playing to determine what happens when good people are put in an environment that fosters evil.

Informed consent is a key component of human subjects research, but it can be controversial in disciplines such as sociology. Regulations require that in most cases informed consent be obtained before research can commence, but consent often is seen as an unrealistic obstacle in the social sciences. Research conducted by social scientists often involve the use of ethnographic methods, the collection of oral histories, and survey procedures, which do not readily lend themselves to the written informed consent process. Obtaining written consent may be problematic for researchers working in situations where language and cultural differences pose as a barrier. This may occur in situations where the individuals are illiterate or merely speak a different language. Some cultures consider the signing of a document taboo or an act reserved for certain situations such as the signing of legal documents. Evidence also indicates that subjects who sign consent forms, like those who participated in Milgram's study, do not always comprehend the full extent of the project (Mitchell 1993). Many social science initiatives include individuals involved in illegal activities where anonymity is essential. In these situations the informed consent document may compromise confidentiality by being the only link to the subject.

Steps taken to protect the privacy of the subject and ensure the confidentiality of the data may instill a false sense of security in the researcher and the subjects. A researcher may code identifiers, destroy data after project completion, use pseudonyms to mask identity, and avoid gathering personal information altogether in an attempt to provide protection. These measures are not infallible, and violations are evident in numerous cases. The use of thinly disguised pseudonyms that provoked the "Springdale" controversy can be seen in Arthur Vidich's *Small Town in Mass Society* (Vidich and Bensman 2000). Sociologist Arthur Vidich and anthropologist Joseph Bensman conducted a study of small town life and assigned the pseudonym "Springdale" to the upstate New York community. It didn't take long for the community's true identity to be revealed, which caused Vidich's and Bensman's research practices to be called into question. Other infractions have involved the subpoena of data, as in the case of Rik Scarce, who underwent 159 days of incarceration for refusing to release his field notes (Scarce 1995). Even with protections in place the subject's privacy and confidentiality may be at risk.

All researchers wrestle with similar issues of research misconduct. A survey published in *American Scientist* (November–December 1993) that measured perceived rather than actual misconduct examined some of those concerns. Doctoral candidates and faculty members representing the fields of chemistry, civil engineering, microbiology, and sociology were asked questions about scientific misconduct, questionable research practices, and other types of wrongdoing. Several conclusions were extracted from the data results, including reports that scientific transgressions occurred "less frequently than other types of ethically wrong or questionable behavior by faculty and graduate students in the four disciplines" surveyed (Swazey, Anderson, and Lewis 1993, p. 552). Other entities, such as the media, chose to concentrate on practices that painted a dire picture of academic integrity.

Funding and sponsor involvement constitute other factors that can create serious ethical dilemmas for researchers. Certain departments, such as sociology, often struggle for financial support and rely heavily on government and corporate sponsorship. Project Camelot, which has been regarded by some as "intellectual prostitution," was used to "predict and influence politically significant aspects of social change in developing nations of the world, especially Latin America" (Homan 1991, p. 27). Warnings by critics like Derek Bok, the former president of Harvard and author of the book "Universities in the Marketplace: The Commercialization of Higher Education" (Princeton University Press) indicate that pressure by academia to attract industry involvement is a precarious undertaking that can lead to the "commercialization of higher education" (Lee 2003, p. A13). These relationships also may result in pressure on researchers to skew results to favor the sponsor. In the end stiff competition for research funding and pressure to attract industry involvement may compromise ethical and professional standards (Homan 1991).

Changes in Science and Technology That Affect Sociology

Regulations and guidelines based on a biomedical model have had a dramatic impact on sociology. After the atrocities that occurred during World War II a series of codes were implemented to focus on the protection of human subjects in research. Some of the more noted ones include the Nuremberg Code, the Declaration of Helsinki, and the 1971 guidelines published by the U.S. Department of Health, Education, and Welfare (DHEW).

The Nuremberg Code, a set of ten principles designed to protect human subjects in research, was a ruling announced in 1947 by the war crimes court against Nazi doctors who conducted experiments on their prisoners. The Declaration of Helsinki was approved by the Eighteenth World Medical Assembly in 1964 and was designed to assist physicians in biomedical research involving human subjects. The continuation of ethical infractions invoked calls for additional regulations. Guidelines published in 1971 by the DHEW were one response to those demands and would prove to be the inspiration for the development of institutional review boards (IRBs) for federally funded research initiatives.

Another instrumental document resulted from the formation of the National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research. The Belmont Report elaborated on the ten points outlined in the Nuremberg Code and placed the emphasis on respect for persons, beneficence, and justice. Those regulations were revised in 1981, and Title 45, Code of Federal Regulations, Part 46, became known as the Common Rule.

Professional codes of ethics are a relatively recent phenomenon. The codes that existed before World War II were found primarily in the major professions of that time, such as medicine and law. Most modern organizations have developed codes based on those in the sciences, but the codes used in the social sciences often lack the power to impose sanctions for noncompliance. Unlike the case in some professional associations, participation in an organization such as the American Sociological Association (ASA) is not necessary for a person to be a sociologist or to conduct social science research. The lack of an enforcement mechanism for ethical violations also weakens the power of codes such as that of the ASA. The notion that professional codes of ethics are merely symbolic has been attributed to the government's decision to implement regulations (Dalglish 1976).

Contributions to Science, Technology, and Ethics Discussions by Sociology

A debate has been brewing among scientists and social scientists who submit research protocols for approval. The DHEW declared on July 12, 1974, that to obtain federal funding for a research project an IRB had to be in place to review projects that involved human subjects in biomedical and behavioral research. Today IRBs apply one set of rules, based on a biomedical format, to review all project submissions. Those requirements have proved to be inapplicable to numerous social science proposals and are next to impossible to carry out in all research settings. Sociologists and other social scientists have joined forces to form alliances, such as the Social and Behavioral Sciences working group, to improve the IRB process for social science researchers. In some cases, however, IRBs continue to interpret "the requirements of the Common Rule in a manner more appropriate to high risk biomedical research, ignoring the flexibility available to them in the Common Rule" (Sieber, Plattner, and Rubin 2002, p. 2).

Sociologists also have collaborated with researchers in science and technology on a number of ethics initiatives. Joint facilities and centers have helped facilitate those efforts by encouraging cross-curriculum dialogue and research. The Hastings Center was founded in 1969 to "examine the different array of moral problems engendered by advances in the biomedical, behavioral, and social sciences" (Abbott 1983, p. 877). The Center for Applied Ethics at the University of Virginia, also founded in 1969, has worked on integrity issues that span various fields and subject matters. Another interdisciplinary effort is the Ethical, Legal and Social Implications Research Program (ELSI). Founded in 1990, ELSI has focused on a number of issues, including informed consent, public and professional education, and discrimination, by bringing together experts from multiple, diverse disciplines and conducting workshops and orchestrating policy conferences to discuss these pertinent issues.

Education is imperative to promote academic integrity, and students in all disciplines should be instructed on matters that may have an adverse effect on their research. Acceptable academic behavior can be conveyed through formal methods such as workshops and symposia or through the use of informal techniques such as discussions with advisers, mentors, and classmates. Conversations that introduce possible solutions to the ethical predicaments encountered in research also can be beneficial. Teaching new researchers how to act in an ethical manner will help reduce the number of violations and will create research professionals dedicated to upholding the morals that are valued in society.

The Future

Ethical dilemmas will continue to plague researchers whether they are in the sciences or the social sciences. A state of risk-free research is not foreseeable, and steps will continue to be taken to minimize the severity and frequency of these problems. Changes in the regulations will be felt most heavily in the biomedical and science fields, but the social sciences will not be spared from increased scrutiny. Some efforts may prove to be worthy and circumvent or minimize ethical quandaries, whereas others may violate personal rights and academic freedom in the process. Cooperation among disciplines is essential to communicate the importance of ethics and create researchers who conduct their work with integrity. In the words of Johann Wolfgang von Goethe, "Knowing is not enough; we must apply; willing is not enough, we must do."

SHARON STOERGER

SEE ALSO *Codes of Ethics; Durkheim, Émile; Human Subjects Research; Informed Consent; Institutional Review Boards; Merton, Robert; Misconduct in Science: Social Science Cases; Privacy; Research Ethics; Sociobiology; Tuskegee Experiment; Weber, Max.*

BIBLIOGRAPHY

Abbott, Andrew. (1983). "Professional Ethics." *American Journal of Sociology* 88(5): 855–885.

Dalglish, Thomas Killin. (1976). *Protecting Human Subjects in Social and Behavioral Research: Ethics, Law, and the DHEW Rules: A Critique*. Berkeley: Center for Research in Management Science, University of California, Berkeley.

Durkheim, Emile. (1993). Ethics and the Sociology of Morals. Translated by Robert T. Hall. Buffalo, NY: Prometheus Books.

Federman, Daniel; Kathi E. Hanna; and Laura Lyman Rodriguez, eds. (2002). *Responsible Research: A Systems Approach to Protecting Research Participants*. Washington, DC: National Academies Press.

Gouldner, Alvin. (1971). *The Coming Crisis of Western Sociology*. New York: Avon Books.

Homan, Roger. (1991). *The Ethics of Social Research*. New York: Longman.

Lee, Felicia R. (2003). "The Academic Industrial Complex." *New York Times*, September 6.

Mitchell, Richard G., Jr. (1993). *Secrecy and Fieldwork*. Newbury Park, CA: Sage.

Report and Recommendations of the National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research. (1978). "The Belmont Report." Washington DC: U.S. Government Printing Office.

Scaff, Lawrence A. (1984). "Weber before Weberian Sociology." *British Journal of Sociology* 35(2): 190–215.

Scarce, Rik. (1995). "Scholarly Ethics and Courtroom Antics: Where Researchers Stand in the Eyes of the Law." *American Sociologist* 26: 87–112.

Sieber, Joan E., ed. (1982). *The Ethics of Social Research: Surveys and Experiments*. New York: Springer-Verlag.

Sieber, Joan E.; Stuart Plattner; and Philip Rubin. (2002). "How (Not) to Regulate Social and Behavioral Research." *Professional Ethics Report* 15(2): 1–4.

Silber, Joan E. (1992). *Planning Ethically Responsible Research: A Guide for Students and Internal Review Boards*. Newbury Park, CA: Sage.

Silber, Joan E. (2001). *Summary of Human Subjects Protection Issues Related to Large Sample Surveys*. Washington, DC: U.S. Department of Justice, Bureau of Justice Statistics. Available at http://purl.access.gpo.gov/GPO/LPS16482.

Stanley, Barbara H.; Joan E. Sieber; and Gary B. Melton, eds. (1996). *Research Ethics: A Psychological Approach*. Lincoln: University of Nebraska Press.]

Swazey, Judith P.; Melissa S. Anderson; and Karen Seashore Lewis. (1993). "Ethical Problems in Academic Research." *American Scientist* 81: 542–553.

Turner, Stephen P., ed. (1993). *Emile Durkheim: Sociologist and Moralist*. London: Routledge.

Vidich, Arthur J., and Joseph Bensman. (2000). *Small Town in Mass Society: Class, Power and Religion in a Rural Community*. Urbana: University of Illinois Press.

SOFT SYSTEMS METHODOLOGY

Soft systems methodology provides a framework for structuring, analyzing, and solving problems in systems that involve people. It integrates logical, cultural, and political analyses of a problem situation in order to imagine, discuss, and then implement actions to improve the situation, with the consensus of the participants. Soft systems methodology is used primarily by managers and consultants working on technical or organizational problems; it has proved particularly useful in the Information Technology/Information Systems sector.

Peter Checkland developed soft systems methodology because classic systems engineering and systems analysis (*hard* systems methodologies), which work excellently in many engineering situations, often disappoint in management situations. Hard systems methodologies are well-suited for designed systems where the task of the analyst is to find the most efficient means of reaching a well-defined goal, but they cannot deal with the cultural and social dimensions in what Checkland terms human activity systems, which are systems that include human self-consciousness and freedom of choice. One of the characteristics of human activity systems is the wide range and importance of world-views, or *Weltanschauungen*, held by the participants in the system, and the consequent lack of clearly defined or agreed goals within such a system. Soft systems methodology is designed to deal with human activity systems where "in the complexity of human affairs the unequivocal pursuit of objectives which can be taken as given is very much the occasional special case" (Checkland 1999, p. A6).

There are four main activities in Checkland's methodology:

1. Finding out about a problem situation, including its cultural and political dimensions;
2. Formulating relevant purposeful activity models (devising scenarios of possible future actions and outcomes);
3. Debating the situation with participants, using the models, seeking from that debate both

a) changes that would improve the situation and are regarded as both desirable and (culturally) feasible, and

b) the accommodations between conflicting interests that will enable action-to-improve to be taken;

4. Taking action in the situation to bring about improvement. (Checkland 1999, p. A15).

Soft systems methodology provides practitioners with almost the same analytical techniques and many of the same conceptual approaches as Harold D. Lasswell's policy sciences, but laced with more pragmatism and less idealism. Soft systems methodology focuses on business and industry applications, it seeks agreed solutions, and is based in management science and engineering. The policy sciences are concerned with representative democracy and public policy, they are rooted in the social sciences, and they emphasize a moral rather than consensual basis for decision making. Both approaches agree that the analyst becomes involved in the system under examination; that the viewpoint of the analyst must be made explicit; that there are non-rational elements in human behavior; and that history, perception, relationships, and culture are important factors in human activity systems.

Peter Checkland, the founder of soft system methodology, was born in Birmingham, England in 1930. He studied chemistry at Oxford University in the 1950s, then worked at ICI Ltd. as a technologist and manager. He moved to the Department of Systems at the University of Lancaster in 1969, and in the early twenty-first century is Professor of Systems, Management Science, in the Lancaster University Management School.

MAEVE A. BOLAND

SEE ALSO *Engineering Method; Lasswell, Harold; Systems.*

BIBLIOGRAPHY

Checkland, Peter. (1999). *Systems Thinking, Systems Practice: Includes a 30-Year Retrospective*. Chichester, UK: John Wiley & Sons. Reissue of the first book on soft systems methodology, with a major retrospective essay reviewing thirty years of developments in the field.

Checkland, Peter, and Sue Holwell. (1998). *Information, Systems, and Information Systems*. Chichester, UK: John Wiley & Sons. Focuses on the place of information technology in human affairs, with an emphasis on IT in organizations.

SOFTWARE

SEE *Free Software; Hardware and Software.*

SOKAL AFFAIR

The Sokal Affair was the central and most highly publicized episode of the "Science Wars," a fracas that roiled the academic atmosphere throughout the 1990s. The main point at issue in these conflicts was the accuracy and indeed the legitimacy of critiques of science and technology propounded by scholars committed to or influenced by postmodern thought and identity politics. The hoax itself, as well as the volume of *Social Text* (no. 46/47, Spring/Summer 1996) in which it appeared, arose chiefly in response to an earlier science wars salvo, the book *Higher Superstition: The Academic Left and Its Quarrels with Science* by Paul R. Gross and Norman Levitt (1994), which aggressively criticized the "science studies" movement that had emerged from poststructuralist and social-constructivist doctrines.

The squabbles ignited by *Higher Superstition* alerted Alan Sokal, a mathematical physicist at New York University, to the controversy. Further research nullified his initial suspicions that the book might merely be yet another "culture wars" diatribe from the right. He concluded, despite his own leftist sympathies, that postmodern and relativistic views of science epitomized the weaknesses he had already discerned in some versions of contemporary left-wing thought. It struck him that a parody article satirizing the pretensions of science studies might provoke useful debate around this issue. The resulting essay, *Transgressing the Boundaries: Toward a Transformative Hermeneutics of Quantum Gravity*, mischievously combined references to arcane physics and mathematics with laudatory citations of major postmodern theorists, ostensibly to support the thesis that postmodern dogma accords with advanced ideas in foundational physics.

The essay was submitted to *Social Text* just as that journal was planning its own rejoinder to *Higher Superstition*. Editor Andrew Ross, himself a prominent target of Gross and Levitt, had recruited a number of well-known proponents of science studies as contributors. When Sokal's Trojan-horse manuscript arrived, its Swiftian character escaped detection and the piece was promptly accepted because of the author's physicist credentials, as well as his authentic leftist pedigree and his feigned detestation of the enemy camp.

The "Science Wars" number of *Social Text* appeared in May 1996. Within days, Sokal unmasked his own hoax in the magazine *Lingua Franca,* and the episode quickly made its way into the mass media. Subsequent denunciations of Sokal by *Social Text*'s editors and supporters did little to staunch the widespread glee that erupted from some quarters.

The greatest significance of the affair lies, indeed, in the very fact that it became so widely known and evoked such intense responses. In itself, Sokal's piece was intentionally sophomoric, a transparently silly joke. It "proved" little more than that a handful of academics had been overeager to recruit a "real" scientist to their side of an acrimonious dispute. Why, then, the enormous uproar?

The answer lies in the hostility that had been building for a decade or more in response to the pretensions and what many saw as the monopolistic ambitions of the postmodern left. Such resentment was hardly limited to scholars of conservative bent: It was widely shared by liberals and leftists who had come to view postmodern academic culture as bizarre and overbearing. Consequently, the Sokal Hoax became the symbolic center of an intellectual firestorm whose stakes extended well beyond anything directly connected to the prank itself. It brought into the open long-brewing anxieties over scholarly priorities and their effect on the academic pecking order. The myopia of *Social Text* came to stand, rightly or wrongly, for the pretensions of postmodern scholarship per se. Sokal's success emboldened many long-suffering professors to decry at last the impostures of a subculture that had long cowed them with its self-ascribed sophistication. Most scientists were understandably amused by the spectacle, but in regard to what was really at issue, they were bystanders. This was, at heart, a battle fought by non-scientists.

In the early twenty-first century, the postmodern left seems to have declined, at least as the hegemonic trendsetter of the academy. For good or ill, many of its social precepts remain central to university culture, but with diminished stridency. "Theory," as postmodernists were wont to use the term, has lost much of its power to intimidate. At the same time, many humanist scholars who once employed the vaunted insights of science studies to disparage science now affect to admire it deeply. Postmodernism and the political style linked to it certainly endure, but in a more subdued mode. The Sokal Affair was by no means the sole or even the most important catalyst for these changes, but it was timely and amazingly effective.

NORMAN LEVITT

SEE ALSO *Science, Technology, and Society Studies.*

BIBLIOGRAPHY

Editors of *Lingua Franca.* (2000). *The Sokal Hoax: The Sham that Shook the Academy.* Lincoln: University of Nebraska Press. Reprints Sokal's "confessional" piece, along with a wide array of comments and observations about the Hoax.

Koertge, Noretta, ed. (1998). *A House Built on Sand: Exposing Postmodern Myths About Science.* New York: Oxford University Press. A collection of essays sharply critical of some of the best-known work in postmodern science studies.

Levitt, Norman. (2000). "Confessions of a Disagreeable Man." *Skeptic* 8(3): 93–97. An insider account of the genesis of the Hoax, with some opinions on its significance.

Ross, Andrew, ed. (1996). *The Science Wars.* Durham, NC: Duke University Press. A book version of *Social Text* 46/47, with some additional pieces included, but with the Sokal hoax article itself deleted.

Sokal, Alan. (1996a). "Transgressing the Boundaries: Toward a Transformative Hermeneutics of Quantum Gravity." *Social Text* 46/47 (Spring/Summer): 217–252. The Sokal Hoax article.

Sokal, Alan. (1996b). "A Physicist Experiments with Cultural Studies." *Lingua Franca* 6(4): 62–64. Sokal's "confession" of the hoax.

Sokal, Alan, and Jean Bricmont. (1998). *Fashionable Nonsense: Postmodern Intellectuals' Abuse of Science.* New York: Picador. A critique by Sokal and another physicist of the misuse of scientific notions by a number of postmodern theorists.

Segerstrale, Ullica, ed. (2000). *Beyond the Science Wars: The Missing Discourse about Science and Society.* Albany: State University of New York Press. Essays on the significance of the "science wars" and the hopes for replacing those squabbles with a less recriminatory dialog.

SPACE

To the question, "Where are you in this moment?" a pilot would answer, "At longitude *x*, latitude *y*, altitude *z*." But if one asks, "Where do you live?", the answer may instead evoke neighborly relations weaved through the years, a climate, old stones, the freshness of water. Depending on who is asked about what, the *where* question can be answered by *space* determinations or by the memories of a concrete *place.* Space and place are two different ways of conceiving the "where" or, using the Latin word for "where" as a *terminus technicus,* two answers to the *ubi* question.

Place and Space

Place is an order of beings vis-à-vis the body. This order (*kosmos* in Greek) always mirrors the great cosmos. This vis-à-vis or mirroring is the essence of what has been called *proportionality* (Illich and Rieger 1996). According to Albert Einstein, the concept of space disembedded itself from the "simpler concept of place" and "achieve[d] a meaning which is freed from any connection with a particular material object" (Einstein 1993, p. xv). Yet Einstein insisted that space is a free creation of imagination, a "means devised for easier comprehension of our sense experience" (Einstein 1993, p. xv). In pure space, however, the body would be out of place and in a state of perceptual deprivation.

The focus here is on the radical monopoly that space determinations exert on the *ubi* question. Wheels and motors seem to belong to space as feet do to places. And just as the radical monopoly of motorized transportation on human mobility leaves some freedom to walk, space determinations leave remnants of placeness to linger in perception and memory. Ethics, then, can only be rebuilt by a recovery of placeness.

Origins of Space

A general conception of space is conspicuously absent from ancient mathematics, physics, and astronomy. The Greek language, so rich in locational terms, had no word for space (Bochner 1998). *Topos* meant place, and when Plato in the *Timaeus* (360 B.C.E.) located the demiurge in an uncreated *ubi* in which one can have no perception because it does not *exist,* he called it *chôra,* fallow land, the temporary void between the fullness of the wild and cultivation. According to Plato, the demiurge's chôra could only be conceived "by a kind of spurious reason," "as in a dream," in a state in which "we are unable to cast off sleep and determine the truth about it" (passage Timaeus 52). In hindsight, one may say that this was a first intuition of the antinomy between place and what is has come to be called "space." In the fourteenth century, Nicolas d'Oresme imagined an incorporeal void beyond the last heavenly sphere, but still insisted that, in contrast, all real places are full and material. Space, still only a pure logical possibility, became a *possibile realis* between the times of d'Oresme and Galileo (Funkenstein 1986, p. 62).

Following the canons of Antiquity and medieval cartography, a chart summarized bodily scouting and measuring gestures. Pilgrims followed *itineraria;* sailors, charts of ports; and surveyors consigned ritually performed acts of mensuration on marmor or brass plates. These were not maps in the modern sense, because they did not postulate a disembodied eye contemplating a land or a sea from above. The first maps in the modern sense were contemporary with early experimentations in central perspective and, like these, construed an abstract *eye* contemplating a distant grid in which particulars could be relatively situated. In 1574, Peter Ramus wrote a *lytle booke* in which he exposed a *calculus of reality* where all topics were divided in mental spaces that immobilized objects in their definitions precluding the understanding of knowledge as an act (Pickstock 1998). Cartesian coordinates and projective geometry gave the first mathematical justification to the idea of an immaterial vessel, unlimited in extent, in which all material objects are contained.

Non-Euclidean Space

Had space been invented, as Einstein contended, or discovered? In the eighteenth century, Immanuel Kant announced that space was an *a priori* of perception. For him, Euclidean geometry and its axioms were the mathematical expression of an entity—space—that cannot be perceived, but, like time, underlies all perceptions. The first attempt to contradict Euclidean geometry was published in Russian in 1829 by Nicolay Lobachevsky (1792–1856), whose ideas were rooted in an opposition to Kant. For him, space was an *a posteriori* concept. He sought to prove this by demonstrating that axioms different from Euclid's can generate different spaces. In light of Lobachevsky's—and then Georg Riemann's (1826–1866)—non-Euclidean geometries, Euclidean geometry appears ex post facto as just another axiomatic construct. There is no a priori space experience, no *natural,* or *universal* space. Space is not an empirical fact but a construct, an arbitrary frame that *carpenters* the modern imagination (Heelan 1983).

Einstein occupies an axial and simultaneously ambiguous position in the history of this understanding. In order to express alterations of classical physics that seemed offensive to common sense, he adopted a mathematically constructed *manifold* (coordinate space) in which the space coordinates of one coordinate system depend on *both* the time and space coordinates of another relatively moving system. On the one hand, like Lobachevsky and Riemann (1854), Einstein insisted on the constructed character of space: Different axioms generate different spaces. On the other, he not only came to consider his construct as ruling the unreachable realms of the universe, but reduced earthly human experience to a particular case of it. In Einstein's space, time can become extension; mass, energy; gravity, a geometric curvature; and reality, a distant shore, indifferent to ethics. This view of space has reigned over the modern imagination for a century. Yet the idea that the realm of everyday experience is a particular case of this general construct has not raised fundamental ethical questions.

Ethics in Space

The subsumption of the neighborhood where one lives into the same category as distant galaxies transforms neighbors into disembodied particularities. This loss of the sense of immediate reality invites a moral suicide. Hence, ethics in the early-twenty-first century requires an epistemological distinction that evokes that of d'Oresme in the fourteenth: Contrary to outer space, the perceptual milieu is a place of fullness. According to its oldest etymology, *ethos* means a place's gait. Space recognizes no gait, no body, no concreteness, and, accordingly, no ethics. The *ubi* question must thus be ethically restated.

Body historians and phenomenologists provide tracks toward an ethical recovery of placeness in the space age. Barbara Duden (1996) argues that one can only raise fundamental ethical questions related to pregnancy by relocating the body in its historical places. For their part, phenomenologists, those philosophers who cling to the *primacy of perception* in spite of tantalizing science-borne and technogenic *certainties*, restore some proportionality between body and place. For Gaston Bachelard (1884–1962), for instance, there is no individual body immersed in the apathetic void of space, but an experience of *mutual seizure* of the body and its natural *ubi*. Maurice Merleau-Ponty (1908–1964) further articulates the complementarity of these two sides of reality. These can be steps toward a recovery of the sense of the vis-à-vis without which there is no immediate reality, and hence no ethics.

JEAN ROBERT

SEE ALSO *Cyberspace; Einstein, Albert; Foucault, Michel.*

BIBLIOGRAPHY

Bachelard, Gaston. (1983). *Water and Dreams. An Essay on the Imagination of Matter*. ed. and trans. Edith R. Farrell. Dallas: Dallas Institute of the Humanities and Culture. Originally published in French in 1956.

Bochner, Salomon. "Space." (1998). In *Raum und Geschichte*, Kurseinheit 4, comp. Ludolf Kuchenbuch and Uta Kleine. Hagen: Fernuniversität.

Coxeter, H. S. (1965). *Non-Euclidean Geometry*. Toronto: University of Toronto Press.

Duden, Barbara. (1996). *The Woman Beneath the Skin*. Cambridge, MA: Harvard University Press. Originally published in 1991.

Einstein, Albert. (1993). "Foreword." In *Concepts of Space: The History of Theories of Space in Physics*, by Max Jammer. New York: Dover. Einstein's text was originally published in 1954.

Funkenstein, Amos. (1986). *Theology and the Scientific Imagination from the Middle Ages to the Seventeenth Century*. Berkeley: University of California Press.

Heelan, Patrick A. (1983). *Space-Perception and the Philosophy of Science*. Berkeley: University of California Press.

Illich, Ivan, and Rieger, Matthias. (1996). "The Wisdom of Leopold Kohr." In *Fourteenth Yearly E. F. Schumacher Conference*. New Haven, Connecticut, October 1994. Reprinted in French as "La sagesse de Leopold Kohr," in *Ivan Illich, La Perte des sens*, trans. Pierre-Emmanuel Dauzat. Paris: Fayard. The French version is the most recent authorized version; the English version is not generally available.

Lobachevsky, Nikolay Ivanovich. (1886). *Geometrische Untersuchungen zur Theorie der Parallellinien*. Kasan, Russia: Kasan University. Originally published in Berlin in 1840.

Merleau-Ponty, Maurice. (1964). *The Primacy of Perception*. Chicago: Northwestern University Press.

Pickstock, Catherine. (1998). *After Writing: On the Liturgical Consummation of Philosophy*. Malden, MA: Blackwell.

Ramus, Peter. (1966). *Logike*. Leeds: The Scholar Press. Originally published in 1574.

Riemann, Bernhard. (1876). "*Über die Hypothesen, welche der Geometrie zu Grunde liegen*" [On the hypotheses that are the base of geometry.]. In *Gesammelte mathematische Werke und wissenschaftlicher Nachlaß* [Collected mathematical works and legacy], ed. Richard Dedekind and Heinrich Weber. Leipzig, Germany: Teubner. Originally published in 1854.

SPACE EXPLORATION

Space exploration is the investigation of the cosmos beyond the upper regions of the Earth's atmosphere using telescopes, satellites, space probes, spacecraft, and associated launch vehicles.

Background

The desire to explore space is nearly primal for Homo sapiens. Early humans quickly spread out of Africa to every region on the planet, then came to speculate that the stars and planets were yet other material places worthy of exploration. The idea to travel to these other worlds was inevitable.

However for thousands of years, humans commonly drew fundamental distinctions between the Earth and non-Earth environments. In the formulation of Aristotle taught that the laws of nature that applied on Earth did not necessarily apply beyond the Earth, thus severely restricting the very possibilities for human space exploration.

During the great age of European exploration of the Earth, astronomers such as Galileo Galilei (1564–1642) and his contemporary, Johannes Kepler (1571–1630), began the modern observational exploration of the heavens, in fact of space, using new techniques and instruments of science. A result of this exploration of space was the scientific revolution itself. Science was now seen as applicable to understanding the entire world, to both heaven and Earth. Civilization was transformed.

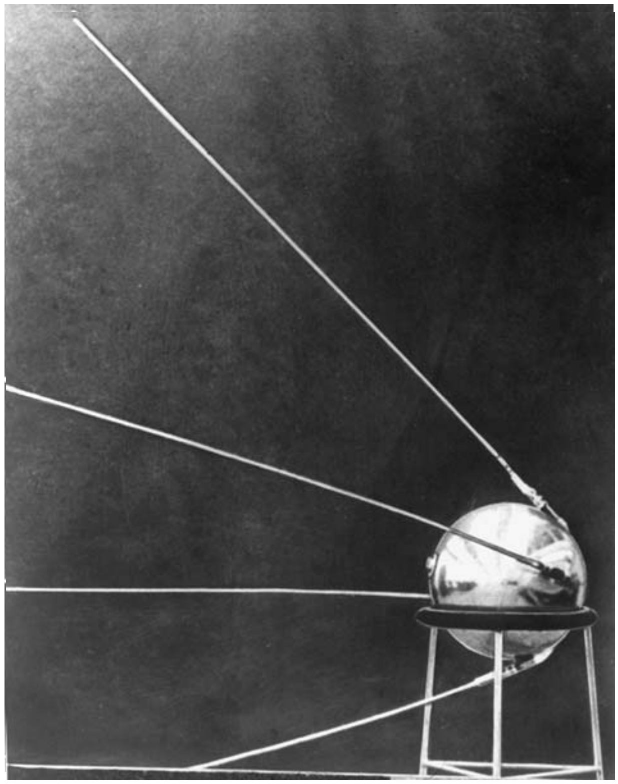
It now seems natural that Kepler's "Somnium," about a journey to the Moon, includes a realistic description of the lunar surface and how a traveler might physically survive such a trip. But this pioneering story began a long tradition of science fiction literature examining ethical and political issues of space exploration and scientific enterprise.

Twentieth-Century Developments

Planning and experiments to develop the science and technology of physical space exploration began with Konstantin E. Tsiolkovsky (1857–1935) in Russia and Robert Goddard (1882–1945) in the United States. Both of these inventors considered the long-term implications of their work for humanity. Application of their technology to weapons of war soon became evident. Although Goddard helped the U.S. military with rocket-assisted take off of conventional aircraft, it was the Germans who made extensive use of Goddard's published rocket development during World War II.

As the war ended, the *space race* began in earnest between the Soviet Union and the United States. Efforts were made by both countries to enlist German scientists, who had worked on the Nazi rocket program. Many Americans were shocked when, on October 4, 1957, the Soviet Union launched the first artificial earth satellite, Sputnik I. Some Americans viewed the Soviet triumph as an indication of U.S. weakness in science and technology, and considered it a political imperative to match and surpass Soviet accomplishments. Many voiced concern about the threat presented by the combination of nuclear weapons with ballistic missiles.

At the same time, some saw a great potential for peaceful exploration and development of the space environment. Ethical issues were debated about both the commercial and military aspects of this new human enterprise. The National Aeronautics and Space Administration (NASA) was created by Congress in 1958, at the height of the Cold War. It is remarkable that the NASA charter specifically states that the agency is restricted from military activity. (Nonetheless NASA would not always adhere to the charter. For instance, design of the space shuttle was driven significantly by military requirements at a time when Congressional support for NASA was waning.)



Sputnik I. Launched by the Soviet Union on October 4, 1957, it was the first artificial earth satellite. *(AP/Wide World Photos.)*

Space Law

Despite international competition, there was early agreement that space and celestial bodies were open to peaceful use by all nations, and that principles of international law would be followed in this new realm. Parallels with, and precedents set by, maritime law guided the formulation of space law and regulation. On December 13, 1963, the U.N. General Assembly adopted the Declaration of Legal Principles Governing Activities of States in the Exploration and Use of Outer Space. Further work by the United Nations resulted in the Outer Space Treaty, first signed by sixty-three nations in 1967, and adopted by most countries in the early twenty-first century.

Although much progress has been made in space law, there are challenging near-term issues. For example, the orbital location and radio frequency allocation of communication satellites is a type of territorial issue. At bottom, these resources are limited. Humans have the ancient challenge, in new guise, of how to share these resources peacefully and wisely. The information content of direct-broadcast satellite transmissions is also a complex issue involving national sovereignty on the one hand, and freedom of expression on the other. Observation or spy satellites bring issues of privacy versus freedom of inquiry and information. The United States, Russia, and others have entered into more than 100 treaties and agreements regarding issues of orbit and frequency allocation, as well as launching, tracking, monitoring, and recovery of satellites and space vehicles.

An astronaut moves along the Space Shuttle Discovery. *(NASA.)*

Human Exploration

The first human to orbit the earth, Soviet cosmonaut Yuri Gagarin, returned safely from space in April of 1961. The U.S. astronaut John Glenn followed with a similar mission the next year. These flights, and the many that followed, helped to transform human perspective of the earth and its place in the universe, just as the unmanned missions were doing. Only eight years after Gagarin's flight Neil Armstrong stepped onto the lunar surface on July 20, 1969.

Following the first earth orbit missions, both nations continued without a reported loss of human life until 1967 when three astronauts were lost during a ground test of Apollo 1 and a cosmonaut was lost during return from a Soyuz space mission. Nonetheless, manned space exploration has had a remarkably good safety record. Any space mission must balance goal, schedule, and budget, as well as recognizing risk and the unknown. In achieving this balance in space missions, it is important to keep in mind Richard Feynman's remarks about the loss of the space shuttle *Challenger*: "For a successful technology, reality must take precedence over public relations, for nature cannot be fooled" (Feynman 1986, F5).

Over the last several decades launch failures have been on the order of 1 percent. The space shuttle record, with a total of 112 successful flights and the loss of shuttle *Challenger*, reflects this value. *Columbia*, on the other hand, was the first loss of an American crew on reentry. In both cases the loss appears to be due to schedule and mission demands taking priority over safety.

The loss of human life in space flight development has been relatively low compared to the pioneering days of aviation. This may in part be due to risk-benefit and budget considerations. Experimental airplanes were relatively inexpensive to create and pilots were willing to take considerable risks. It was cost effective to risk pilot and plane to develop the new technology. This is not the case with spaceflight development and exploration. The loss of one mission costs billions of dollars and results in untold costs in schedule slippage and decreased political support. It is remarkable though that during the Mercury, Gemini, and Apollo spaceflights, there was no loss of human life. The Russian space effort has also been relatively free from loss of human life. The most well known soviet accident, Soyuz 11 in 1971, resulted in the death of three crew members as they returned to earth. Overall the loss of life in the U.S. and Russian programs has been similar, if one includes the unannounced Soviet losses of perhaps twelve.

The live coverage loss of *Challenger* and *Columbia* reminded the world that spaceflight is not yet routine. Exploration at the frontier must always remain riskier than day-to-day experience. There is, however, reasonable expectation that near-earth spaceflight will become safer in the foreseeable future. It remains to be seen how the advent of commercial spaceflight will change the equation, but the long term effect should be for improved safety.

Ethical Issues

Although certainly chartered upon a wider canvas, the challenges in space development are, in the first instance, those related to the ongoing challenges faced by the nation states. These issues are mostly of increased degree, rather than entirely new for humans. The ethics of space exploration from this perspective are addressed in such documents as the ESA-UNESCO report, *The Ethics of Space Policy* (Pompidou 2000).

Beyond these issues are those prompted by questions about the impact on human civilization of asteroid and comet orbit modification, space elevators-to-orbit development, or planetary, space, and asteroid colonization. Such endeavors could have impact on civilization beyond that of *normal* human activity.

Also of importance are issues such as interplanetary contamination, the terraforming of planets, and contact with extraterrestrial intelligence. These issues center on questions about the effect of the universe on human beings, and their effect on it.

An elementary case of this sort is the detection of primitive extraterrestrial life in the form of microbes or microfossils. Because the nature of such life is not known, one can only make informed speculation about what the effects might be on civilization and on life on Earth. Or, indeed, what effect humankind might have on such life.

Space exploration may result in the detection of extraterrestrial life or even other civilizations. A scientific Copernican-Darwinian worldview suggests the likelihood of finding evidence of this sort. In any case, it appears likely that people will continue to look for such evidence.

Several outcomes of the detection of life elsewhere in the universe have been suggested: a mostly harmless event, with gain in the knowledge that other life exists in the universe; a major change in life itself or civilization; the loss of civilization; the change or loss of dominant species; loss or change of all *higher order* species; loss of the planetary biosystem; or some unpredicted transformation of life and civilization. These changes are not necessarily in only one direction.

Several decades prior to the physical exploration of space the British ethicist and philosopher Olaf Stapledon (1886–1950) and the crystallographer J. D. Bernal (1901–1971), wrote about some of these wider issues of space exploration. Their pioneering efforts influenced later thinkers from the futurist and novelist Arthur C. Clarke (b. 1917) to the British-American physicist Freeman Dyson (b. 1923).

Responding to Ethical Issues

Humans have attempted to develop some approaches for dealing with the new ethical issues presented by space exploration. Prevention of potential contamination to the Earth's biosphere was practiced during the first lunar expeditions. Astronauts, spacecraft, lunar samples, and equipment were isolated upon their return to Earth from the Moon. The Lunar Receiving Laboratory is in operation to this day, protecting lunar rocks and soil, even though there is now no risk to life on this planet. Space probes are decontaminated prior to leaving the Earth in most cases. Considerable care of this sort was taken with spacecraft, such as Viking (1975) and Sojourner (1996) that would land on the Martian surface. The trajectory of Galileo (1989) was purposely changed, at the end of its mission, in order to send the spacecraft to fiery destruction in the upper atmosphere of Jupiter to insure no contamination of the Jovian moons with terrestrial microorganisms.

In 1991 the Declaration of Principles Concerning Activities Following the Detection of Extraterrestrial Intelligence was drafted by the International Academy of Astronautics (Billingham 1994). The Board of Directors of the International Institute of Space Law approved the declaration. This document is an effort to outline a responsible and orderly set of activities for scientists and others to follow after the detection of extraterrestrial intelligence. An obvious objective of this protocol is to protect life and civilization on Earth.

One can optimistically view the development of portions of the agreements regarding space exploration as the emergence of a principle of non-interference with extraterrestrial life. In a sense humankind seems to be developing a sort of *prime directive* rule of space exploration, which was once only addressed in science fiction. The prime directive restricts human beings from interfering with any extraterrestrial life that is *less developed* than they are.

Carl Sagan (1934–1996) and others have argued that the sort of extraterrestrial life that is likely to be detected will either be of an elementary sort, or a civilization well beyond our imagination. If this turns out to be the case, then the proper conduct, in either of these situations, will not be the sort fancied in the popular space operas of interstellar diplomacy and conflict. Humans would be either the fortunate caretakers of a wholly new primitive life system or the subjects of scientific interest, perhaps protected or transformed beyond recognition.

The American biologist and essayist Stephen Jay Gould (1941–2002), pointed out that the revolution of Copernicus and Galileo was about *real-estate*, but that the Darwinian revolution was about *essence* and thus had much the greater impact. This situation is reflected in questions about the present and future exploration of space. Presently human explorers are experiencing the Galilean, or real estate, phase of the space enterprise. But soon the essence, or Darwinian, phase may commence. Beginning in the mid-1990s, many planets, orbiting other stars, were found by astronomers. Spaceborn experiments directed at trying to detect some telltale signs of life on planets of other solar systems are planned for the first half of the twenty-first century. Even in the Earth's home-system there is hope for detecting life: The oceans that may exist below the ice surface of the Jovian satellite Europa are currently of prime interest to astrobiologists.

The nation states of Earth have created many agreements for the peaceful exploration of space. Space law is now an active field. Humankind has made a start in constructive and peaceful conduct during the early stages of space exploration.

Space exploration is not a one-way enterprise. The "pale blue dot" vision of earth in space, the close-up images of the many worlds of this solar system, returned samples from space, and the countless Hubble space telescope vistas, are transforming the human mind. This transformation is playing a key part in the evolution of the ethics of space exploration—an evolution that may now be at a stage where there is a need to develop a preliminary "prime directive," in order to define conduct with other life in the galaxy. The need may be closer than imagined.

MICHAEL GILMORE

SEE ALSO *Apollo Program; Galilei, Galileo; National Aeronautics and Space Administration; Space Shuttle* Challenger and Columbia *Accidents; Space Telescopes.*

BIBLIOGRAPHY

Bernal, J. D. (1969 [1929]). *The World, the Flesh, and the Devil.* Bloomington: Indiana University Press.

Billingham, John, et al., eds. (1994). *Social Implications of the Detection of Extraterrestrial Civilization.* Mountain View, CA: SETI Press.

Chaikin, Andrew. (1994). *A Man on the Moon.* New York: Penguin Books.

Crowe, Michael J. (1986). *The Extraterrestrial Life Debate 1750–1900.* New York: Cambridge University Press.

Dyson, Freeman. (1979). *Disturbing the Universe.* New York: Harper & Row, Publishers.

Feynman, Richard P. (1986). *Appendix F, Personal Observations On The Reliability Of The Shuttle.* Report of the Presidential Commission on the Space Shuttle Challenger Accident, vol. 2, p. F5. U.S. Government Printing Office.

McDougall, Walter A. (1985). *. . .the Heavens and the Earth: A Political History of the Space Age.* New York: Basic Books

Pompidou, Alain, Co-ordinator. (2000). *The Ethics of Space Policy.* New York: UNESCO.

Shklovskii, Iosif S., and Sagan, Carl. (1966). *Intelligent Life in the Universe.* San Francisco: Holden-Day, Inc.

Stapledon, Olaf. (1968). *"Last and First Men" and "Star Maker": Two Science Fiction Novels.* New York: Dover Publications, Inc.

SPACE SHUTTLES *CHALLENGER* AND *COLUMBIA* ACCIDENTS

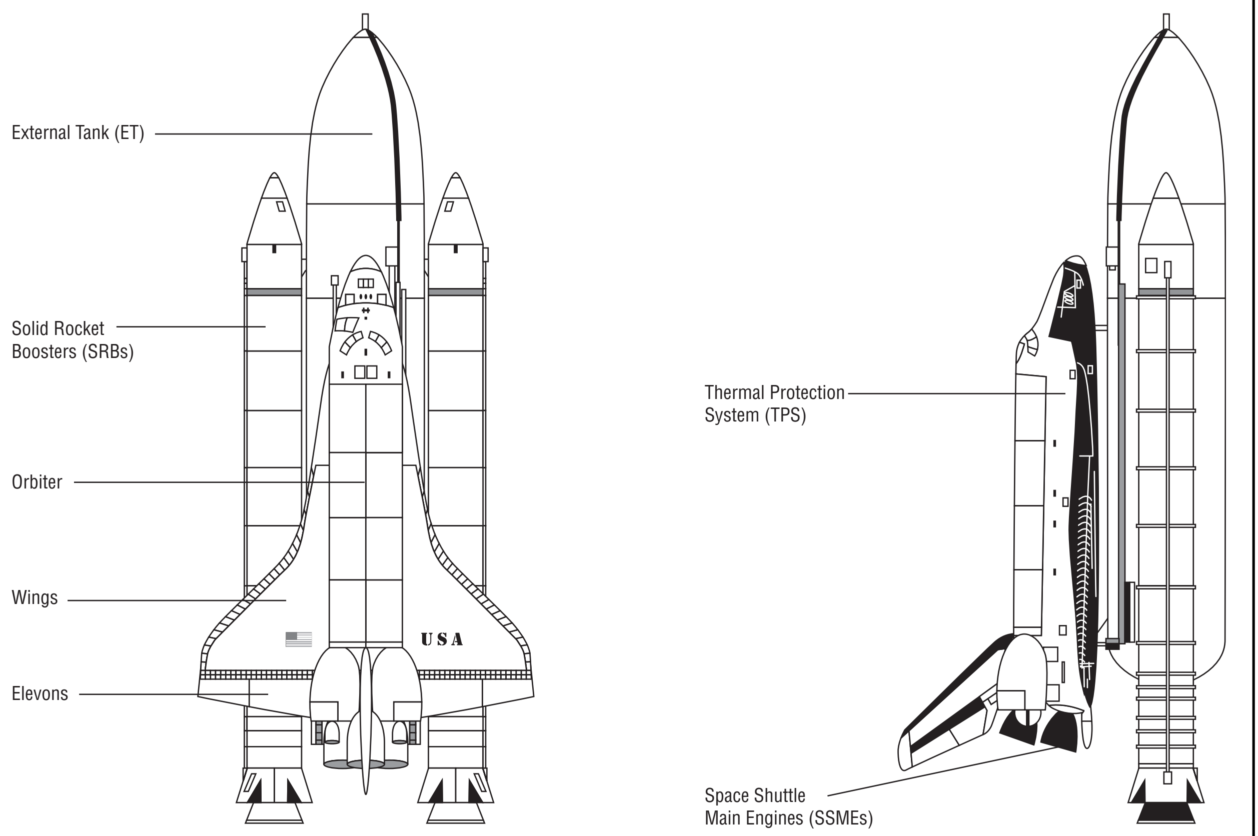
The losses of the space shuttles *Challenger* in 1986 and *Columbia* in 2003 dramatically illustrated the risks involved in the human exploration of space, and provide starkly instructive case studies in the ethics of science and technology.

A central mission of the National Aeronautics and Space Administration (NASA) is human exploration of space. Given this legitimate political commitment to human space exploration, the space shuttle program is ethically and politically acceptable insofar as the agency in charge, NASA, promotes careful and honest examination of the human risks and, in reaching the compromises unavoidable in balancing safety against performance, involves those most subject to the risks and those making the political commitment.

The careful, honest examination of risk cannot be done once; it must continue as flight experience accumulates. In balancing safety and performance the shuttle's design both represents NASA's understanding of the system and predicts that the shuttle's flight will safely meet performance requirements. To count as a success, a shuttle flight must perform as the design predicts, not merely return "safely" to Earth. As long as flight does not conform to design, that is, has "anomalies," the design remains provisional; it is not fully understood; and the system is "developmental" not "operational." Both disasters revealed that NASA truncated the examination of risk by deeming the shuttle "operational"; by treating as "successful" flights that did

FIGURE 1

Space Shuttle System



SOURCE: National Aeronautics and Space Agency.

The figure shows the launch configuration of the main elements of the Space Shuttle System, in "top" and starboard views: The winged Orbiter, which sits atop the large External Tank. On each side of the external tank are the two Solid Rocket Boosters.

not perform as predicted; and by "accepting" risks inherent in anomalous performance. Continuing instances of anomalies signaled the existence of inexplicable risks, which, accepted, culminated in the disasters.

Shuttle History and Design

After Apollo NASA needed a large program to justify its size and budget. It ambitiously planned a shuttle, a space station, and planetary exploration, but budgetary constraints limited the post-Apollo program to the space shuttle. To secure approval of the shuttle, NASA promised to launch all U.S. payloads. Also the reusable orbiter was presented as a means of long-run cost savings: With regularly scheduled, once-per-week operational launches promised by the mid- to late 1980s, the shuttle was to pay for itself. To develop fifty shuttle payloads every year, however, would have required a space budget ten times as large as NASA's actual budget. There was clearly an unrealistic presentation of feasibility on the part of NASA and uncritical thinking on the part of the U.S. Congress. The promises remain a root cause of pressure to launch the shuttle on schedule.

As Figure 1 shows, the shuttle consists of two solid rocket boosters (SRBs) to provide major thrust at launch, an external tank that carries fuel for the orbiter's main engines, and the orbiter, which carries the crew, payload, and main engines. The burnt-out SRB casings drop into the ocean where they are retrieved and later reused. The orbiter returns to Earth for servicing and reuse. The external tank is taken nearly to orbit before separation from the orbiter, and burns up on reentry. The official investigative reports, cited below, describe the shuttle, normal operations, and each disaster.

Shuttle development presented many design problems. One of the most challenging was a "thermal protection system" to protect the orbiter from the heat of reentry, when temperatures may exceed 5,000 degrees Fahrenheit. Another was providing a reliable seal between SRB segments.

Disasters Compared

The two disasters were very different superficially. The *Challenger* disaster occurred in the first moments of launch on an unusually cold January 28, 1986. Because of the cold weather, an O-ring seal between SRB segments leaked hot combustion gas, which quickly triggered the explosion that destroyed the vehicle. The dynamics of launch cause the joints between SRB segments to flex, and to prevent leaks the O-rings must be resilient enough to "follow" this flexure and maintain their seal. The cold O-rings were too stiff to follow the joint flexure.

The *Columbia* disaster culminated during reentry on February 1, 2003, after completion of the mission's on-orbit tasks. During launch the external tank had shed a large piece of foam insulation, which struck the orbiter's left wing, damaging its thermal protection system. Because of this unknown damage to the wing during launch, the heat of reentry destroyed the wing, leading to the breakup of the orbiter.

Similarities between the cases in three areas—no-return decisions, misunderstood anomalies, and overridden concerns from engineers—reveal the common ethical issues.

NO-RETURN DECISIONS. In both cases an explicit no-return decision left no chance to avoid disaster: For *Challenger* this occurred at launch—specifically, the ignition of the SRBs. For *Columbia* this came at initiation of reentry—the firing of the retro-rockets. Between the identification of an anomaly and this no-return decision there was time to have averted the disaster.

Regarding *Challenger*, the danger of a cold launch was suspected from heat damage to SRB seals—anomalies—in previous flights over several years. But the analysis of trends of seal damage as related to temperature omitted flights suffering no seal damage, all of which occurred at warm temperatures. This omission obscured the relationship of damage to temperature. If the many no-damage, warm launches had been considered, the significance of the few high-damage, cold launches would have emerged and convinced engineers that cold launches were unsafe (Vaughan 1996).

With respect to *Columbia*, occurrences of shedding of foam—anomalies—were known even before the *Challenger* accident. Foam strikes were "accepted" because efforts to prevent foam shedding were unsuccessful but flights were "successful." If NASA can fix the shedding problem in the halt in shuttle flights that followed the *Columbia* accident, so it could have during the similar halt after *Challenger*. This would have caused minimal (if any) delay and would have prevented the second disaster.

MISUNDERSTOOD ANOMALIES. The root cause of both disasters was misunderstanding anomalies. The 2003 *Columbia* disaster report quotes the 1986 *Challenger* report to show that the causes were identical. In effect, anomalies in performance—if followed by a successful landing—were considered evidence of safety instead of what they really were, evidence that the shuttle did not perform as designed. Thus safely landing after foam shedding or seal erosion reinforced the conviction of safety. This "normalization of deviance" violates the trust given NASA to accomplish human spaceflight safely (Vaughan 1996).

OVERRIDEN CONCERNS FROM ENGINEERS. In both cases working-level engineers most familiar with the relevant systems expressed timely concerns that could have averted the disaster, and their concerns were overridden. Regarding *Challenger*, engineers at the SRB contractor wanted to postpone the launch for a few hours or for a day for warmer weather, and were heard by company management in last-minute "readiness-to-launch" reviews, but management overrode them after NASA officials expressed frustration and desire to launch. They were overridden in part because of the inadequate trend analysis mentioned above. Warmer conditions could have averted the disaster. Desire to launch prevailed. With respect to *Columbia*, because the impact seemed more significant than the many previous instances of foam striking the orbiter, NASA engineers reviewing launch videos were alarmed. They requested a damage assessment but were overridden by management without a hearing. Had management honored the request, the disaster might have been prevented—the crew rescued but the orbiter lost (CAIB 2003).

The engineers did not push their arguments because of fear for their careers. Deciding to launch a shuttle had changed from a process requiring agreement that the system is safe to launch, per the design, to a process assuming launch and requiring anyone asking for delay to prove it unsafe. As "accepted" risks, damage to seals and strikes by foam were no longer an issue. This acceptance meant that a major foam strike on a launch shortly before *Columbia* (on October 7, 2002) was not declared an anomaly (CAIB 2003). Consistent with NASA's 1982 declaration of the shuttle as "operational," insulation strikes and seal damage became normal, while raising questions about these issues became deviant. William Langewiesche (2003) shows the depth of NASA managers' belief that insulation striking the orbiter was not a risk; he shows that only seeing an experimental demonstration of damage to a mock wing could destroy their belief, and that the demonstration left them in shock. Raising questions about foam shedding to such managers would damage one's career.

A healthy organization provides an environment and information conducive to decisions that advance the organization's goals within ethical constraints. Clearly, pressure to launch biased decisions by overemphasizing the partial, short-term goal of launching on schedule, reified in a lack of substantive, ethical discussion preceding the fatal no-return decisions. Astronauts, those most at risk, were not represented in the discussions. As the official reports reveal, typical predecision discussions were formal and procedural and laden with acronyms, emphasized the need to launch, and lacked ethical substance.

RADFORD BYERLY, JR.

SEE ALSO *Apollo Program; Engineering Ethics; National Aeronautics and Space Administration; Space Exploration.*

BIBLIOGRAPHY

Langewiesche, William. (2003). "*Columbia*'s Last Flight." *Atlantic Monthly* 292(4): 58–87. An accessible but rigorous analysis of the accident and NASA's reaction to it.

U.S. *Columbia* Accident Investigation Board (CAIB). (2003). *Report of the Columbia Accident Investigation Board*, Vol. 1. Arlington, VA: Author. The official report on *Columbia*; comprehensive.

U.S. House. Committee on Science and Technology. (1986). *Investigation of the* Challenger *Accident*. 99th Cong., 2nd sess. The congressional report on *Challenger*, essentially a supplement to executive branch *Challenger* report immediately below.

U.S. Presidential Commission on the Space Shuttle *Challenger* Accident. (1986). *Report of the Presidential Commission on the Space Shuttle Challenger Accident*. 5 vols. Washington, DC: Author. Official executive branch report on *Challenger*; comprehensive.

Vaughan, Diane. (1996). *The* Challenger *Launch Decision: Risky Technology, Culture, and Deviance at NASA*. Chicago: University of Chicago Press. How NASA's culture contributed to the accident.

INTERNET RESOURCES

U.S. *Columbia* Accident Investigation Board (CAIB). "The CAIB Report." Available from http://www.caib.us/news/report/.default.html.

U.S. Presidential Commission on the Space Shuttle *Challenger* Accident. "Report of the Presidential Commission on the Space Shuttle *Challenger* Accident." Available from http://history.nasa.gov/rogersrep/51lcover.htm.

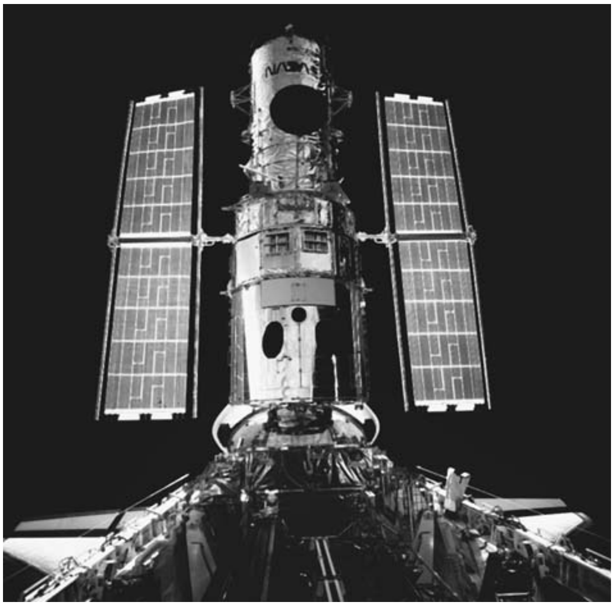
SPACE TELESCOPES

The idea of a space-based telescope dates back to a proposal by R. S. Richardson in a 1940 issue of *Astounding Science Fiction*, but Richardson thought the moon would be a suitable venue. The U.S. proposal to put a telescope in orbit around the earth was made by Lyman Spitzer in "Astronomical Advantages of an Extra-Terrestrial Observatory," a paper written for a project for the Rand Corporation in 1946. In 1958, after a call for proposals by the Space Science Board of the National Academy of Sciences, the National Aeronautics and Space Administration (NASA) Space Sciences Working Group began developing proposals for orbiting astronomical observatories. The idea of an orbiting observatory received support at the highest government levels on the basis of arguments for national prestige, which was in need of shoring up after the launch of *Sputnik I* in 1956 by the Soviet Union.

Project Development

In 1960 and 1961 NASA initiated the process that eventually led to the Hubble Space Telescope (HST). It issued several calls for proposals for launch vehicles and astronomical hardware. By separating the two issues NASA created the grounds for serious planning problems because the limitations of the launch vehicle would have serious implications for the size and design of the observatory. By not insisting on coordinating the two from the start, NASA was, perhaps unknowingly, preparing the ground for later arguments about the constitution of the observatory.

In 1969 after debates among a variety of interest groups, the National Academy of Sciences clearly backed the proposal for a space-based telescope. NASA soon bought into the idea. However, NASA always has been and continues to be a management enterprise of considerable complexity with a myriad of problems that lead to difficulties in making decisions. Much decision



The Hubble Space Telescope, attached to a space shuttle. Named after Edwin Hubble, the telescope was launched into orbit in 1990 as a joint project of NASA and the European Space Agency. Initial optical errors were corrected in 1993, and high-quality imaging began in 1994. HST is projected to continue operating until 2009. (© 1996 *Corbis*.)

making at NASA is influenced strongly by politics. The many and often competing interests NASA managers felt they had to satisfy ranged from internally competing science groups to contractors, politicians, public interest groups, regional NASA facilities, and national priorities, along with international considerations. In addition, there was always competition from other NASA projects. Funds were limited, and the demands were many. The space telescope, as was the case with many other projects, stalled.

Among other activities under way at NASA at the time when the space telescope was being debated was the planning of a space shuttle program, which was approved in 1972. To restart the stalled planning for the space-based telescope, NASA proposed that the launch vehicle for the telescope be the shuttle. That proposal had serious design implications for the telescope, which would have to fit into the baggage bay of the shuttle.

The Large Orbiting Observatory project was beset by arguments that delayed its completion. There were arguments over where the central control would be: The Goddard Space Flight Center at Beltsville, Maryland, or The Marshall Space Flight Center at Hunbtsville, Alabama.. There were arguments over who would have authority over what; what kinds of instruments should be built; how much money was available; which contractor would build the instruments; how much existing technology, such as military spy satellite technology, could be appropriated; and eventually, who would be blamed for the big mistake of the spherical aberration of the primary mirror and how it would be fixed.

The Large Orbiting Observatory, by now called the HST, was completed in 1986, shortly before the *Challenger* disaster. The grounding of the shuttle program forced a four-year delay in launching the HST. When the HST finally orbited in 1990, it was discovered immediately that its primary mirror had a spherical aberration: The images it sent to earth were blurry. After a number of investigations, including congressional hearings, it was concluded that the mistake was due to a failure of both the engineering team at the contractor for the mirror, Perkin-Elmer, and its management. Perkin-Elmer agreed to repay the government $25 million.

The problems with the Hubble eventually were fixed, and the HST has been instrumental in revolutionizing scientists' conception of the universe. It allowed astronomers to look deeper into space than ever before, revealing features of the universe that confirmed some theories and made others doubtful.

Reflections

When one reflects on the history of the HST, the variety of factors that played a role in its development, and its impact on astronomical understanding, several themes emerge. First, the building of a large and expensive scientific instrument is not a simple process. Furthermore, instruments with the size and complexity of the HST require such vast resources that only a national government or another entity capable of putting together a conglomerate of considerable size can undertake a project of such magnitude. Second, in a world of limited resources the commitment to undertake one project of that size means that other projects will suffer. Thus, not only was there considerable tension between advocates of earth-based telescopes and advocates of space-based ones, directing funds toward the HST meant that less money was available for new and larger earth-based telescopes. Third, most of the conflicts involving the HST were clashes of values that often were multidimensional.

The initial battle over launching a large space telescope as opposed to several smaller, more specialized telescopes was not just an argument about whether the project was feasible. In a 1983 symposium sponsored by the Smithsonian Institution the physicist Freeman Dyson (b. 1923) argued against the idea of doing science with instruments with the size and scale of the HST and for a smaller, diversified kind of science employing specialized, smaller, and much cheaper instruments. Dyson was arguing against big science, which had become a distinctive characteristic of the U.S. physics community.

Dyson may have had a point. The U.S. physics community had continued to rely on large instrument projects to a risky extent. The lesson was learned the hard way when the Super-Conducting Super Collider (SSC) project was canceled fifteen years after it had been proposed and billions of dollars had been spent. The physics community reacted as if it had received an amputation: It had no visible capacity to do microphysics at the cutting edge.

This episode shows the flaw inherent in insisting on a hegemony in a science. The lesson to be learned from the Hubble, however, actually goes in the other direction. The turn to big science/technology need not limit the scientists to one large project; it also can generate small science projects in its wake. Smaller and less expensive types of telescopes, such as an infrared telescope, are being placed in orbit to discover what the Hubble could not reveal. What was missing from the thinking about the SSC were ideas about what would follow from it by way of subsidiary projects such as smaller more specialized experimental devices.

The HST illustrates other value clashes as well. Many people argue against this kind of project while people are suffering from hunger, disease, and lack of education. Big science/technology, it is claimed, is a luxury at a time when many millions are living in misery. This is a hard argument to refute, and it is not clear that one should try. It is important to be reminded of the human cost of science and technology. At the same time it is possible also to consider another human dimension to big science/technology that although it does not refute the argument from human physical need speaks to a different form of human need.

In the Middle Ages there was much misery. In Europe most of the population lived in squalor, disease was rampant, and ignorance was the norm. However, despite those circumstances, people in that era gave of their time, labor, and meager belongings to build some of humankind's most magnificent edifices: Gothic cathedrals. The cathedrals of Europe present a statement of humanity's commitment to seek more than it can find on earth. Projects such as the HST may be considered a continuation of that quest.

JOSEPH C. PITT

SEE ALSO *National Aeronautics and Space Administration; Space Exploration.*

BIBLIOGRAPHY

Chaisson, Eric J. (1998). *The Hubble Wars*. Cambridge, MA: Harvard University Press. A personal account of some of the internal battles in the Hubble saga.

Needell, Allan A., ed. (1983). *The First 25 Years in Space: A Symposium*. Washington, DC: Smithsonian Institution Press.

Pitt, Joseph C. (2000). *Thinking about Technology*. New York: Seven Bridges Press. Formulates the author's philosophical position behind the observations at the end of this article concerning value conflicts.

Smith, Robert W. (1989). *The Space Telescope*. New York: Cambridge University Press. The most detailed and definitive history of the Hubble project.

SPECIAL EFFECTS

Special effects (which typically refers to visual effects in live-action moving-image media but also includes audio effects and other possibilities) are the methods used to produce on-screen (or on-air) events and objects that are physically impossible or imaginary, or too expensive, too difficult, too time-consuming, or too dangerous to produce without artifice. The ethics of the related technologies are seldom discussed but are nevertheless significant.

Origins

Cinematic special effects grew out of trick photography and began with the trick film tradition popularized by early filmmakers such as Georges Méliès (1861–1938), a special effects pioneer who was the first to develop many in-camera techniques. Silent films used a variety of special effects techniques, particularly in the genres of science fiction and horror. Many new special effects technologies became possible after the invention of the optical printer in 1944, resulting in a new generation of science-fiction films in the 1950s that used the new techniques, as well as more realistic-looking effects in other films. Finally, the late 1980s and 1990s saw another advance in effects technology: the rise of digital special effects created in computers, which allowed live-action footage to be combined with anything that could be rendered in computer graphics.

Special effects are a large part of the film industry in the early twenty-first century, with a number of companies such as Industrial Light & Magic and Digital Domain specializing in the production of special effects.

Jim Carrey as Stanley Ipkiss in a scene from the 1994 film *The Mask*.

Special effects can be found in almost every genre of filmmaking, in both big-budget and low-budget films, as well as on television, most notably in advertising, where high budgets and short formats allow filmmakers to experiment with expensive new techniques.

Types of Special Effects

Special effects can be divided into four types: practical effects, in-camera effects, optical effects, and digital effects. Practical effects, also known as physical effects, are those that occur in front of the camera, such as rigged explosions, pyrotechnics, animatronics figures or puppetry, makeup effects, and so forth. Practical effects have the advantage of occurring on the set where they appear directly in the scene and the action of the shot, and require no postproduction processes.

In-camera effects are achieved through forms of trick photography and are made in the camera at the time of shooting. Such effects include shots taken at different camera speeds, shots using lens filters, and day-for-night shooting, all of which change the kind of image being recorded. Superimpositions and multiple-exposure matte shots require the film to be exposed, rewound, and exposed again, adding two or more images together onto the same piece of film before it is developed (this combining of imagery is also called *compositing*). Foreground miniatures, glass shots, and matte paintings make use of the monocular nature of the camera by falsifying perspective and making small objects close to the camera look as if they are part of larger objects farther away from the camera. Buildings can be extended and other large set pieces can thus be made inexpensively through the use of detailed models and paintings done with the correct perspective. Front projection and rear projection processes combine foreground sets and actors with backgrounds made from projected imagery (most typically as moving background imagery placed behind an actor driving a car).

Optical effects involve the use of an optical printer, a device invented by Linwood Dunn in 1944 that allows images on developed pieces of film to be rephotographed and composited together onto a single piece of film. An optical printer is basically a camera and a projector (or multiple projectors, in some cases) set up with a camera in such a way that film frames can be rephotographed directly from another strip of film. Optical processes allow frame-by-frame control and greater preci-

A special-effects artist signs autographs near a model of the character Gollum from the *Lord of the Rings* film trilogy. The groundbreaking CGI character was built around an actor's voice, movements, and expressions by using a motion capture suit which recorded his movements and applied them to the digital character. *(© Reuters NewMedia Inc./Corbis.)*

sion in spatially positioning elements than is possible with in-camera compositing. Perhaps the most common form of optical compositing is the matte shot, wherein a foreground element is combined with a background, without the background visible through the foreground element (as would be the case with superimposition). To achieve this, keying processes are used for the production of foreground elements, and the most typical of these, blue screening and green screening, place the actor in a solid-color background, which is later optically removed from the shot. A holdout matte is made from the foreground element, which leaves a part of the rephotographed background plate unexposed, and the foreground element is later exposed onto the same plate, fitting into the unexposed area. Traveling mattes also make this technique possible for moving objects and moving camera shots.

Digital effects are all done in a computer. Images are either shot with digital cameras or scanned from film into a computer, where they are edited and composited digitally. Digital effects avoid the generational loss (the loss that occurs when film images are rephotographed onto another piece of film) that happens during optical rephotography, and the computer makes matteing much easier and faster and gives the effects technician greater control over the image. Digital effects technology also allows computer-generated imagery to be combined with live-action footage, and allow images to be controlled down to individual pixels. Light, shadow, and color can all be adjusted, and digital grading can replace color correction and matching that was previously done during the color timing (the matching of colors from shot to shot during postproduction) of prints in postproduction. Digital effects were experimented with during the 1980s and came into common use during the mid-1990s as techniques were developed and computer systems became powerful enough to make digital effects work affordable.

Some special effects (such as dinosaurs, space battles, monsters, and so forth) are obviously special effects no matter how well they are done, because the objects or events they portray clearly do not or no longer exist. Other effects, known as "invisible effects," are less noticeable because they portray objects and events (for example, background buildings, smoke, and building extensions) that do not call attention to themselves and that usually could have been done conventionally had the budget allowed it. Another type of invisible effects are effects in which something is erased or removed from the image. One example is wire removal, in which the wires used to fly an actor or object are digitally erased during postproduction.

Ethics

The alteration and faking of photographs has existed as long as photography itself. Whether or not the use of special effects is ethical depends on the intentions and truth claims of the work in which they appear. By altering, combining, or fabricating images, special effects work reduces or removes the correspondence, or indexical linkage, that an image may have to its real-world referent. Thus, while special effects may be acceptable in films that are fictional or are clearly re-creations of events, one would not expect to find them in news or documentary footage that claims to be a record of actual events. Even when they are used in an entirely fictional film, how special effects are used can still greatly determine how a film is received by an audience. For example, Jackie Chan's earlier films, in which he actually does all his own stunts, are more impressive than his later films in which some of his stunts are the result of wire work and special effects. Likewise, while the digital crowd scenes in *The Lord of the Rings: The Two Towers* (2002) and *Star Wars, Episode II: Attack of the Clones* (2002) are impressive, one is still aware that they are special effects, unlike the massive crowd scenes in older movies such as *Gandhi* (1982) and the Russian version of *War and Peace* (1966–1967), which were all done using actual crowds. At the same time, not only are special effects used to create spectacle, but their creation itself has become a spectacle, as witnessed by "making of" featurettes often found among the DVD extras. For many, knowing how an effect was made can enhance the viewing experience rather than spoil the effect.

Advances in special effects have made fantastic ideas possible and allowed filmmakers to give them concrete expression. The fact that many effects in the early twenty-first century are photo-realistic and seamlessly integrated into live-action footage also means that a discerning viewer will need a certain degree of sophistication. Combined with unlikely storylines, the use of special effects, which makes unlikely or impossible events appear possible and plausible, may help to erode the ability of younger or unsophisticated viewers to distinguish between what is plausible and what is not. Despite the fact that the films in which special effects appear are often clearly fictional, seeing photo-realistic representations of what look like actual events can make an impression on some viewers, particularly in a culture in which so much of what people see of the world is mediated through film and television imagery. At the same time, because of magazines, books, and DVD extras detailing special effects techniques and technology, contemporary viewers often are more aware of how special effects are done and how they are incorporated into a film.

MARK J. P. WOLF

SEE ALSO *Computer Ethics; Entertainment; Movies; Video Games.*

BIBLIOGRAPHY

McAlister, Michael J. (1993). *The Language of Visual Effects*. Los Angeles: Lone Eagle Publishing. A dictionary of special effects terminology.

Rickitt, Richard. (2000). *Special Effects: The History and Technique*. New York: Watson-Guptill. A good overview of the history and techniques of special effects.

Vaz, Mark Cotta, and Craig Barron. (2002). *The Invisible Art: The Legends of Movie Matte Painting*. San Francisco: Chronicle Books. A book on a specific effect, matte paintings, which are the background images used in wide shots and combined with live action.

Wolf, Mark J. P. (2000). "Indexicality." In *Abstracting Reality: Art, Communication, and Cognition in the Digital Age*. Lanham, MA: University Press of America. A look at how digital technology has changed art, communication, and how people view their world and environment.

SPEED

The word *speed* is derived from the Middle English *spede* (good luck), which in turn originated from older roots meaning to prosper or succeed. In its contemporary usage, speed refers to a rate of change. It commonly denotes the time it takes to travel a certain distance (e.g., a rate of 60 miles per hour), but it is also used to describe the time needed to perform certain tasks or operations, especially in information processing (e.g., a computer with a 500-megahertz processing speed). Individual artifacts such as cars, airplanes, and computers are achieving ever-greater speeds, which has effectively decreased and in some cases nearly eliminated distance. The speed of modern travel and communication has shrunk the world and radically altered the experience of time and place for individuals, corporations, and nations. Increased speed at this level of analysis presents several important safety and ethical issues.

The Technological Singularity and Other Analyses

But even more profound implications derive from the speed at which the very processes of technological innovation and knowledge creation occur. Moore's law (holding that growth in the number of transistors per integrated circuit will be exponential) was generalized to all technologies by Raymond Kurzweil in his "law of accelerating returns." Some futurologists claim that this acceleration will lead to a "technological singularity." This denotes the point in the development of a civilization at which technological change accelerates beyond the ability of present-day humans to fully comprehend, guide, predict, or control it. It derives mostly from the use of the term *singularity* in physics to indicate the failure of conventional models to predict change as one approaches a gravitational singularity—an event or location of infinite power such as a black hole, where matter is so dense that its gravity is infinite. When a black hole absorbs nearby matter and energy, an event horizon separates this region from the rest of the universe, constituting a rupture in the structure of space and time. Vernor Vinge (1993) developed the concept of technological singularity and applied it more specifically to the advent of greater-than-human intelligence. Beyond the technological singularity lies a fundamentally transformed world, perhaps one dominated by machines that have goals inconsistent with those of humanity. Vinge concluded that if the singularity can happen it will, because the competitive advantage afforded by advances in technology assures their implementation.

Many other analyses of modernity have noted this acceleration and described its personal and social consequences. Theodore Kaczynski, the Unabomber, warned of its actual and impending dehumanizing effects. Alvin Toffler (1970) summed up this wider rendition of speed with his coinage "future shock," as the overwhelming rate of change transforms institutions, shifts values, and undermines cultural and personal foundations. Toffler argued that the rate of change can be even more important than the direction of change in terms of psychological and social impacts. With his concept of "cultural lag," William F. Ogburn (1922, revised 1950) focused more on differential rates of change between interdependent parts of society. For example, science and technology usually operate at a much faster—though in his 1950 revised version, Ogburn admitted it might not be an ever increasing—rate than cultural beliefs and social institutions. Deborah G. Johnson (2001) argued that this differential speed creates "policy vacuums" as social decisions lag behind technological innovation. The French essayist and urbanologist Paul Virilio (1995) similarly claimed that immediacy and instantaneity present the most pressing challenges and ethical concerns at the personal, economic, political, and military levels.

Perception and Experience

In a psychological and even existential sense the perception of relative speeds is rooted in the workings of human consciousness. Oliver Sacks (2004) noted how early psychologists used developments in cinematography to elucidate the perception of time. Late-nineteenth-century innovations in cinecameras allowed photographers to register larger or smaller numbers of events over a given period by adjusting the frames exposed per second. This allowed them to capture the frenzied flapping of bees' wings or the slow unfurling of fern crosiers and re-present them at the rate of normal human perception.

In his *Principles of Psychology* (1890), William James (1842–1910) used the metaphor of altering the frames per second exposed to light to explain the human perception of time. If we were able to process 10,000 events per second instead of the usual ten, then time (measured, as it must be, by our experiences or sense impressions of the world) would slow down. So too, if we were able to process only one-thousandth of the sensations per second than normal, then time would speed up. In the former case, the sun would stand still. In the latter case, mushrooms would spring up and shrubs would rise and fall like restlessly boiling water. Human consciousness is a roll of film spinning at such a rate as to expose a certain number of frames per second, thus giving rise to normal perceptions of time and the speed, as it were, of human awareness or being.

Later sensory psychologists have examined cases of aberrant time perception. For example, several subjects have reported a tremendous slowing of time when suddenly threatened with mortal danger. The metaphorical explanation often proposed for these phenomena is that the human brain, in moments of extreme stress, is able to reduce the duration of individual frames and expose more of them per second. This accelerates thought and increases the speed of decision-making capabilities. From a physiological perspective, such instances may result from a flood of excitatory or a relaxation of inhibitory neurotransmitters.

Certain drugs also provide departures from normal time. Hashish makes events appear to slow down, whereas mescaline and amphetamines accelerate them. Indeed the latter drug is commonly referred to as "speed," indicating the subjective, phenomenological quality of time as a function of brain chemistry and consciousness. Sacks notes there are persistent disorders of neural speed, some of which can be caused by encephalitis lethargica and Parkinson's disease. Some patients can experience radical slowing of thought and movement, which can sometimes be reversed by reducing dopamine deficiencies with the drug L-dopa.

On another experiential level, Virilio states that the primary consequences of the increasing speed of modern life are personal, amounting to disorientation concerning reality. He argues that the globalized, instantaneous flows of information in cyberspace undermine the deep-seated spatial and temporal anchors of the human experience. His views find support, for example, in the way that some virtual relationships have led to tragic decisions by teenagers who become victims of sexual predators on the web. The lightning speed of cyberspace communications has undoubtedly altered fundamental human experiences such as love and intimacy. In many urban areas the Internet is reshaping dating and courtship. Love at hyperspeed brings conveniences by matching supply and demand in a more systematic fashion than haphazard meetings, but it also shifts the meaning of relationships in ways that require personal and social adjustment.

The speed of Internet and satellite communication provides the benefit of instantaneously connecting loved ones separated by great distances. Cyberspace, however, may give only a false sense of closeness. For example, the members of a suburban family in the United States usually have hectic schedules that scatter them significantly in physical space and, when by means of a cell-phone family plan, computer messaging, or both, they succeed in communicating mostly on-the-go, this form of communication eclipses more traditional ones occurring in such shared places as the dinner table or the living room.

It is nevertheless important not to romanticize the past. At least since the 1950s in industrialized countries, family time and communication between fathers and their children were infrequent in many households. The increase of dual-income families and the rise of television viewing have further undermined family intimacy. Nonetheless, the experience of cyberspace communications is qualitatively different in that the interlocutors' bodily presences and languages are absent from voice or text messages.

Despite variances in the range of speeds at which human thought can operate, there are basic neurological determinants that limit human cognitive capacities (e.g., serial computations, recognition, and associations). These limits are frequently tested by the accelerated flows of information and technical change in modern life, but drugs, supplements, and perhaps even neural human–computer interfaces may be able to expand cognitive processing speeds. Cognitive prostheses can improve human cognition, much as eyeglasses improve vision. For example, an airplane cockpit display has been developed that shows crucial information so that a pilot can understand what the aircraft is doing in a fraction of a second instead of the usual few seconds (Bower 2003). Such technologies are based in human cognitive studies research on information processing and visual tracking.

There is, however, controversy about whether such mind-expanding devices are a blessing or a curse, because they bring about even greater pressures by increasing the speed of information processing. This raises the stakes in case of human or machine error. Beyond concerns of safety, however, these actions raise profound issues about how humans synchronize with nature and society. Toffler (1970) echoed the sentiments of many critics of modernity by suggesting that there is something dangerous and even alienating about the rapid tempo of change. Individuals and society are maladapted to such breakneck speeds, and we require social and personal mechanisms to regulate change and decelerate it to a more human pace.

Economic Consequences

At least since Karl Marx's critique of industrial capitalism in the mid-nineteenth century, many theorists and workers alike have disparaged some of the effects of greater speed introduced into manufacturing processes by automated production equipment. They argue that these devices should conform to the humans operating the equipment, not the other way around; otherwise, increased speed jeopardizes the physical and mental health of workers. Critics also point out that these changes often involve exploitation by decreasing bargaining power, pay, status, and/or self-esteem. The increased speed and efficiency of machines has also caused unemployment as human workers become less profitable. Tracking the economic consequences of technological innovation is difficult, however, because it often creates new employment opportunities elsewhere.

The increased speed of financial and economic activity raises more concerns than just competitiveness versus risks to physical and mental health. Indeed, on a larger scale, it could be argued that the competitive profit motive driving capitalism is a major cause of the accelerating pace of modern life. Internet transactions have globalized financial markets as investments can be made at the speed of light and funds shuffled between countries at the press of a button. Transnational businesses are able to create information networks that bypass the traditional power of the nation-state. Toffler (1980) noted the rise of "third wave" societies based on information, communication, and technologies operating at rapid speeds. Not only does this shift power in the sense that nonstate actors make more and more major decisions, but it also increases the interconnectivity of third wave countries because communication linkages and knowledge have largely replaced industrial processes as their economic lifelines.

Interconnectivity brought about by increased reliance on swift, automated information technologies allows for a more fluid and responsive economy and greater specialization of production. It also, however, increases volatility and vulnerability to shocks anywhere in the system. This had led some (e.g., Siegele 2002) to propose the need for economic "circuit breakers" to protect global markets from cascading failures. Such precautionary measures and restrictions, however, need to be balanced against the benefits of free flows of global capital. Furthermore, even if the speed and integration of information flows may lead to more sudden downturns, they can increase the rate of economic recovery as well. Nonetheless, economic laws, regulations, and institutions are forced to globalize at the same speed as the technology in order to secure and harmonize economic activities.

The instantaneity of communication has generated the real-time economy, which has large macroeconomic effects and impacts at the level of individual companies. Real-time enterprises, ideally, will be able to monitor internal and external conditions in order to react to changes instantaneously. Through increased communication with customers, they will also be able to rapidly offer new products and services, thus more tightly coupling demand and supply. The flood of information threatens to overload companies, which have responded by developing software to optimize supply chains and automate certain responses to real-time cues.

Rapidly changing markets and technologies increase competitive pressures for firms to increase integration and flexibility, which can lead to organizational problems. The emergence of the real-time economy more directly pins economic vitality on the smooth functioning of integrated technologies. A software virus, for example, could cause massive economic collapse. Ludwig Siegele (2002) offers the conclusion that such drawbacks are not inherent in the technologies, but arise from the way they are used. But he adds, "it is worth asking to what extent we want computers to run our lives" (p. S20).

Cultural benefits are also generated by the speed of new communication technologies. For example, the time gap between the release of a Hollywood movie in the United States and its debut elsewhere in the world has been drastically cut, symbolizing the free flow of art and culture made possible by these new speeds. In some cases this may foster greater cross-cultural understanding and tolerance. Some, however, perceive this as a threat to local economies and cultures, which now must accelerate to keep up with foreign competition. Cultural homogenization may result.

Social and Political Consequences

Economic consequences of increased technological speed spill over into social changes. Harriet B. Presser (1999) noted that the use of rapid communication technologies is one factor in the widespread prevalence of nonstandard work schedules. The globalization of markets and the ability to be "on call" all the time require expanded hours of operation. This affects the family lives of workers and requires social institutions such as daycare to adapt to changing needs. The increased reliance on rapid communication technologies by the military also carries social and political consequences. Such advances in the U.S. military have tested the limits of telecommunication capacity, or bandwidth, which is expensive to expand. Although the real-time information gained can help protect both troops and civilians, politicians face trade-off dilemmas concerning the best investment of public funds.

Real-time politics has brought both beneficial and detrimental effects to democratic processes. The immediacy of citizen participation in government may contribute to political accountability and strengthen civic commitments. For example, the Internet has sparked a new wave of social responsibility by organizing protestors around the world (McPherson and Schapiro 2001). It allows like-minded activists to communicate, build consensus, coordinate activities and information, and provide mutual moral support. Campaigns against "sweatshop" labor have been primarily organized via the Internet. Such forms of communication may even help foster democracies in nations controlled by tyrants. One drawback, however, is that passions unleashed at the speed of the Internet often outstrip facts and evidence, which can delegitimize well-meaning social reformers.

Other negative effects can result from real-time politics. Virilio argues that representative democracy is undermined by the virtualization of government and the rise of opinion democracy patterned on viewer counts and opinion polls. Political leaders may pander to public opinion rather than make unpopular, but perhaps better, decisions. Public opinion polls often reflect short-term interests, whereas leaders must balance these with long-term common-interest goals. The greater speed of communication often undermines careful deliberation and reasoned judgment, but it can also better inform such deliberation. But referendum reforms were altering the balance of participatory and representative democracy before the real-time computerization of politics. So, cyber-speeds may aggravate more than cause this dilemma.

Increasing speed of information flows can exacerbate the complexity and multiplicity of policy issues, leading to issue overload. This is a situation in which the multitude and complexity of issues exceeds what individuals can understand and societies can handle through the courts (leading to court-case overload), legislation (producing tunnel-vision laws), or executive or other institutional channels (Breyer 1993).

On a larger scale, Stewart Brand (1999) argued that the accelerating pace of technological change, the short-term perspective of consumerist lifestyles, and the short-term focus of political election cycles have all eroded the concept of long-term responsibility. The acceleration of experiential time effectively reduces the timescale of interest, thus shrinking the horizon of felt obligation. Brand writes, "Our ever hastier decisions and actions do not respond to our long-term understanding, or to the gravity of responsibility we bear" (p. 8). In order not to be doomed by speed, we must slow down enough to allow time to apply the brakes in case of emergencies.

He proposed a balancing corrective to this shortsightedness to help us accept our long-term responsibilities to nature and future generations. In cooperation with others, Brand founded the Long Now Foundation in 1996 and began to design the Clock of the Long Now, a giant mechanical clock to be set somewhere in the U.S. desert to record time for 10,000 years. The goal is to embody deep time in a way that counterbalances the shrinking timescales experienced by those caught up in the speed of modern life.

A. PABLO IANNONE
ADAM BRIGGLE

SEE ALSO *Artificial Intelligence; Communication Systems; Cyberculture; Cyberspace; Economics and Ethics; Information Overload; Internet; Turing Tests; Work.*

BIBLIOGRAPHY

Bower, Bruce. (2003). "Mind-Expanding Machines: Artificial Intelligence Meets Good Old-Fashioned Human Thought." *Science News* 164(9): 136–138.

Brand, Stewart. (1999). *The Clock of the Long Now: Time and Responsibility*. New York: Basic.

Breyer, Stephen. (1993). *Breaking the Vicious Circle: Toward Effective Risk Regulation*. Cambridge, MA: Harvard University Press.

Johnson, Deborah G. (2001). *Computer Ethics*, 3rd edition. Upper Saddle River, NJ: Prentice Hall.

McPherson, Michael S., and Morton Owen Schapiro. (2001). "When Protests Proceed at Internet Speed." *Chronicle of Higher Education*, 23 March, B24.

Ogburn, William F. (1922). *Social Change with Respect to Culture and Original Nature*. New York: Huebsch. Ogburn's first systematic formulation of cultural lag as a part of his theory of social change, which was presented in the chapter "The Hypothesis of Cultural Lag." Later editions, including the 1950 revision of the book, were published by Viking.

Presser, Harriet B. (1999). "Toward a 24-Hour Economy." *Science* 284(5421): 1778–1779.

Sacks, Oliver. (2004). "Speed: Aberrations of Time and Movement." *New Yorker* 80(23): 60–69.

Siegele, Ludwig. (2002). "How About Now? A Survey of the Real-Time Economy." *Economist*, 2 February, S3–S20.

Toffler, Alvin. (1970). *Future Shock*. New York: Random House. Argues that there can be too much change in too short of a time, and therefore we need to improve our ability to wisely regulate, moderate, and apply technology to serve human ends.

Toffler, Alvin. (1980). *The Third Wave*. New York: Morrow. Develops the thesis that information societies are a qualitative shift beyond industrial societies and explains several consequences of this shift.

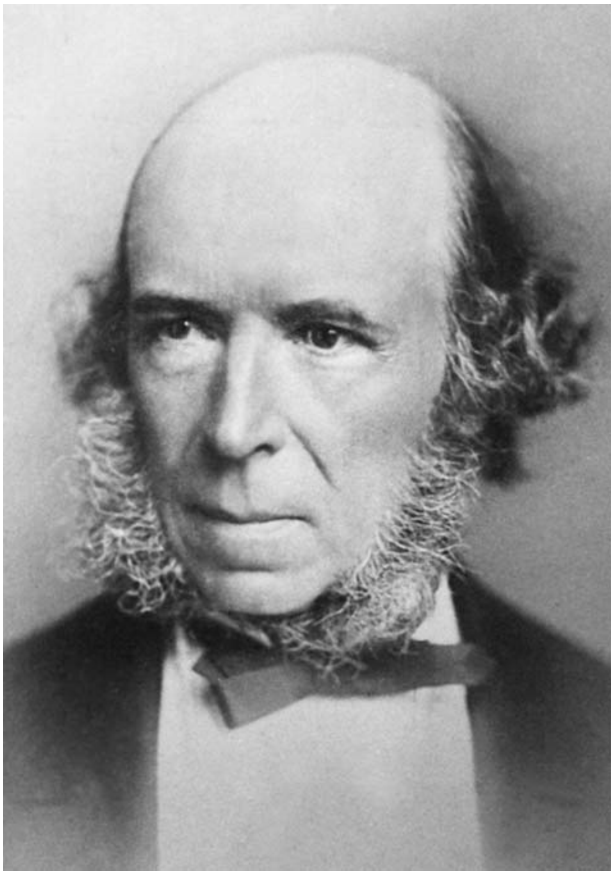
Vinge, Vernor. (1993). "Technological Singularity." *Whole Earth Review*, no. 81: 88–95.

INTERNET RESOURCE

Virilio, Paul. (1995). "Speed and Information: Cyberspace Alarm!" trans. Patrice Riemens. *CTHEORY.net*, 27 August. Available from http://www.ctheory.net/text_file.asp?pick=72.

SPENCER, HERBERT

British philosopher and sociologist, Herbert Spencer (1820–1903) was born in Derby, England, on April 27, and became well known for developing and applying evolutionary theory to sociology, philosophy, and psychology. Following an informal education in the anti-establishment views of his father, he briefly trained as a civil engineer before becoming a journalist and political writer. Spencer began writing books in the early 1850s, and presented a systematic and comprehensive account of his views on ethics, sociology (government, politics, and education), and biology in the nine-volume *A System of Synthetic Philosophy* (1862–1893). Although his ideas were influential during the last few decades of the nineteenth century, his reputation subsequently waned. Spencer died in Brighton, England, on December 8.



Herbert Spencer, 1820–1903. Spencer was an English philosopher, scientist, engineer, and political economist. In his day his works were important in popularizing the concept of evolution and played an important part in the development of economics, political science, biology, and philosophy. *(The Library of Congress.)*

Basic Ideas

Spencer's scientific and empirical method exhibits affinities with Auguste Comte's positivism. Central to his approach was the synthetic practice of deriving fundamental principles from disparate phenomena in many sciences and then demonstrating how the principles of one science interact with and affect the other fields of inquiry. Using Charles Darwin's evolutionary theory, Spencer thus constructed a general account of human progress that came to be known as "Social Darwinism."

For Spencer, natural progress was the necessary process of evolution from simple to more complex and heterogeneous forms, but this was not, he insisted, teleological or purpose-driven. Spencer coined the phrase "survival of the fittest," which Darwin employed in later editions of *On the Origin of Species* (first published in 1859), but neither thinker addressed the ambiguity (that is, are individuals, groups, or species the relevant unit of selection?) and near tautology of this phrase ("fitness" is often defined in terms of survival, so that survival of the fittest is akin to saying survival of that which survives the best). Although Darwin admired Spencer, the two disagreed on several aspects of evolutionary theory including the possible inheritance of acquired characteristics.

Human life is on a continuum with the evolutionary unfolding of the natural world, and, because progress toward complexity and individuation are necessary, human nature cannot be thought of as stable and unchanging. Rather, humans are collections of instincts and sentiments that must continually adapt to the changing societal context. Society is likewise an extension of the organic human body and nature. Finally Spencer argued that society too expresses evolutionary laws or principles that can serve as the foundation of morality and law. Evolutionary science, then, serves as the base of his comprehensive natural law philosophy of morality and politics and explains how *The Principles of Biology* (1864, 1867) flows naturally into the conclusions reached later in *The Principles of Sociology* (1882, 1898) and *The Principles of Ethics* (1892).

Spencer believed that modern evolutionary science had weakened traditional beliefs in ethics as a supernatural code of divine commandments. Science could fill this ethical vacuum left by religion, by providing the principles from which to deduce a naturalistic ethics of rational egoism. Science ought, therefore, to command the dominant position in education, displacing art and the humanities (1861). Spencer reconciled the apparent contradiction between his naturalized, a-teleological laws of society and morality, on one hand, and human freedom and purpose, on the other, by arguing that it is precisely individual freedom that alone can guarantee continued evolutionary progress. Indeed for Spencer, individual liberty is primary and relations with others are largely contractual, made from the realization that social life is necessary to reach certain individual goals.

Furthermore, in a move that is similar to John Stuart Mill and the logical commitment implied in Alan Gewirth's "principle of generic consistency," Spencer claimed that morality contains a "law of equal freedom." This law states that individuals must recognize the individuality of others and curtail their freedom so as not to infringe on the freedom of others. This sort of minimalist, contractual view of society underpins his *laissez faire* political philosophy from *Social Statics* (1851) to *Man versus the State* (1884). The state's function is condensed to dispensing justice, which amounts to protecting individual rights. These rights follow naturally from the law of equal freedom, because the recognition of others' individuality immediately implies the duty to recognize their rights.

Decline and Continuing Influence

Spencer's decline can be attributed to several inconsistencies in his work, growing social unease with founding society on evolution, social rejection of his strongly libertarian principles, and the demise of any residual scientific belief in the inheritance of acquired characteristics. Yet some of Spencer's voluminous thoughts continue to be of influence. His work on intellectual and physical education has left deep imprints on modern curricula. His political thought, especially his defense of natural rights, has been invoked by libertarian philosophers such as Robert Nozick. And Spencer's idea that nature shows a progressive trend toward increased complexity of organization has been revived by some biologists and social theorists. Robert Wright (2000) argues that evolution tends to produce ever more complex forms of life, because cooperation through expanded forms of organization produces selective advantages. In human social evolution, this explains the move from primitive hunting-gathering tribes to large states and finally to global systems. New technologies—such as the agricultural production of food or the transmission of information through computer networks—make possible wider forms of social cooperation.

The evolutionary theorist Stephen Jay Gould (1989) nevertheless rejected Spencer's idea of progressive evolution and argued instead that the history of life is a random process that could have turned out differently. By contrast paleobiologist Simon Conway Morris (2003) sees evidence for evolutionary patterns inclined to produce intelligent life. If Gould is right, then the human sense of purpose has no ontological support. If Conway Morris is right, human purposefulness might fulfil an end inherent in the universe from the beginning. The fundamental issue—with deep moral and religious implications—is whether the universe is pointless or purposeful. This was also the central tension underlying Spencer's lifelong attempts to bridge the natural and the human worlds.

ADAM BRIGGLE

SEE ALSO *Evolutionary Ethics; Scientific Ethics; Social Darwinism.*

BIBLIOGRAPHY

Conway Morris, Simon. (2003). *Life's Solution: Inevitable Humans in a Lonely Universe*. Cambridge, UK: Cambridge University Press. Contra Gould, Morris argues that the historical course of evolution is strongly selection-constrained and thus progress toward intelligent beings is inevitable.

Gould, Stephen Jay. (1989). *Wonderful Life: The Burgess Shale and the Nature of History*. New York: W.W. Norton. Details the science behind different interpretations of the Burgess Shale formation in order to put forward his notion of biological contingency or the non-directedness of life's history, namely, that small initial differences could have made subsequent evolution radically different.

Spencer, Herbert. (1851). *Social Statics*. London: Chapman. Argues that civilization is a natural, continual process of humans adapting to changing circumstances and that progress toward perfection is the same as the achievement of a perfect adaptation to surroundings.

Spencer, Herbert. (1861). *Education: Intellectual, Moral, and Physical*. London: Williams and Norgate. Outlines Spencer's educational theory.

Spencer, Herbert. (1862–1893). *A System of Synthetic Philosophy*. 10 vols. London: Williams and Norgate. Contains all of Spencer's major works, including *The Principles of Psychology* (1855), *First Principles* (1862), *The Principles of Biology* (1864, 1867), *The Principles of Sociology* (1882, 1898), and *The Principles of Ethics* (1892).

Spencer, Herbert. (1884). *Man versus the State*. London: Williams and Norgate. Champions a *laissez-faire* state and free market toward the ultimate goals of freedom, peace, and justice.

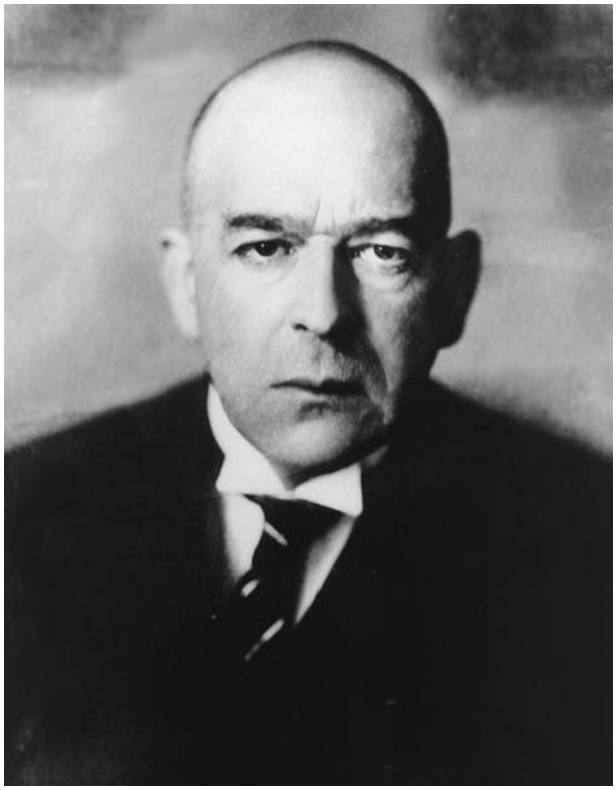
Wright, Robert. (2000). *Nonzero: The Logic of Human Destiny*. New York: Pantheon. Uses game theory to argue that cultural evolution leads to higher levels of complexity just as biological evolution does.

SPENGLER, OSWALD

Oswald Spengler (1880–1936) was born in Blankenburg, Germany, on May 29, and attended the universities of Munich, Berlin, and Halle, where he studied mathematics and the natural sciences, which led to his becoming a secondary school teacher of mathematics in Hamburg. He abandoned teaching in 1911 to work on his magnum opus—*The Decline of the West* (1918–1922)—which he did steadily during the World War I. He intentionally published the first volume to coincide with the German military defeat and industrial collapse of 1918, and the second four years later. From this time until his death in Munich on May 8, he wrote other, shorter books and pamphlets on social and political subjects, including *Man and Technics* (1931).

Despite his marginal status in the German academic world and the controversy with which his ideas were greeted, Spengler's influence on social science was far greater than that of those who tried furiously to refute him. His impact derives from the fact that in examining the nature of Western Europe and North America he makes predictions about its future, drawing inferences based on a metaphysical reading of history during a period of serious crisis.

The key to Spengler's philosophical anthropology and accompanying philosophy of history is his use of the Faustian legend in popular German literature to interpret modern technology. According to him, humans are the only predators able to select and design weapons for attacking nature and each other. At some point around the tenth century this ability developed to such an extent in Western European culture that humans seized for themselves the prerogatives of domination over nature. This inexorable destiny is a radical break with earlier periods of thought, in which humans saw themselves as subject to nature; yet it was a destiny made possible by nature, when nature gave human beings both mental superiority and hands. The hands are fundamentally weapons. More than a *tool of tool,* as described by Aristotle, the hand perfects itself in conflict more than manufacture. Indeed just as Spengler interprets the plough as a weapon against plant life, so he sees instruments of worship as arms against the devil. But Spengler does not confuse technology with tools or technological objects. Technology is a set of procedures or practical means for producing a particular end in view. In Spengler's words, technology *is the tactics of living,* a conception that goes beyond human life. Following Friedrich Nietzsche, he identifies life with struggle, a fierce and merciless struggle that springs from the will to power, with the machine being the *subtlest of all possible weapons*.



Oswald Spengler, 1880–1936. The German philosopher is famous for his *Decline of the West*. He held that civilizations, like biological organisms, pass through a determinable life cycle and that the modern West was approaching the end of such a cycle. (© *Corbis-Bettmann.)*

Having placed the origin of Faustian culture in the Nordic countries, Spengler interprets the Enlightenment as the moment when the machine replaced the Creator. The machine became a god, with factories for temples and engineers for priests, whose mysteries were the esoteric features of mechanization. Nineteenth-century machine age industrialization imposed itself on nature with standardized, inert forms that are hostile to the natural world and the precursors of decline. But in order to feed the *technological-machinist army* Western Europe and North America furthered the destruction of nature across the globe, creating an untameable monster that threatens to conquer humans themselves and lead culture to a grandiose suicide. The tragedy of humanity lies in humans raising their hands against their own mother—nature. All the great cultures defeats. The struggle against nature is a struggle without hope, even though people pursue it to the end.

Contrary to the views of Enlightenment theorists such as Henri de Saint-Simon or Auguste Comte, the domination of nature by Faustian technology does not seek human emancipation, but is the manifestation of a blind will to power over the infinite. As Hermínio Martins (1998) argues, Spengler rejects the rationality of technological history. The history of Western European and North American technology is simply human tragedy because the infinite is always greater than efforts to tame it. Inspired also by Nietzsche's cyclic vision of history, Spengler sees culture, rooted in the soil, being replaced by civilization, in which the intellect prevails, decaying again eventually into culture.

The significance that Spengler attributes to technology, his defense of science-as-technology, his cultural pessimism, and his hostility to liberal, democratic values and institutions were commented on by Max Weber, and influenced thinking during the Nazi regime, despite the fact that he rejected national socialism completely in 1934. Many of his insights and expressions regarding the essentially non-transferable character of Western European and North American technological culture as a destiny, the will to power as the foundation of technology, and the conceptual and ontological dependency of science on technology are further echoed in Martin Heidegger and Ernst Jünger, as well as in some members of the first generation of the Frankfurt school.

JOSÉ LUÍS GARCIA

SEE ALSO *Faust; German Perspectives.*

BIBLIOGRAPHY

Hughes, H. Stuart. (1952). *Oswald Spengler: A Critical Estimate.* New York: Charles Scribner's Sons.

Martins, Hermínio. (1998). "Technology, Modernity, Politics". In *The Politics of Postmodernity,* eds. James Good, and Irving Velody. Cambridge, England: Cambridge University Press.

Spengler, Oswald. (1918 [1922]). *Der Untergang des Abendlandes* [The Decline of the West], 2 vols. Munich: C. H. Beck. English translation by Charles Francis Atkinson (London: George Allen & Unwin [1926/1928]).

Spengler, Oswald. (1931). *Der Mensch und die Technik: Beitrag zu einer Philosophie des Lebens* [The Man and Technics: A Contribution to a Philosophy of Life]. Munich: C. H. Beck. English translation by Charles Francis Atkinson (London: George Allen & Unwin [1932]).

SPORTS

Ethical issues related to science and technology in sports only began to attract critical attention during the second half of the twentieth century. This paralleled the increasing scientific study of sports and the creation of sports science, as well as the discovery and development of performance enhancing drugs and technological transformations in sports equipment. The latter two influences have been especially problematic, and have played a central role in the emergence of critical studies in the field.

Modern Sports Development

This scientizaton reflects a shift in values concerned with sports. Allen Guttmann describes, in *From Ritual to Record* (1978), how the development of timing technology introduced the possibility of records, now a dominant feature of modern sports. The late-nineteenth century British public school games, which championed *muscular Christianity,* repositioned physical exertion as central to the development of a productive and civil society. It also led to the politicization of sports and, along with the revived modern Olympic movement, which began in 1896, steadily became a focus of international political propaganda. With a philosophy that champions humanistic virtues of peace, culture, and education, the modern Olympic movement is less about sports contests than about ideology. It occupies an ambiguous social position as an organization that has devalued amateurism and embraced commercialization, while maintaining that there is something philosophically and socially meaningful about the games.

Ethical discussions concerning technology in sports generally focus on establishing what constitutes just or fair competition. The limited accessibility of a technology is often used as a reason for prohibiting its use in competition. In addition if the use of a particular innovation contravenes the agreed upon rules, that use may also be unethical. However because disputes exist as to what rules have been agreed to, the ethical issues are often blurred.

Drugs and Sports

During the 1980s, concerns about technology in sports focused largely on technologies of doping and drug use. This was prompted by a series of doping incidents in international sports, some of which resulted in death or serious injury for a number of athletes (Brown 1980, Houlihan 2002). The situation was accentuated by high-profile cases, for example that of the Canadian runner Ben Johnson who was stripped of the gold medal he won at the 1988 Olympics in Seoul after testing positive for anabolic steroids. Discussions about doping continue, accentuated by the emergence of new technologies, such as genetic modification, that challenge the ability of anti-doping authorities to detect *cheaters* (Miah 2004). Gene doping could challenge ethical theories in sports: Are genetically enhanced athletes cheats if they are altered before birth (embryogenesis)? Also if the genetic technologies at issue are not harmful to athletes, there is no persuasive health argument to support a ban on their use.

Sports Artifacts

Beyond doping, the increased use of technology and technologically advanced artifacts in sports raises a number of ethical questions (Miah and Eassom 2002, Gelberg 1998). Innovative techniques have radically changed some sports or events, such as the Fosbury flop in high jumping or the O'Brien shuffle in shot put. These have been seen as ethically contentious, though legitimate, because they increased the demands placed on athletes in competition.

Since the late-twentieth century, events in the sporting world have clearly illustrated the ethical implications that arise from the use of technology in sports. A few examples are the development of running shoe technology; lighter and stronger implements, such as golf clubs, cricket bats, and tennis rackets; and innovations such as the Fast-Skin swimming suit, which was used for the first time at the 2000 Olympics in Sydney. Many new sports technologies have been accepted. Technologically advanced running shoes, tennis rackets, bicycles, golf clubs, and others have been identified as beneficial improvements to sports because they enhance the safety of an activity or allow athletes to perform without interference from inadequate, cumbersome technology.

Technology has even democratized participation in sports to some extent, with the mass production of equipment permitting more people to play sports with the same kind of equipment used by elite athletes. However, this has also carried a burden of making elite sports subservient to the public or more specifically, sport spectators. Television audiences often dictate scheduling for competitions, which raises problems for sports federations, because so-called prime-time television schedules can conflict with the time of day when it is most desirable for athletes to compete.

One of the central components of these ethical discussions is the degree to which technologies are replacing the athlete in performance or are dehumanizing sports (Hoberman 1992). For example, double-stringed (so-called spaghetti strung) tennis racquets were banned in the 1980s because they offered too much performance enhancement by enabling athletes to exert an unusually high amount of spin on the ball. There is an ethical concern about the *means* that allow athletes to achieve high levels of performance: An *undeserved enhancement* is considered unethical. Yet it can be argued that sports performances are necessarily technological and athletes must embrace their cyborgian identities by recognizing technology as a valued aspect of their performance.

When technology appears to make a sport easier for athletes, thus seemingly undermining or *devaluing* the performance, there are also ethical issues raised. Of key importance is what is meant by devaluing sports, because it is possible that technology could also be described as removing performance inhibitors, which is desirable when such inhibition is athletically irrelevant. For example, highly sophisticated running shoes might appear to enhance performance, or alternatively can be said to reduce inhibitions caused by the natural weakness the human foot.

This argument requires determining the factors that are *athletically relevant* to specific sports, an often contentious issue that can appeal to definitions of the goals of sports (Suits 1973). Do piezoelectric circuits in skis remove a performance inhibitor or make the activity unacceptably easier? The technology is designed to reduce the vibrations felt by skiers, thus giving them better control. It can certainly be argued that the new technology has made the activity easier because athletes no longer have to deal with the same degree of vibration as before. However it can also be argued that vibration is an irrelevant aspect of skiing—skiing does not test the ability of athletes to cope with vibration—and thus that the technology is not ethically suspect. Breaking records in the wake of technological advances in a particular sport suggests that an activity has become easier as a result of the innovation or that the advances have contributed to enhanced performance. It is, however, sometimes more accurate to conclude that the new technology has enabled a more representative measure of athletic performance.

Other ethical discussions involve whether technology changes the nature of the sport. For example, despite having sanctioned many changes to the construction of competitive bicycles, the International Cycling Union (ICU) banned Graeme Obree's *superman* design, in which one rides with arms stretched out in front of the body (like Superman), crouched over the handlebars. The ICU justified the ban by arguing that the new design would be generally unavailable, and thus the competitive sport would actually be different than the *normal* cycling experienced by the average rider. The ban seems to have been imposed because the innovation created a new concept of what constituted cycling, which conflicted with some kind of traditional, ideal form.

However some technological changes are beneficial to sports and disallowing them because they change traditional concepts is wrong. Changes to the construction of the javelin in the 1980s paved the way for a new type of successful participant, as opposed to the athletes who had been traditional winners in the event. However without such changes the natural progress of the sport would have resulted in athletes throwing the javelin into the audience, possibly requiring elimination of the activity from track and field competitions.

Conclusion

Alasdair MacIntyre's (1985) articulation of practice communities, which discusses the intrinsic good of sports and the distinction between novice and expert, is a useful retheorization of sports values (Morgan 1994). William Morgan's thesis is an explanation of the political economy of sports and the problematic hierarchical structures that have marginalized specific voices within specific practice communities. According to Morgan, there are two possibilities when sports are altered through technological developments. Society must either redescribe the activity—such as in the case of the javelin throw when the sport changed to sustain its character. Or society must accept the emergence of cyborg-athletes, which entails a redefinition of what it means to be a human being. By offering a subtle shift in the perception of humanness, sports provide an arena in which what it means to be human, as a living being and as an athlete, is ambiguous, liberated, and technologized.

ANDY MIAH

SEE ALSO *Drugs.*

BIBLIOGRAPHY

Brown, W. Miller. (1980). "Ethics, Drugs and Sport." *Journal of the Philosophy of Sport* 7: 15–23. One of the early papers on the doping issue; asks what should be against the rules in the first place.

Gelberg, J. Nadine. (1998). "Tradition, Talent and Technology: The Ambiguous Relationship between Sports and Innovation." In *Design for Sport,* ed. Akiko Busch. London: Thames and Hudson. A cross-disciplinary analysis of technology in sport, considering the aesthetics and tradition of technology as binding factors in ethical discussions about progress in sport.

Guttmann, Allen (1978). *From Ritual to Record: The Nature of Modern Sports.* New York: Columbia University Press. This book draws attention to the evidence that recrords and measurement have not always been grounding values in elite sport.

Hoberman, John M. (1992). *Mortal Engines: The Science of Performance and the Dehumanization of Sport.* New York: Free Press. A socio-historical analysis of doping in elite sport. Hoberman argues that the situation in elite sport is intractable.

Houlihan, Barrie. (2002). *Dying to Win: Doping in Sport and the Development of Anti-Doping Policy.* Strasburg, France: Council of Europe Publishing. A comprehensive analysis of anti-doping policy, Houlihan's work reveals the inadequacy of ethical theorizing within applied sports settings.

MacIntyre, Alaisdair. (1985). *After Virtue: A Study in Moral Theory,* 2nd edition. London: Duckworth.

Miah, Andy. (2004). *Genetically Modified Athletes: Biomedical Ethics, Gene Doping, and Sport.* London: Routledge. The first book length study of ethical issues arising from genetic modification in sport. Argues for genetic exceptionalism in sport and for anti-doping organizations to reconsider characterizing genetic modification as just another form of doping.

Miah, Andy, and Simon B. Eassom, eds. (2002). *Sport Technology: History, Philosophy & Policy.* Oxford: Elsevier Science. Provides a foundation for theorizing technological issues in sport, building upon themes in cultural studies of the cyborg, otherness and gender.

Morgan, William J. (1994). *Leftist Theories of Sport: A Critique and Reconstruction.* Urbana: University of Illinois Press. Questions the legitimacy of sporting structures and their capacity to enable democratically sensitive, ethical decision making.

Suits, B. (1973). "The Elements of Sport." In *The Philosophy of Sport: A Collection of Original Essays,* ed. Robert G. Osterhoudt. Illinois: Charles C. Thomas Publishers. Suits is a founding father of philosophy of sport. His theoretical insights on defining games, play, and sports continue to underpin discussions about the ethics of sport technology.

STAKEHOLDERS

The stakeholder concept derives from a simple premise: Organizations and technologies exist in constellations of relationships. Organizations operate in a network of market and nonmarket relationships with other organizations, groups, and individuals. Likewise technologies emerge and exist in a network of suppliers, end users, and others who bear the impact of the technology. Generally with reference to both organizations and technologies, these related parties are termed *stakeholders*, meaning that they hold a stake in the outcomes of the organization or technology.

Stakeholder research has important implications for science, technology, and ethics, as stakeholder thinking concerns itself both with the distribution of benefits among stakeholders and the procedures by which stakeholders work together toward desirable ends. After a brief history of the concept, this entry summarizes the distributive and procedural aspects of stakeholder thinking, particularly as they apply to three areas: corporate decision making, technology assessment, and environmental regulation.

History of the Concept

The stakeholder concept has its origins in the study of corporations and how they make decisions. R. Edward Freeman's *Strategic Management: A Stakeholder Approach* (1984), is regarded as seminal in the study of stakeholders, though Freeman attributes the term to scholars at the Stanford Research Institute in the 1960s. Farther back still, the premise that organizations must concern themselves with the demands of multiple constituencies traces back to classic management studies by Chester Barnard and Mary Parker Follett.

Contemporary discussions of stakeholders address three main questions. Social scientists have examined two. First, what are the consequences of different approaches to managing stakeholder groups? For example, Thomas Jones (1995) argues that a corporation's ethical treatment of its stakeholders has demonstrable financial implications. Second, why do stakeholder groups behave the way they do? For example, Tim Rowley and Mihnea Moldoveanu (2003) trace collective action by stakeholder groups to both the interests and the collective identity of group members. Put simply, the first question concerns the *instrumental* value of managing stakeholders effectively; the latter is a *descriptive* question aimed at helping decision makers to understand the environment in which they operate (Donaldson and Preston 1995).

Philosophers have concentrated on a third and equally important question: How should corporations behave toward stakeholders? This inquiry reflects the essentially normative nature of the concept—the term *stakeholder* itself serves as a counterpoint to the claim that corporations are responsible only to their stockholders—and has given rise to the search for a so-called *normative core* for stakeholder theory, a fundamental set of principles governing the ethical treatment of stakeholders (Donaldson and Preston 1995). Drawing on a host of ethical theories, ethicists have developed Kantian, feminist, rights-based, and Rawlsian arguments, among others.

The Distributive Dimension

In practical terms, much stakeholder research (especially in the third, normative, stream) addresses the issue of distribution: how corporations, public policy makers, and technology managers allocate rights and values across multiple stakeholders. Normative stakeholder arguments offer ways to assess the moral quality of these distributive patterns, and these arguments have important implications for ethical issues in the realm of science and technology.

For example, the question of who should benefit from emergent technologies—nanotechnology, pharmaceutical advances, and the human genome, among others—is, at its core, a question of distribution (Singer and Daar 2001) that stakeholder theory helps to resolve. Specifically the principle of stakeholder fairness developed by Robert Phillips (2003) derives from a widely accepted notion of reciprocity and holds that obligations accrue to participants in a cooperative scheme in proportion to contributions by stakeholder groups.

This logic also applies to the less tangible benefits and costs of technology. An emerging issue concerns the steps technology managers take to prevent employees from inappropriately using information technology resources such as e-mail and the Internet. The conflict is not over material resources but rather the tension between the privacy rights of employees, who seek to use these resources for personal reasons without the threat of invasive monitoring, and the property rights of stockholders, who would bear the cost of lawsuits if inappropriate technology use results in hostile work environment lawsuits. An exclusive emphasis on stockholder interests might advocate a total ban on the use of these technologies for nonbusiness purposes, whereas stakeholder theory would suggest a moderate position, allocating rights proportionally and allowing, for example, some personal use of information technology resources along with unobtrusive forms of monitoring to protect stockholder interests.

The Procedural Dimension

Stakeholder research also addresses procedural concerns that are central to the application of stakeholder theory to science and technology. Evan and Freeman (1993) draw on a Kantian perspective to spell out principles specifying how corporations should engage with stakeholders. They suggest, in part, that stakeholders have a right to participate in decisions that affect them. This concern for procedural justice extends to decisions in the realm of science and technology, where technologies, development paths, and potential science-related policies must be evaluated in light of stakeholder interests. Consequently one finds frequent reference to the procedural aspects of stakeholder theory in the areas of technology assessment and environmental regulation. Here stakeholder theory maintains that those groups with a vested interest in a technology, action, or organization should have an opportunity to express those interests and, in some cases, to participate in decision making. As some have argued, this participation should take the form of comprehensive dialogue among various stakeholder groups .

As diverse development agencies, corporations, and government regulators (from the United Nations to the World Bank to Motorola Corporation) apply these procedural principles by initiating dialogue with stakeholders concerning new technologies and environmental policies, they discover that the procedural aspect of stakeholder management is not only ethically desirable but highly practical. As stakeholder thinkers have long maintained, sharing information, ongoing dialogue, and meaningful participation in decision making enables better collaboration, reduces conflict, and ensures smoother implementation of policies and technologies (Freeman 1984, Johnson-Cramer, Berman, et al. 2003).

In sum, the value of stakeholder theory in resolving ethical issues in science and technology lies, to date, in offering prescriptions (a) that answer the distributive questions arising from development, utilization, and marketing of new technologies by businesses, and (b) that guide the procedural treatment of stakeholders in diverse areas such as technology assessment and environmental regulation. Ultimately amidst efforts to develop general principles and insights, stakeholder researchers have done little to apply their insights to specific questions about science and technology. The potential is clear, but much work remains to be done to demonstrate the usefulness of stakeholder theory in this domain.

MICHAEL E. JOHNSON-CRAMER
ROBERT PHILLIPS

SEE ALSO *Georgia Basin Futures Project; Management: Models; Participation; Science Policy.*

BIBLIOGRAPHY

Donaldson, Thomas, and Lee Preston (1995). "The Stakeholder Theory of the Corporation: Concepts, Evidence, and Implications." *Academy of Management Review* 20(1): 65–91. A review of the first ten years of stakeholder research, this article identifies three streams of relevant work: descriptive-empirical, instrumental, and normative. The authors also advance a normative argument, rooted in the theory of property, for attending to multiple stakeholders.

Evan, William, and R. Edward Freeman. (1993). "A Stakeholder Theory of the Modern Corporation: Kantian Capitalism." In *Ethical Theory and Business*, ed. Tom Beauchamp and Norman E. Bowie. Englewood Cliffs, CA, Prentice Hall.

Freeman, R. Edward. (1984). *Strategic Management: A Stakeholder Approach*. Boston: Pitman. The seminal work in stakeholder research, this book advances the idea that organizations have stakeholders and organizational performance depends on an organization's ability to satisfy its multiple stakeholders.

Johnson-Cramer, Michael; Shawn Berman; et al. (2003). "Reexamining the Concept of Stakeholder Management." *Unfolding Stakeholder Thinking*, Vol. 2., ed. Jorg Andriof, Sandra Waddock, Sandra Rahman, and Bryan Husted. London: Greenleaf. This chapter offers more specific analysis of what it means to manage stakeholders. It outlines a model based on both procedural concerns (how policies toward stakeholders are formulated) and substantive concerns (the content of those policies).

Jones, Thomas. (1995). "Instrumental Stakeholder Theory: A Synthesis of Ethics and Economics." *Academy of Management Review* 20(2): 404–437. Jones argues that business firms that are dishonest or opportunistic will incur higher costs in contracting with stakeholders. This logic underlies the instrumental argument that firms that do not satisfy stakeholders perform poorly.

Phillips, Robert. (2003). *Stakeholder Theory and Organizational Ethics*. San Francisco: Berrett-Koehler. Phillips's book represents the most recent advance in normative stakeholder theory, offering a response to the stakeholder identification problem (that is, who actually count as stakeholders?).

Rowley, Timothy J., and Mihnea Moldoveanu. (2003). "When Do Stakeholders Act? An Interest and Identity-based Model of Stakeholder Mobilization." *Academy of Management Review* 28(2): 204–219.

Singer, Peter, and Abdallah Daar. (2001). "Harnessing Genomics and Biotechnology to Improve Global Health Energy." *Science* 294: 87–89.

STATISTICS

• • •

Basic Concepts of Classical Inference
History, Interpretation, and Application

BASIC CONCEPTS OF CLASSICAL INFERENCE

Statistics may be defined as the study and informed application of methods for drawing conclusions about the world from fallible observations. It has three distinct components: (1) It is based on the mathematical theory of probability, (2) as inductive inference it belongs to the philosophy of science, and (3) its subject matter is any of a wide range of empirical disciplines.

Humanity has been counting, measuring, and recording from antiquity, but the formal history of statistics dates to the first systematic analyses of official registries in the seventeenth century. The origin of the name is from the eighteenth century, the German *Statistik*, meaning "study of the state" or political science (generally qualitative). It was appropriated in the 1780s for use in English as *statistics*, an unusual new name for the quantitative analysis of conditions in a country (replacing *political arithmetic*), in order to attract public attention (Pearson 1978). Applied subsequently to measurement error in astronomy, the statistical approach using probability spread in the nineteenth century to social phenomena, to physics, and then to biology. Formal statistical inference came into being around the turn of the twentieth century, motivated in large measure by the study of heredity and evolution.

Intensive developments of theory and methodology, with the enormous impact of the electronic computer, have made statistics the most widely used mathematical discipline, applied to virtually every area of human endeavor. Analysis and interpretation of empirical results is basic to much of modern technology and the controversies surrounding its use. Statistical methodology, readily available in computer software packages, is easy to apply but not so easy to understand. Lack of professional competence, conflicts of interest, and oversimplified reporting by the media pose real dangers of abuse. Yet intelligent participation in the shaping of public policy requires the insights of a thoughtful, well-informed electorate.

There is a vast and constantly growing body of statistical methods, but the most commonly reported results employ the classical, or Neyman-Pearson, theory of statistical inference. Presented herein are the basic concepts of the classical theory in concise form. Further details, with many examples, can be found in textbooks on various levels of mathematical sophistication.

Descriptive versus Inferential Statistics

Statistics can be understood as descriptive or inferential. *Descriptive statistics* are methods for organizing, summarizing, and communicating data, or the data themselves. The resulting tables and graphs may represent complete information on a subject or only a selected sample. *Inferential statistics*, the subject here, refers to methods for reaching conclusions extending beyond the observations actually made, to statements about large classes of potential observations. It is inference from a sample, beyond its description.

From Sample to Probability

Statistics begins with data to explore a question about some large *target population* (of people or objects) that can be expressed in quantitative form. It is often impossible to observe the entire population of interest, and therefore a sample is selected from the best available, sometimes called the *sampled population*, to distinguish it from the target population.

RANDOM SAMPLE. The sample, on which the inference will be based, should be representative of the population, and thus be selected at random. This means that each member of the population should have an equal chance of being selected—an aim that in real-life situations can at best be approximately met. For example, to determine what proportion of patients with a certain type of cancer would benefit from a new treatment, the outcome of interest could be the proportion surviving for one year after diagnosis, with the study sample drawn from patients being seen in a particular hospital. The representativeness of the sample is always a key question in statistics.

STABLE RELATIVE FREQUENCY. It is known from experience that the observed proportion of a characteristic of a population becomes stable with increasing sample size. For example, the relative frequency of boys among the newborn fluctuates widely when studied in samples of size 10, and less so with samples of size 50. When based on samples of size 250, it is seen to settle just above .5, around the well-established value of .51. It is the observed stability of frequency ratios with increasing sample size that connects statistics with the mathematical concept of probability.

FREQUENTIST DEFINITION OF PROBABILITY. Classical statistical inference uses the *frequentist* definition of probability: The probability of an event denotes the relative frequency of occurrence of that event in the long run. This definition is reflected in a fundamental principle of probability, the *law of large numbers:* In the long run, the relative frequency of occurrence of an event approaches its probability. The probability may be known from the model, such as obtaining a six with a balanced die, namely 1/6. This is an example of the classical definition of probability, pertaining to a finite number of equally likely outcomes. Otherwise by definition the probability is whatever is obtained as long-run relative frequency. The size of the sample is of central importance in all applications.

The frequentist definition is embedded in the axiomatic approach to probability, which integrates statistics into the framework of modern mathematics. There are three basic axioms, using concepts of the theories of sets and measure. Expressed simply, the axioms state that: (1) the probability of any event (set) in the sample space of events is a number between 0 and 1, (2) the probability of the entire sample space is 1, and (3) if two events are mutually exclusive (only one of them can occur), then the probability that one or the other occurs is the sum of their probabilities.

RANDOM VARIABLES AND THEIR DISTRIBUTIONS. The numerical or coded value of the outcome of interest in a statistical study is called a *random variable*. The yes/no survival status of a cancer patient one year after diagnosis is a *binary* random variable. In a sample of size n, the number of patients surviving is some number S_n between 0 and n, called a *binomial* random variable. S_n/n is the relative frequency of surviving, and $1 - S_n/n$ the relative frequency of not surviving one year. The distribution of S_n, to be discussed below, is the binomial distribution showing the probabilities of all possible outcomes between 0 and n. An example of a *continuous* random variable X is the diastolic blood pressure (in millimeters of mercury) of patients treated for hypertension, at a given point of treatment. The relative frequency of different values assumed by X is the observed distribution of the random variable.

The concrete examples of a random variable and its distribution have direct counterparts in the mathematical theory of probability, and these are used in the development of methods of inference. A random sample of size n in statistics is considered a sample of n independent, identically distributed random variables, with independence a well-defined mathematical concept. These are abstract notions, often omitted in elementary presentations that give only the computational formulas. But they are the essential link for going from an observed set of numbers (the starting point of statistics) to mathematical entities that are the building blocks of the theory on which the methods of statistics are based.

PARAMETERS OF A DISTRIBUTION. The *probability distribution* of a random variable X describes how the probabilities are distributed over the values assumed by X along the real line; the sum of all probabilities is 1. The distribution is defined by *parameters*, constants that specify the location (central value) and shape of the distribution, often denoted by Greek letters. The most commonly used *location* parameter is the *mean* or *expected value* of X, $E(X)$, denoted by μ ("mu"). $E(X)$ is the weighted average of all possible outcomes of a random variable, weighted by the probabilities of the respective outcomes. A parameter that specifies the *spread* of the distribution is the variance of the random variable X, Var(X), defined as $E(X - \mu)^2$ and denoted by σ^2 ("sigma square"). It is the expected value of the squared deviations of the observed values from the mean of the distribution. The square root of the variance, or σ, is called the *standard deviation* of X.

THE BINOMIAL DISTRIBUTION. An important distribution deals with counting outcomes and computing proportions or percentages, often encountered in practice. Independent repetition of an experiment with a binary outcome and the same probability p of success n times yields the *binomial distribution* specified by the parameters n and p. The random variable X, defined as the number of successes in n trials, can have any value r between 0 and n, with probability function

$$P(X = r) = C(n, r)p^r(1 - p)^{n-r},$$

where $C(n, r)$ is the combination of n things taken r at a time and has the form

$$C(n, r) = \binom{n}{r} = \frac{n!}{r!(n - r)!}.$$

($n!$, called "n factorial," is the product of integers from 1 to n, with $0! = 1$. For example, $4! = 1 \times 2 \times 3 \times 4 = 24$.) It can be shown that for a binomial random variable, $E(X) = np$, and $\mathrm{Var}(X) = np(1 - p)$. As the sum of n outcomes coded 0 or 1, X is also denoted by S_n.

THE NORMAL DISTRIBUTION. The most basic distribution in statistics is the *normal* or *Gaussian distribution* of a random variable X, defined by the probability density function

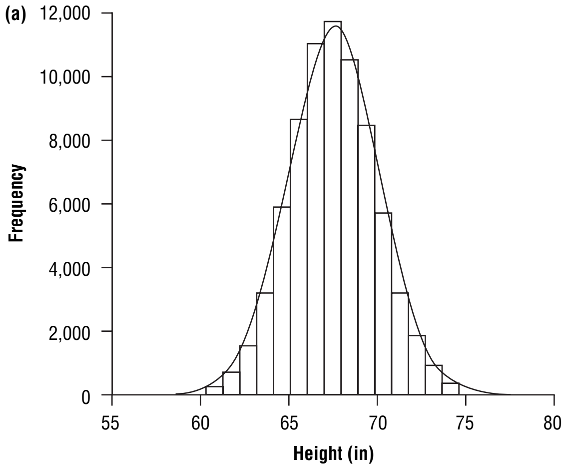
$$f(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(x-\mu)^2}{2\sigma^2}},$$

where μ is the mean and σ is the standard deviation. The formula includes the constants $\pi = 3.142$ and $e = 2.718$, the base of the natural logarithm.

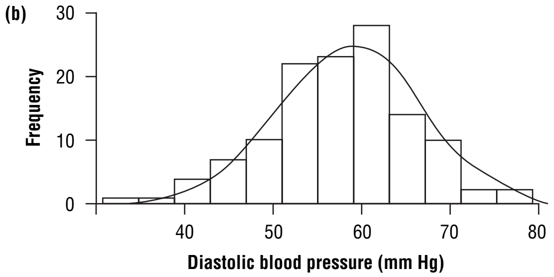
One reason for the importance of this equation is that many variables observed in nature follow an approximate normal distribution. Figure 1 shows frequency histograms of two samples, of height and diastolic blood pressure, with the corresponding normal distribution. The smoother fit in Figure 1a is the result of the

FIGURE 1

Frequency Histograms



Frequency histogram of heights of young adult males, with an approximating normal distribution.



Frequency histogram of diastolic blood pressure of schoolboys, with an approximating normal distribution.

SOURCE: Armitage, Peter. (1971). *Statistical Methods in Medical Research.* New York: Wiley, p. 73.

far larger sample size as compared with the number of observations used in Figure 1b.

THE STANDARD NORMAL DISTRIBUTION. An important special case of the normal distribution is the *standard normal*, with mean 0 and standard deviation 1, obtained by the transformation

$$Z = \frac{X - \mu}{\sigma}.$$

Any normal variable can be transformed to the extensively tabled standard form, and the related probabilities remain the same. Figure 2 shows areas under the normal curve in regions defined by the mean and standard deviation, for both the X-scale and Z-scale. It is useful to remember that for a normally distributed random variable, about 95 percent of the observations lie within two standard deviations of the mean.

THE SAMPLE MEAN. Statistical inference aims to characterize a population from a sample, and interest is often in the *sample mean* as an estimate of the population mean. Given a sample of n random variables $X_1, X_2, \ldots, X_n$, the sample mean is defined as

$$M = \bar{X} = \frac{X_1 + X_2 + \cdots + X_n}{n}.$$

If the variables are independently distributed, each with mean μ and variance σ^2, then the *standard error of the mean* is

$$SE = SE(\bar{X}) = \frac{\sigma}{\sqrt{n}}.$$

For simplicity of notation, the symbols M and *SE* are used below.

THE CENTRAL LIMIT THEOREM. The normal distribution plays a special role in statistics also because of the basic principle of probability known as the *central limit theorem:* In general, for very large values of n, the sample mean has an approximate normal distribution. More specifically, if $X_1, X_2, \ldots, X_n$ are n independent, identically distributed random variables with mean μ and variance σ^2, then the distribution of their standardized mean

$$\frac{M - E(M)}{SE} = \frac{\bar{X} - \mu}{\sigma/\sqrt{n}}$$

tends to the standard normal distribution as $n \to \infty$. Nothing is said here about the shape of the underlying distribution. This principle, observed empirically and proved with increasingly greater precision and generality, is important to much of statistical theory and methodology.

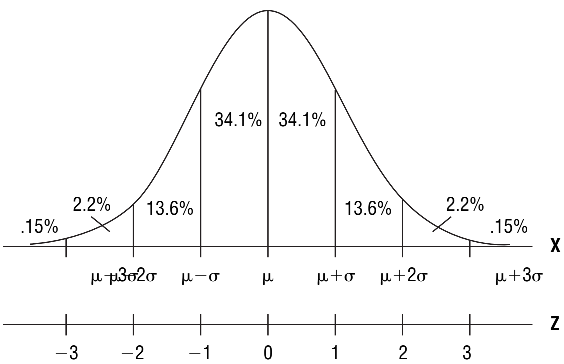
APPLICATION TO THE BINOMIAL DISTRIBUTION. In the case of the binomial distribution, where $X = S_n$ is the sum of n independent random variables with outcomes 0 or 1,

$$M = \frac{S_n}{n} \text{ and } E(M) = p,$$

$$\mathrm{Var}(M) = \frac{p(1-p)}{n} \text{ and } SE = \sqrt{\frac{p(1-p)}{n}}.$$

FIGURES 2–3

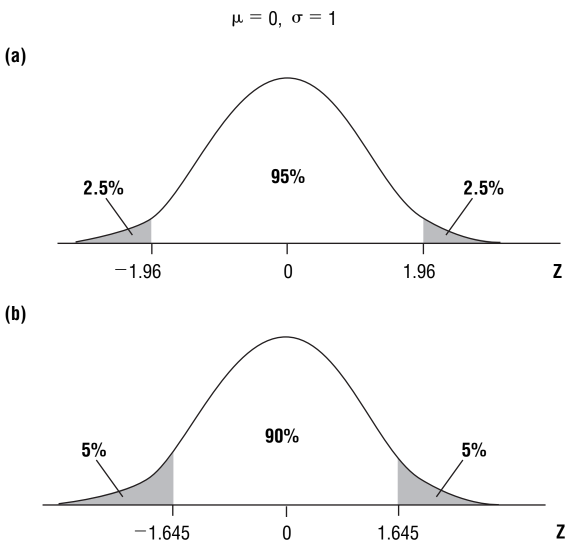
Figure 2: Normal Distribution



Areas under the normal curve in regions defined by the mean μ and standard deviation σ. Z-scale represents standard normal distribution (μ = 0, σ = 1).

SOURCE: Courtesy of Valerie Miké.

Figure 3: Standard Normal Distribution



Rejection regions for tests at 5% significance level
a. Two-sided test (both tails of distribution)
b. One-sided test (either upper or lower tail)

SOURCE: Courtesy of Valerie Miké.

By the central limit theorem, the distribution of the standardized mean

$$\frac{M - E(M)}{SE} = \frac{S_n/n - p}{\sqrt{p(1-p)/n}}$$

tends to the standard normal distribution as $n \to \infty$. (The approximation can be used if both $np > 30$ and $n(1 - p) > 30$. A so-called continuity correction of $-1/2n$ in the numerator improves the approximation, but is negligible for large n.)

Inference: Testing Statistical Hypotheses

Performing tests of statistical hypotheses is part of the scientific process, as indicated in Table 1, ideally with the professional statistician as member of the research team. The conceptual framework of subject matter specialists is an essential component, as is their close participation in the study, from its design to the interpretation of results.

FORMAL STRUCTURE. The formal steps of testing, summarized in Table 2, involve defining the null hypothesis, denoted H_0, to be tested against the alternative hypothesis H_1. The aim is to reject, or "nullify," the null hypothesis, in favor of the alternative, which is typically the hypothesis of real interest. The test may be two-sided or one-sided. For example, if the mean of a distribution is μ_0 under the null hypothesis, one may use the *two-sided test*, usually displayed as follows:

$$H_0 : \mu = \mu_0 \ \text{ vs. } \ H_1 : \mu \neq \mu_0.$$

$$\text{Reject } H_0 \text{ if } |z| > z_{\alpha/2} = c,$$

that is, if the absolute value of the *test statistic* z, calculated from the observations, is outside the *critical value* c, determined by the significance level α ("alpha"). The corresponding *one-sided test* would be one of the following:

$$H_0 : \mu \leq \mu_0 \ \text{ vs. } \ H_1 : \mu > \mu_0.$$

$$\text{Reject } H_0 \ \text{ if } z > z_\alpha = c.$$

$$H_0 : \mu \geq \mu_0 \ \text{ vs. } \ H_1 : \mu < \mu_0.$$

$$\text{Reject } H_0 \ \text{ if } z < z_\alpha = c.$$

An outcome in the *rejection region*, the tail(s) of the distribution outside c, is considered unlikely if the null hypothesis is true, leading to its rejection at significance level α. The form of the test used, one- or two-sided, depends on the context of the problem, but the actual test used should always be reported.

AN EXAMPLE IN TWO PARTS. A senator, running for reelection against a strong opponent, wants to know his standing in popular support. An eager volunteer conducts a survey of 100 likely voters (Case #1) and reports

TABLES 1–2

Table 1: Testing a Statistical Hypothesis: the Scientific Context

1. Conceptual framework or paradigm
2. Formulation of testable (falsifiable) hypothesis
3. Research design, including selection of sample
4. Data collection
5. Data analysis
6. Interpretation of results
7. Generalization to some population: Inference
8. Follow-up in further studies

SOURCE: Courtesy of Valerie Miké.

Table 2: Testing a Statistical Hypothesis: the Procedure

1. Set up *null hypothesis* vs. *alternative hypothesis.*
2. Collect data in accordance with research design.
3. Analyze data for overall patterns, outliers, consistency with theoretical assumptions, etc.
4. Compute the *test statistic,* to be compared with the *critical value,* which divides the distribution of the test statistic under the null hypothesis into "likely" and "unlikely" regions, determined by the *significance level* α. The conventional division is 95% and 5%, for $\alpha = .05$.
   a. If the test statistic is in the 95% region, considered a "likely" outcome, do not reject the null hypothesis.
   b. If the test statistic is in the 5% region, considered an "unlikely" outcome, reject the null *hypothesis.* The result is said to be *statistically significant* at P= .05.
5. Review analysis with subject matter specialist, for possible implications and further studies.

SOURCE: Courtesy of Valerie Miké.

back that 55 plan to vote for the senator. Meanwhile, a professional pollster retained by the campaign manager takes a sample of 1,100 likely voters (Case #2), and also obtains a positive response from 55 percent. What can they conclude?

Each may choose a two-sided test of the null hypothesis that the true proportion p of supporters is .5, at significance level $\alpha = .05$:

$$H_0 : p = .5 \quad \text{vs.} \quad H_1 : p \neq .5.$$

By the central limit theorem for the binomial distribution each can use the test statistic z, assuming the standard normal distribution,

$$z = \frac{M - .50}{SE},$$

and carry out a z-test for Case #1 ($n = 100$) and Case #2 ($n = 1{,}100$). The sample mean M is .55 for each, but SE involves the sample size:

Case #1:
$$SE = \sqrt{p(1-p)/n} = \sqrt{.5 \times .5/100} = .05$$
$$\text{so that} \quad z = \frac{.55 - .50}{.05} = 1.0.$$

(To distinguish between a random variable and its observed value, the latter is often denoted in lower case, such as Z versus z.) As seen in Figure 3a, this test statistic is just one standard deviation from the mean under the null hypothesis, well within the likely region. Figure 3b shows that even a one-sided test would require a test statistic of at least $z = 1.645$ to reject H_0. The senator cannot be said to be ahead of his opponent.

Case #2:
$$SE = \sqrt{p(1-p)/n} = \sqrt{.5 \times .5/1{,}100} = .015$$
$$\text{so that} \quad z = \frac{.55 - .50}{.015} = 3.33.$$

Figure 3a shows that this test statistic is greater than the critical value 1.96, leading to rejection of the null hypothesis. The pollster can report that the senator is statistically in the lead, whereas the volunteer's result is inconclusive.

ERRORS ASSOCIATED WITH TESTING. Two types of error that may occur in testing a statistical hypothesis are shown in Table 3: Type I, rejecting H_0 when it is true, and Type II, not rejecting it when it is false. (The expression "accept" instead of "do not reject" H_0 is sometimes used, but strictly speaking the most that can be asserted is that the observed result is consistent with, or is a "likely" outcome under, the null hypothesis; it is always a tentative conclusion.) The Type I error means that when H_0 is rejected at $P = .05$ (or $\alpha = .05$, the significance level of the test), an outcome in the rejection region would occur by chance 5 percent of the time if H_0 were true. The Type II error, its probability denoted by β ("beta"), is not as well known; many users of statistical methods even seem unaware that it is an integral part of the theory. The complement of β, or $(1 - \beta)$, the probability of rejecting H_0 when it is false, is called the *power* of the test.

THE P-VALUE. In reporting the results of a study, statistical significance is usually indicated in terms of what has become known as the P-value, written as $P < .05$ or $P < .01$, referring to the significance level α. In analyses carried out by computer, the software typically also provides the actual value of P corresponding to the observed test statistic (properly doubled for two-sided

TABLES 3–4

Table 3: Errors Associated with Testing a Statistical Hypothesis

Conclusion of test	Null hypothesis true	Null hypothesis false
Do not reject H_0 "Not statistically significant"	No error	Type II error (β)
Reject H_0 "Statistically significant"	Type I error (α or P) Significance level	No error (1-β) Power

SOURCE: Courtesy of Valerie Miké.

Table 4: Power of Test: Example of a Randomized Clinical Trial

Assume one-year survival rate with current treatment is 50% and with new treatment is

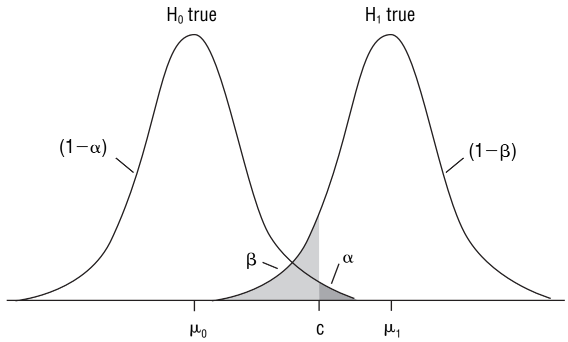
n	55%	60%	65%	75%	85%	95%
25	.06	.11	.19	.46	.78	.98
50	.08	.17	.33	.74	.97	*
100	.11	.30	.58	.96	*	*
250	.20	.61	.93	*	*	*
500	.35	.89	*	*	*	*
1,000	.61	.99	*	*	*	*
2,500	.94	*	*	*	*	*

First column shows n = number of patients in each treatment group. Entries in columns 2–7 represent power of test (1–β) = probability of rejecting H_0 for different values of H_1; α = .05, two-sided test (arcsine transformation). For entries marked (*) the power is greater than .995.

SOURCE: Courtesy of Valerie Miké.

FIGURE 4

Relationship Between Significance Level and Power



Relationship between significance level (α) and power ($1-\beta$), for one-sided test of H_0 vs. H_1 and critical value c.

SOURCE: Courtesy of Valerie Miké.

tests). In Case #1 above, the value corresponding to $z = 1.0$ can be read off Figure 2 as $P = .32$. For Case #2, the value for $z = 3.33$ is seen as $P < .003$; it can be looked up in a table of the normal distribution as $P = .0024$. In results reported in the applied literature, at times only the observed *P*-value may be given, with no discussion of formal testing.

THE POWER OF THE TEST. Tests of the null hypothesis can be carried out without reference to the Type II error, but along with α and the sample size *n*, consideration of β is crucial in the research design of studies. The level of β, or equivalently, the power of the test, is always defined in terms of a specific value of the alternative hypothesis. The relationship between α and β for fixed *n* is shown in Figure 4 for a one-sided test of μ_0 versus μ_1. Changing the critical value *c* shows that as α increases, β decreases, and vice versa. A shift of μ_1 in relation to μ_0 indicates that the distance between them affects the power of the test.

Power as a function of sample size and alternative hypothesis is illustrated in Table 4. Assuming that a certain type of cancer has a one-year survival rate of 50 percent with the standard treatment, a randomized clinical trial is planned to evaluate a promising new therapy. The table shows the power of a two-sided test at $\alpha = .05$ for a range of possible survival rates, with the new treatment and different numbers of patients included in each arm of the study.

For example, if there are 100 patients in each group, a new treatment yielding a one-year survival rate of 75 percent would be detected with probability (power) .96. "Detect" here refers to the probability that the observed difference in survival rates will be statistically significant. But if the improvement is only to 60 percent, the corresponding power is a mere .30. To detect this improvement with high power (.99) would require a sample size of 1,000. In any particular case, investigators have a general idea of what improvement can reasonably be expected. If the survival rate in the study arm is unlikely to be higher than 60 percent, then a clinical trial with just a few hundred patients is not a good research design and may be a waste of precious human and financial resources.

Inference: Estimating Confidence Intervals

An intuitive everyday procedure is point estimation, obtaining a summary figure, such as the sample mean, for some quantity of interest. But it is generally desirable to give an indication of how good—how precise—this estimate is, and this is done with the confidence interval.

THE FORMAL STRUCTURE. It is assumed here that the normal distribution is applicable, so that the terms already introduced can be used, with estimation of the population mean μ by the sample mean M. By definition, the following holds for the standard normal z-statistic

$$P\left(-z_{\alpha/2} < \frac{M-\mu}{SE} < z_{\alpha/2}\right) = 1-\alpha.$$

As can be seen from Figure 3a, for $\alpha = .05$ this becomes

$$P\left(-1.96 < \frac{M-\mu}{SE} < 1.96\right) = .95.$$

Rewriting the expression inside the parentheses yields

$$P(M-1.96SE < \mu < M+1.96SE) = .95,$$

which is called a 95 percent confidence interval for the unknown population mean μ. It means that in a long sequence of identical repeated studies, 95 percent of the confidence intervals calculated from the sample would include the unknown parameter. There is always a 5 percent chance of error, but a larger sample size yields a smaller *SE* and narrower limits.

TWO-PART EXAMPLE CONTINUED. In the senator's reelection campaign, the point estimate M = .55 was obtained with different samples by both the volunteer and the pollster, and here the unknown parameter estimated by M is the true proportion *p*. Using the expression above yields

Case #1: $P(.45 < p < .65) = .95,$

for $n = 100,\ SE = .05.$

Case #2: $P(.52 < p < .58) = .95,$

for $n = 1{,}100,\ SE = .015.$

The critical value $c = 1.96$ for the standard normal (two-sided, $\alpha = .05$) is close to 2.0, and results are often presented in the form M ± 2*SE*.

Case #1: $.55 \pm .10$

Case #2: $.55 \pm .03$

The latter expression may be reported by the media as "55 percent with a 3 percent margin of error," putting the senator clearly in the lead. What is omitted is that this is a 95 percent confidence interval, with a 5 percent chance of error on the interval itself.

RELATIONSHIP BETWEEN TESTING AND ESTIMATION. Any value included in a $(1-\alpha)$ confidence interval would in general be accepted (not rejected) as the null hypothesis in the corresponding test of significance level α, and values outside the interval would be rejected. In this example the null hypothesis of $p = .50$ was rejected in Case #2, but not in Case #1. The confidence interval is a useful, informative way to report results.

Overview

A statistical study may be *observational* or *experimental* and may involve one or more samples. The polls and the clinical trial were examples of a *one-sample* survey and a *two-sample* experiment, respectively. The methods of inference described a simple prototype of the Neyman-Pearson theory, using the binomial and standard normal distributions, but they are valid in a wide range of contexts. Other important probability distributions include two generated by a stable random process: the *Poisson*, for the number of events occurring at random in a fixed interval, and the *exponential*, for the length of the interval between the occurrence of random events. Radioactive decay, traffic accidents in a large city, and calls arriving at a telephone exchange are random processes that illustrate both distributions.

If the variance of a normal distribution is unknown and estimated from the sample (using a computational formula involving the observations), the *z-test* used above is replaced by the *t-test* for small samples ($n < 30$), with its own distribution. For larger samples the normal distribution is a close approximation. The *chi-square test*, perhaps the most widely used method in applied statistics, assesses the relationship between two categorical variables (each taking on a finite number of values, displayed in a two-way table), or the "goodness-of-fit" of observed data to a particular distribution. *Multivariate techniques* deal with inferences about two or more random variables, including their interaction; basic among these are *correlation* and *regression*. Important and central to the design of experiments is the *analysis of variance*, a method for partitioning the variation in a set of data into components associated with specific causes, in order to assess the effect of any hypothetical causes on the experimental result.

There are specialized techniques for *time series* and *forecasting*, for *sample surveys* and *industrial quality control*. *Sequential analysis* refers to procedures for repeated testing of hypotheses along the way, to minimize the sample size needed for a study. The class of *nonparametric methods* uses tests that do not assume a specific parametric form for the probability distributions, all within the classical theory. *Decision theory* formulates statistical problems as a choice between possible decisions based on the concept of utility or loss.

The same data can often be analyzed by different techniques, using different assumptions, and these may yield conflicting results. Statistical theory aims to provide the best methods for a given situation, tests that are most powerful across the range of alternatives, and estimates that are unbiased and have the smallest variance. Given an adequate model, statistics can control the uncertainty attributable to *sampling error*. But it cannot control *systematic error*, when the data are not even closely representative of the assumed population. Inference is based on an abstract logical structure, and its application to messy reality always requires the mature judgment of experienced investigators.

VALERIE MIKÉ

SEE ALSO *Biostatistics; Epidemiology; Meta-analysis; Probability; Qualitative Research.*

BIBLIOGRAPHY

Anderson, David R.; Dennis J. Sweeney; and Thomas A. Williams. (1994). *Introduction to Statistics: Concepts and Applications*, 3rd edition. Minneapolis/St. Paul: West Publishing. A textbook of applied statistics with many examples; no calculus required.

Cox, D. R., and D. V. Hinkley. (1974). *Theoretical Statistics*. London: Chapman and Hall. A graduate level text on the theory of modern statistics.

Cox, D. R., and D. V. Hinkley. (1978). *Problems and Solutions in Theoretical Statistics*. London: Chapman and Hall. Additional material pertaining to the text above.

Fisher, R. A. (1990). *Statistical Methods, Experimental Design, and Scientific Inference*, ed. J. H. Bennett. Oxford: Oxford University Press. Three classic works by a founder of modern statistics, published in a single volume.

Freedman, David; Robert Pisani; and Roger Purves. (1998). *Statistics*, 3rd edition. New York: Norton. An introductory text presenting concepts and methods by means of many examples, with minimal formal mathematics.

Kotz, Samuel; Norman L. Johnson; and Campbell B. Read, eds. (1982–1999). *Encyclopedia of Statistical Sciences*. 9 vols. plus supp. and 3 update vols. New York: Wiley.

Kruskal, William H., and Judith M. Tanur, eds. (1978). *International Encyclopedia of Statistics*. 2 vols. New York: Free Press.

Lehmann, E. L. (1959). *Testing Statistical Hypotheses*. New York: Wiley. A theoretical development of the Neyman-Pearson theory of hypothesis testing.

Miller, Irwin, and Marylees Miller. (2004). *John E. Freund's Mathematical Statistics with Applications*, 7th edition. Upper Saddle River, NJ: Prentice Hall. An intermediate-level introduction to the theory of statistics.

Pearson, Karl. (1978). *The History of Statistics in the 17th and 18th Centuries against the Changing Background of Intellectual, Scientific, and Religious Thought: Lectures by Karl Pearson Given at University College, London, during the Academic Sessions, 1921–1933*, ed. E. S. Pearson. London: Griffin. Includes documentation on the origin of the name *statistics*.

Snedecor, George W., and William G. Cochran. (1989). *Statistical Methods*, 8th edition. Ames: Iowa State University Press. A classic text of applied statistics.

Strait, Peggy Tang. (1989). *A First Course in Probability and Statistics with Applications*, 2nd edition. San Diego, CA: Harcourt Brace Jovanovich. Thorough presentation of mathematical concepts and techniques, with hundreds of examples from a wide range of applications.

HISTORY, INTERPRETATION, AND APPLICATION

Numerous jokes are associated with statistics and reflected in such caustic definitions as "Statistics is the use of methods to express in precise terms that which one does not know" and "Statistics is the art of going from an unwarranted assumption to a foregone conclusion." Then there is the time-worn remark attributed to the English statesman Benjamin Disraeli (1804–1881): "There are three kinds of lies: lies, damned lies, and statistics."

Statistics may refer to individual data, to complete sets of numbers, or to inferences made about a large population (of people or objects) from a representative sample of the population. The concern here is with inferential statistics. Its methodology is complex and subtle, and the risk of its abuse very real. There is no end in sight for the public being inundated with numbers, by the market and all kinds of interest groups. It has been estimated that children growing up in a pervasive television culture are exposed to more statistics than sex and violence combined. It was another Englishman, the novelist and historian H. G. Wells (1866–1946), who said: "Statistical thinking will one day be as necessary for efficient citizenship as the ability to read and write."

For those who understand, statistics is an exciting venture, a bold reaching out by the human mind to explore the unknown, to seek order in chaos, to harness natural forces for the benefit of all. Its development was integral to the rise of modern science and technology, its critical role recognized by the brilliant founders of new disciplines.

After a brief sketch of the history of statistical inference, this article offers a commentary on interpretations of statistics and concludes with a discussion of its applications that includes a case study of statistics in a scientific context.

Highlights of History

This quick survey of the history of statistics is presented in two sections, beginning with the emergence of statistical inference and then turning to the use of statistical concepts in philosophical speculation.

FROM STATISTICAL THINKING TO MATHEMATICAL STATISTICS. The normal distribution, which plays such a central role in statistics, was anticipated by Galileo Galilei (1564–1642) in his *Dialogue concerning the Two Chief World Systems—Ptolemaic and Copernican* (1632). He spoke of the errors in measuring the distance of a star as being symmetric (the observed distances equally likely to be too high as too low), the errors more likely to be small than large, and the actual distance as the one in which the greatest number of measurements concurred—a description of the bell-shaped curve. Discovered by Abraham de Moivre (1667–1754), the normal distribution was fully developed as the law of error in astronomy by Pierre-Simon de Laplace (1749–1827) and Carl Friedrich Gauss (1777–1855).

The statistical approach was applied to social phenomena by the Belgian astronomer Adolphe Quetelet (1796–1874), in what he called *social physics*, by analogy with *celestial physics*. He introduced the concept of the *average man* to show that observed regularities in the traits and behavior of groups followed the laws of probability. He strongly influenced Florence Nightingale (1820–1910), the British nursing pioneer and hospital reformer, who urged governments to keep good records and be guided by statistical evidence.

The fundamental contributions of the Scottish physicist James Clark Maxwell (1831–1879) to electromagnetic theory and the kinetic theory of gases would lead to communications technology and ultimately to Albert Einstein's special theory of relativity and Max Planck's quantum hypothesis. Having learned of Quetelet's application of the statistical error law to social aggregates, Maxwell theorized that the same law governed the velocity of gas molecules. His work in statistical mechanics and statistical thermodynamics foreshadowed a new conception of reality in physics.

The Austrian monk Gregor Johann Mendel (1822–1884) carried out plant crossbreeding experiments, in the course of which he discovered the laws of heredity. Traits exist as paired basic units of heredity, now called genes. The pairs segregate in the reproductive cell, and the offspring receive one from each parent. Units corresponding to different traits recombine during reproduction independently of each other. Mendel presented his results at a scientific meeting in 1865 and published them in 1866, but they were ignored by the scientific community and he died unknown.

Statistical inference as a distinct discipline began with Francis Galton (1822–1911), a cousin of Charles Darwin, whose *On the Origin of Species* (1859) became the inspiration of Galton's life. The theory of evolution by natural selection offered Galton a new vision for humanity. He coined the term *eugenics* to express his belief that the conditions of humankind could best be improved by scientifically controlled breeding. He devoted himself to the exploration of human inheritance in extensive studies of variability in physical and mental traits, constructing what would become basic techniques of modern statistics, notably regression and correlation. In 1904 he established the Eugenics Record Office at University College, London, which in 1911 became the Galton Laboratory of National Eugenics, with Karl Pearson (1857–1936) appointed its director.

A man of classical learning and deep interest in social issues, Pearson was attracted to Galton's work in eugenics. Becoming absorbed in the study of heredity and evolution by the measurement and analysis of biologic variation, he developed a body of statistical techniques that includes the widely used chi-square test. In 1901 he founded the journal *Biometrika*. But he never accepted Mendel's newly rediscovered laws of inheritance involving hereditary units as yet unobserved, and engaged in a feud with Mendelian geneticists. Pearson was appointed the first professor of eugenics in 1911, with his Biometric Laboratory incorporated into the Galton Laboratory of National Eugenics, and the department became a world center for the study of statistics. When he retired in 1933, the department was split in two; his son Egon Pearson (1895–1980) obtained the chair in statistics, and Ronald A. Fisher (1890–1962) became professor of eugenics.

Trained in mathematics and physics, Fisher emerged as the greatest single contributor to the new disciplines of statistics and genetics and the mathematical theory of evolution. He did fundamental work in statistical inference, and developed the theory and methodology of experimental design, including the analysis of variance. Through his books *Statistical Methods for Research Workers* (1925), *The Design of Experiments* (1935), and *Statistical Methods and Scientific Inference*

(1956), he created the path for modern inquiry in agronomy, anthropology, astronomy, bacteriology, botany, economics, forestry, genetics, meteorology, psychology, and public health. His breeding experiments with plants and animals and his mathematical research in genetics led to the publication of his classic work, *The Genetical Theory of Natural Selection* (1930), in which he showed Mendel's laws of inheritance to be the essential mechanism for Darwin's theory of evolution.

Egon Pearson collaborated with the Russian-born mathematician Jerzy Neyman (1894–1981) to formulate what is now the classical (Neyman-Pearson) theory of hypothesis testing, published in 1928. This is the theory used across a wide range of disciplines, providing what some call the null hypothesis method. Neyman left London in 1937 to become a strong force in establishing the field in the United States. Another major contributor to American statistics was the Hungarian-born mathematician Abraham Wald (1902–1950), founder of statistical decision theory and sequential analysis.

STATISTICS AND PHILOSOPHY. Statistical developments in the eighteenth century were intertwined with natural theology, because for many the observed stable patterns of long-run frequencies implied intelligent design in the universe. For Florence Nightingale in the nineteenth century, the study of statistics was the way to gain insight into the divine plan.

Francis Galton had a different view. For him the theory of evolution offered freedom of thought, liberating him from the weight of the design argument for the existence of a first cause that he had found meaningless. Karl Pearson, author of *The Grammar of Science* (1892), was an advocate of logical positivism, holding that scientific laws are but descriptions of sense experience and that nothing could be known beyond phenomena. He did not believe in atoms and genes. For him the unity of science consisted alone in its method, not in its material. Galton and Pearson gave the world statistics, and left as philosophical legacy their vision of eugenics.

James Clark Maxwell was a thoughtful and devout Christian. He argued that freedom of the will, then under vigorous attack, was not inconsistent with the laws of nature being discovered by contemporary science. The statistical method, the only means to knowledge of a molecular universe, yielded information only about masses of aggregates, not about individuals. He urged recognition of the limits of science: "I have endeavored to show that it is the peculiar function of physical science to lead us to the confines of the incomprehensible, and to bid us behold and receive it in faith, till such time as the mystery shall open" (quoted in Porter 1986, p. 195).

In 1955 Fisher, by then Sir Ronald Fisher, said in a London radio address on the BBC: "It is one of the evils into which a nation can sometimes drift that, for about three generations in this country, the people have been taught to assume that scientists are the enemies of religion, and, naturally enough, that the faithful should be enemies of science" (Fisher 1974, p. 351). Scientists, he insisted, needed to be clear about the extent of their ignorance and not claim knowledge for which there was no real evidence. Fisher's advice remains sound at the start of the twenty-first century.

Interpretation: A Commentary

The following are comments on various aspects of statistics, painted of necessity in broad strokes, and concluding with some thoughts concerning the future.

STATISTICS AND THE PHILOSOPHY OF SCIENCE. Two distinct types of probability—objective and subjective—have been recognized since the emergence of the field in the seventeenth century. The classical (Neyman-Pearson) theory of hypothesis testing is based on the objective, frequentist interpretation. The subjective, degree-of-belief interpretation yields variations of so-called Bayesian inference. The latter involves combining observations with an assumed prior probability of a hypothesis to obtain an updated posterior probability, a procedure of enduring controversy. But the frequentist theory, as pointed out by its critics, does not provide any measure of the evidence contained in the data, only a choice between hypotheses. The American mathematical statistician Allan Birnbaum (1923–1976) did pioneering work to establish principles of statistical evidence in the frequentist framework, his two major related studies being "On the Foundations of Statistical Inference" (1962) and "Concepts of Statistical Evidence" (1969). Exploring the *likelihood principle*, Birnbaum reached the conclusion that some sort of confidence intervals were needed for the evaluation of evidence. A leading advocate of the subjective approach, of what he called personal probability, was another American statistician, Leonard J. Savage (1917–1971), author of the classic work *The Foundations of Statistics* (1954).

Statistics as commonly taught and used is that based on the frequentist theory. But there is lively interest in Bayesian inference, also the focus of serious study by philosophers (Howson and Urbach 1993). The entire subject has been engaging philosophers of science, giving rise to a new specialty called the philosophy of probability. An example is the edited volume *Probability Is the Very Guide of Life: The Philosophical Uses of Chance* (Kyburg and Thalos 2003), a collection of essays by philosophers of probability that explores aspects of probability as applied to practical issues of evidence, choice, and explanation—although without consensus on conceptual foundations. The title refers to a famous remark of Bishop Joseph Butler, one of the eighteenth-century natural theologians who saw statistical stability as a reflection of design and purpose in the universe (Butler 1736). Another edited volume, *The Nature of Scientific Evidence: Statistical, Philosophical, and Empirical Considerations* (Taper and Lele 2004), has contributions by statisticians, philosophers, and ecologists, with ecology used as the illustrative science. What remains clear is the persistent conflict between the frequentist and Bayesian approaches to inference. There is no unified theory of statistics.

STATISTICS IN THE FIELD. At the other end of the statistical spectrum is the approach expressed by the term *exploratory data analysis* (EDA), introduced by John W. Tukey (1915–2000), the most influential American statistician of the latter half of the twentieth century. Exploratory data analysis refers to probing the data by a variety of graphic and numeric techniques, with focus on the scientific issue at hand, rather than a rigid application of formulas. Tukey's textbook on EDA (1977) contains techniques that can be carried out with pencil and paper, but the approach is well suited to computer-based exploration of large data sets—the customary procedure. EDA is an iterative process, as tentative findings must be confirmed in precisely targeted studies, also called *confirmatory data analysis*. The aim is flexibility in the search for insight, with caution not to oversimplify the science, to be wary of pat solutions.

Practicing statisticians need to understand established theory, know the methods pertaining to their area of application, and be familiar with the relevant software. They must know enough about the subject matter to be able to ask intelligent questions and have a quick grasp of the problems presented to them. For effective communication they must be sensitive to the level of mathematical skills of the researchers seeking their assistance. It is easy to confuse and alienate with technical jargon, when the intention is to be of service. What is asked of them may range from short-term consultation—analysis of a small set of data, or help with answering a statistical reviewer's questions on a manuscript submitted for publication—to joining the research team of a long-range study that is being planned. Unless otherwise agreed, it is understood that frequentist theory will be used, with routine preliminary exploration of the data. A statistician who strongly prefers the Bayesian approach may recruit investigators interested in collaborating on Bayesian analysis of suitable scientific problems.

Some points to remember: Statistics is a tool—more precisely, a collection of tools. Creative researchers know a lot of facts and have hunches and ideas; they may seek interaction with a compatible statistician to help sort things out, and that is where the tools come in. Which ones are actually used may not matter so much in the end. On occasion, the statistician's real contribution may not even involve formal analysis. A mind trained in mathematics views problems from a special perspective, which in itself may trigger insight for the scientist immersed in the material. Other situations require structured research designs with specification of proposed methods of analysis. These include cooperative studies, such as large multinational clinical trials involving hundreds of investigators. But in any case and even in the most masterful hands, statistics can be no better than the quality of the underlying science.

THE FUTURE OF STATISTICS. The explosive growth of information technology, with its capacity to generate data globally at a fast pace and in great volume, presents the statistical profession with unprecedented opportunity and challenge. The question is not that of either/or, of theory versus practice, but of perspective and balance: Continue exploration on every front, but make what is established widely available. Apply what is known, and do it well. Make sure that wherever statistics is potentially useful, it is at hand.

A promising development here is the Cochrane Collaboration, founded in 1993, an independent international organization dedicated to making accurate, up-to-date information about health care interventions readily available around the globe (Cochrane Collaboration). The organization promotes the search for evidence in the form of randomized clinical trials and provides ongoing summary analyses. By late 2004 there were twelve Cochrane centers worldwide, functioning in six languages, serving as reference centers for 192 nations, and coordinating the work of thousands of investigators. Such a vast undertaking must use objective criteria and uniform statistical methods that can be precisely communicated. That is the strength of the standard frequency approach.

In the realm of theoretical advances, some economic constraints may be cause for concern. Young graduates in academic positions, often struggling in isolation while carrying heavy teaching loads, are under great pressure to produce publications, any publications, to attain job security and professional advancement. This may not be the wisest use of their intellectual potential. A man of wit, Tukey would say that one should do theory only if it is going to be immortal. By contrast, those in a practical setting, such as a large biostatistics department, have to cope with the endless flow of data to be analyzed, under the constant pressure of immutable deadlines. The loss of major research grants may put many jobs in jeopardy, including their own. There should be other, readily available and steady sources of support that provide time for reflection, to find and explore areas of interest that seem to offer promise down the road. Such a path should include attention to what is happening in philosophy and close involvement with a field of cutting-edge empirical research. The great founders of statistics were widely read, hands-on scientists.

Application of Statistics

In the last decades of the twentieth century statistics continued its vigorous growth into a strong presence not only in the sciences but also in political and social affairs. Its enormous range of applications, with specialized methodology for diverse disciplines, is reflected in the thirteen-volume *Encyclopedia of Statistical Sciences*, published between 1982 and 1999 (Kotz, Johnson, and Read). The term *statistical science* refers to statistical theory and its applications to the natural and social sciences and to science-based technology. The best general advice in the application of statistics is to proceed with care and suspend hasty judgment. This is illustrated by a case study of the diffusion of neonatal technology.

STATISTICS IN CONTEXT: A CASE STUDY. The role of statistics in the interplay of forces affecting technological innovation was explored in a case study in neonatal medicine, a specialty created by technology (Miké, Krauss, and Ross 1993, 1996, 1998). It is the story of transcutaneous oxygen monitoring (TCM) in neonatal intensive care, introduced as a scientific breakthrough in the late 1970s and rapidly adopted for routine use, but abandoned within a decade. The research project included interviews with executives and design engineers of ten companies marketing the device, with investigators who had pioneered the technology, and with directors of neonatal intensive care units (NICUs).

Supplemental oxygen, essential for the survival of premature infants, had been administered since the 1930s, first via incubators and then by mechanically assisted ventilation. But in the 1940s an eye disease often leading to blindness, initially called retrolental fibroplasia (RLF) and later renamed retinopathy of prematurity (ROP), became the major clinical problem of surviving prematurely born infants. Over fifty causes were suggested, and about half of these were formally evaluated, a few in prospective clinical trials. When in the mid-1950s supplemental oxygen was identified as the cause of ROP in two large randomized clinical trials, the recommended policy became to administer oxygen only as needed and in concentrations below 40 percent. By this time more than 10,000 children had been blinded by ROP worldwide.

But subsequent studies noted higher rates of mortality and brain damage in surviving infants, as the incidence of ROP persisted and then rose, with many malpractice suits brought on behalf of children believed to have been harmed by improper use of oxygen. There was an urgent need for better monitoring of oxygen in the NICU.

Measurement of oxygen tension in arterial blood by means of the polarographic Clark electrode had been possible since the 1960s. The procedure was only intermittent, however, and the related loss of blood harmful to tiny, critically ill newborns. The new technology of TCM involved a miniaturized version of the Clark electrode that could monitor oxygen continuously across the skin, bypassing the need for invasive blood sampling. But the device was difficult to use, babies were burned by the electrode, and ROP was not eliminated. Within years TCM was being replaced by pulse oximetry, a still more recent technology with problems of its own.

A number of issues emerged. Subsequent review found serious flaws in the two randomized clinical trials that had implicated oxygen, and a series of methodological errors was noted in the early studies of other possible causes. The effectiveness of TCM in the prevention of ROP had not been shown before the adoption of the technology, and results of a randomized trial finally published in 1987 were inconclusive. It became clear that the oxygen hypothesis was an oversimplified view. ROP had a complex etiology related to premature physiology, even as the patient population itself was changing, with the survival of smaller and smaller infants.

A mistaken view of disease physiology, coupled with preventive technology advocated by its pioneers, heralded by the media, and demanded by the public—with industry only too eager to comply—led to the adoption of an untested technology that was itself poorly understood by those charged with its use. There was no special concern with statistical assessment, reliance on regulations of the Food and Drug Administration (FDA) being the norm. And there is no clear-cut way to assign ultimate responsibility. The study concluded with the overarching theme of complexity and uncertainty.

SUMMING UP Statistics is a powerful tool when in competent hands, one of the great intellectual achievements of the twentieth century. Ethical issues pertain to its misuse or lack of adequate use.

Elementary texts of applied statistics have traditionally been called "cookbooks," teaching mainly the "how" and not the "why." But in the present-day fast food culture hardly anyone cooks any more, and this applies equally to statistics. Computer software provides instant analysis of the data by a variety of techniques, allowing the user to pick and choose from the inevitable sprinkling of "significant" results (by definition of the meaning of *P*-value) to create a veneer of scientific respectability. Such meaningless and misleading activity, whatever the reason, can have harmful consequences. Another danger of abuse can come in the phrasing of questions in public opinion polls, known to affect the response, in a way that biases the results in favor of the sponsor's intended conclusion.

The ideal role of statistics is to be an integral part of the investigative process, to advise, assess, and warn of remaining uncertainties. The public needs to be informed and offer its support, so that the voice of statistics may be clearly heard in national life, over the cacophony of confusion and conflicting interests. This theme has been developed further in the framework of a proposed *Ethics of Evidence*, an approach for dealing with uncertainty in the context of contemporary culture (Miké 2003). The call for education and responsibility is its predominant message.

VALERIE MIKÉ

SEE ALSO *Biostatistics; Epidemiology; Galilei, Galileo; Galton, Francis; Meta-analysis; Nightingale, Florence; Probability.*

BIBLIOGRAPHY

Birnbaum, Allan. (1962). "On the Foundations of Statistical Inference (with Discussion)." *Journal of the American Statistical Association* 57(298): 269–326.

Birnbaum, Allan. (1969). "Concepts of Statistical Evidence." In *Philosophy, Science, and Method: Essays in Honor of Ernest Nagel*, ed. Sidney Morgenbesser, Patrick Suppes, and Morton White. New York: St. Martin's Press.

Box, Joan Fisher. (1978). *R. A. Fisher: The Life of a Scientist*. New York: Wiley. Biography written by Fisher's daughter who had also been his research assistant.

Butler, Joseph. (1736). *The Analogy of Religion, Natural and Revealed, to the Constitution and Course of Nature*. London: Printed for James, John, and Paul Knapton.

Fisher, R. A. (1930). *The Genetical Theory of Natural Selection*. Oxford: Clarendon Press. 2nd edition, New York: Dover, 1958.

Fisher, R. A. (1974). "Science and Christianity: Faith Is Not Credulity." In *Collected Papers of R. A. Fisher*, Vol. 5 (1948–1962), ed. J. H. Bennett. Adelaide, Australia: University of Adelaide. A 1955 talk given in London on BBC radio.

Fisher, R. A. (1990). *Statistical Methods, Experimental Design, and Scientific Inference*, ed. J. H. Bennett. Oxford: Oxford University Press. Three classic works by a founder of modern statistics, published in one volume.

Galilei, Galileo. (1967 [1632]). *Dialogue concerning the Two Chief World Systems—Ptolemaic and Copernican*, trans. Stillman Drake. 2nd edition. Berkeley and Los Angeles: University of California Press. Includes description of the bell-shaped curve of error, known subsequently as the normal distribution.

Gigerenzer, Gerd; Zeno Swijtink; Theodore Porter; et al. (1989). *The Empire of Chance: How Probability Changed Science and Everyday Life*. Cambridge, UK: Cambridge University Press. Summary of a two-volume work by a team of historians and philosophers of science, written for a general audience.

Hacking, Ian. (2001). *An Introduction to Probability and Inductive Logic*. Cambridge, UK: Cambridge University Press. Introductory textbook for students of philosophy, with many examples, explaining different interpretations of probability.

Howson, Colin, and Peter Urbach. (1993). *Scientific Reasoning: The Bayesian Approach*, 2nd edition. Chicago: Open Court.

Kotz, Samuel; Norman L. Johnson; and Campbell B. Read, eds. (1982–1999). *Encyclopedia of Statistical Sciences*. 9 vols. plus supp. and 3 update vols. New York: Wiley.

Kruskal, William H., and Judith M. Tanur, eds. (1978). *International Encyclopedia of Statistics*. 2 vols. New York: Free Press.

Kyburg, Henry E., Jr., and Mariam Thalos, eds. (2003). *Probability Is the Very Guide of Life: The Philosophical Uses of Chance*. Chicago: Open Court. Collection of essays by philosophers of probability.

Miké, Valerie. (2003). "Evidence and the Future of Medicine." *Evaluation & the Health Professions* 26(2): 127–152. Presents the *Ethics of Evidence* in the context of contemporary medicine and culture.

Miké, Valerie; Alfred N. Krauss; and Gail S. Ross. (1993). "Reflections on a Medical Innovation: Transcutaneous

Oxygen Monitoring in Neonatal Intensive Care." *Technology and Culture* 34(4): 894–922.

Miké, Valerie; Alfred N. Krauss; and Gail S. Ross. (1996). "Doctors and the Health Industry: A Case Study of Transcutaneous Oxygen Monitoring in Neonatal Intensive Care." *Social Science & Medicine* 42(9): 1247–1258.

Miké, Valerie; Alfred N. Krauss; and Gail S. Ross. (1998). "Responsibility for Clinical Innovation: A Case Study in Neonatal Medicine." *Evaluation and the Health Professions* 21(1): 3–26.

Pearson, Karl. (1991 [1892]). *The Grammar of Science*. Bristol, UK: Thoemmes Press. 3rd edition, London: Adam and Charles Black, 1911. A classic work on the philosophy of science.

Porter, Theodore M. (1986). *The Rise of Statistical Thinking, 1820–1900*. Princeton, NJ: Princeton University Press. A general history, considering scientific and economic currents that gave rise to the field.

Savage, Leonard J. (1954). *The Foundations of Statistics*. New York: Wiley. 2nd edition, New York: Dover, 1972. A classic work by the advocate of personal probability.

Stigler, Stephen M. (1986). *The History of Statistics: The Measurement of Uncertainty before 1900*. Cambridge, MA: Harvard University Press, Belknap Press. A thoroughly researched history, with detailed discussion of the origin of statistical methods.

Stigler, Stephen M. (1999). *Statistics on the Table: The History of Statistical Concepts and Methods*. Cambridge, MA: Harvard University Press. A collection of essays, a sequel to the author's 1986 work.

Tanur, Judith M.; Frederick Mosteller; William H. Kruskal; et al., eds. (1972). *Statistics: A Guide to the Unknown*. San Francisco: Holden-Day. A collection of forty-four essays describing applications of statistics in everyday life, written for the general reader.

Taper, Mark L., and Subhash R. Lele, eds. (2004). *The Nature of Scientific Evidence: Statistical, Philosophical, and Empirical Considerations*. Chicago: University of Chicago Press. A collection of essays, with ecology used to illustrate problems in assessing scientific evidence.

Tukey, John W. (1977). *Exploratory Data Analysis*. Reading, MA: Addison-Wesley. Textbook for an approach championed by the author, a prominent statistician, with many simple examples that do not require use of a computer.

Wald, Abraham. (1971). *Statistical Decision Functions*, 2nd edition. New York: Chelsea Publishing. Classic work of the founder of the field.

Wald, Abraham. (2004 [1947]). *Sequential Analysis*. New York: Dover. Another classic work by Wald, who also founded sequential analysis.

INTERNET RESOURCE

"The Cochrane Collaboration." Available from http://www.cochrane.org. Web site of the organization.

STEINMETZ, CHARLES

Electrical engineer and socialist Charles Proteus Steinmetz (1865–1923), born in Breslau, Germany, on April 9, was a public figure of the Progressive Era who tried to *engineer* a better society by creating an early code of engineering ethics, running for political office, and advocating a technocratic form of socialism. He died on October 26 in Schenectady, New York.

Trained in mathematics and physics, Steinmetz emigrated to the United States in 1889 to avoid being arrested for his socialist activities as a student in Germany. He became a leading researcher in the areas of magnetic hysteresis (a property of the metal cores used in transformers and electrical machines) and theories of alternating currents, electrical machinery, and high-voltage transmission lines. As chief consulting engineer of the newly formed General Electric Company (GE), which he joined in 1893, Steinmetz trained a generation of engineers in the use of advanced mathematics to design electrical equipment, established an engineering research laboratory, and published several books while teaching part-time at Union College in Schenectady, New York, the headquarters of GE. A dwarfed hunchback with a flair for publicity, he gained a national reputation as an electrical wizard for creating lightning in the laboratory and engaging in politics within and outside the engineering profession.

Steinmetz developed a distinct philosophy regarding the social responsibility of engineering. He argued that engineers should compromise with business interests in regard to ethical concerns within professional societies and address political issues on their own. In this way, engineers could maintain control over the profession against commercial interests and be able to promote political solutions in a wider arena.

Steinmetz carried out that philosophy in 1912 when he helped write the first code of ethics for the American Institute of Electrical Engineers (AIEE), the forerunner to the Institute of Electrical and Electronics Engineers (IEEE). Steinmetz was a president of the AIEE (1901–1902) and an active member of its first two ethics committees. The AIEE code, established in 1912, favored the interests of the employer over that of the engineer—up to a point. Rather than making engineers responsible for defective equipment, as the first draft of the code had done, for example, the revised code required engineers simply to report the problem, a common element in twenty-first century engineering codes of ethics. Inside GE, Steinmetz advised engineers in his group to keep silent rather than defend a company position with which they disagreed.

Steinmetz was active in politics at all levels. He served as president of the board of education under George Lunn, the socialist mayor of Schenectady in 1912, and was president of the city council in 1915. An evolutionary socialist who belonged to the conservative wing of the Socialist Party of America, Steinmetz drew on his corporatist experiences at GE, his work in local politics, his presidency of the AIEE, and as president of the National Association of Corporate Schools (NACS) to develop a theory of corporate socialism, which he expressed in some detail in *America and the New Epoch* (1916). In this form of technocracy, an enlightened industrial corporation, one that attended to the welfare of its workers, was the model for society. He proposed that the U.S. government be reorganized like an efficient corporation with democratic safeguards. The government would own and operate transportation and communication systems. An Industrial Senate, composed of leaders of large corporations, would coordinate and supervise industry. A democratically elected Tribunicate would set national and foreign policy, but could only veto the Senate.

Near the end of his life, Steinmetz acted on his belief that widespread electrification, by requiring cooperation to build networks and regulate consumption, would lead to socialism. He ran for New York state engineer in 1922 on a platform of harnessing the full power of Niagara Falls. The same year, he offered to help Vladimir Ilyich Lenin electrify Russia, in accord with Lenin's proposal text "Soviets + Electricity = Socialism."

To resolve the tensions he faced as a corporate engineer and a socialist, Steinmetz developed a patchwork of compromises that allowed agencies, such as the AIEE and NACS, and engineering colleges to retain autonomy by cooperating with industrial corporations. This would prepare corporations to become the model for the state and thus would be a step on the road to socialism. His ideas influenced President Woodrow Wilson's *war collectivism* and later proposals for the New Deal.

Steinmetz was able to promote his peculiar combination of conservative and radical views because of his public status as an electrical wizard, a new breed of scientific researcher that replaced cut-and-try inventors such as Thomas Edison. Steinmetz used his public position to demonstrate one way in which corporate engiees could address ethical and social issues in engineering.

RONALD KLINE

SEE ALSO *Engineering Ethics.*

BIBLIOGRAPHY

Jordan, John M. (1989). "Society Improved the Way You Can Improve a Dynamo: Charles P. Steinmetz and the Politics of Efficiency." *Technology and Culture* 30: 57–82.

Kline, Ronald R. (1992). *Steinmetz: Engineer and Socialist.* Baltimore, MD: Johns Hopkins University Press.

Layton, Edwin T., Jr. (1986 [1971]). *Revolt of the Engineers: Social Responsibility and the American Engineering Profession.* Baltimore, MD: Johns Hopkins University Press.

Steinmetz, Charles P. (1916). *America and the New Epoch.* New York: Harper & Brothers.

STEM CELLS

SEE *Embryonic Stem Cells.*

STRAUSS, LEO

Leo Strauss (1899–1973) was the most influential political philosopher of the twentieth century as well as its most extraordinary teacher. He was born into an Orthodox Jewish family in Kirchain, Hessen, Germany, on September 20. Strauss completed a doctorate at Hamburg in 1921 and immigrated to the United States in 1938. He taught at several American universities and attracted many gifted students. Their respect for his thought has led to those students being called disciples or *Straussians.* He died on October 18 in Annapolis, Maryland.

Philosophy and History

Like many scholars who left Germany in the 1930s, Strauss believed that a philosopher's work must be understood in the light of a political situation. Perhaps uniquely, he thought that all philosophers are in the *same* situation. Every regime, every society that sustains a government, is founded on certain shared opinions about what is noble and sacred, what is just, and what is in the common interest. Philosophers want to replace those cherished opinions with knowledge. This means that philosophy is by definition potentially subversive and is always likely to arouse the hostility of the regime. The story of Socrates' trial and execution is the best expression of this problem.

Strauss's view of philosophy is closely connected to his doctrine of esoteric writing, which is elaborated in

Persecution and the Art of Writing (1952). When philosophers write books, they must take pains both to protect philosophy from the hostility of citizens and to protect political life from subversion by philosophy. Their complete teachings can be communicated only by hints and clues. For example, a philosopher may write in one place that nothing should be taken seriously unless it is founded on experience and write in another place that religion is not founded on experience; only an attentive reader will be able to tell how seriously the author takes religion.

Because he read philosophy in this way, Strauss rejected the historicism that was prevalent in his time. According to historicists, person-to-person communication is not possible across historical boundaries; it is necessary to study past thinkers as objects in their historical context rather than as persons trying to talk to their later readers. Strauss taught that it is possible to understand Aristotle as he understood himself, for at least in the respect discussed above his situation is not fundamentally different from that of his modern readers. Strauss's most important book, *Natural Right and History* (1953), presents a sustained challenge to historicism. It is likely that the title implies a challenge to the philosopher Martin Heidegger's (1889–1976) *Being and Time* (1927). For Strauss, it is possible to arrive at a grasp of being that is not radically dependent on the flow of history.

Quarrels in Philosophy

Philosophy is the desire for wisdom, not the possession of wisdom. It may never amount to more than a clear grasp of the most fundamental questions. Strauss organized those questions into a number of historical quarrels. One of the most important is that between Athens and Jerusalem. Jerusalem stands for the concept of biblical revelation: Everything human beings must know is revealed to them in God's law. Athens stands for reason: Human beings can find out what they want to know by means of relentless questioning. Strauss taught that this quarrel was the most important source of intellectual vitality in Western civilization. However, although Strauss wrote extensively about Jewish philosophy and theology, his students disagree about how seriously he took biblical revelation.

With the power of revelation fading in modern civilization, Strauss sought to revive another quarrel: the one between the ancients and the moderns. The ancient thinkers, classical and medieval, looked to an authority higher than the human (nature or God) as the standard of truth and justice and based their political teachings on duties and virtues. The moderns began with a more or less explicit rejection of ancient thought. They viewed humankind as independent of any higher authority and based their teachings on rights rather than duties and on frank appraisals of human nature. Strauss argued, against the scholarly orthodoxy, that classical political philosophy had to be taken seriously as an alternative to the modern version. It is not clear whether he believed that ancient thought is superior on the whole.

Political Philosophy and Science

Strauss did consider classical social science to be manifestly superior to its modern counterpart. Social science in Strauss's time aspired to be "value-free." It sought to explain social facts the way a physicist explains the momentum of particles, without contaminating the explanation with historically conditioned expectation or judgment. However, the clarity the scientific method secures for physics induces a dangerous blindness when it is applied to human things: "A social science that cannot speak of tyranny with the same confidence with which medicine speaks of cancer cannot understand social phenomena for what they are" (Strauss 1991, p. 177). Classical social science recognized that human communities may flourish or fall victim to decay, and so it had something useful to say.

However, classical social science seems to rest on the strength of Strauss's analogy between the science of medicine and the sciences of politics and ethics. The physician not only can describe human biology but can prescribe remedies because medicine distinguishes what is naturally healthy from what is not. Can a knowledge of human nature similarly allow a philosopher to identify what is just and what is unjust, what saves and what destroys families and cities? The Platonists argued that it could, and Strauss refers to their teaching as classical natural right.

Classical natural right is concerned with articulating a hierarchy of natural ends. Thus, the perfection of human capacities, which the ancients called virtue, is primary and provision for survival, comfort, and freedom is secondary. Early modern political philosophy rejected the former and concentrated on the latter. That was largely a consequence of the rejection of Aristotelian teleology by modern science. Aristotle ascribed goals and purpose, or *teloi,* to nature. Modern thought recognizes only mechanical forces as natural; goals are products only of human will.

According to Aristotle, the issue between the mechanical and biological accounts of nature turns on how one interprets the motion of heavenly bodies. On this count the victory of modern science seems complete: There is no teleology on a cosmological scale. Because a value-free social science is useless, it becomes necessary to accept a dualism consisting of nonteleological physical sciences and social sciences that allow teleology. In a letter Strauss ascribes to Plato the view that this dualism cannot be reconciled. Strauss seems to have accepted this limitation for the most part, confining himself to political questions and largely ignoring not only modern natural science but classical biology and physics as well.

However, Strauss was choosing not the ancients over the moderns but Plato over Aristotle. Aristotle believed that biology could bridge the gap between "knowledge of inanimate [nature] and knowledge of man" (Strauss 1991, p. 279). His biology gives full weight to matter and momentum but recognizes a role for formal and teleological explanations. If Strauss had lived a bit longer, he would have witnessed some rehabilitation of Aristotle as a philosopher of biology, and that might have led him to reconsider the question.

Philosophy and Moderation

Although Strauss ignored contemporary science, he was attentive to its roots in modern thought. The early moderns proposed the unlimited conquest of nature for the purpose of the eventual satisfaction of all human desires. That project would include the conquest of human nature by some state, and that state would have to become universal and homogeneous if it were to eliminate all contradictions between states or between citizens. Such a state would need technologies of manipulation and coercion beyond any previously available to a government. Once the state accomplished its goal, perhaps it would whither away. Why would it be necessary to govern those whose every desire is satisfied?

However, if, as Strauss suspected, the complete satisfaction of human desires is impossible, the last state would in fact become a pervasive and immortal tyranny. This would mean the end of freedom and hence of philosophy. Strauss preferred Socratic philosophy to its modern counterpart at least insofar as it combined the pursuit of wisdom with moderation. It would be far better to settle for a decent form of government than to risk everything for one that is perfect. Of course, the philosopher will, because of the nature of this choice, be especially aware of its imperfections.

Accordingly, Strauss was both a supporter and a critic of modern liberal democracy. Although democracy is almost certainly the best viable form of government, Strauss had witnessed the weakness of the Weimar Republic in Germany and was concerned that a similar failure of nerve would affect Western democracies in their confrontation with communism. Moreover, democracy seemed problematic for philosophical reasons. Philosophers must stand apart from their fellow citizens and put more confidence in what reason tells them than in what the majority says. Philosophy is therefore elitist by necessity. Finally, because it is difficult to combine wisdom and political power, Strauss distrusted radical politics in any form. Anticommunism, elitism, and an insistence on political moderation have not endeared Strauss or the Straussians to their more orthodox colleagues in the universities.

KENNETH C. BLANCHARD, JR.

SEE ALSO *Aristotle and Aristotelianism; Democracy; Plato.*

BIBLIOGRAPHY

Deutsch, Kenneth L., and John Murley, eds. (1999). *Leo Strauss, the Straussians, and the Study of the American Regime*. Lanham, MD: Rowman and Littlefield.

Deutsch, Kenneth L., and Walter Soffer, eds. (1987). *The Crisis of Liberal Democracy: A Straussian Perspective*. Albany: State University of New York Press. Includes essays by students and other persons influenced by Strauss. Especially interesting are a number of arguments about the meaning and depth of Strauss's allegiance to political interests in general and modern liberal democracy in particular.

Drury, Shadia. (1988). *The Political Ideas of Leo Strauss*. New York: St. Martin's Press. This polemic is the best known critique of Strauss and his ideas. Drury sees no mysteries or ambiguities: Strauss was simply antiliberal.

Strauss, Leo. (1952). *Persecution and the Art of Writing*. Westport, CT: Greenwood Press.

Strauss, Leo. (1953). *Natural Right and History*. Chicago: University of Chicago Press. Strauss's best known work; includes a critique of historicism and a profound exploration of classical and modern natural right.

Strauss, Leo. (1959). *What Is Political Philosophy? and Other Studies*. Chicago: University of Chicago Press. A good general collection of Strauss's essays.

Strauss, Leo. (1991). *On Tyranny*, rev. and expanded edition, including the Strauss- Kojève correspondence, ed. Victor Gourevitch and Michael S. Roth. New York: Free Press. First published in 1963, this collection includes the famous debate between Strauss and the Hegelian philosopher Alexandre Kojève as well as their letters to each other. It may be the clearest introduction to Strauss's view of philosophy.

Strauss, Leo. (1997). *Jewish Philosophy and the Crisis of Modernity: Essays and Lectures in Modern Jewish Thought*, ed. Kenneth Hart Green. Albany: State University of New York Press. An excellent collection of essays on Jewish philosophy and theology, including the important "Jerusalem and Athens."

Strauss, Leo, and Joseph Cropsey, eds. (1987). *History of Political Philosophy*, 3rd edition. Chicago: University of Chicago Press. First edition, 1963; second edition, 1972. A collection of essays by Strauss and his students, with each essay focusing on a different political philosopher.

STRESS

Stress is an engineering concept that is applied metaphorically in the life sciences and social sciences. The ethical implications of stress in the social sciences lie in its perceived significance for work and health in technologically advanced societies. Stress provides an exemplary case for the interactions of science, technology, and ethics.

Origins

Although the word *stress* existed long before it became a technical term—it originally meant hardships and afflictions, as in "the stress of weather"—the earliest modern meanings of the term belong to engineering. In the nineteenth century considerations of stress in a modern sense took shape in several fields: strength of materials, thermodynamics, and medicine. William Rankine (1820–1872), who did pioneering work in civil engineering and thermodynamics, defined stress as the forces a material exerts in response to external forces applied to it. Those engineering developments applied not only in theory but also in practice as the steam engine, railroads, and heavy industry transformed the everyday world. If the resultant stresses are not taken into consideration, buildings and bridges collapse.

At that time physicians turned their attention to engineering aspects of the human body. In the eyes of nineteenth-century physicians, "overstrain" and "overpressure" of the nervous system and the heart produced serious and even fatal diseases. In part, "overstrain of the heart" and "neurasthenia" expressed people's anxiety over the "strange disease of modern life" (Arnold 1853 [1965]) with its harried pace and engineered infrastructure.

Twentieth-Century Developments

In the twentieth century the experimental psychologist Walter B. Cannon (1871–1945) developed the concept of homeostasis to call attention to an organism's response to emergency situations: the fight or flight syndrome. In "The Stresses and Strains of Homeostasis" (1935) Cannon reviewed the forces that lessen the efficiency of homeostatic processes in an organism. The physiologist Hans Selye (1907–1982) studied other endocrine responses to external threats, leading to his concept of stress as "a specific syndrome which consists of all the nonspecifically-induced changes within a biologic system" (Selye 1976, p. 64). Laboratory studies represented the intersection of clinical work in psychosomatic medicine and psychiatry, especially the work of the migraine identifier Harold G. Wolff (1898–1962) and others. Two military psychiatrists, Roy Grinker (1900–1993) and John Spiegel (1911–1991), who treated U.S. Army Air Corps crews published their findings in *Men under Stress* (1945). Through such investigations stress emerged as a central category to describe the effects of modern warfare and then was extended to include all of modern life. The meaning of stress was complicated by the fact that Selye's definition referred to the response, whereas in the other cases it referred to the stimulating cause of psychosomatic distress.

In the 1970s the related notion of trauma, or excessive stress, became a key to legitimating posttraumatic stress disorder as a diagnosis for American veterans of the Vietnam War. Stress as a cause of war neuroses later was extended backward to include puzzling illnesses that appeared during the American Civil War (irritable heart and nostalgia), World War I (shell shock, traumatic neurosis, neurasthenia), and World War II (combat fatigue). Trauma and stress became emblematic of the violence, productive and destructive, of technologically advanced societies.

After the 1950s stress became a key term in cybernetics and the social sciences. In cybernetics and systems theory the concept of stress was applied to all levels of organization, from the cellular to the global, organism and machine. One result has been vagueness in the meaning of the term, especially in the social sciences: Stress can refer to objective features of life events measured by psychological instruments such as the Social Readjustment Rating Scale of Thomas H. Holmes (1918–1988) and Richard H. Rahe (b. 1936), subjective features as in Richard S. Lazarus's (1922–2002) notion of the cognitive appraisal of threat as vital in the stress-coping process, and an interaction between situational and dispositional factors.

Stress as a category has had the most significant impact in the areas of health and work. A stress-diathesis model of illness causation proposes that excessive demands (stress) on adaptive capacities interact with psychosocial and biological predispositions (the diathesis), resulting in the breakdown of the weakest link in an individual's biopsychosocial systems. Thus, one person develops asthma, another depression, and a third cardiovascular disease. Although oversimplified, this suggests the thrust of contemporary thinking about possible causal links between stress and disease. Insofar as considerations of stress affect health, they affect work, and stress management has become important in the regulation of behavior in technologically advanced societies.

Ethics

The ethical implications of stress are twofold. First are the implications that arise from the experience of what is called stress. Stress plays a role in defining the limits of human performance: If demands are excessive, psychological or physical illness can result. Individual, corporate, and social responsibilities for minimizing stress and its effects have become significant. Excessive stress has become the basis for legal action. Although social inequalities are sources of stress, the emphasis in some societies, such as the United States, has been on individuals assuming increased personal responsibility for lifestyle choices that can result from and/or lead to stress and its deleterious effects.

Second are the implications that arise from the way that stress frames the trials and troubles of living. The construct of stress reframes the tribulations of living in rationalized or engineered terms: Stress is what individuals and organizations seek to manage. Ethical considerations thus appear in terms of efficiency and control. Management as the norm for dealing with stress reduces the ethical act to devising means to adjust to ends that may not be questioned.

ROBERT KUGELMANN

SEE ALSO *Psychology; Social Indicators.*

BIBLIOGRAPHY

Arnold, Matthew. (1853 [1965]). "The Scholar–Gipsy." In *The Poems of Matthew Arnold,* ed. Kenneth Allott. New York: Barnes & Noble.

Cannon, Walter B. (1935). "The Stresses and Strains of Homeostasis." *American Journal of the Medical Sciences* 189: 1–14.

Cooper, Cary L., and Philip Dewe. (2004). *Stress: A Brief History*. Oxford: Blackwell. This useful volume gives special attention to work-related stress and to Lazarus's concept of cognitive appraisal.

Grinker, Roy R., and John Spiegel. (1945). *Men under Stress*. Philadelphia: Blakiston. A study of American aviators in World War II and the psychosomatic illnesses many suffered as a result of the stress of war.

Kugelmann, Robert. (1992). *Stress: The Nature and History of Engineered Grief*. Westport, CT: Praeger. A phenomenological and historical study focusing on how it is that people describe life's difficulties as "stressful," and dealing with the ethical implications of stress management.

Selye, Hans. (1950). *The Physiology and Pathology of Exposure to Stress*. Montreal: Acta. Selye here summarized the physiological research on stress, the general adaptation syndrome, and diseases of adaptation.

Selye, Hans. (1976). *The Stress of Life,* revised edition. New York: McGraw-Hill. Selye's classic statement, written for a general audience. Includes what he saw as the ethical implications of his research.

INTERNET RESOURCE

Brown, Stephen D. (1997). "The Life of Stress: Seeing and Saying Dysphoria." Unpublished Ph.D. diss. Reading, UK: University of Reading. Available from http://devpsy.lboro.ac.uk/psygroup/sb/thesis.htm. The history of stress through a poststructuralist approach, looking at theories, practices, and discourses of stress, including the self-help literature. Examines the role of technology and the ethics involved in stress.

SURVEILLANCE

SEE *Monitoring and Surveillance.*

SUSTAINABILITY AND SUSTAINABLE DEVELOPMENT

The concept of sustainable development (SD) has been a part of the global ecological dialogue among scientists and governmental leaders for more than two decades. One outcome of the 1992 United Nations Conference on Environment and Development (UNCED, or the Earth Summit) was The Earth Charter, a policy statement about the ethics of international SD. The Charter opens, "We must join together to bring forth a sustainable global society founded on respect for nature, universal human rights, economic justice, and a culture of peace" (Earth Charter International Secretariat 2000).

This statement captures the ethical context in which policy-makers developed the SD concept.

The most commonly used definition of SD comes from the 1987 report prepared for the Earth Summit, *Our Common Future* (1987). SD is "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987). The 178 heads of state that gathered at the Earth Summit sought to address both the *environmental problem* and the *socioeconomic development problem*. The SD concept presented a paradigm in which officials viewed environment and development as partners rather than adversaries. The WCED view of SD presumed that socioeconomic growth and environmental protection could be reconciled in an equitable manner.

The SD idea contrasts with development that focuses on socioeconomic gain often at the expense of the environment. Some natural resource extractive industries, such as mining and fishing, deplete resources in the name of promoting socioeconomic growth. Unsustainable development, however, can be devastating for the environment and society. In 1992, for instance, the northern cod fishery collapsed in Newfoundland due to overfishing. The government, in light of this natural resource drawdown, called for a two-year moratorium on cod fishing so that the stocks could recover. This action affected thousands of workers (Haedrich and Hamilton 2000). The tension between biological/ecological concerns and human socioeconomic concerns, in this case and others like it, highlights the importance of finding a balance between society and the environment.

While the WCED definition has the greatest international recognition, a range of definitions are associated with SD. David Pearce and colleagues, for example, present a thirteen-page annex of definitions of the term. What the WCED brief definition has in common with others is that it identifies three main, but not equal, SD goals: (a) socioeconomic growth; (b) environmental protection; and (c) social equity. Interest groups highlight different aspects of this three-part definition. The economic concerns of national and transnational industrialists are incorporated into the definition, as are the concerns of environmentalists, and the socioeconomic concerns of nongovernmental organizations and governments wishing to alleviate poverty and injustice.

While the WCED popularized the concept, the phrase *sustainable development* had already been around for at least ten years. The International Union for the Conservation of Nature used the term in *World Conservation Strategy (1980)*. *World Conservation Strategy*, however, emphasizes ecological sustainability, not the integration of ecological, economic, and social sustainability. SD draws upon *limits to growth*, *appropriate and intermediate technologies*, *soft energy paths*, and *ecodevelopment* discourses of the 1970s and 1980s (Humphrey, Lewis, and Buttel 2002, Mitcham 1995).

For example, the limits to growth debate centers around the much-publicized *The Limits to Growth* (1972), a study produced by Donella Meadows and others for the Club of Rome (Humphrey and Buttel 1982, Mitcham 1995). The book presents evidence that severe biophysical constraints would impinge upon the growth and development of societies. *The Limits to Growth* predicts ecological collapse if current growth trends continued in population, industry, and resource use. The study provoked tremendous international debate, attention, and critique (Sandbach 1978). The limits to growth idea became politically unpopular in the less developed countries (the Global South) "on the grounds that it was unjust and unrealistic to expect countries of the [Global] South to abandon their aspirations for economic growth to stabilize the world environment for the benefit of the industrial world" (Buttel 1998, p. 263).

While the limits to growth debate asks whether environmental protection and continued economic growth are compatible, the mainstream SD discourse assumes that the two are complimentary and instead focuses on *how* SD can be achieved (Baker, et al. 1997). The SD discourse does not assume there are fixed limits to socioeconomic development; it is pro-technology, pro-growth, and compromise oriented. The WCED report clearly states, "The concept of sustainable development does imply limits—not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities. But technology and social organization can be both managed and improved to make way for a new era of economic growth" (Ekins 1993, p. 91).

The discourse on SD presents a shift in thinking about human development. SD is presented as a solution to the problems of economic development and environmental degradation. International aid agencies, such as the U.S. Agency for International Development (USAID) and the World Bank, adopted the SD framework for the design of their development programs. The emergence of the concept came at the same time that environmental policymakers began framing environmental problems such as biodiversity loss, the greenhouse effect, and the thinning of the ozone layer, as *global problems*. No longer was it enough to *think globally, act locally*. In an era of globalization, the new interpretation of environmental problems suggested that people must *think globally, act globally*. SD ethically frames many of these actions.

The Definitional Problems of SD

While critics of SD come from many policy positions, they all agree on its lack of clarity. What should be *sustained* in SD: the economy, the environment, human welfare? Whose *needs* and whose *development* should be promoted? What should be *developed?* Is *development* the same as growth? Does development refer to production growth, as is typically indicated by growth of gross national product; does it refer to environmental growth, such as an improvement of environmental resources; or does development refer to growth in human welfare, including health, working conditions, and income distribution? (Ekins 1993). To deal with some of these problems, analysts and communities have begun constructing indicators for SD, such as those being created by "sustainable cities," such as Seattle (Portney 2003).

Some critics of the concept argue that it is old wine in new bottles in that it only requires slight modifications to existing modes of production, existing political structures, and existing values. New laws, international treaties, and better education, among others, will produce SD. Marxist interpretations, such as that put forward by Sharachandra Lélé, note that the concept "Does not contradict the deep-rooted normative notion of development as economic growth. In other words, SD is an attempt to have one's cake and eat it too" (Lélé 1991, p. 618). Fred Buttel, nonetheless, points out some of the advantages of the concept:

> SD still does focus our attention on the two great contradictions of the world today: The long-term compromising of the integrity of ecosystems (local as well as global ones) and the tendency toward reinforcement of the socioeconomic processes of social exclusion of billions of the world's people. Because of its relevance to spotlighting attention on these two great institutional failures of our epoch, SD allows a range of groups to contest structures and policies and to develop alternative visions of the future. (Buttel 1998, p. 265)

The treatment here assumes that there are three realms involved in SD that must be harmonized: ecological, economic, and social. Edward Barbier asserts that the objective of SD is "to maximize the goals across all these systems through an adaptive process of trade-offs (1987, p. 104). In sum, for development to be sustainable, the environment should be protected; people's economic situation should be improved; and social equity should be achieved.

Alternative Theoretical Perspectives on SD

According to some social theorists and science policy analysts, the impending scarcity of oil, the carbon buildup in the atmosphere, and the potential for global climate change are among the leading ecological problems now facing the world. These problems do not speak well for the sustainability of western cultural traditions, such as the national and international expansion of free market capitalism. Yet modern social theorists and science policy analysts are not of one mind as to how science, technology, and society may deal with these ecologically critical, global sustainability issues in the twenty-first century. Three different models to approach a sustainable future are outlined: the conservative, ecological modernization model; the state-oriented, managerial model; and the radical, neo-Marxian model.

THE CONSERVATIVE, ECOLOGICAL MODERNIZATION PERSPECTIVE. Some theorists and science policy analysts foresee the twenty-first century as the period of ecological modernization. As the impending global ecological crisis gathers force, capitalists—the leaders of national and multinational business and industry—will reflect upon their vital predicament and, through the power of the market and innovative technologies, create sustainable societies throughout the world.

In 1997 Amory and Hunter Lovins of the Rocky Mountain Institute together with Ernst von Weizsacher, Director of the Wuppertal Institute (Germany), published *Factor Four: Doubling Wealth, Halving Resource Use*. Their work, in the spirit of ecological modernization, focuses on waging a worldwide *efficiency revolution—increasing energy savings by a factor of four*. They note that, historically, production efficiency improved through technological changes in labor practices: industrialization, automation, and robotics. For them, the new focus of the production efficiency revolution will be gains in the use of natural resources, notably energy. To wage this revolution, they propose harnessing the power of markets through price adjustments to create incentives for technological innovation.

The authors of *Factor Four* cast a wide net, focusing on how the efficiency revolution applies to transportation, design and building methods, natural resource conservation, agriculture, and energy. Common to these ways of using energy and natural resources more efficiently is the argument that "in many cases saving resources could cost less than buying and using them" (von Weizsacher, Lovins, and Lovins 1997, p. 146). Their examples include the Morro Bay, California, homebuilding program. In that program, builders were required to demonstrate that they reduced water consumption by twice what their next new home owners would consume by free installation of water efficient plumbing in already existing homes. Other examples include the use of more costly fluorescent lamps that last ten times longer than incandescent lamps; laptop computers that use one percent of the electricity consumed by desktop units; and more efficient air conditioning, in part through *superwindows* made to emit light, not heat.

Von Weitzsacher, Lovins, and Lovins identify former President Clinton's Partnership for a New Generation of Vehicles as a voice of the efficiency revolution. The hypercar is the centerpiece of this partnership between government and the Big Three U.S. auto makers—DaimlerChrysler, Ford, and General Motors. Capable of making a coast-to-coast trip on a single tank of fuel, the hypercar achieves fuel efficiency through the dual strategy of a streamlined, *slippery* body that is ultralight and a hybrid-electric/gasoline power unit. The hypercar also circumvents the problem of managing the waste build-up of engine batteries that could leak acid into the ground, water, or both.

The ecological modernization approach may contribute to economic growth and environmental protection, however, it is not clear whether it promotes or enlarges social equity. The model has been especially prevalent in Europe (Mol and Spaargaren 2002).

THE STATE-ORIENTED, MANAGERIAL PERSPECTIVE. A managerial approach seeks to reform, but not revolutionize, the existing political and legal structure of societies to achieve SD. Some recent programs undertaken by national governments and government-funded international development agencies exemplify managerial approaches. One such managerial effort is biodiversity conservation. Biodiversity protection addresses the goals of SD by preserving biological diversity and providing the potential for long-term social and economic benefits through sustained resource use and tourism. This effort at SD is exemplified by work on Ecuador done by environmental sociologist Thomas Rudel in 2003.

Esmeraldas, located in northwestern Ecuador, consists of tropical rain forests that contain an array of rarely seen biodiversity. It also has one of the highest deforestation rates in Latin America (between 2–4% annually). The rapid deforestation of this ecologically significant environment drives international efforts to make forestry sustainable in Ecuador. At least three social forces impel the rapid deforestation of Esmeraldas's lush tropical forests: It contains commercially valued hardwood; it is accessible to urban markets; and there is economic and population pressure to attain work logging the rain forest.

Over the last half of the twentieth century, the Ecuadorian government established an extensive set of national parks and forest reserves. Two reserves are located in Esmeraldas, the Cayapas-Mataje Reserve and the Cotacachi-Cayapas Reserve. A state-appointed forest service manages all of Ecuador's forest reserves. The forest service issues logging permits to the urban-based lumber companies and receives a stumpage tax for harvested trees in the reserves. The Ecuadorian government uses the tax receipts to pay forest service officers and to pay off government debt to international economic development agencies. Thus a fourth cause to deforestation in this area is that this state managerial arrangement encourages the exploitation of Ecuador's rain forests.

In spite of this state-induced system of tropical deforestation, increasingly influential national and international environmental groups and development organizations working in Ecuador have managed to promote sustainable forestry practices in the reserves. One such arrangement involves an economic development contract between the Ecuadorian government and USAID. The goal of this program is to form and develop Sustainable Use of Biological Reserves (SUBIR) in Ecuador. Using USAID funds, Ecuadorian officials fund ecologists to set the annual volume of rain forest harvesting equal to the annual rate of rain forest growth in the reserves and buffer zones adjacent to the reserves. In the rural community of Playa de Oro outside of the Cotacachi-Cayapas Reserve, village leaders are trying to take advantage of SUBIR by developing ecotourism. Thus the USAID program is leading to both sustainable forestry and economic growth for a rural village.

In another example, Deutche Gesellschaf fur Technische Zusammenarbeit (GTZ), the German equivalent of USAID, has organized a council of more than fifty Afro-Ecuadorian village leaders to practice sustainable forestry, to bargain collectively with the lumber companies, and to replant whatever trees are harvested. By practicing sustainable forestry, and by gaining a fairer return on the trees harvested in the reserves, Esmeraldas villages are an important, new experiment in sustainability in a highly diverse ecosystem.

These Ecuadorian SD efforts represent two of thirty-two working contracts involving international economic development agencies, national and provincial officials, village leaders, lumber companies, and environmental organizations. These efforts simultaneously attempt to alleviate problems of poverty, inequality, and biodiversity loss through land conservation. They are not without problems; however, they are a concrete attempt at reconciling the tensions between ecological, economic, and social systems.

THE RADICAL, NEO-MARXIAN PERSPECTIVE. Marxists or, in this designation, radicals, conceptualize environmental problems as inherent irrationalities in the capitalist mode of production (Humphrey, Lewis, and Buttel 2002). Radicals insist that economic expansion is the basic causal force by which capitalism resolves economic and social crises. The capitalist class and their allies, such as state officials, deflect discontent with social inequality by perpetuating economic growth necessary for the increased wages and rising material standards of living for the working class. Through this material, wage-based enfranchisement of workers, the capital class avoids the overt repression of workers, protects their own privileged relationship to private property, and garners monetary profit, at a substantial cost to the environment.

Anthropologist Ramachandra Guha's *The Unquiet Woods* (2000) illustrates the radical framework in the context of Badyargah. Located in the foothills of northern India's Himalayas, Badyargah is a cluster of homogeneous, egalitarian rural villages in the state of Tehri Garhwal. For centuries, the villagers of Badyargah, practiced a form of sustainable subsistence agriculture. Badyargah villagers lived well on fresh fish, rice, wheat, millet, and the meat of their lambs and sheep. The sustainability of Badyargah's agriculture began to decline following the first state-subsidized road building in the mid-1960s. At the time India's national government began boosting private capital expansion by awarding private logging contracts to outside lumber companies. Once a national forest surrounding a Badyargah village was harvested, Indian state foresters strictly excluded villagers from reentry to protect the regeneration of commercially valued trees.

Anticipating a particularly large commercial logging contract in 1979, Badyargah village leaders began planning rural, grassroots resistance. They contacted Sunderlal Bahuguna, a leading environmental activist in the Indian hill region. Bahuguna and his followers persuaded residents of forest-dependent villages to practice Chipko. To resist logging, the villagers hug trees. The Chipko movement forces loggers to choose between sparing the trees or taking human lives. As part of this episode, Bahuguna went on a well-publicized hunger strike, and, day and night, 3,000 villagers guarded the site of the anticipated commercial logging. The government and contractor abandoned the logging plans.

This radical, grassroots resistance movement to protect local forests for use by the villagers was by no means an isolated episode in this part of rural India. Local, radical resistance to commercial logging in Tehri Garhwal became so prevalent that the government forestry department declared a fifteen-year, statewide moratorium on commercial logging beginning in 1982. Yet scholarly observers such as Guha do not anticipate the end of the Chipko movement in northern India. The modernization process, driven by capitalism, is bringing large dams, increased mining, and mountaineer tourism into the region. "The intensification of resource exploitation," Guha writes, "has been matched almost step by step with a sustained opposition, in which Chipko has played a crucial role, in catalyzing and broadening the social consciousness of the Himalyan peasantry" (Guha 2000, p. 179). Whether this radical environmentalism will bring back the sustainable rural economy of rural northern India remains to be seen.

Assessment

Beginning with the international debates over the implications of *The Limits to Growth* in the 1970s, scientists, environmentalists, and state officials have extensively engaged in global efforts to seek international consensus about the meaning and practice of SD. SD policies, ultimately, involve ethical decision-making about how science and technology can be applied in economic development efforts worldwide. The examples used to illustrate contemporary SD efforts highlight an important point. There is no one-size-fits-all model of SD.

Ecological modernization appears to be central to SD efforts in the Global North (the more developed, industrialized nations) in the early twenty-first century. Led by profit-oriented entrepreneurs trained in science and technology, ecological modernization aims to ecologize the economies of advanced industrial countries. Ecological modernization as an SD effort, exemplified by the hypercar, has a strong appeal to capitalists and mainline environmental groups. This form of modernization emphasizes ecological rationality in the use of natural resources for profit. Using the ethical criteria for SD, however, indicates that ecological modernization trades off social equity concerns for the sake of environmental and economic gains.

The grassroots, rural resistance movements against modernization in parts of the Global South—exemplified by the Chipko movement in northern India—is an oppositional struggle for SD. Reflecting the Gandhian tradition of nonviolent resistance that brought India to national independence in the mid-twentieth century, the Chipko movement brings sustainable rural subsistence traditions to SD efforts in India. The Chipko movement trades off economic growth for the sake of social equity and environmental integrity.

Rural development in the province of Esmeraldas, Ecuador, underscores the not-one-size-fits-all nature of SD. According to Rudel, forest-dependent organizations in Esmeraldas have initiated lobbying efforts to lift the national ban on timber exports. Because of the sustainable harvesting practiced by these Ecuadorian organizations, and because of the relatively high wages earned by the new logging cooperatives, Esmeraldas's export lumber could be ecologically approved by an international, third party certification agency. This potential certification could mean a higher demand for Ecuadorian tropical woods in the international lumber market. That potential development, in turn, could bring more wealth, sustainable forestry, and, possibly, more income equality among Esmeraldas workers—the three criteria needed for fully meeting the ethical standards for SD. Esmeraldas, thus, could become an exemplary SD model in the early-twenty-first century.

TAMMY L. LEWIS
CRAIG R. HUMPHREY

SEE ALSO *Change and Development; Development Ethics; Ecological Footprint; Ecology; Georgia Basin Futures Project; Mining; Modernization; Progress; Sierra Club; Waste.*

BIBLIOGRAPHY

Baker, Susan; Maria Kousis; Dick Richardsom; and Steven Young. (1997). *The Politics of Sustainable Development: Theory, Policy, and Practice Within the European Union*. London: Routledge.

Barbier, Edward B. (1987). "The Concept of Sustainable Economic Development." *Environmental Conservation* 14(2):101–110.

Buttel, Frederick H. (1998). "Some Observations on States, World Orders, and the Politics of Sustainability." *Organization & Environment* 11: 261–286.

Earth Charter International Secretariat. (n.d.). *The Earth Charter: Promoting Change for Sustainable Development*. San Jose, Costa Rica: Author. A document produced by the 1992 Earth Summit in Rio de Janiero.

Ekins, Paul. (1993). "Making Development Sustainable." In *Global Ecology*, ed. Wolfgang Sachs. London: Zed Books. One of Europe's leading ecological economists outlines three principles to achieve sustainable development in the north and south.

Guha, Ramachandra. (2000). *The Unquiet Woods: Ecological Change and Peasant Resistance in the Himalaya*. Berkeley: University of California Press. A leading environmental anthropologist analyzes the causes of a grassroots struggle to protect sustainable forestry practices in rural India.

Haedrich, Richard L., and Lawrence C. Hamilton. (2000). "The Fall and Future of Newfoundland's Cod Fishery." *Society & Natural Resources* 13: 359–372.

Humphrey, Craig R., and Frederick H. Buttel. (1982). *Environment, Energy, and Society*. Belmont, CA: Wadsworth Publishing.

Humphrey, Craig R.; Tammy L. Lewis; and Frederick H. Buttel. (2002). *Environment, Energy, and Society: A New Synthesis*. Belmont, CA: Wadsworth Publishing. An entire review of environmental sociology, the book includes a unique chapter on sustainable development.

International Union for the Conservation of Nature. (1980). *World Conservation Strategy*. Gland, Switzerland: Author. One of the earliest uses of the term *sustainable development*.

Lélé, Sharachandra M. (1991). "Sustainable Development: A Critical Review." *World Development* 19: 607–621.

Meadow, Donella N.,; Dennis L. Meadows; Jorgen Randers; and William W. Behrens III. (1972). *The Limits to Growth*. New York: Universe. Computer simulations of the world ecosystem suggest that severe biophysical constraints are impinging upon the growth of present-day societies.

Mitcham, Carl. (1995). "The Concept of Sustainable Development: Its Origins and Ambivalence." *Technology and Society* 17: 311–326. This paper, in the author's own words, considers "the historical and philosophical background of sustainability, the immediate origins of the concept of sustainable development, sustainable development and its near neighbors, and critiques of sustainability" (p. 312).

Mol, Arthur P. J., and Gert Spaargaren. (2002). "Ecological Modernization and the Environmental State." In *The Environmental State Under Pressure*, ed. Arthur P. J. Mol and Frederick H. Buttel. Two of Europe's leading social theorists outline the meaning of ecological modernization and its consequences for governments in environmental policy making.

Pearce, David. W.; Anil Markandya; and Edward B. Barbier. (1989). *Blueprint for a Green Economy*. London: Earthscan.

Portney, Kent E. (2003). *Taking Sustainable Cities Seriously: Economic Development, the Environment, and Quality of Life In American Cities*. Cambridge, Mass.: MIT Press.

Rudel, Thomas K. (2003) "Organizing for Sustainable Development: The Biodiversity Crisis and an Encompassing Organization in Esmeraldas, Ecuador." In *Environment, Energy and Society: Exemplary Works*, eds. Craig R. Humphrey; Tammy L. Lewis; and Frederick H. Buttel. Belmont, CA: Wadsworth Publishing. An environmental sociologist reports on a case from the tropical rainforest in Ecuador that has achieved some success in moving toward sustainable development.

Sandbach, Francis. (1978). " The Rise and Fall of the *Limits to Growth* Debate." *Social Studies of Science* 8: 495–520.

Von Weitzsacher, Ernst; Amory Lovins; and Hunter Lovins. (1997). *Doubling Wealth, Halving Resource Use*. London: Earthscan.

World Commission on Environment and Development. (1987). *Our Common Future*. New York: Oxford University Press. Contains the classic or standard definition of SD.

SYSTEMS AND SYSTEMS THINKING

A system is defined by a set of distinctive relationships among a group of components that interact with one another and their environment through the exchange of energy, matter, and/or information. These relationships produce a new entity, the whole, that requires its own level of analysis. The technical use of the concept of a system in science and technology dates back to the 1950s. Systems thinking subsequently become a catchall term for different postwar developments in a variety of fields, such as cybernetics, information theory, network theory, game theory, automaton theory, systems science and engineering, and operations research. An underlying theme in these developments is a shift from reductionistic thinking and compartmentalized organization to holistic thinking aimed at understanding linkages among parts and increasing organizational communication. The rise of systems thinking has broad ethical and societal implications that range from practical changes in public decision making to the emergence of a worldview critical of some instances of scientific and technological hubris.

A Taxonomic History

During the second half of the twentieth century amalgams of the terms *system* and *systems* became ubiquitous. Computer and operating systems were joined by biological, business, and political systems. Systems science and systems engineering were complemented by systems management, systems medicine, and the practice of looking at the earth as a system. However, the systems thinking in all these cases can be divided into three basic types: systems theory, systems methodology, and systems philosophy. In the history of systems thinking each realm has followed its own path, with many overlaps and interactions.

SYSTEMS THEORY. The birth of systems theory took place in the technical sciences during World War II when the scientist Norbert Wiener (1894–1964) studied control problems with antiaircraft fire. Those studies concerning communication and control in particular technical systems inspired Wiener to more general reflections on what he came to call the science of cybernetics (Wiener 1948). Although Wiener did not stress the system concept, system, he argued in effect that any type of system can be understood with the help of general laws or principles. In Wiener's cybernetics two main ideas figure: feedback, with its regulating and stabilizing properties, and transmission of information, which helps transform the many parts of a complex system into a whole. A mathematical elaboration of the concept of information was developed by Claude E. Shannon (1916–2001).

The success of cybernetics and information theory created a fertile climate for a theoretical movement based on new principles and oriented toward concepts such as system, organization, and regulation. A leading figure in the rise and development of systems theory was the biologist-philosopher Ludwig von Bertalanffy (1901–1972), who attempted to overcome mechanistic reductionism, in biology in particular but also in scientific thought in general, and persistently opposed a machine view of the world. Although he agreed with Wiener that cybernetics can provide insights into the teleological behavior of systems, he argued that the principle of feedback adopts essentially a machine view.

For von Bertalanffy (1968) a machine is composed of durable components and therefore is primarily static in character. A characteristic of the cybernetic model is that fixed structures must be present to make regulation by feedback possible. An organism, however, is characterized primarily by a dynamic ordering and maintains its structures in a continuous process of building up and breaking down (e.g., human red blood cells are replaced at a rate of 2 million to 3 million per second). The organism is thus not a closed system with a static mechanical structure but an open system in flowing or dynamic equilibrium. Such systems also are characterized by emergent properties: characteristics that are not evident when one studies system components in isolation from one another. Systems theory often is seen as a way to retain holism and organicism without positing teleological or vitalist philosophies.

Opposing Wiener's claim that the cybernetic model is the basis for a universal science, von Bertalanffy argued that the open-system model has universal validity and provides the proper foundation for a "general system theory." In 1954 he and others, among them Kenneth Boulding, Anatol Rapoport, and Ralph Gerard, founded the Society for General Systems Research, which later was renamed the International Society for the Systems Sciences (ISSS). The ISSS brought together areas of research with dissimilar contents but similar structures or philosophical bases to enable researchers in various fields to develop a common language. Systems theory in this sense aspired to become a transdisciplinary science.

Systems theory and the quest for a general systems theory received a new impetus in the 1960s when Heinz von Foerster (1911–2002) introduced the concept of self-organization and later, in the 1970s, when Humberto R. Maturana and Francisco J. Varela (1980) proposed the concept of autopoiesis and developed the model of the organism as an autopoietic system. The term *autopoiesis* means "self-creation" and refers to the propensity of living and certain other nonequilibrium systems to remain stable for long periods despite the fact that matter and energy flow through them. Ilya Prigogine (1917–2003) further refined systems theory with the notion of dissipative systems: open systems that exchange energy, matter, and information with their environment; operate far from thermodynamic equilibrium; and display the spontaneous appearance of complex organization.

According to the social theorist Niklas Luhmann (1995), the concepts of self-organization and autopoiesis allow a further step, moving from a general systems theory based on the open-system model to a general theory of self-referential systems of social meaning and communication. Luhmann's application of systems theory to modern societies rejected the normative orientation of sociologists such as Émile Durkheim (1858–1917) and Talcott Parsons (1902–1979). He argued instead that systems theory has to drop all references to actors and their self-interpretations and focus on the ways in which complex social systems arise, much as living organisms do, through autopoiesis.

SYSTEMS METHODOLOGY. Systems methodology is concerned with the scientific method for approaching practical problems in technology and society. It may be defined as the theoretical study of practice-oriented methods in science and engineering, in which the notion of the system indicates an approach that is intended to be integrating and holistic. As with systems theory, systems methodology arose out of postwar developments in technology, in this case systems engineering and operations research. Although operations research usually is concerned with the operation of an existing system, systems engineering investigates the planning and design of new systems.

The dominance of reductionistic and mechanistic thinking that was criticized by von Bertalanffy (1968) in his quest for a general system theory also became an important issue in systems methodology. As a leading representative, Russell L. Ackoff (1974) defended a systems approach to counter what he called "Machine Age" thinking. Together with C. West Churchman he founded one of the first systems groups in the United States at the philosophy department at the University of Pennsylvania shortly after World War II. Comparable developments took place in England at the University of Lancaster with the pioneering work of Geoffrey Vickers and Peter Checkland. Checkland observed that variants of systems thinking transferred from technology to the social domain were not especially successful. Following from that observation Checkland started to seek an alternative for the engineer's approach and tried to shift from what he called "hard systems thinking" (technical, quantitative models) to "soft systems thinking" (the incorporation of human values and perspectives).

A new impetus to the development of systems methodology came from the work of the social theorist and philosopher Jürgen Habermas (b. 1929). Habermas critiqued the dominance of technical categories in Luhmann's theory and the absence of human actors with conscious intentions in the development of modern society. In the 1980s this inspired a younger generation to work out a program termed critical systems thinking. Michael Jackson, Robert Flood, and Werner Ulrich became influential in this area.

In the late 1990s, inspired by the legacy of the Dutch philosopher and legal theorist Herman Dooyeweerd (1894–1977) an attempt was made in systems thinking to break with the Western idea of human autonomy and autonomous rationality. Fundamental to that research program was the notion of intrinsic meaning and the normativity of reality. Merging Dooyeweerd's theory of modalities and Stafford Beer's cybernetic theory of management, J. D. R. de Raadt launched "multi-modal systems thinking." Sytse Strijbos followed another more radical strategy by focusing on the underlying ontology and philosophical underpinnings of systems methodology. Borrowing from Dooyeweerd's notion of disclosure, Strijbos laid the foundations of "disclosive systems thinking." Industrial ecology and product life-cycle analyses are other versions of systems methodology that are used to make large-scale decisions with the goal of achieving sustainable energy and material flows (Graedel and Allenby 2003).

SYSTEMS PHILOSOPHY. Although systems philosophy was mentioned earlier in conjunction with systems theory (Wiener, von Bertalanffy, and others all attempted to develop the philosophical implications of their work) and systems methodology (for a while Ackoff and Churchman were based in an academic philosophy department), this approach merits independent recognition. In the 1970s, for instance, the Hungarian philosopher Ervin Laszlo tried to build on von Bertalanffy's ideas for a new scientific worldview, including a philosophy of nature, to develop a systems philosophy that would bring the latest developments in science to bear in conceptualizing the social problems of the emerging global society (Laszlo 1972). However, for clarity it is useful to distinguish at least four senses in which the terms *system* and *philosophy* have been connected.

First, there is the traditional sense in which philosophy aspires to be systematic, that is, to cover all the basic issues in a manner that properly subordinates and relates them. It is in this sense that one speaks of a philosophical system such as those of the philosophers Immanuel Kant (1724–1804) and Georg Friedrich Wilhelm Hegel (1770–1831). This is the oldest but in the current instance least significant connection.

Second, in the 1970s Laszlo aspired to formulate a systems philosophy keyed to the latest developments in science and to the urgent problems of contemporary global society. This type of systems thinking plays heavily into larger changes both in cultural norms and in social laws and institutions. Laszlo has been a prolific author whose books range from promotional work on systems philosophy to analyses of world modeling, sustainability, globalization, consciousness, and future studies. He is the founding editor of *World Futures: The Journal of General Evolution*, which began publication in 1980. Systems philosophers of this type often draw inspiration from process philosophy, especially the ideas of Alfred North Whitehead (1861–1947).

A more hard-nosed version of systems philosophy is found in the work of the Argentine-Canadian philosopher Mario Bunge (1979). For Bunge systems science is a research program for the construction of a "scientific metaphysics" built on well-defined, scientifically based concepts but having broad generality.

Third, systems philosophy deals with the philosophical issues of systems theory. Systems philosophy in this sense may be related to philosophical analyses of chaos and complexity and efforts to draw from those studies general implications for understanding nature and acting in the world. Chaos theory and complexity theory especially emphasize emergent properties and the self-organization of complex systems.

Fourth, systems philosophy concerns the philosophical foundations of systems methodology and thus deals with issues about human intervention in the world. It is a distinguishing feature of E. G. Churchman's work in management science that it closely connected with a philosophy of the systems approach. Management to Churchman has to deal with the ethical challenge to design improvement. But what constitutes an improvement and how can we design improvement without understanding the whole system?

Implications and Assessment

Systems thinking denotes the effort to define a nonreductive method for conceptualizing and explaining phenomena in both nature and society. As such it has a number of ethical and political implications that may be indicated roughly as follows.

First, systems thinking often claims to give a better account of the genealogy of ethics than did previous analyses. Ethics is described as an emergent property of complex living systems. Second, the opposition of systems thinking to nonsystems thinking almost always has a moral dimension. Systems thinking is said to be superior to nonsystems thinking in both theory and practice because it understands the world more accurately and provides better guidance for human action. Just as systems science yields better knowledge of the complexities of nature and artifice, systems engineering and systems management ground more effective interventions in nature, the construction of large-scale artificial systems, and the maintenance and management of their complex interactions.

These morally flavored claims can, however, cut two ways: to promote science and technology or to delimit them. On the one hand, systems thinking has played a large role in advancing scientific knowledge and technological development in the post–World War II era. It has done this both in the form of specific methodologies and theories and in the inculcation of a general receptivity to and awareness of interconnectivity in scientific and engineering communities. Some of its most significant impacts have occurred in biology, especially in the rise of ecology and in refinements of genomics. Institutional changes in the social structure of knowledge, especially increased interdisciplinarity, also have resulted from systems thinking.

On the other hand, systems thinking at times has criticized the modern scientific and technological project. In this critique of technological hubris, connections can be developed easily, for instance, between systems thinking and environmental thinking. Although he did not use the term, Aldo Leopold (1887–1948) essentially argued that the concept of the system forms the foundation of ethics: "All ethics so far evolved rest upon a single premise: that the individual is a member of a community of interdependent parts" (Leopold 1949, p. 203).

In a like manner Fritjof Capra (1997) has argued that new research on the organization of living systems promotes a reexamination of social policies. Systems thinking is both a scientific shift and a cultural paradigm shift away from mechanism and reductionism, but the relationship between those two shifts is complex and ethically charged. Capra, for instance, argues that systems research supports social egalitarianism, but that argument raises ethical questions about deriving political and moral conclusions from observations about nature. This is the same dilemma often raised by political conclusions drawn from the more reductionistic theories of sociobiology. The focus on wholeness, interconnectedness, and complexity thus has had an ambiguous impact on the larger realm of cultural and philosophical thought.

Thus, although it doubtlessly has been associated with some criticisms of technological and scientific hubris, systems thinking also has generated new versions of that hubris. For example, Luhmann's brand of systems thinking seeks to abstract a "grand theory" or a universal framework that is not concerned with individual humans, only the abstractions of information exchange. That led Habermas to label it as a version of "antihumanistic" sociology that denies the ability of individuals and institutions to guide social change consciously. Indeed, worldviews that stress holism always create a risk of losing lose sight of individual values such as dignity, freedom, and intentionality. In this case modern societies are seen as polycentric, and democratic participation and control as illusory, in the face of overwhelming complexity. However, it is difficult to conceive of justice and many other social values being realized by an autopoietic process devoid of intentional agency.

Similar two-sided features can be identified in proposals by Brad Allenby and others for the development of earth systems engineering and management. The bottom line is that systems and systems thinking remain ambivalent in their ethical import with regard to science and technology, but that ambivalence also may be their basic strength. Surely there is a sense in which science and technology need to be promoted and criticized at the same time.

SYTSE STRIJBOS
CARL MITCHAM

SEE ALSO *Complexity and Chaos; Reliability of Technology: Technical and Social Dimensions; Soft Systems Methodology.*

BIBLIOGRAPHY

Ackoff, Russell L. (1974). *Redesigning the Future: A Systems Approach to Societal Problems*. New York: John Wiley & Sons. The crux of the book is the provocative claim that "God's work is to create the future. Man must take it away from Him."

Beer, Stafford. (1959). *Cybernetics and Management*. New York: Wiley. The first of several books in which the author has developed his Viable System Model. Invited by President Salvador Allende, he applied this cybernetic model in the early 1970s in an ambitious project to regulate the whole social economy of Chile.

Bunge, Mario. (1979). *A World of Systems*. Boston: D. Reidel. This constitutes volume 4, part 2, of Bunge's *Treatise on Basic Philosophy*.

Capra, Fritjof. (1997). *The Web of Life: A New Scientific Understanding of Living Systems*. New York: Anchor.

Churchman, C. West. (1968). *The Systems Approach*. New York: Dell. A slightly revised and updated version appeared in 1979.

Flood, Robert L. (1990). *Liberating Systems Theory*. New York: Plenum. First volume in the series "Contemporary Systems Thinking," series ed. Robert L. Flood.

Graedel, T. E., and B. R. Allenby. (2003). *Industrial Ecology*. Upper Saddle River, NJ: Prentice-Hall. The field of industrial ecology has quickly developed since the 1990s as one of the latest separate branches of systems thinking and practice.

Laszlo, Ervin. (1972). *The Systems View of the World: The Natural Philosophy of the New Developments in the Sciences*. New York: George Braziller. See also the subsequent update of this book, *The Systems View of the World: A Holistic Vision for Our Time*. Cresskill, NJ: Hampton Press, 1996.

Leopold, Aldo. (1949). *A Sand County Almanac: And Sketches Here and There*. London: Oxford University Press.

Luhmann, Niklas. (1995). *Social Systems*, trans. John Bednarz, Jr. Stanford, CA: Stanford University Press. Originally published in German in 1984.

Maturana, Humberto R., and Francisco J. Varela. (1980). *Autopoiesis and Cognition: The Realization of the Living*. Boston: D. Reidel.

Strijbos, Sytse. (1988). *Het Technische Wereldbeeld: Een wijsgerig onderzoek van het systeemdenken* [The Technical Worldview: A philosophical investigation of systems thinking]. Amsterdam: Buijten and Schipperheijn. The study gives a critical discussion of important sources of systems thinking and of a fundamental philosophical critique. It focuses on the claim made by Von Bertalanffy and a "group" around him that systems thinking overthrows the technical worldview and establishes a new conception in place.

Von Bertalanffy, Ludwig. (1968). *General System Theory: Foundations, Development, Applications*. New York: George Braziller. A classic study in systems theory.

Wiener, Norbert. (1948). *Cybernetics: Or, Control and Communication in the Animal and the Machine. A classic study in systems thinking.* New York: Wiley.

T

TAYLOR, FREDERICK W.

Frederick Winslow Taylor (1856–1915), who believed that his system of scientific management provided the foundations for a scientific ethics, was born in Germantown, Pennsylvania, on March 20. His early education took place in private schools in Pennsylvania, Europe, and New Hampshire, and he was accepted for admission into Harvard University. But fascinated by the relationship among science, technology, and ethics, he decided on an apprenticeship at a steel company in Philadelphia, where, from 1878 to 1884, he advanced from common laborer to a supervisory mechanical engineer. In the process he became familiar with *soldiering,* when workers, to protect jobs and keep piece-rates high, increased output while bosses were watching and decreased it otherwise. An ardent believer in the Puritan work ethic, Taylor was troubled by this inefficient and unethical behavior, and came to believe that he had a solution not only for the Midvale Steel Company but for institutions throughout the world. He pursued this vision until his death in Philadelphia, Pennsylvania, on March 21.

Frederick W. Taylor, 1856–1915. Taylor consolidated a system of managerial authority, often referred to as scientific management, that encouraged a shift in knowledge of production from the workers to the managers. *(© Bettmann/Corbis.)*

Taylor's Studies

Taylor began by systematically studying machinery and human beings to discover precisely how much a diligent worker, using the best machines and procedures, could produce in a day. For example, his empirical analysis of metal-cutting machinery allowed him to more than double the machine's speed, and by analyzing the machinist's procedures into elementary motions, and timing them with a stop watch, he was able to minimize wasteful motions and optimize beneficial ones. This led to a belief that all tasks, from the lowliest to the highest, could be made more efficient, and the resulting increase in productivity would optimize everyone's compensation and job satisfaction. He argued that a "single best way" existed for accomplishing every task, and that his scientific analysis of human technology interventions achieved an ethical goal: the resolution of the age-old conflict between labor and management.

After Taylor left Midvale in 1890, he spread the gospel of scientific management while occupying a series of positions from Maine to Wisconsin. He lived at a time when many Americans believed science and technology had the solution to many problems of humanity, but also during a time when bitter strikes sometimes resulted in the deaths of workers. Labor leaders and politicians criticized Taylor's claim that his system would end owner-worker hostility and render unions and strikes unnecessary. They pointed out that workers could not be treated in the same way as machines, and that several creative ways existed for accomplishing tasks rather than Taylor's one best way. Others questioned Taylor's yoking of productivity and morality. Taylor emphasized that wise work produced ethical workers, whereas others insisted that human morality motivated hard work.

During the final decades of Taylor's life, his obsession with efficiency deepened. Managers as well as laborers often resented his despotic attempts to change traditional methods of work and management. To those who said that scientific management was antidemocratic, he insisted that his techniques energized workers, promoted their self-reliance, increased their wages, and shortened their work week. To those who said that scientific management was unethical, he emphasized that his methods enhanced fellow feeling among workers and between workers and managers because he promoted true justice by encouraging the maximum efficiency and prosperity of all those involved in his system. But labor leaders and some politicians saw scientific management simply as a tool for maximizing production and profits to the neglect of the emotional and physical health of the workers. For them, Taylor's methods debilitated workers and increased accidents.

Taylor's Influence

In the early decades of the twentieth century, Taylor's ideas continued to generate both critics and advocates. In 1911 Taylor's disciples founded the Society to Promote the Science of Management (called, after his death, the Taylor Society) and he himself published *The Principles of Scientific Management*. In 1912 Taylor's system was debated at a Congressional hearing during which he defended his system as a force for good, but some committee members felt that he did not grasp the deep asymmetry between labor and management. Nevertheless, in its report the committee found some things to praise in scientific management—for example, standardization.

In the years after Taylor's death, Taylorism spread around the world. Taylor's disciples preached the gospel of efficiency to a wider audience than just businessmen—including housewives, teachers, even clergy. Like Taylor, his disciples viewed his doctrines as a means of transforming society, because the pivotal point differentiating civilized from uncivilized societies was productivity. Some of Taylor's disciples criticized their master—for example, Frank Gilbreth advocated replacing stopwatch studies with "micromotion" analyses in which each minute of a worker's activities was filmed and divided into a hundred units. Even Vladimir Lenin was influenced and thought Taylorism compatible with communism.

However, humanists such as Lewis Mumford (1895–1990) felt that Taylor's system got it backward: Humans come before and transcend systems. Some even saw Taylorism as deeply unethical, because its mechanistic treatment of workers was both an illusion and a delusion. During the twentieth century scientific management evolved and diversified, and it was no longer a unified and consistent body of thought. Although Taylor's goals of establishing social and economic justice and ending class conflict have not been achieved, his ideas, transformed and diversified, continue to influence various ideologies of science, technology, and ethics.

ROBERT J. PARADOWSKI

SEE ALSO *Management.*

BIBLIOGRAPHY

Copley, Frank Barkley. (1923). *Frederick W. Taylor: Father of Scientific Management*, 2 volumes. New York: Harper. For many years this was the standard biography, but it tends to be hagiographical.

Haber, Samuel. (1964). *Efficiency and Uplift: Scientific Management in the Progressive Era, 1890–1920*. Chicago: University of Chicago Press. An analysis of how some Taylor disciples created reform programs "without an appeal to conscience."

Kanigel, Robert. (1997). *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency*. New York: Viking. The best critical biography of scientific management's founder.

Nadworny, Milton J. (1955). *Scientific Management and the Unions, 1900–1922*. Cambridge, MA: Harvard University Press. Historical study that emphasizes industrial relations, industrial management, and syndicalism in the United States.

Nelson, Daniel. (1980). *Frederick W. Taylor and the Rise of Scientific Management*. Madison: University of Wisconsin Press. A chronological account of an "unlikely revolutionary" that stresses Taylor's interaction with contemporary businesses and his relationship to workers.

Taylor, Frederick Winslow. (1947 [1911]). *The Principles of Scientific Management*. New York: Harp. Taylor's best and most influential account of his ideas.

TECHNICAL FUNCTIONS

One common way to describe artifacts is in terms of how they technically *function*. In a telephone sound is transformed into electronic signals that are then transmitted over some distance and transformed back into sound by another telephone. Such technical functions are strongly related to human uses. Telephones are designed and built so that they can be used for transmitting the human voice over distances well beyond its normal range. Because references to technical functions are often the basis for assessing human uses of artifacts, and insofar as such assessments express certain values, the relation between technical functions and uses is an issue for any ethics of technology.

Judging Actions and Artifacts

All intentional human behaviors or actions are subject to normative judgments. These judgments are of two sorts: deontic and evaluative. Deontic judgments express what one ought and ought not to do or what one has reasons for doing. Evaluative judgments describe something as good or bad. Using an artifact is subject to these types of judgments, in the first place because it is a form of action. It is generally wrong, for example, to hurt another person with a knife, which is merely a specification of the judgment that one ought, generally, not to hurt someone.

Additionally, however, the use of artifacts is subject to judgments that relate directly to the particular function of the artifact. For instance, one may say that it is wrong to use a Phillips screwdriver to open a paint can. Assuming that the attempt to open the can is itself perfectly in order, the *wrong* here is not morally wrong but *instrumentally* or functionally wrong: Using the Phillips screwdriver will not smoothly lead to the desired outcome. Typical for artifact use, such judgments may be translated, so to speak, to the artifacts themselves. An artifact is said to perform its function well or to function poorly or to malfunction. One can also say that a particular artifact, in the prevailing circumstances, *ought to do such-and-such a thing*. Even natural objects can, in a context of use, be subject to such judgments, for instance when one says that a particular stone is *a good stone to use as a hammer*.

Functions

The use of the term function in the previous paragraphs sets aside a considerable philosophical debate about the meaning of functions, one that has taken place largely in relation to the analysis of functions in biology (the function of the heart is to pump blood) and the social sciences (the function of religion is to create social cohesion).

Briefly there are two major competing concepts of functions: system functions as first stated by Robert Cummins, and proper functions as first stated by Larry Wright (1973) and further analyzed by Ruth Millikan, Karen Neander, and others. According to Cummins (1975), who is primarily concerned with biological systems, something has a function insofar as it contributes to the capacity of some system. According to Millikan, by contrast, the *proper* function of an organ or system is what helps to account for the survival and proliferation of its ancestors (1993). Millikan aims for a theory of functions that applies to artifacts as well as organisms.

Against these attempts to bring all uses of the notion of function under a single theory, Beth Preston (1998) argues for a *pluralistic theory of functions* that includes Cummins's system functions and Millikan's proper functions. Wybo Houkes and Pieter Vermaas (2004) hold that theories of artifacts are overly function-oriented and that a theory of artifact functions can be derived from a theory of artifact actions. For Preston, as well as for Houkes and Vermaas and for many others, functions often become the locus in both science and technology for the uniting of deontic and evaluative judgments.

Uniting Deontic and Evaluative Judgments

There is, however, no consensus of what precisely unites deontic and evaluative judgments insofar as they jointly comprise the realm of the normative. One account proposed by Joseph Raz (1999) and Jonathan Dancy (2005) holds that normative facts are facts expressing how other facts—natural or positive facts—matter to the question how to act. The deontic judgment that *To do X is right* then expresses the normative fact that there is the positive fact of X possessing certain features, *and* that these features are such that, in the circumstances at hand, the balance of reasons points toward the doing of X. The evaluative judgment that *X is good* similarly expresses the normative fact that the features of X are such that one has reason, perhaps even a compelling reason, to adopt a certain positive attitude toward X. What this positive attitude could be depends on the nature of X.

In contrast to a lack of clarity concerning the normative in general, there is wide agreement among philosophers that *instrumental* value should be sharply distinguished from *moral* or *ethical* value. To see the difference between these two forms of value, consider the statement: This is a good knife to kill Mrs. Robinson with. The knife is instrumentally good as a *means* to an end, but the *end*, the killing of Mrs. Robinson, is *morally bad.* One has reason to disapprove of Mrs. Robinson's violent death, and ought to prevent it. But *given* that the killing of Mrs. Robinson is sought, to do it with this knife may be considered a good and recommendable choice. Instrumental value is therefore in a sense conditional: It concerns the fitness of a particular means to the realization of an end once that end is given, whereas it is not concerned with any pros or cons regarding the end itself.

The distinction between moral value and instrumental value is closely related to a distinction among the sorts of reasons that back up an act or an attitude or a belief. If means M is fit to end E such that one ought to choose M or choose to do M, this concerns an ought on rational grounds. By contrast, if M is morally good or bad, such that one ought to approve or disapprove of M, this concerns an ought on moral grounds. This way of distinguishing rational grounds from moral grounds sees the notion of rationality exclusively as instrumental rationality. Not all philosophers will agree, however, that rationality should be viewed thus.

Designing and Using Artifacts

The design and use of artifacts is involved with both kinds of grounds for normative judgments, but in particular cases it is not always obvious whether one or the other kind is at issue. Malfunction judgments and judgments of poor or proper functioning certainly have a special relation to considerations of rationality. A statement such as *Artifact A malfunctions* expresses the positive fact that A does not or will not show the behavior it was designed to show. However, this positive fact does not exhaust the meaning of the statement. It also seems that when an artifact malfunctions or functions poorly, human beings *by definition* have a reason not to use it, or at least not to use it as designed, on rational grounds. One cannot go as far as saying that the notion of malfunction or of poor functioning semantically implies that the item ought not be used. There may be reasons such that, on balance, it is rational to use the thing anyway. But if one applies the judgment of malfunction prior to any considerations of use, as a mere factual statement of the artifact's failure to show a certain behavior, it makes no sense to then ask whether that fact means anything about what one will do with the artifact. When an artifact is said to malfunction, one necessarily has at least *a* reason not to use it as designed.

Similarly to say that a particular artifact functions well is not just to say that it shows a certain behavior, as a positive fact, regardless of anything that one might do with it. This judgment implies that the item shows a particular behavior and that one has a reason to use it as designed. In this case, however, the conditionality of instrumental reason really has a bite: One has an overall reason to use something to produce the result that using the artifact in question produces. If one does not have a reason to use a car in the first place, because one is not going anywhere, then neither does one have a reason to use this particular car, which happens to be a very good car.

Whether one also has a reason *on moral grounds* not to use a malfunctioning or poorly functioning artifact, or even ought not to use such an artifact on moral grounds, is a question that raises different issues. The judgment might be motivated, for instance, by fear that the artifact's use would pose a hazard for other people. But such judgment often depends on the particular case at hand and thus is not covered in the *meaning* of malfunction. It is hardly worthwhile to discourage someone from using a Phillips screwdriver to open a paint can on moral grounds.

The rationality of artifact use depends critically on knowledge. To judge that the use of a particular object is the best means to achieve a certain goal requires an adequate knowledge of the object's properties and the effects of manipulating it in the prevailing circumstances. The use of the object can be rational only to the extent that the user's beliefs about the object are rationally justified. Rationally, in this sense, refers to *epistemic* rationality, and not *practical* rationality, which was the form of rationality relevant in the preceding considerations. In practical rationality, the issue is what it is best to *do,* or what one has a reason to do, given one's end of realizing a particular situation. For epistemic rationality the issue is what it is best to *believe,* or what beliefs one has a reason to adopt, given the end of holding as many true beliefs as possible or holding only true beliefs.

Proper Use and Good Design

When someone uses an artifact in disregard of its designed function, that is, according to some privately conceived use plan, reasons of epistemic rationality seem all that matter. (The concept of function as a use plan is developed at length by Houkes, Vermaas, Dorst and de Vries, 2002.) When the artifact's use fails to have the desired result, there is no one to blame. This is no longer true when an artifact is used for its designed function, in circumstances that are consistent with the artifact's use plan as explicated in the instructions for use. When handing over an artifact to a client who ordered it, or to the market, the designer/producer is committed to the veracity of the predictions made about the artifact's behavior. These predictions have the force of a promise, and the commitment accordingly has the character of a moral obligation. One could say that a designer ought, on moral grounds, to be epistemically rational. In practice the extent of this obligation is articulated in the form of standards that say how much research and testing is sufficient to vindicate the claims that are to be made about the artifact's performance.

It is part of the human condition that neither the criteria of epistemic and practical rationality nor the criteria of moral obligations can guarantee the realization of plans. One may be disappointed by fellow human beings as well as, metaphorically speaking, by nature. The ubiquity of uncertainty shows in the use of language when one says that a particular artifact *ought to do* something when handled in a certain way. This may express the idea that one is epistemically justified in one's belief that the artifact will perform as expected, given the amount of research and testing adopted in designing or in repairing the artifact, but at the same time there is a recognition that there is always the possibility that something was overlooked. The statement may also express the idea that one *has a right* to the artifact's performance, on the basis of a promise by a designer/producer, retailer, or repair service person, while there is at the same time the awareness that such promises are occasionally broken.

It seems natural that in what is summarily described as *good design* the grounds distinguished above play a role. An artifact that can be termed a good design must be instrumentally fit for its function in a range of plausible circumstances. However a well-designed artifact must also be one that it is morally vindicated to use. This can either mean that it is not likely to lead to outcomes of low moral value, for instance by being safe, or that it is likely to lead to outcomes of high value, which will often be a comparative matter.

Thus the features of a particular artifact may give rise to reasons, even compelling reasons, for its use in order to contribute to the realization of one's goals, by which such artifact is instrumentally good. It may also have features such that one has reasons, even compelling reasons, to approve and promote its use, by which it is morally or ethically good. Additionally, artifacts are often judged on the basis of a third criterion, previously not discussed, namely aesthetic appeal. Technical artifacts may have both instrumental and ethical value, or both instrumental and aesthetical value, or even all three. Some trash receptacle for public use may not only function perfectly as a trash receptacle, but it may also encourage people to use it to a larger extent than another type of trash receptacle, and on top of that be considered a beautiful object.

MAARTEN FRANSSEN

SEE ALSO *Engineering Design Ethics; Engineering Ethics.*

BIBLIOGRAPHY

Audi, Robert. (1989). *Practical Reasoning*. London: Routledge. An introductory text on practical rationality.

Cummins, Robert. (1975). "Functional Analysis." *Journal of Philosophy* 72(20): 741–765. The classical text for the theory that an object's function is its contribution to the overall behavior of a system of which it is a part.

Dancy, Joseph. (2005). "Ethical Non-Naturalism." In *The Oxford Handbook of Ethical Theory*, ed. David Copp. Oxford: Oxford University Press. Proposes, among other things, a general characterization of normativity.

Fransen, Maarten. (2005). "The Normativity of Artefacts." *Studies in History and Philosophy of Science* 36(x). Analyzes the interrelations between the various normative statements in which artifacts figure and their grounding on criteria of rationality and morality.

Grice, Paul. (1991). *The Conception of Value*. Oxford: Oxford University Press. A general text on the notion of value and evaluation.

Houkes, Wybo, and Pieter Vermaas. (2004). "Actions versus Functions: A Plea for an Alternative Metaphysics of Artifacts." *The Monist* 87(1): 52–71. Argues that use is a more basic notion to make sense of artifacts than function. Discusses (ir)rational and (im)proper use of artifacts.

Houkes,Wybo; Pieter Vermaas; Cees Dorst; and Marc de Vries. (2002). "Design and Use as Plans: An Action-Theoretical Account." *Design Studies* 23(3): 303–320. Develops the notion that the function of an artifact has to be understood from the role it plays in a use plan by which an individual seeks to produce a certain end.

Korsgaard, Christine. (1996). *The Sources of Normativity*. Cambridge, UK: Cambridge University Press. A general philosophical text discussing various conceptions of normativity.

Millikan, Ruth Garrett. (1993). *White Queen Psychology and Other Essays for Alice*. Cambridge, MA: MIT Press. This is a more accessible statement of a view first argued in Millikan's *Language, Thought, and Other Biological Categories: New Foundations for Realism*, Cambridge, MA: MIT Press, 1984, that all functional statements, including those concerning the function of language and the meaning of sentences, an be grounded in terms of evolutionary biology.

Preston, Beth. (1998). "Why is a Wing like a Spoon? A Pluralist Theory of Function." *Journal of Philosophy* 95(5): 215–254. Argues that only a pluralist theory of function is able to do justice to biological as well as artifact functions.

Raz, Joseph. (1999). *Engaging Reason: On the Theory of Value and Action*, 2nd edition. Oxford: Oxford University Press. An important text, first published in 1975, on the relation between value and reasons for acting.

Wright, Georg Henrik von. (1963). *The Varieties of Goodness*. London: Routledge & Kegan Paul; New York: The Humanities Press. Discusses the interrelations among a broad spectrum of evaluative terms.

Wright, Larry. (1973). "Functions." *Philosophical Review* 82(2): 139–168. First statement of the view that an object's function is what is causally responsible for its existence, which underlies later evolutionary accounts such as Millikan's.

TECHNICISM

The term *technicism* is parallel in construction to "scientism" and serves many of the same purposes, although it is less common. While closely associated with the process of "technicization," technicism, like all "isms," offers a special perspective on the world and its character. The belief in technology as central to the world can take different forms, but is most commonly manifest in what may be called ethical technicism.

Origins

In the *Gorgias* Plato (c. 428–347 B.C.E.) already identified the character of technicism, the belief in means as in some sense primary over ends. Gorgias, a sophist, has separated his rhetorical skills (*technai*) from any firm subordination to substantive social or cultural traditions, not to mention to the good. This is a position that Socrates (c. 470–399 B.C.E.) strongly criticizes, but according to Karl Polanyi (1886–1964), Lewis Mumford (1895–1990), and other historians, it is precisely such a project of separating culture into various components and then pursuing each on its own terms that is the foundation of modern technology. When technics is pursued in terms of its own logic it becomes technology.

According to Max Weber (1864–1920), in his posthumously published studies titled *Economy and Society* (1922), traditional societies contain "techniques of every conceivable types of action, techniques of prayer, of asceticism, of thought and research, of memorizing, of education, of exercising political or hierocratic domination, of administration, of making love, of making war, of musical performance, of sculpture and painting, of arriving at legal decisions" (vol. 1, p. 65). But in traditional societies these techniques are embedded in mores and counter-mores institutions. The planting of crops is done efficiently, but also in accord with certain religious rituals. The building of houses is done effectively, but also with respect for various craft traditions and social distinctions. Efficiency and effectiveness do not operate independently of other social, culture, religious, aesthetic, ethical, and political constraints.

In the German tradition Max Scheler (1874–1928) was among the first to use the term *Technizismus* (technicism) to name an attitude toward the world that takes the pursuit of material effectiveness in means as itself a fundamental ideal. The term appears in Scheler's 1926 book *Die Wissensformen und die Gesellschaft*, but was also used in papers as early as 1914 in which he provided phenomenological sketches of different types of persons and leaders. For Scheler, it is the historical development of modern technological civilization that gave rise to technicism as a form of discourse (Janicaud 1994) or consciousness (Stanley 1978) that chooses to privilege means over ends—that is, to center public life around the pursuit of ever more effective means, while relegating questions of ends to issues of personal or private choice and decision-making. From this perspective, technicism has become a pejorative term especially among nonbehavioral social scientists.

Ethical Technicism

Among the first philosophers to analyze the ethical implications of separating out means from ends was José Ortega y Gasset (1883–1955). In the English translation of his *The Rebellion of the Masses* (1929), Ortega identifies three principles as fundamental to the twentieth century: liberal democracy, scientific experiment, and industrialism. "The two latter may be summed up in one word: technicism" (1932, p. 56). In fact, insofar as liberal democracy is also committed to public policies that promote the maximization of means, leaving ends to be determined by individuals, technicism covers the first principle as well. (In Spanish Ortega actually used the word *técnica*, but the translation "technicism" is significant as one of the earliest English occurrences in a new sense. In the previous century "technicism" meant simply excessive reliance on technical terminology.)

The next decade, in *Meditación de la técnica* (1939), Ortega outlined a historical movement from the chance inventions that characterize archaic societies, through the trial-and-error techniques of the artisan, to the scientific technologies of the engineer. According to Ortega, the difference between these three forms of making lies in the way one creates the means to realize a human project—that is, in the way technicalness or technicity is manifest. In the first epoch technicity is hidden behind accidents, whereas in the second, technicity is cultivated and protected in craft traditions. In the third, however, the inventor has undertaken scientific studies of technics and, as a result, "prior to the possession of any [particular] technics, already possesses technics [itself]" (*Obras completas* V, p. 369). It is this third type of technicity that constitutes "modern technicism" (and here Ortega himself uses the term *tecnicismo*).

But technicism understood as the science of how to generate all possible means independent from any lives making and using context creates a unique existential problem. There is a temptation to pursue technical invention as a good in itself, to become lost in the technical means as exciting or valuable in their own right. Prior to the modern period human beings were limited by circumstances in which they at once acquired a way of life and the technical means to realize it. Now in liberal societies they are given in advance a plethora of technical means but no well-defined sense of the good other than personal choice. "To be an engineer and only an engineer is to be everything possibly and nothing actually" (*Obras completas* V, p. 366). In the midst of modern technicsm Ortega discovers a crisis of imagination and choice. Insofar as people can be anything at all, why should they be any one thing? What Ortega imagined has become real in the case of those who play with their avatars in cyberspace while failing to become something in the world.

Epistemological Technicism

The engineer Billy Vaughn Koen, however, proposes the engineering method as the fundamental way of knowing and acting in the world in a way that turns technicism from an ethical problem into an epistemological method. Koen does not use the term technicism, perhaps because of its negative connotations. But his argument is that engineering is the method that all human beings use, and indeed must use, whenever they solve problems. "*To be human is to be an engineer*" (2003, p. 7; italics in original) whether one knows it or not. There is simply no alternative.

For Koen, "The *engineering method* is the use of heuristics to cause the best change in a poorly understood situation within the available resources" (p. 59). Heuristics are simply strategies based on some hunch, rule of thumb, or intuition, about what might work, that include both a rejection of any absolute sense or certainty and a willingness to revise in response to experience in order to make things better. In Koen's perspective, the engineering method is universal precisely because it does not claim to be universal. The engineering response to Ortega's problem is simply to try something. No situation of even apparently unlimited possibilities can remain that way forever. There is in the end an excitement about an epistemological technicism that sees necessity as unnecessary and is therefore willing to play with possibilities and see what happens.

WILHELM E. FUDPUCKER

SEE ALSO *Scientism; Technicization.*

BIBLIOGRAPHY

Janicaud, Dominique. (1994). *Powers of the Rational: Science, Technology, and the Future of Thought,* trans. Peg Birmingham and Elizabeth Birmingham. Bloomington: Indiana University Press. Originally published as *La puissance du rationnel.* (Paris: Gallimard, 1985).

Koen, Billy Vaughn. (2003). *Discussion of the Method: Conducting the Engineer's Approach to Problem Solving*. New York: Oxford University Press.

Stanley, Manfred. (1978). *The Technological Conscience: Survival and Dignity in an Age of Expertise*. New York: Free Press.

TECHNICIZATION

The challenges posed by modern science and technology to ethics include the challenge of technicization. Technicization is a process that some contend infects and thereby corrupts ethics. To understand this claim requires an understanding of the process of technicization (related terms: technicism, technization, technicalization, scientism, scientization, mechanization) in relation to the task of ethical reflection.

Technological civilization is made up not only of machines but also and more importantly the methods or "techniques" that produce machines. Technique is rooted in the human capacity for language that gives humans the ability to imagine ever-new goals and the means to achieve them. For most of human history techniques were embedded in a wider array of cultural beliefs and practices and passed on as part of the culture from one generation to the next. One did things in a certain way because that was how one's ancestors did them. Such techniques were not inherently related to science.

When modern science intersected with ancient technologies beginning in the seventeenth century, the result was the technicization of society. This occurred when scientific investigation systematically evaluated not only the array of techniques historically available from all cultures for accomplishing human ends but also systematically studied the process by which techniques come to be invented, so as to refine the efficiency and effectiveness of the invention process itself. The ultimate goal of the science of technical development is the creation of the most efficient techniques in all areas of human endeavor so that every aspect of life is shaped by technical norms of efficiency.

The application of science to technique transforms the way human beings understand themselves and human societies organize themselves and their tasks. In premodern societies "essence" was thought to precede "existence"—that is, human beings thought of their selves and their institutions as having a preordained natural course of development (their *telos*) as part of an unchanging sacred natural order established by the gods and ancestors and/or nature itself.

From the ancient Greeks right on through the Enlightenment, social, political and ethical theory was dominated by the assumption that there is either a supernatural (the Platonic tradition and its successors) or a natural (the Aristotelian tradition and its successors) telos or archetype that must be discovered and implemented in human society. Society, as the Greeks said, is the cosmos writ small and later thinkers such as Hobbes and Rousseau still gave assent to such a view although there understandings of "nature" certainly differed. Even when Kant split noumena from phenomena he still assumed a universal rational human nature. Hence, whereas there was comparative reflection on social organization and speculation as to the best order for society from the time of the ancient Greek philosophers, it was assumed that the best order could not be discovered in the practices of social convention (the artificial) but only through the discovering the right order of nature (its true essence and telos).

Society is not an empirical object. The awareness of society as a realm separate from nature is a work of the human imagination. It was only with the emergence of the comparative and cross-cultural studies of the social sciences in the nineteenth century that society came to be imagined as existing as a distinct realm apart from nature, an artificial or humanly made order that had no inner telos. Society came to be understood as a technological or artificial product, Existence precedes essence and society is what humans make of it.

In this way, with the emergence of the critical historiographical and ethnographical techniques of the social sciences in the nineteenth century, the mythic stories of "natural order" were demythologized and replaced with a technological understanding of society. This transformation came to be expressed in four new ways of thinking about self and society: (1) the *existential self*, (2) the *managerial society*, (3) *public policy*, and (4) *social ethics*. Because the order of society is not fixed and given with the order of nature, humans must (1) choose who they shall become individually and as a society (2) reorganize the structures of society to make such choices possible, (3) engage in public debate in order to make choices about what kind of society they want to create and (4) therefore engage in social ethics as the attempt to define the norms by which they shall make such choices and so invent themselves.

In premodern societies ethics is primarily the ethics of virtue and so is concerned with individual choices. The task of ethics is to actualize one's essential "human nature" in accord with one's *telos*, within the social order as the cosmos writ small. Once institutions are seen as human creations based on choice rather than being fixed and given as part of a sacred cosmic order of nature, ethics is forced to enlarge its horizons to engage in the critique of institutional behavior without reverting to the essentialist model of cosmological thinking. A technological civilization fundamentally transforms the understanding of the task of ethics by introducing the novel idea of social ethics as a post-essentialist critique of society as a technological artifact through those public policies or social choices that shape one's personal identity and institutional life.

For some (for example, Niklas Luhmann, 1927–1998) the technological civilization that emerges out of the new social scientific consciousness of the artificiality of society seems to promise greater freedom and control, and so a greater scope for ethics through managerial social policy. However, others (such as Jacques Ellul 1912–1994, Jürgen Habermas b. 1929) argue technicization threatens to undermine that freedom and the practice of ethics by producing the technobureaucratic rationalization and mechanization of society.

Indeed, a major motif among the giants of sociology (Karl Marx, Émile Durkheim, Max Weber) is the mechanization of society so as to create what Weber called "the iron cage" of technobureaucratic societies. In this view, managerial societies are dominated by bureaucracies of scientific-technical experts who identify and promote the most efficient ways to meet human needs in all areas of endeavor (that is, maximizing results while minimizing costs and energy expenditures), and technical efficiency eliminates choice. The focus shifts from ends to means. The less efficient society cannot compete with the more efficient society any more than the less efficient business can compete with the more efficient business.

This process of technicization threatens the human ability to think and act ethically. Insofar as ethics entails the Socratic question—*Is what people call good really the good?*—how can that question be raised and acted on in a society that defines efficiency as the ultimate good? How can ethicists expect to succeed in introducing nontechnical norms such as justice and compassion in a society that seems to make acting on nontechnical norms virtually impossible? And how can norms be asserted at all in a post-essentialist technological society?

The seriousness of this problem is evidenced by the technicization of ethics itself. In a technical civilization only people who have technical expertise command respect and are socially and financially rewarded. In response ethicists' reflections have become increasingly too technical and specialized to be understood by society at large and so must be left to the calculations of technobureaucratic experts. As a consequence the Socratic task of the "gadfly" who calls into question what people call "good" in order to introduce a broader (nontechnical) vision and practice of "the good life" is in danger of being neutralized as irrelevant. If the ethical task of the gadfly is to be possible, it will have to begin by calling into question the "technological bluff" of the adequacy of technical language and norms as sufficient for realizing the good life.

DARRELL J. FASCHING

SEE ALSO *Scientism; Technicism.*

BIBLIOGRAPHY

Ellul, Jacques. (1990). *The Technological Bluff,* trans. Geoffrey W. Bromiley. Grand Rapids, MI: Eerdmans. A critique of the ideological discourse of technology as the only solution to human problems.

Fasching, Darrell J. (1993). *The Ethical Challenge of Auschwitz and Hiroshima: Apocalypse or Utopia?* Albany: State University of New York Press. An analysis of the technological or artificial nature of human identity and the implications for developing a post-essentialist cross-cultural and interreligious global ethic to guide public policy.

Habermas, Jürgen. (1984–1987). *The Theory of Communicative Action,* trans. Thomas McCarthy. 2 vols. Boston: Beacon Press. A critique of the rationalization or technicization of society that calls the "technological bluff" into question and relocates ethical reflection in a utopian theory of communicative action.

Mumford, Lewis. (1970). *The Myth of the Machine,* Vol. 2: *The Pentagon of Power.* New York: Harcourt Brace Jovanovich. The second volume of Mumford's history of technology; focuses on the mechanization of society.

Rammert, Werner. (1999). "Relations that Constitute Technology and Media that Make a Difference: Toward a Social Pragmatic Theory of Technicization." *Techné: Journal of the Society for Philosophy and Technology* 4(3): 23–43. Also available from http://scholar.lib.vt.edu/ejournals/SPT/.

TECHNOCOMICS

Technocomics are illustrated narratives in which science and technology play a major role in the determination of character and action. Superhero comics are often good examples, insofar as many of their protagonists receive superpowers as an unexpected consequence of some scientific phenomenon. Peter Parker becomes Spider-Man, for instance, during a school outing to a science museum where he is accidentally bitten by a radiated spider; the X-Men all experience genetic mutations as a result of environmental contamination and thus confront problems of social prejudice and responsibilities between generations. Technocomics as a genre are thus closely related to science fiction and may serve to both mirror and shape popular reflection on questions related to science, technology, and ethics.

The comic book superhero first emerged from pulp fiction in the 1930s in what is known as the Golden Age of DC Comics and its protagonists such as Superman, Batman, and Wonder Woman, who were only marginally associated with science and technology. The post-World War II period saw a decline in the popularity of these figures. But in the 1960s, Marvel Comics brought about a Silver Age by creating a new pantheon of superheros including Spider-Man, the Incredible Hulk, and the X-Men, all of whom reflected a deeper concern for the ethical issues associated with science and technology in the nuclear age. The following analy-

Superman. *(AP/Wide World Photos.)*

tic introduction assumes some familiarity with this particular genre as it has developed in the United States, a genre that has also extended to movies, video games, and, in the early-twenty-first century, to some advanced simulations such as *Technocracy* (see Brucato, Long, and DeMayo 1999). For more general introductions to technocomics see the work of Mike Benton (1992), Richard Reynolds (1994), and Geof Klock (2002).

Radiation: Science as Savior and Scapegoat

Radiation has from the very beginning played a key role in technocomics, which perhaps reflects twentieth-century American societal fascination with, as well as aversion to, nuclear technology and its applications during times of both war and peace. Many superheroes of both the Golden and Silver ages of comics derived their special abilities from some type of radiation in one of three ways. The first, rarest, and perhaps most optimistic way is when the character comes to reside in a different environment and is exposed to a form of radiation that alters the physiology of his already existing anatomy. Superman, one of the earliest protagonists of the Golden Age of comics, is an example of this type of superhero. Originally the source of his special powers were unexplained; later, however, they were linked to the effects on his body of the light radiation from the Earth's yellow sun as opposed to that of the red sun of his home planet Krypton. Later comics involving Superman included a substance called Kryptonite (no relation to the element Krypton), whose green and other forms had various effects on him, including the nullification of his powers.

The second way in which radiation bestows superpowers in technocomics illustrates one of the most common fears of the nuclear age—mutation. This preoccupation with the unexpected, negative effects of radiation (which gave rise to a series of Godzilla movies in Japan), is manifested in such Silver Age technocomic protagonists as the X-Men, who are born with superpowers because ambient radiation from atomic bombs has changed their genetic codes.

Yet the third way in which superheroes derive their powers from radiation in these comics is the most prevalent—the alteration of an individual's genetic makeup through accidental or intentional exposure (such as nuclear accidents, atomic experiments, and others). Some of the most famous superheroes who have attained their powers in this way include Spider-Man, the Teenage Mutant Ninja Turtles, Dr. Manhattan, Daredevil, and Captain Atom. The most representative of this type of superhero, however, is the Incredible Hulk, whose alter ego, Dr. Bruce Banner, was a research scientist for the military-industrial complex who was attempting to develop a gamma bomb for the U.S. Army. During the first test of this bomb, Banner entered the testing area to save a civilian from the explosion, thus exposing himself to the gamma radiation that causes him, in a Jekyll-and-Hyde-like manner, to transform into the Hulk, a huge, immensely strong creature.

Human Response: Technology as Superpower

While superhuman characters such as Superman and Spider-Man experienced permanent changes that made their special powers innate, other characters have developed and employed technology in an attempt to achieve superhero status. Technological research and development organizations began to appear in superhero comics (such as Advanced Idea Mechanics [A.I.M.], a criminal organization in the Marvel universe, and Scientific Technological Advanced Research Laboratories (S.T.A.R.), a scientific organization in the DC universe), creating new technology to both the benefit and detriment of society. Devices such as ray guns, flying cars, and power armor appear in myriad forms in these comics, in which technological processes and pharmaceuticals such as cloning and *supersoldier sera* are also common. The list of technologically assisted superheroes and supervillains is long, and the majority of them utilize special suits and gear. The most famous of these characters include Iron Man, Green Arrow, the Punisher, Nick Fury and the Supreme Headquarters International Espionage Law-Enforcement Division (S.H.I.E.L.D.), the Atom, Hank Pym, Blue Beetle, Owl Man, Doctor Doom, Lex Luthor, Booster Gold, Captain America, the Engineer, and Batman (who nevertheless would be a force to reckon with even without his Bat Computer and infamous utility belt).

One of the most unique of these superheroes, Booster Gold, is of special interest because his origins illustrate ambivalent feelings toward the corporate technological complex. Booster, a twenty-fifth-century football player banished from professional sports for illegal betting, steals a force field belt, flight ring, and a time sphere which he and a robot named Skeets use to travel back in time. He then becomes the CEO of Booster Gold International, a monolithic holding company and tax shelter, as well as *America's Most Popular Super Hero*.

Still other superheroes use technology in the form of symbiotes (organisms, alien or otherwise, that grant abilities to their hosts), chemical alterations of their bodies, and even artificially intelligent constructs. Perhaps the most famous example of a chemically enhanced superhero is Captain America. According to the account of his origins, during World War II the United States developed an experimental supersoldier serum. It was first tested on Steve Rogers, a frail man unfit for combat, to whom it gave increased mental and physical capabilities. The doctor who created the formula was soon after killed by a Nazi spy, leaving Rogers as the first and only supersoldier—Captain America.

Still other superheroes and supervillains have obtained their powers through a combination of the effects of radiation and technological enhancement. A good example here is one of the X-Men, Wolverine, a born mutant who is later *improved* with technology. Wolverine's original mutations included animal senses and an amazing capacity for self-healing. This latter power enabled the Weapon X Program to implant the unbreakable metal adamantium into his bones without killing him, thus making him virtually indestructible.

The Ethics of Power

Ethical questions regarding science and technology make natural themes for technocomics, given the great number of technologically created superheroes and supervillains who serve as their protagonists. One of the most common of these questions is that regarding the limits of scientific experimentation. J. Robert Oppenheimer's concern about the atomic bomb finds its echo in technocomics: Does ability imply permission? Do humans have the right to use technology just because they have invented it? These questions are debated time and again in the pages of technocomics (for example, in the cases of the Weapon X Program, the origin of the Hulk, and Brainiac 5's creation of Computo). Such comics play an important ideological role, because they are often a young person's first introduction to these questions, and furthermore offer a safe, fictional representation that spurs critical thinking about the real dilemmas (such as human cloning) faced by contemporary society.

Many technocomic superheroes demonstrate the desire to use their powers ethically and strive to accept a responsibility to others that they believe accompanies their special gifts. For example, heroes such as the almost omnipotent Professor X and Spider-Man (whose message "With great power comes great responsibility" has become a mantra for generations of comics fans) seem to be always defending and disseminating their belief that those who possess special abilities must not exploit those who do not.

Homo Superior: Social Darwinism in Technocomics

Although Social Darwinism is a misapplication of a scientific theory, it generates many debates in technocomics, especially given their superhuman protagonists. Should the strongest, most talented, and most intelligent rule the world to the detriment of the weak? Perhaps the most important site of this debate in the technocomic world is found in the X-Men comics, in the conflict between Professor X and his archrival, Magneto. Magneto is a superpowerful mutant who survived life in a concentration camp during World War II, and has therefore experienced firsthand the horrors that humans are capable of inflicting on one another. He is convinced that mutantkind (human beings who have mutated and developed superior abilities) is the next step in human evolution and that mutants should therefore take their place as the new rulers of the world. Professor X, however, takes the stance that mutants—however different they may be—are still humans and must learn to live alongside less-gifted humans.

Technoscientific Authoritarianism

Ethical questions surrounding technoscientific authoritarianism are often present in technocomics, given

Spider-Man. *(AP/Wide World Photos/Courtesy Marvel Comics.)*

that absolute power is a goal that many technically enhanced supervillains strive for. A particularly relevant instance of this debate, albeit ultimately unresolved, appears in those Marvel comics dealing with Doctor Doom, the supreme ruler of a fictional country called Latveria. This country is described as being free from racism and social unrest; its inhabitants enjoy economic prosperity while remaining ecologically and physically safe and sound. But while the government of Latveria is considered to be an *enforced monarchy* by Doom and his subjects, all others consider it a dictatorship. The question of whether it is acceptable to give up democratic and personal freedoms to a technocrat in return for safety and security arises. At one point in the Marvel universe, Doctor Doom manages to take control of the entire world after which he eliminates disease and hunger and brings about world peace with an iron hand. Even the staunch defender of democracy, Captain America, has to admit that, while the method Doom uses is unacceptable, the changes he brings about are in the best interest of humanity. Nevertheless, at the end of the series, Doom is removed from power and the world reverts to its previous state, with relief food rotting on the docks in Africa, arguments breaking out in the United Nations, and the winds of war again stirring worldwide. Readers are left to decide for themselves which type of government is preferable.

Subsequently, in 2004, Captain America, the technologically enhanced supersoldier, was involved in a critique of the very military industrial complex that created him. He is sent to Guantanamo to oversee the treatment of the Taliban and Al-Qaeda prisoners being held there by the heavily armed, technologically superior U.S. soldiers, and is shocked at the human rights abuses he witnesses being committed by members of his own team.

Questionable Experimentation and Creation: Progress versus Safety

Questions surrounding the ethical ramifications of experimentation, especially experimentation on living beings, arise frequently in technocomics. Should experiments be done if they are not safe for the individuals involved? Is questionable scientific experimentation ethical if it causes human and/or animal suffering in pursuit of the alleviation of future suffering? Are technological processes that extend the quantity of life worth their possible toll in quality of life? The previously mentioned Weapon X Program in which Wolverine gains his adamantium skeleton, along with the ambivalent feelings many superheroes have toward their own powers, is only one of the ambiguous situations in technocomics that promote such ethical pondering.

Artificial intelligence (AI) plays a central role in many technocomics. The philosophical questions raised in this regard range from the ontological (Is a machine that can think a living creature?), to the epistemological (How does one recognize life?), to the ethical (Is it ethical to try to create a machine that can think? If a thinking machine has accidentally been created, should it be shut off? Should humans allow themselves to become so dependent on machines in general, and on artificial intelligence in particular?).

Not only does sentient AI life exist in the world of technocomics, but it is also often imbued with the theological categories of good and evil. One example can be found in the *Avengers* series of comics, in which the scientist/Avenger Hank Pym accidentally creates Ultron, an evil, artificially intelligent being who is able to remodel himself as well as to create other AI machines. The Vision, one of the machines modified by Ultron, using his newly acquired free will for more noble purposes, rebels against his programming, joins the Avengers, and even marries. Similarly, in the *Brainiac* series of stories, Brainiac 5 creates an AI machine named Computo, that ends up killing dozens of people before being turned off.

Using Technocomics

Technocomics have introduced many scientific and ethical questions into the minds of readers, and can be expected to continue to do so by incorporating into fiction new technologies and scientific theories as they emerge in the real world. Technocomics have been a source of entertainment for so long that their value as teaching tools are often overlooked. Nevertheless, in the early-twenty-first century, there is increasing awareness of the effectiveness of using technocomics to spark scientific and philosophical debate in the classroom. The Department of Chemistry at the University of Kentucky, for example, supports a web site linking science to technocomics that lists, in periodic table structure, the occurrences of elements in comic books, both in the form of facts and misconceptions. At times the superpowers portrayed in technocomics, as well as the scientific errors that they frequently entail, can be as useful as scientific facts for teaching purposes. James Kakalios, a professor at the University of Minnesota, incorporated such misconceptions in a course titled "Everything I Know of Science I Learned from Reading Comic Books," which compares and contrasts the science portrayed in technocomics with real-world physics, including thermodynamics and the material sciences. Kevin Kinney of DePauw University discusses many misconceptions of biology in comic books, such as those related to superpowers and the amount of nutrients that would be needed to fuel them.

Interestingly while science fiction in general has logically been appropriated by teachers of ethics as a springboard for debates about ethical issues in science and technology, the use of technocomics for these same purposes appears to have been overlooked. Nevertheless the success of film adaptations of such technocomics as *The Hulk* (2003), *Spiderman* (2002, 2004), and *X-Men* (2000, 2003) will almost certainly guarantee serious reconsideration as to how these works both reflect and mold popular opinions and conceptions about the nature—ethical or otherwise—of scientific investigation and technological innovation.

MATTHEW BINIEK
JAMES A. LYNCH

SEE ALSO *Movies; Popular Culture.*

BIBLIOGRAPHY

A.I.M (Advanced Idea Mechanics) *Strange Tales* #146. Marvel Comics Group, Marvel Entertainment Group, Inc.

"The Batman." *Detective Comics* #27, May 1939. DC Comics.

Benton, Mike. (1992). *Superhero Comics of the Golden Age: A History*. Dallas: Taylor.

"Booster Gold, Origin." *Boo$ter Gold* #7, August 1986. DC Comics. First appearance.

Brucato, Phil; Steve Long; and Tom DeMayo. (1999). *Guide to the Technocracy*. La Mesa, CA: White Wolf. A general introduction to the history and characters of the White Wolf role playing simulation game called *Technocracy*.

"Captain America. *Captain America Comics* #1, March 1941. Marvel Comics Group, Marvel Entertainment Group, Inc. First appearance and origin.

The Engineer. *The Authority* #1, May 1999. Image Comics. First appearance.

"The Hulk/Bruce Banner." *The Incredible Hulk* #1, May 1962. Marvel Comics Group, Marvel Entertainment Group. First appearance and origin.

Klock, Geof. (2002). *How to Read Superhero Comics and Why*. New York: Continuum. Applies Harold Bloom to superhero interpretation.

Reynolds, Richard. (1994). *Super Heroes: A Modern Mythology*. Oxford: University of Mississippi Press. Identifies seven laws for super heroes, including devotion to justice, secret identifies, lost parents, and accountability only to conscience, which are interpreted as key issues in male adolescent development.

"Superman." *Action Comics* #1, June 1938. DC Comics. First appearance and origin.

"Wolverine." *The Incredible Hulk* #180, October 1974. Marvel Comics Group, Marvel Entertainment Group, Inc. First appearance.

"X-Men." *X-Men* (First Series) #1, 1963. Marvel Comics Group, Marvel Entertainment Group, Inc. First appearance.

TECHNOCRACY

Technocracy may be generally described as an organizational structure in which decision makers are selected based on their specialized, technological knowledge, and/or rule according to technical processes. It has also been defined more simply as rule by experts. In all such cases technocracy constitutes a particular interaction between science, technology, and politics that has led to significant ethical debate.

Historical Development

The concept of technocracy needs to be qualified because the idea of rule by experts is at least as old as Plato's proposal for philosopher kings. Similarly, in his *New Atlantis* (1627), Francis Bacon envisaged an ideal society directed by scientists. But the contemporary meaning of technocracy presupposes the existence of complex industrial societies and the large-scale production and consumption processes that arose at the beginning of the twentieth century. It is only under these conditions that a class of experts in organization and production, namely engineers or technologists, could form. Technocracy, then, is rule by this particular type of expertise. Its advocates either assume or explicitly state that the efficient, rational production and distribution of goods for material abundance is the primary or even exclusive goal of society, because only in this way could they justify expert governance in these fields.

Early in the nineteenth century, the French writer Henri de Saint-Simon (1760–1825) foreshadowed calls for modern technocracy by arguing that the organization of production was more important to society than any other political end. By the 1890s, an emerging ambiguity in the social role of engineers led some to question their traditional subservience to employer goals. Unlike doctors, lawyers, and most other experts, engineers used their expertise to shape productive and technological systems, thereby transforming entire societies. Many began to feel that their power enabled or even obliged them to bring about social progress. With his idea that scientific laws would govern the efficient management of labor and use of resources, Frederick Taylor (1856–1915) provided a practical platform to extend the domain of engineering expertise into management and politics.

Henry Gantt (1861–1919) and James Burnham (1905–1987) further argued for the independence of engineers in their critiques of societal irrationalities and inefficiencies. Thorstein Veblen (1857–1929) critiqued wastefulness in the dominant political and economic system (i.e., the capitalist price system) and argued that engineers were best suited to direct society, because their objectivity was preferable to the short-sighted greed of business leaders. One of his disciples, Howard Scott (b. 1926), formed the Technical Alliance (in 1918) and later—rivalling with the "Continental Committee on Technocracy" (led by Harold Loeb and Felix Frazer)—Technocracy Inc. (in 1933). Members of Technocracy Inc. advocated a transition away from the price system and the establishment of a "governance of function," or a Technate, on the North American Continent. They argued that the scientific design of social operations would guarantee abundance for all.

Types of Technocracy

Analytically there exist at least seven variations on the technocracy theme. First, there is the notion of "expertocracy," or a conspiracy of experts who usurp decision making powers from democratically elected representatives. Second, technocracy can serve as a form of social engineering, where administrative procedures and organizational contrivances, rather than experts, gain power and form a "technological state." Third, there is a technocracy of work best articulated by Taylor's *Principles of Scientific Management* (1911). Fourth, the technological imperative of "can implies ought," in which means and feasibility determine goals, may create a technocracy that values the improvement of instrumentalities as a primary end. Fifth, there is the systems technocracy that may emerge from dynamic, interdependent systems engineering and by thereby administrating soci(et)al and political systems. Sixth, technocracy can refer to a situation in which laws are enforced by designing systems such that it is almost impossible to break them and that societal decisions and developments are totally streamlined by them and/or computerization. Finally, there is the technocratic movement spearheaded by Technocracy Inc. Additionally, the term has also been applied to a number of dictatorship governments and to a virtual reality game that claims to be based on "the inexorable advance of real-life technocracy" (see the web site at www.white-wolf.com/Games/Pages/MagePreview/technocracy.html).

Nevertheless, only four of these possibilities exhibit continuing viability. The idea of technocracy as expertocracy remains the most popular: a conspiracy of experts taking power through their personal, knowledge-based control of complex decision making. In the version promoted by Veblen (1925) this would involve rule by engineers especially in industrial corporations. But other alternatives might stress the intelligence and efficiency of more localized expertise, such as medical doctors to run health care systems. In all instances, expertocracies are argued to increase intelligence and efficiency in technical action—but threaten democracy.

A second widely discussed possibility focuses on the scientific optimization of social engineering through public administration. Here it is not experts as persons but administrative procedures and organizational structures that would exercise power. No individual or group would rule; individuals or groups would at most have a role in properly managing institutions and processes. This is the vision of technological politics presented by Jacques Ellul and others in which technological and administrative decisions replace political deliberation. Legislation by elected officials would wither under such an automated bureaucracy.

During the 1960s the idea of a technological imperative led to the articulation of another important version of technocracy, although one that has declined in intellectual salience. According to critical social theorist Herbert Marcuse (1898–1979) and science fiction writer Stanislaw Lem (b. 1921), there is a strong tendency for technical possibilities to determine social or political goals. Anything that can be done or produced will be done or produced, even becoming a matter of need. Means would determine ends; can implies ought. In a society established along these lines, improvement of instrumentalities becomes of singular value; the constant improvement of technology becomes the goal.

A fourth form of technocracy that continues to be examined conceives it in system terms. This is an important new variation on the technocracy theme. Systems engineering as well as systems analyses of the interconnections and complexities of society (as in the work of Niklas Luhmann) suggest a new kind of systems-technocracy. Discussions of systems-technocracy and the special case of "computerocracy" have emerged as serious issues in association with the rise of the so-called era of "information and systems technology" (Hans Lenk 1971, 1973).

Is systems-technocracy the wave of the future? There certainly are trends pointing in this direction, and the discussion should not be left to sociologists and politicians only. Instead, the single-focus framework of the social sciences should be combined with historical, engineering, and philosophical approaches to create an adequately interdisciplinary perspective. From such a perspective it can be argued that in a pluralistic technoscientific society the best way forward is to steer a pragmatic middle path between the extremes of an inhumanly efficient technocracy, a ruthless power politics, and a vulgar democracy devoid of intelligence.

Assessment

As Jean Meynaud (1964) summarized the issue, the decades-old debate on technocracy comes down to the fact that there is no conspiracy on the part of the technical community to usurp political power, though technical matters have taken on ever increasing importance.

Because the complexity of social, technological, economic, and ecological systems has increased, there is a progressive demand for technological, scientific, and organizational expertise. At the same time, narrow expertise calls forth a complementary needs for generalists, people with a broad view ("specialists of the general") of interdisciplinary complexes who can take a systems approach toward problems.

Historically speaking, the technocracy debate simply continued the social criticisms of technology from the early part of the twentieth century. Its dominant characteristic has been a pessimistic attitude that ignores the extensive ways technology has humanized the world. But the privileged position of experts in particular cases has not led to the demise of politics in the so-called "technolocal state" (Helmut Schelsky) or of the importance of its interplay between conflicting and overlapping interest groups and power structures. The opposite seems to be the case. The most significant outcome of the technocracy debate is thus an awareness that complex political decisions cannot be replaced by the technological or "computerocratic" procedures of optimization and maximization.

There are several explanations for this. Most significant is the fact that complex political decisions involve both information and the adjudication of a plurality of values. The inexplicable and undecidable character of political questions in contrast to technological answers, as was argued by Hans Lenk (1973), has largely been confirmed by experience. Society and the state are not machines with mere objective standards of performance, and there is no scientifically generated "one best way" (as Schelsky believed) to solve many technical, let alone political, problems. Attempts to apply science to societal problems with this intention often lead to interminable debates among competing experts, while the underlying values at stake remain unexamined.

Yet it remains true that technical matters have taken on ever increasing importance in the complex problems of modern societies and computerocracy as a virulent version of systems technocracy is an imminent danger in our hi-tech societies. The challenge for democratic governance is to integrate technical experts with non-expert participants to strike common interest solutions in contexts where many elements are beyond the comprehension of all but a few specialists. These interdisciplinary contexts may even demand generalists capable of integrating diverse sets of knowledge and perspectives.

HANS LENK

SEE ALSO *Ellul, Jacques; Expertise; Participation.*

BIBLIOGRAPHY

Akin, William E. (1977). *Technocracy and the American Dream: The Technocrat Movement, 1900–1941*. Berkeley: University of California Press.

Armytage; W. H. G. (1965). *The Rise of the Technocrats: A Social History*. London: Routledge.

Beville, G. (1964). *Technocratie Moderne*. Paris: Librairie générale de droit et de jurisprudence.

Boisdé, R. (1964). *Technocratie et Démocratie*. Paris: Plon.

Burnham, James. (1941). *The Managerial Revolution*. New York: John Day.

Elgozy, G. (1965). *Le Paradoxe des Technocrates*. Paris: Denoël.

Ellul, Jacques. (1954). *La Technique Ou L'enjeu du Siècle*. Paris: Economica. (The Technological Society, New York: Knopf 1964).

Elsner Henry. (1967). *The Technocrats: Prophets if Automatization*. Syracuse, NY: Syracuse University Press.

Fischer, Frank. (1990). *Technocracy and the Politics of Expertise*. Newberry Park, CA: Sage Publications.

Koch, Claus, and Dieter Senghaas, eds. (1970). *Texte Zur Technokratiedieskussion* [Materials on the Debate about Technocracy] Frankfurt: Europaeische Verlagsanstalt.

Lenk, Hans. (1971). *Philosohphie im Technologischen Zeitalter* [Philosophy in the Technological Era] Stuttgart: W. Kohlhammer.

Lenk, Hans. (1984). "Toward a Pragmatical Social Philosophy of Technology and the Technological Intelligentsia." In *Research in Philosophy and Technology*, ed. by Paul T. Durbin.

Lenk, Hans. (1991). "Ideology, Technocracy, and Knowledge Utilization." In *Europe; America, and Technology: Philosophical Perspectives*, edited by Paul T. Durbin. Dordrecht/ Boston/ London: Kluwer.

Lenk, Hans, ed. (1973). *Technokratie als Ideologie: Sozialphilosophische Beiträge zu einem politischen Dilemma* [Techncracy as Ideology: Social Philosophical Contributions to a Political Dilemma]. Stuttgart: W. Kohlhammer.

Marcuse, Herbert. (1964). *One-Dimensional Man: Studies in the Ideology of Advanced Industrial Society*. Boston: Beacon Press.

Meynaud, Jean. (1960). *Technocratie et Politique*. Lausanne: Études de science politique.

Meynaud, Jean. (1964). *Technocratie, mythe, ou réalité?* Paris: Paynot. English translation by Paul Barnes: *Technocracy* (New York: Free Press, 1969).

Radaelli, Claudio M. (1999). *Tecnocracy in the European Union*. London: Longmans.

Schelsky; Helmut. (1965). *Auf Der Suche Nach Der Wirklichkeit*. [In Search of Reality] Duesseldorf/Cologne: Eugen Diederichs.

Scott, Howard. (1929). "The Scourge of Politics in a Land of Manna." In *The One Big Union Monthly* Sept., pp. 14 ff.

Taylor, Frederick. (1911). *The Principles of Scientific Management*. New York: Harper and Brothers.

Veblen, Thorstein. (1921). *The Engineers and the Price System*. New York: Huebsch.

TECHNOETHICS

Technoethics is a term coined in 1974 by the Argentinian-Canadian philosopher Mario Bunge to denote the special responsibilities of technologists and engineers to develop ethics as a branch of technology. However, in 1971 the chemical engineer and theologian Norman Faramelli had used a word of only one less letter, *technethics*, to argue for a general ethics of technology from a Christian theological perspective. In 1973 the *Britannica Book of the Year* defined the same term, without referencing Faramelli, as indicating "the responsible use of science, technology and ethics in a society shaped by technology."

Bunge's use is the more significant and radical. For Bunge engineers and managers, because of their enhanced powers, acquire increased moral and social responsibilities. To meet these responsibilities they cannot rely on traditional moral theory; since moral theory itself is underdeveloped having "ignored the special problems posed by science and technology" (Bunge 1977, p. 101). Instead, engineers must adapt science and technology, tools that are foreign to most philosophers, to construct a new theory of morality.

According to Bunge, rational moral rules have exactly the same structure as technological rules. Technological rules come in two types: ungrounded and grounded. Ungrounded technological rules either are irrational or are based on empirical evidence that has not been systematized. Grounded technological rules are based on science. According to an earlier argument, Bunge (1967) sees technology as being constituted by scientific theories of action. Modern technology develops when the rules of prescientific crafts, which are based on trial-and-error learning, are replaced by the scientifically "grounded rules" of technological theories.

During the late 1990s and the early 2000s the term *technoethics*, especially in Spanish and Italian cognates, appeared anew in an effort to parallel another coinage from the 1970s: *bioethics*. However, the prefix *techno* has connotations that are at odds with *bio*, which references life and its nuances. Ethics is a living field. *Techno* denotes the hard-edged and loud, as in *technomusic*, *technoart*, and *technoeconomics*. Given these uses, *technoethics* fails to connote as readily the broad concerns that have been easy to include in bioethics. Indeed, Bunge's use of the term seems more appropriate.

In the preparation of the *Encyclopedia of Science, Technology, and Ethics* there was some initial debate about making it an "Encyclopedia of Technoethics." The conclusion, however, was that such an alternative would have been inadequate in building bridges between a number of applied ethics fields ranging from computer and engineering ethics to research and environmental ethics, including history, literature, and philosophy along the way. The expansive if less catchy title *Encyclopedia of Science, Technology, and Ethics* defines in a more inclusive way the scope of a reference work that should appeal to scholars; professionals in the sciences, engineering, and the humanities; and general readers.

CARL MITCHAM

SEE ALSO *Chinese Perspectives; Science, Technology, and Society Studies.*

BIBLIOGRAPHY

Bunge, Mario. (1967). *Scientific Research II: The Search for Truth*. New York: Springer. See especially the chapter titled "Action," pp. 121–150.

Bunge, Mario. (1977). "Towards a Technoethics," *Monist* 60(1): 96–107. This is the first publication of a paper presented at the International Symposium on Ethics in an Age of Pervasive Technology, Technion-Israel Institute of Technology, December 21–25, 1974, with abridged proceedings published in Melvin Kransberg, ed., *Ethics in an Age of Pervasive Technology*, Boulder, CO: Westview, 1980.

Esquirol, Josep M., ed. (2002). *Tecnología, Ética y Futuro: Actas del I Congreso Internacional de Tecnoética*. Bilbao, Spain: Editorial Desclée de Brouwer.

Esquirol, Josep M., ed. (2003). *Tecnoética: Actas del II Congreso Internacional de Tecnoética*. Barcelona: Publicaciones Universitat de Barcelona.

Faramelli, Norman J. (1971). *Technethics: Christian Mission in an Age of Technology*. New York: Friendship Press.

TECHNOLOGICAL FIX

Technology is often couched in terms of solving problems such as curing disease, providing for reliable food production, or affording efficient means of transportation. Indeed, technology has proved powerfully effective for solving any number of problems, from the massive project of sending people into space to the minor chore of fastening pieces of paper together. But in a 1966 article, atomic physicist Alvin M. Weinberg raised the following question: Are there some types of problems that cannot—or should not—be *fixed* by technology? Weinberg coined the term *technological fix* to describe the use of technology to respond to certain types of human social problems that are more traditionally addressed via political, legal, organizational, or other social processes. Although Weinberg advocated the use of technological fixes in some cases, the term has come to be used frequently as a pejorative by people critical of certain uses of technology.

Writing during the cold war, Weinberg cites nuclear weapons as an example of a technological fix for war. The technological ability to unleash global devastation serves as a deterrent to international aggression. But critics argue that such a solution is at best tenuous, and at worst lessens people's resolve to work diplomatically at ameliorating the underlying clashes of ideology, economy, and culture that lead to war. Nuclear weapons also served as an alternative to maintaining a large standing army such as that of the Soviet Union, thus shifting social sacrifice from the less to the more democratically acceptable—from personal service to government investment in advanced technological weapons research and development. It is this aspect of technological fixes—their tendencies to mask the symptoms of complex social problems without addressing their causes or true costs—that generally evokes ethical concern.

For example, if large numbers of children are being disruptive or having trouble concentrating in school, is the liberal prescription of psychotropic drugs a viable technological way to ease the problem, or does this simply allow parents and teachers to abdicate their responsibilities for good parenting and maintaining discipline, respectively? If employees are using company computers for personal business or entertainment, is installing software to monitor and curb such behavior a viable technological solution, or does this simply foster an atmosphere of distrust without addressing the causes of the problem, perhaps poor morale or inefficient tasking?

These are difficult questions because there are surely some children who could benefit from psychotropic drugs, and there are arguably certain situations in which an employer has a legitimate need to monitor an employee's use of the computer. But once such technological fixes become available, they run the risk of proliferating into universal *easy ways out*. Or they may simply shift the locus of the problem; in the case of the work computers, spy software does not guarantee greater employee productivity, only that employees will not be unproductive in a particular way.

Despite these criticisms, sociologist Amitai Etzioni (1968) defended the use of what he called technological *shortcuts*. Etzioni argued that many of the concerns levied against such shortcuts were based on conjecture rather than hard evidence. For example, when better lighting is installed on city streets in an effort to discourage crime, critics claim that this approach treats only the symptoms and does not do anything to address the underlying motivations for crime, nor does it necessarily reduce crime overall; rather, they claim, it just shifts the criminal activities to other locations. But while sounding plausible, such criticisms are typically unsupported by any definitive data. The questions to be asked in this example are, where do criminals go, and what do they do, when their previous stalking grounds are illuminated? "No one knows," writes Etzioni, but "[t]he one thing we do know is that the original 'symptom' has been reduced" (p. 45).

Etzioni also pointed to the deep-seated and intractable nature of many social problems, which suggests the near impossibility of ever implementing any comprehensive solutions via social transformation, particularly given fervent political disagreement about the propriety of various transformation strategies. Thus stopgap shortcuts may be the only recourse. "Often," writes Etzioni, "our society seems to be 'choosing' not between symptomatic (superficial) treatment and 'cause' (full) treatment, but between treatment of symptoms and no treatment at all" (p. 48).

The fundamental difficulty with technological fixes—or shortcuts—is the inherent incompatibility between problem and solution. Technologies are most useful for solving specific, well-defined, and stationary problems, such as how to get cars from one side of a river to the other (for example, using bridges). In contrast, social problems, such as crime, poverty, or public health, are broad, ill-defined, and constantly evolving. Weinberg, like Etzioni, was not naïve about this difficulty, writing, "Technological Fixes do not get to the heart of the problem; they are at best temporary expedients; they create new problems as they solve old ones" (p. 8).

BYRON P. NEWBERRY

SEE ALSO *Science, Technology, and Society Studies.*

BIBLIOGRAPHY

Etzioni, Amitai. (1968). "Shortcuts to Social Change?" *Public Interest* 12: 40–51. A sociologist argues for the use of technological means to treat the symptoms of pressing social problems.

Weinberg, Alvin M. (1966). "Can Technology Replace Social Engineering?" *Bulletin of the Atomic Scientists* 12(10): 4–8. An atomic scientist discusses the merits of using technology to eliminate or attenuate social problems as an alternative to pursuing the more difficult strategy of changing prevalent social attitudes.

TECHNOLOGICAL INNOVATION

Technological innovation has been a leading agent of social change, worldwide, since the late 1700s, serving as the conduit into society of developments in science and technology. As such, it has been at the center of ethical issues ranging from the morality and justice of the early Industrial Revolution to the consequences of genetic engineering, nanotechnology, and artificial intelligence (AI). In spite of its extraordinarily high social visibility, however, innovation is almost universally misunderstood and misrepresented, typically as synonymous with invention. Invention, in turn, is presented as a value-free, hence ethically neutral, application of new or existing technical knowledge. Treating innovations as inventions implies that ethical issues associated with their implementation derive not from factors intrinsic to innovations, but from how society chooses to implement them. Such an interpretation frees innovators from moral responsibility for the ethically problematic consequences of their activities, as well as buffering these activities from public assessment.

What Innovation Is

Innovation is a social process in which technical knowledge and inventions are *selectively* exploited on behalf of (corporate or government) institutional agendas driven by marketplace values or political policies. Inventions, and more broadly scientific and engineering expertise, are merely raw materials for technological innovation, which is the value-laden, ethically provocative process that determines *whether* an invention is introduced into a society, the *form* in which it is introduced, and the *direction* of its subsequent development as society responds to the innovation. The introduction of the automobile, television, nuclear power plants, and the Internet are examples of the value-laden innovation process, including how societal responses feed back into the course of innovation developments over time.

Conceptual Emergence and Practical Engagement

The beginning of the twentieth century saw leading economists focused on determining the conditions for supply-demand equilibrium. For Austrian economic theorist Joseph Schumpeter (1883–1950), however, what needed to be analyzed was not equilibrium but the disequilibrium created by economic growth. Looking back over the nineteenth century and the first decade of the twentieth, Schumpeter argued that entrepreneurship in combination with technological innovation—that is, risking capital by creating new businesses that transform inventions into innovations—was the engine of economic growth in modern societies. This combination of innovation and entrepreneurship created new wealth, destroyed old wealth, and created new concentrations of social and political power. Schumpeter defended what he called the *creative destruction* that often accompanied implementing innovations. The creation of synthetic dye, electric power, and the automotive industries, for example, undermined established industries based on natural dyes, steam and water power, and horse drawn transportation. Businesses were indeed destroyed, jobs were lost, people suffered but, Schumpeter claimed, *better* businesses were created, employing more people in *better* jobs. Schumpeter eventually also defended the wasteful and often frivolous character of the combination of innovation and entrepreneurship in an industrial capitalist environment driven by opportunistic profit-seeking.

After World War I, individual thinkers, among them the American economist Thorstein Veblen (1857–1929) and future U.S. president Herbert Hoover (1874–1961), argued that technological innovation would be central to national security and industrial competitiveness. Only in Germany, however, was there a strong national commitment to an innovation-driven military and industrial agenda, initiated by Prince Otto von Bismarck in the 1860s and developed further by all subsequent German governments, especially the National Socialists. In the United States and Great Britain, by contrast, calls for such national commitments were repeatedly rejected. For example, George Ellery Hale (1868–1938), one of the world's leading astronomers and the person responsible for maintaining America's leadership in telescopy from 1897 into the 1980s, failed in his attempt to win government acceptance of his plan to harness academic scientists to the nation's war effort during World War I. He failed again in his postwar attempt to create a national research foundation to be cosponsored by the federal government and major corporations.

World War II changed all this. The role that technology and science played in waging and winning the war for the Allies, especially the role of the U.S. Office of Scientific Research and Development (OSRD) headed by Vannevar Bush (1890–1974), led if anything to an overestimation of the power of innovation in the postwar period. In his report titled *Science: The Endless Frontier* (1945), Bush argued that U.S. industrial prosperity and military security would in the future be critically dependent on continuous science-based technological innovation. The federal government needed to create mechanisms for government-subsidized basic research, primarily at universities, to *feed* the commercial innovation process. For Bush, this was the lesson of such OSRD accomplishments as the Manhattan Project, of the Massachusetts Institute of Technology's (MIT) Radiation Laboratory or RadLab that produced a constant stream of electronic warfare and counterwarfare technologies, and of mass-produced cheap antibiotics and blood products. Yet as Bush later acknowledged, this *push* or linear model, in which basic research leads to applied science, which then leads to commercial technological innovations, overestimates the dependence of innovation on basic science. This view was confirmed in Project Hindsight (1966), a Department of Defense study of twenty weapons systems, introduced since 1946, that concluded that basic science affected less than 10 percent of these systems. A follow-up study by the National Science Foundation (NSF), TRACES (Technology in Retrospect and Critical Events in Science [1968]), defended the basic research-driven model in the Bush report by looking back fifty years instead of twenty.

Since 1970 research by historians of technology has supported a version of the Project Hindsight conclusion. While basic research sometimes *pushes* innovation, innovation far more often *pulls* research, which may then enable further innovation. The exponential growth of innovation in the semiconductor and computer industries exemplifies this relationship.

Bush's report and its basic science push model nevertheless anchored postwar-U.S. science and technology policy. For the first time in U.S. history, there was a mandate for large-scale federal support of basic as well as applied scientific research. The ethics of giving scientists public funds to do research on subjects of their choice gave rise to contentious political debates that held up creation of the NSF in 1950. But the NSF budget for basic research was then and has remained modest compared to the budgets for applied research linked to innovation, which until 1989 was driven primarily by Cold War military agendas and secondarily by the evolving war on cancer, war on AIDS, and Human Genome Project agendas of the National Institutes of Health (NIH) and the U.S. space program.

In the 1960s leading political figures including Presidents John F. Kennedy, Lyndon B. Johnson and Richard M. Nixon promoted innovation as the key to U.S. economic growth. In 1962 President Kennedy explicitly identified industrial innovation as the source of new jobs and new wealth that would be shared by all. But it was only in the 1970s and after, in the wake of the Silicon Valley phenomenon and the astonishing pace of wealth creation in the semiconductor and computer industries, that a national consensus recognized the civilian economy as critically dependent on innovation for growth. It was in the 1960s and 1970s that Schumpeter's identification of innovation and entrepreneurship as engines of economic growth was rediscovered. It had sparked little interest when published in 1911 or even after Schumpeter's migration to Harvard University in the 1930s. Nor did University of Chicago economist Frank Knight (1885–1982) stimulate interest in the link between innovation and entrepreneurship with his pioneering 1921 study of the dynamic role played by risk in creating new businesses. Knight coupled a penetrating analysis of the economics of innovation-driven entrepreneurship to a stinging moral critique of the wastefulness of innovation in a capitalist economy. The importance of the ideas of Schumpeter and Knight would be appreciated only when innovation had engaged the general political consciousness and conscience. Early-twenty-first-century American economist Paul Romer is an influential neo-Schumpeterian, arguing that growth is generated by ideas of which innovation is a symptom and defending the virtues of the unmanaged U.S. innovation model over the managed innovation models in Japan and east Asia.

The Ethics of Innovation

Recognition of the scale and scope of innovation-enhancing policies provoked broad criticism of social and ethical implications of the dependence of society on innovation. Jacques Ellul in *The Technological Society* (1954), for instance, argued that such dependence reflected a gamble that would compel societies to transform themselves into vehicles for supporting continuous innovation at the expense of traditional personal and social values. Ellul's ethical and political critique of technology-based society attracted many followers who developed it further in the 1960s and 1970s, and were significantly responsible for the creation of university-based science, technology, and society (STS) studies programs as an academic response to the new institutionalization of innovation by government and industry. Alvin Toffler's *Future Shock* (1970) was a more popular caution against and criticism of the personal as well as social disorientation caused by continuous innovation. Its commercial success suggests a responsive chord of concern in the general public, which nevertheless embraced the flood tide of innovations affecting every aspect of personal and social life, locally, nationally, and globally, that poured into the marketplace during the last third of the twentieth century.

By the turn of the twenty-first century, that economic prosperity was keyed to continuous technological innovation in a global competitive environment was enshrined as an ineluctable fact, a principle of nature, a kind of categorical imperative. *Innovate or stagnate* not just economically, but culturally as well. Open to serious debate in principle were such questions as whether innovation-induced social change constituted true growth or was just change; whether such change was progressive, improving the quality of life, or just sound and fury busyness signifying nothing very deep. Yet public debates on such questions rarely took place. What was broadly recognized as inescapable, though, was that the innovation-driven economic growth process institutionalized after World War II and adopted globally by 2000 was characterized by a kind of positive feedback. Only *continuous* growth was possible; stasis, with the loss of the expectation of growth, threatened economic collapse.

Meanwhile the accumulated scholarship of the STS studies community generated new insights into the innovation process. Contrary to the inherited wisdom that technical knowledge was value-free, innovation is in fact ethically *preloaded*. Innovations enter the marketplace incorporating a broad range of value judgments primarily determined by the agendas of the commercial institutions and governmental agencies pursuing innovation on behalf of those agendas. The so-called *negative externalities* of innovation—including Schumpeter's *creative destruction* of superseded technologies along with their institutions, facilities, and people—also include negative environmental impacts, the introduction of new forms of personal and social life, and the creation of new vested economic, social, and political interest groups and power centers, each committed to perpetuating itself. All such concomitants of innovation raise ethical concerns that dwarf the public processes available for addressing them.

Organizational theorist and Nobel economics laureate Herbert Simon noted in the 1960s that complex systems are by definition ones whose behaviors include unpredictable outcomes. Technological innovations often result in the implementation by society of complex systems to support them. As a result, even with the best of corporate, governmental, and public intentions, it is impossible to predict in advance all of the consequences, negative or positive, of innovations in, for example, antibiotics, television, the Internet, and cell phones. Such unpredictability motivated Bill Joy—a cofounder of Sun MicroSystems Corporation, its chief scientist, and a cocreater of the Java programming language—to issue a passionate call in 2001 for a moratorium on innovation in biotechnology, nanotechnology, and robotics. Joy's argument was that these three technologies were converging and had the potential for unpredictable consequences that posed profound threats to human survival. Joy stumped the nation warning academic, industrial, and public audiences of the potential for catastrophic harm from continuing our postwar policy of unfettered innovation followed by catch-up attempts at regulation as problems arose.

A similar moratorium had been argued for in 1974 by Paul Berg, inventor of recombinant DNA technology. Berg's call, following a year-long cessation of research in his own lab, led to the 1975 Asilomar Conference, which substituted heightened laboratory safeguards for a moratorium, and subsequently sanctioned a biotechnology innovation free-for-all. In the 1980s, Jeremy Rifkin and others attempted to block innovation in genetically modified food crops and plants, to little if any avail. Joy's call did provoke a substantial response within the technology community. Raymond Kurzweil, an eminent engineer-inventor, debated Joy on a number of occasions, orally and in print, championing unrestricted innovation as both progressive and capable of containing any unanticipated harmful consequences of innovation. In spite of rapid commercial development of biotechnology and nanotechnology industries at the start of the twenty-first century, the public was not engaged in the ethical issues raised by innovations that were under research and development, in the prototype stage, or being introduced into the marketplace.

STEVEN L. GOLDMAN

SEE ALSO *Business Ethics; Invention; Science, Technology, and Society Studies.*

BIBLIOGRAPHY

Bush, Vannevar. (1980). *Science: The Endless Frontier*. New York: Arno Press. Originally published in 1946, the seminal U.S. science policy document.

Chandler, Alfred Dupont. (1980). *The Visible Hand*. Cambridge, MA: Belknap Press. A history of American industry's exploitation of innovation.

Ellul, Jacques. (1967). *The Technological Society*. New York: Vintage Books. The most influential attack on modern technology as antidemocratic and antihuman.

Erwin, Douglas H., and David C. Krakauer. (2004). "Insights into Innovation." *Science* 304: 1117–1118.

Galbraith, John K. (1998). *The Affluent Society*. Boston: Houghton Mifflin. Originally published in 1958, a still powerful critique of consumerism and greed.

Hughes, Thomas P. (1989). *American Genesis: A Century of Invention and Technological Enthusiasm, 1870–1970*. Chicago: University of Chicago Press. An excellent history of technological innovation American style.

Mowery David C., and Nathan Rosenberg. (1998). *Paths of Innovation*. Cambridge, UK, and New York: Cambridge University Press. An in-depth examination of four industries created by innovation.

Rosenberg, Nathan. (1983). *Inside the Black Box: Technology and Economics*. Cambridge, UK, and New York: Cambridge University Press. An economist's analysis of the relation between invention, innovation, commerce, and society.

Schumpeter, Joseph. (1983). *Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle,* trans. Redvers Opie. New Brunswick, NJ: Transaction Publishers. Expands Schumpeter's focus on innovation to a comprehensive theory of business cycles as inevitable in a growing economy.

TECHNOLOGY ASSESSMENT

SEE *Constructive Technology Assessment; Technology Assessment in Germany and Other European Countries; United States Office of Technology Assessment.*

TECHNOLOGY ASSESSMENT IN GERMANY AND OTHER EUROPEAN COUNTRIES

From its mid-1970s origins, technology assessment (TA) in Germany and in Western Europe has been presented as a methodical, ethical, and theological as well as natural-, engineering- and social-science-oriented reflection on the technological preconditions for the formation and design of modern societies and the impacts of technology on such societies. TA analyzes both the development of technologies and the entities that have the competence, resources, and strategic potential to create them. Using prediction procedures, decision-theory approaches, and model simulations—all of which resemble economic models—the goal is to raise awareness of the desired and undesired, synergetic, and cumulative consequences of new technologies, if possible before they become issues of public debate. TA further aims to reveal the basic values underlying any *assessment*.

Representative Institutions

Understood as a form of *political counseling,* a series of TA institutions were founded by some Western European parliaments. Among these institutions are the following:

- Scientific and Technical Options Assessment (STOA), by the European Parliament (1985)
- Office Parlementaire d'évaluation des choix scientifiques et technologiques (OPECST), France (1983)
- Büro für Technikfolgen-Abschätzung beim Deutschen Bundestag (TAB) or Office of Technology Assessment at the German Parliament (1990)
- Rathenau Institute, Netherlands (1986)
- Parliamentary Office of Science and Technology (POST), United Kingdom (1989)

There are also parliamentary institutions in Denmark, Austria, Finland, Belgium, Greece, Norway, Switzerland, Sweden, and Spain, which in the near future will join this circle of parliamentary counselors in the cooperative European Parliamentary Technology Assessment (EPTA). Some Eastern European countries, in particular Poland, Hungary, and the Czech Republic, have also established independent TA institutions. Of the independent institutions founded in Germany, of particular interest is the Institut für Technikfolgenabschätzung und Systemanalyse (ITAS or Institute for TA and System Analysis) of the Karlsruhe Research Center (RZE), a member of the Helmholz-Gemeinschaft Deutscher Forschungszentren (Helmholz Association of National Research Centers), the largest scientific organization in Germany. ITAS is also the operating authority of TAB. ITAS publishes the only significant TA journal in Germany titled *TA in Theory and Practice*.

Two major research institutes in the Helmholtz Community Association of National Research Centers among those that conduct projects on sustainability research relating to TA, should be mentioned: Forschungszentrum Jülich (Juelich Research Institute) and the Deutsches Zentrum für Luft- und Raumfahrt (DRL) (German Center for Aviation and Space Flight), Cologne. Another national organization is the European Academy for Research on the Consequences of Scientific/Technical Development, which is located in Bad Neuenahr and primarily supported by the state of Rhineland Palatinate and by the DLR. It is less technology-transfer oriented than, for example, the ITAS or TAB because its research is focused more on basic questions concerning the acceptability of technology use as an element of forward-looking policies. The Academy for TA, founded in Stuttgart in 1991, was closed by the state of North Rhine-Westphalia at the end of 2003. This was a severe setback for TA research in Germany, in particular because the academy had an impressive public profile as a result of its efforts to link socially relevant discourse with areas of science, economics, and politics.

Research Themes

Among the important TA topics in Germany, sustainability dominates current research. Indeed efforts are aimed at institutionalizing the principles of sustainable development at all levels of national and transnational political systems.

In addition to biotechnology (as related to agriculture, pharmacy, textiles, and food), research into gene technology, diagnostics, and therapy are at the center of public interest. In Germany discussions have concentrated on the fields of biomedicine, and in particular on the ethical justification of research using human embryos and preimplantation diagnoses (PID). Stem-cell research is examined in terms of future application to tissue and organ regeneration. The acquisition of stem cells from embryos, or so-called therapeutic cloning, is the subject of numerous investigations. The compatibility of biomedical developments with the principle of human dignity as defined by the German basic law (or constitution) and the EU constitution is an especially important issue.

The development of nanotechnology is also of interest, especially because this field has frequently been presented as a key technology for the twenty-first century. Applications of nanotechnology are projected in the fields of space flight, agriculture, information processing, and medicine. The implementation of nanotechnology materials is discussed in relation to ecological and medical issues.

In the context of the process of globalization—especially in university research projects—there are TA questions about the consequences and effects of the virtualization of social life—politics, economics, ecology, culture, and law. With regard to politics, studies have focused on e-government, electronic democracy, and the dismantling of nation-states. With regard to economics, TA has concerned itself mainly with the transformation of work. In addition, TA continues to address classic issues such as traffic, new energy sources (nuclear fusion), privatization of health systems, pharmacology, food technology, multimedia technology, and information or data processing.

Evaluation

The German and European TA landscape deserves evaluation on the basis of the following: Have the numerous TA activities had any influence? If so, what kind of influence have they had on technological developments and on related underlying decisions? *Technological Assessment in Europe: Between Method and Impact* (2003), a study by ITAS and the European Academy, is a useful guide in answering these questions. This study presents a typology of three types of impacts: the generation of knowledge; the alteration of opinions and forms of behavior; and the initiation of action.

The study concludes that: "Based on the typology of the impacts on TA it is shown that the impacts of TA present more than just the direct influences of political decisions . . . TA—independent of whether it is more classically scientific or participatory—contributes in various ways to society's communication process and to the political decision process: Through the preparation of a balanced basis of knowledge, through the initiation of a new discussion in a gridlock situation, through the working out of new perspectives on a problem" (Decker and Ladikas 2004, p. 78).

Finally the report of the European Science and Technology Observatory (ESTO), an association of twenty European institutions, should be mentioned. In 2002 at the direction of the Institute for Prospective Technological Studies (JRC-IPTS) of the European Commission, ESTO produced an overview of technology-forecasting activities in Europe.

This working document arose within the frame of the ESTO project "Monitoring of Technology Forecasting Activities," funded by the Joint Research Center Institute for Prospective Technological Studies (JRC-IPTS) of the European Commission. This project was part of a larger ESTO monitoring activity, which ran from February 2000 until June 2001. The main results of this ESTO activity are published in "Strategic Policy

Intelligence: Current Trends, the State of Play Perspectives, IPTS Technical Report series, EUR 20137 EN.

RABAN GRAF VON WESTPHALEN

SEE ALSO *Discourse Ethics; German Perspectives.*

BIBLIOGRAPHY

Decker, Michael, and Miltos Ladikas. (2004). "EU: Procekt: Technology Assessment in Germany; Between Method and Impact (TAMI)."*Technikfolgenabschätzung* 1(13): 71ff.

European Commission, Joint Research Centre (JRC). (2002). *Monitoring of Technology Forecasting Activities—ESTO Project Report.* Düsseldorf, Germany: VDI Technology Center, Future Technologies Division.

Graf von Westphalen, Raban, ed. (1999). *Technikfolgenabschätzung als politische Aufgabe,* 3rd edition. Munich, Germany: Oldenbourg Verlag. An overview of methods and mode of operations based on case studies.

Grunwald, Armin. (2002). *Technikfolgenabschätzung—eine Einfülrung.* Berlin: Edition Sigma. The best German language introduction in the field of technical-impact assessment.

TECHNOLOGY LITERACY

SEE *Public Understanding of Science.*

TECHNOLOGY: OVERVIEW

Technology may be broadly defined as the making and using of artifacts. In its simplest forms, however, use will involve no more than natural objects, and in more abstract instances fabrication and use can both be of concepts—in which case logic may be described as a technology. The etymology of the word leads back to the Greek *techne,* from which is derived *technique* and *technics.* In the opening lines of *Nicomachean Ethics,* Aristotle (384–322 B.C.E.) observed that "Every *techne* and every inquiry, and similarly every *praxis* and pursuit, is believed to aim at some good" (1.1.1094a). Thus the centrality of human ends or intentions to technology makes ethical analyses vital. Ethical inquiry is made difficult, however, by the diversity of ways technology can be understood. According to one proposed analysis, technology may be distinguished into objects, knowledge, activities, and intentions (Mitcham 1994). Each of these types of technology constitutes a source and challenge for ethics.

Historical Dimensions

Before considering these different types of technology, which are covered in a plethora of entries in this encyclopedia, there are historical transformations from technics to technology to acknowledge. These transitions, which are also often described as shifts from ancient to modern or from prescientific to scientific technology, can be discussed in terms of artifacts and attitudes. In relation to artifacts, humans used lithic (or stone) tools from the early Paleolithic period (about 2.6 million years ago) up to the close of the Neolithic period around 5,000 years ago. The widespread control of fire occurred roughly 124,000 years ago and crops were domesticated around 10,000 years ago. Up until approximately 40,000 years ago, the interplay between human physiology and technics no doubt influenced the evolution of human cognitive and other physical capacities.

The development of bronze and iron tools marked the end of the Neolithic and the transition into the classical age, in which technological artifacts in the form of structures became increasingly significant. Premodern structures, initially in the early civilizations of Egypt, Mesopotamia, India, and China, then especially in China's Han dynasty (206 B.C.E.–220 B.C.E.) and the Greek and Roman periods in Europe, became interrelated with governance, and the works of architects began to influence daily life. In the European Middle Ages progressive developments in mechanics and the harnessing of nonhuman sources of power promoted further change in artifactual history.

The emergence of technology in a distinctly modern sense is correlated with the rise of modernity itself. Through the Industrial Revolution tools, machines, structures, industrial processes, and mass-produced consumer goods increased in complexity and number, acquiring an unprecedented societal influence. Additionally, during and after the Enlightenment, technology became progressively associated with accumulating scientific knowledge, to the point where, in the late twentieth century the connection was occasionally denominated with the term *technoscience.*

In relation to attitudes, which exhibit inherently ethical components, history may be broken out into a threefold taxonomy of arguments about technology and its proper role in the good life. Although partially historical, these basic attitudes (with countless gradations) nevertheless continue to coexist today. First, ancient or premodern attitudes about technology were generally skeptical, tending to view it as a necessary but dangerous turning away from God or the gods. Artifacts were judged to be less real than natural objects, technical information was not considered true wisdom, and technical affluence was thought to undermine higher goods such as individual virtue and political stability.

Second, modern Enlightenment attitudes about technology were optimistic, viewing it as a means of socializing individuals and creating public wealth. The will to technology was ordained by God or nature. Technical engagement with the world provided true knowledge, and nature and artifice were judged as operating by the same mechanical principles.

Finally, Romantic attitudes about technology reintroduced a degree of premodern uneasiness to constitute an ambivalence that tried to strike a middle ground between premodern skepticism and modern enthusiasm. Technology was viewed as one manifestation of human creativity, and thus to be affirmed, but also as manifesting a lamentable tendency to crowd out other forms of creativity. Technology engendered freedom but simultaneously alienated individuals from affective strength, weakened cultural bonds, and introduced new forms of social control. Artifacts expanded the processes of life, but imagination and vision deserved to be defended against the encroachments of technical knowledge.

Technology as Object

Technology is most commonly thought of in terms of artifacts, physical objects designed and produced by human beings. Ethical issues related to artifacts include the concerns of health and safety. These are especially illustrated by elements of risk and uncertainty, because it is often impossible to predict how objects will interact with the complex physiological, social, and ecological contexts in which they are deployed. Important work in engineering design seeks to integrate safety concerns throughout the process, but in some sense accidents and failures may be an inevitable part of complex modern artifacts.

Other ethical issues stem from justice and equity concerns that arise, for example, in cases of technology transfer and other manifestations of globalization. Matters of justice and equality are also involved in the representation of females and minorities in technology development and application policies. Freedom is a further important consideration in debates about technological determinism (in the thought of Jacques Ellul) or the liberating potential of technology (as argued by Julian Simon). Moreover, philosophers such as Langdon Winner have argued that artifacts have politics, in that they may be intentionally designed to limit the freedoms of certain groups. Other objects inherently lead to different political systems of control along the spectrum from authoritarianism to democracy.

Technological objects raise additional ethical and phenomenological questions about how they influence individual and group self-identities. For example, the design of buildings and public spaces in urban environments, in addition to impacts on safety, health, and equity, influence community character and quality of life. Finally, there is a sense in which technological objects as consumer goods can alter both culture and, through pollution and waste, the natural environment.

Not only do many of the key themes just mentioned have their special entries, but sample encyclopedia entries on almost any technology—from "Airplanes" and "Biological Weapons" to "Movies" and "Television"—illustrate these issues. Entries on thinkers such as "Anders, Günther," "Ellul, Jacques," "Illich, Ivan," and "Simon, Julian" present particular arguments. Slightly more general discussions that emphasize structures and hardware can be found in "Architectural Ethics" and "Computer Ethics," respectively.

Technology as Knowledge

Much of the philosophical work on technology as knowledge has naturally been epistemological, but ethical issues have also received consideration. One of these concerns freedom of speech and censorship. For example, terrorist threats highlight the dual-use character of technical knowledge, which may often be used for beneficial as well as nefarious purposes. This raises age-old questions about whether some knowledge should be forbidden, or if not, how its production and exchange should be regulated. Because technoscientific knowledge is not easily separable from applications, it may not be feasible or wise to argue that ethical considerations need only take place after knowledge has been produced.

With advances in genetics and information technologies, the issue of intellectual property rights has sparked debate about the ethical and societal implications of the private ownership of technical knowledge. Pertinent topics in this area are open-source software and the patenting of genetic material. In agriculture, the latter area has raised difficult questions about the legal status of indigenous technical know-how. Another important topic is the increasing privatization of academia driven by incentives for university researchers to patent the technological products that result from their research. This raises ethical issues about the proper role of the academy and the value of open information exchange in science.

One last broad set of ethical issues is raised by the theme of expertise and the role of experts, especially engineers, in a democracy. Many problems in modern industrial societies require the specialized knowledge of engineers, but most would claim that a technocracy, or rule by experts, represents an undesirable departure from democratic ideals. (It is worth noting, however, that in some cases technocrats are praised because of their lack of attachment to fundamentalist political or religious ideologies; technical knowledge and competence has its virtues.) Although engineers have much to offer regarding management and policy decisions, many nontechnical or political issues tend to become unproductively debated as if they could be resolved by technical knowledge. Other issues related to the accumulation of specialized knowledge by experts are the deskilling of the workforce, equity concerns about access to education, and widespread technological illiteracy even in societies utterly dependent on the smooth functioning of technological systems. All of these issues raise important questions about knowledge as a form of power.

Encyclopedia entries that deal directly with technology as knowledge thus include those on "Expertise," "Intellectual Property," "Public Understanding of Science," and "Technocracy." Related questions are also addressed in more general entries on, for example, "Computer Ethics" and "Information Ethics."

Technology as Activity

Technology as activity shades from personal to institutional and social modes. It may conveniently be divided into the two broad themes of production and use. With regard to production, most of the ethical issues are internal to the various technical professions. They raise issues of professional, engineering, and management ethics, which are often formalized in codes of ethics and are being increasingly integrated with professional training and education programs. Different ethical issues arise along the spectrum of engineering functions from the initiating actions of inventing and designing to the subsequent processes of testing, constructing, and operating. But across the board one common theme is that of the social responsibility of engineers, managers, and the organizations in which they are embedded.

Technology as activity is nevertheless more complex than a one-way flow of products from invention to application or use. Not only are engineers influenced in subtle ways by cultural norms, their work is often consciously informed and directed by formal and informal involvements of governments and publics. These take the broad form of technical standards, regulation, and technology policy, as various institutions and actors engage in decision-making procedures about which technologies to produce, ban, limit, or otherwise manage. Examples include regulatory bodies such as the Food and Drug Administration (FDA), advisory bodies such as bioethics commissions, and technology assessment agencies such as the Office of Technology Assessment (OTA) or tools such as environmental impact statements. Public decisions about the production and use of technology raise manifold ethical issues about who should be involved, how involvements should be structured, how risks, costs, and benefits should be measured, and what goals should drive the policymaking process. Broader debate occurs over the proper roles of market mechanisms and government control.

Ethical analyses of the use of technology flow naturally from the fact that such uses are subordinate to, or in the service of, some goal. Issues of use often raise the question of whether artifacts can be considered ethically neutral. For example, computer technology can be used to help researchers find cures for diseases, or it can be used to hack into financial systems and steal money. Although it is common to conceptualize technology in this way, there is significant evidence for the nonneutrality of technology.

Indeed technological changes fundamentally alter human experiences in ways that can be judged good or bad, but certainly not neutral. Such changes are best illustrated by work, the most prominent form of technology as activity. The large-scale production and use of modern technologies has brought about the transformation of craftwork into industrial labor, which is marked by division of labor, mass production standardization, and bureaucratic organization.

For more analysis of the ethical issues related to technology as activity it is thus useful to consider encyclopedia entries on "Professions and Professionalism," specific professional organizations such as the "Institute of Electrical and Electronics Engineers," and regulatory agencies such as the "Food and Drug Administration" and the "Federal Aviation Administration." Also relevant would be entries on the principles that are said to guide much technical activity such as "Efficiency," "Safety," and "Reliability."

On a philosophic note, it is also important to consider how technological activities or processes of a more impersonal sort alter human relationships and relationships between humans and nature. The entry on "Tools and Machines" makes suggestions with regard to human–human relationships. The entry on "Arendt, Hannah," provides further background to her argument about the ways traditional technics or premodern technology was limited by the materials and energy given in nature. The development of steam, electric, and nuclear power qualitatively changed this human–nature relationship. Finally, Arendt noted how technology as action is a deeply troubling contradiction. Traditionally, action was associated with the political realm and its qualities of plurality, indeterminacy, and choice. Modern mass society has subordinated this realm to the pursuit of scientific technology and technologically mediated work, an effort that seeks to replace the contingencies of nature and the polis with the control and certainty of technology. Ethical and metaphysical quandaries result about the modern attempt to control, manage, and even make nature. Much of the rhetoric around the notion of ecological sustainability, for example, is dominated by concerns of control and efficiency rather than political and ethical considerations of the meaning of the good life and humankind's proper relationship with other species. And contemporary worries about the uncertainty of much scientific and technical knowledge would arise only in a world that aspired to certainty in human affairs.

Technology as Intention

Technology as intention is at once the most basic yet the most difficult to consider. As Aristotle noted, neither technics nor technology can exist without the exercise of intentionality. Moreover, because ethics is itself so closely tied to the idea of intentions and their assessment, to think of technology as intention would seem to bring technology more closely into the ethical realm than to think of technology as object, knowledge, or perhaps even action. At the same time, the slipperyness of intentionality presents its own difficulties, especially in relation to technology. Is there any such thing as a distinctively technological intention in the same way there are technological objects, forms of knowledge, and activities? Is it possible, for instance, to distinguish between religious, political, and technological intentions—or between premodern and modern technology in terms of intentionalities? Or are intentions just mental states to which technical activities are necessarily subordinated? Is there one intention to procure food, which can then be achieved by, say, political or technological means? But surely the intentional selection of technological over political means constitutes a kind of technological intention. (See, in this respect, the entry on "Technological Fix.")

The most common way in which intentionality has been invoked when examining the ethics of technology is in fact in relation to the idea of modern technology as emanating from a distinctive will or volition, a philosophical argument more common to phenomenological than to analytic traditions in philosophy. Discussions of technology as volition span the spectrum from technology as a creative life force to technology as a restricting urge to control. Technology can be celebrated in a Nietzschean aesthetics of self-making in the project to wrest control of life from the vagaries of nature and even achieve immortality. But there is a sense in which technologies have a "will of their own" and are not infinitely plastic to the impress of different human intentions. Perhaps it is not just human intentions or volitions that shape technology, but technologies that also influence human intentions. There are limits to what one can do with any particular technology: It is difficult to use a hammer to screw a nut onto a bolt.

To analyze technology as a form of intentionality further requires that ethical assessments of use be coupled with empirical work on the properties of technologies. One form this has taken is to conceptualize intending as a form of decision making, which may in turn be undertaken by rational analysis. More generally, the increasing powers unleashed by modern technology suggest a need for increased knowledge of what ends they are to serve and knowledge of the consequences before they are put into use. But such needs must themselves be translated into action. And failure to take action is a form of weakness of intention or will that recurs frequently in situations of public and personal decisions about technology.

Most discussions of the ethics of technology deal with specific technologies: biomedical technologies, computers, nuclear weapons, and more. But in a few instances philosophers working in the phenomenological tradition have sought to bridge technological divides and consider the parameters of technology as a whole. Here the contributions of such thinkers as "Anders, Günther" and "Jonas, Hans" as well as "Heidegger, Martin" are especially significant. Related discussions can be found in entries on such philosophical schools as "Existentialism" and "Critical Social Theory."

Generalization

The distinctions between ethical issues in technology as object, as knowledge, as activity, and as intention should not serve to excuse anyone from thinking about ethics and technology in other ways as well—or for seeking to integrate these four modes of the manifestation of technology. For instance, Albert Borgmann's provocative interpretation of modern technological objects as tending toward what he terms the "device paradigm" of supplying some commodity with minimal human engagement and contextual dependency at the same time depends on a unique form of (virtual) knowledge and sponsors a distinctive type of (unfocused) activity. Borgmann's ethical assessment of technological devices is coordinate with his ethical judgment regarding technological knowledge and activity. To distribute ethical issues across a spectrum of manifestations of technology may serve simply as a provisional means for appreciating the breadth of concerns that fall under the idea of relating technology and ethics. Similarly, Don Ihde's analysis of different forms of human engagement with technology—from embodied extension to perceptual transformation—crosses the boundaries of technology as object, knowledge, and action in ways that invite scientists, engineers, and the general public to ask broad ethical questions about the techno-lifeworld they are in the process of creating.

Finally, the breadth of concerns must not be thought of as one determined only by problems. The praise of technology that is distinctive of the modern project and Enlightenment aspirations invests technology with rich ethical promise for better goods and services, understanding, human health, and intentional fulfillment. From this perspective the ethical problems are addressed so that they can be negotiated with that distinctively human behavior that originally gave rise to all technology, ancient and modern, in order to pursue and promote true human flourishing. Problems need not be limitations; they can also be conceived as the stimulus to new achievements.

ADAM BRIGGLE
CARL MITCHAM
MARTIN RYDER

SEE ALSO *Architectural Ethics; Computer Ethics; Engineering Design Ethics; Engineering Ethics: Overview; Ethics: Overview; Expertise; Industrial Revolution; Professions and Professionalism.*

BIBLIOGRAPHY

Barbour, Ian G. (1993). *Ethics in an Age of Technology*. San Francisco: HarperSanFrancisco. This is the second of two volumes, the first of which dealt with science and religion.

Borgmann, Albert. (1984). *Technology and the Character of Contemporary Life: A Philosophical Inquiry*. Chicago: University of Chicago Press. A provocative interpretation of the special character of modern technology as object.

Chadwick, Ruth, ed. (2001). *The Concise Encyclopedia of the Ethics of New Technologies*. San Diego, CA: Academic Press. Thirty-seven articles on various technologies (biotechnology, genetic engineering, nuclear power) and related issues (brain death, intrinsic and instrumental value, precautionary principle) selected from the *Encyclopedia of Applied Ethics* (1998).

Ihde, Don. (1990). *Technology and the Lifeworld: From Garden to Earth*. Bloomington: Indiana University Press. A broad phenomenological analysis of human-technology interactions.

Jonas, Hans. (1984). *The Imperative of Responsibility: In Search of an Ethics for the Technological Age*, trans. Hans Jonas and David Herr. Chicago: University of Chicago Press. Combines two German books published first in 1979 and 1981.

Kaplan, David M., ed. (2004). *Readings in the Philosophy of Technology*. Lanham, MD: Rowman and Littlefield. Includes substantial sections on ethics and politics.

Mitcham, Carl. (1994). *Thinking through Technology: The Path between Engineering and Philosophy*. Chicago: University of Chicago Press.

Mitcham, Carl, and Robert Mackey, eds. (1983). *Philosophy and Technology: Readings in the Philosophical Problems of Technology*. New York: Free Press. The "Ethical-Political Critiques" section includes a number of classic texts; other articles in this early collection are also relevant.

Tavani, Herman T. (2003). *Ethics and Technology: Ethical Issues in an Age of Information and Communication Technology*. Hoboken, NJ: Wiley.

Winner, Langdon. (1986). *The Whale and the Reactor: A Search for Limits in an Age of High Technology*. Chicago: University of Chicago Press.

INTERNET RESOURCE

"The Online Ethics Center for Engineering and Science." Case Western Reserve University. Available from http://onlineethics.org.

TECHNOLOGY TRANSFER

Technology transfer is a complex and multi-faced process. Initially, transfer occurs from research laboratories such as universities to the market. Prior to 1980 when The Patent and Trademark Laws Amendment Act, more commonly know as the Bayh-Dole Act was passed, there was limited flow of government-funded inventions to the private sector. In 1980, the federal government held title to approximately 28,000 patents. Fewer than 5 percent of these were licensed to industry for development of commercial products (U.S. Government Accounting office, 1998). The Bayh-Dole Act permitted universities to retain title to inventions developed under government funding and encouraged universities to collaborate with companies to promote the utilization of invention arising from federal funding. Since the passage of this Act, partnerships between universities and industry have moved new discoveries from the laboratory to the market place for the benefit of society.

There is substantial evidence to suggest that the Bayh-Dole Act has promoted a considerable increase in the technology transfer from universities to industry, and ultimately to the people around the world. However, it is obvious that economic interests were the driving forces for the change in governmental policy. Licensing by universities, National Institutes of Health or other governmental agencies in life sciences has yielded substantial profits to pharmaceutical companies, sometimes at the cost of human suffering. If the public good is not served by, or is undermined by technology transfer, then it is ethically justified to change public policy.

Historically, and to a large extent even in the early twenty-first century, the transfer of technology occurs between and among developed nations. However, new forms of multi-national enterprise imply a dispersion of production tasks across globe. In the case of developing countries, the technology must meet the local needs and be socially accepted. If the technology is not appropriate it may cause negative economic, social, and environmental impacts. The chemical disaster in Bhopal, India, is a case in point. Methylisocyanate (MIC) leaking from a Union Carbide corporation pesticide plant immediately killed more than 2,000 people and injured or disabled more than 200,000 others. The death toll has reached 20,000 since December 3, 1984, when the accident occurred. Information about hazardous technologies was lacking, workers were poorly trained, and major safety equipment was inoperative because of poor maintenance. In this case the technology should have been modified to make it adaptable to the new environment.

Mechanisms of Technology Transfer

The most important legitimate channels for technology transfer are licensing, foreign direct investment, and joint ventures. Most technology transfer takes place in the form of licensing under specific terms and conditions agreed to by both suppliers and recipients. The suppliers gain monetary rewards, whereas the recipients expand their economic opportunities.

Foreign direct investment refers to a process by which multinational corporations (MNCs) transfer production operations to the developing countries through wholly owned subsidiaries. In this context, the transfer of technology takes place internally between parent MNCs and their branches and subsidiaries in different countries. This enables MNCs to retain technology within the corporations.

Joint ventures have emerged as an alternative to foreign direct investment because most developing countries have issued investment laws that regulate foreign investment. These laws promote joint ventures between local and foreign partners. Consequently, with greater emphasis on national participation and control by the developing countries, technology transfer has assumed a new meaning, although control over proprietary technology and know-how has remained with MNCs.

Technology Transfer and Ethical Issues

Given these basic mechanisms of technology transfer, one may nevertheless ask: Why technology transfer? Can technology transfer improve the economic conditions of people living in the developing countries? Can technology transfer create global equity?

Proponents of globalization have suggested that technology and its diffusion can improve living standards, increase productivity, generate employment opportunities, improve public services, and create competitive markets for products. Have these goals been achieved? There are two contending theories: the dependency theory and the bargaining theory.

DEPENDENCY THEORY. Proponents of this theory (Cardoso and Faletto 1979) claim that, because of the insistence of multinational corporations on foreign direct investment (which transfers technology from the parent companies to the foreign subsidiaries), developing countries are denied access to modern technologies. These theorists contend that technology is key to development and, if denied, developing countries will remain dependent on developed countries. This will create negative economic outcomes, such as increased inequality and wage stagnation. Consequently, the balance of trade between developed and developing societies will remain unequal and therefore exploitive. Sunil K. Sahu (1998) suggests that such technological dependence creates an enclave economy for the developing countries, and that it will be difficult for their economies to expand or even survive.

BARGAINING THEORY. This theory takes a view opposite that of dependency theory. Bargaining theory recognizes the potential benefit that MNCs can bring to their host countries. In other words, the technologies of the advanced countries do not have adverse effects on the economy of the developing societies. Raymond Vernon (1971), an advocate of this theory, has developed a concept known as "obsolescing bargaining" that explains the relationship between MNCs and host countries. The bargaining power of the developing countries tends to increase after a certain period, specifically when technology becomes stabilized and competition for the same technology by other developed countries intensifies. The competition among developed countries increases the choices available to the developing countries. Additionally, once the foreign investment is "sunken," the host country is in a much stronger position to negotiate a better deal, and at this point MNCs cannot credibly threaten to withdraw (Stepan 1978). Vernon also suggests that the monopoly of the innovator is not permanent because most products tend to pass through a transition from "monopoly to oligopoly to workable competition" (Vernon 1971, p. 91). This is also known as the product life-cycle theory.

Can Technology Transfer Create Global Equity?

Technology transfer has accelerated the process of globalization, and it is suggested that it may lift all people and raise their living standards. The Industrial Revolution brought new wealth first in Europe and then in the United States. Since the Industrial Revolution, the difference between the rich and the poor in the world has increased. It is estimated that the difference between the per capita incomes of the richest and poorest countries was 3 to 1 in 1820, 11 to 1 in 1913, 35 to 1 in 1950, 44 to 1 in 1973, and 72 to 1 in 1992 (UNDP 1999). The gap is further reflected in how the world's wealth is distributed. The wealthiest 20 percent of the world's people—all from developed countries—control 85 percent of global income. The remaining 80 percent of people share 15 percent of the world's income. Such disparity has led to greater poverty in the developing countries. Statistics show that the number of people who are living on less than $1 per day (a frequently used poverty line) was rising in the late twentieth and early twenty-first centuries. The number of these people grew from 1.2 billion in 1987 to 1.5 billion in 2000, and there could be nearly 2 billion poor people by 2015. In addition, approximately 45 percent of the world population live on $2 per day (World Bank 2000). Some countries such as South Korea, Taiwan, Singapore, Hong Kong, and China have benefited from global economies, but others have not. The growth of proprietary technology, covered by patents and industrial property rights, has served as a major barrier to new entrants, and it will continue to do so unless proprietary rights are modified.

MURLI M. SINHA

SEE ALSO *Development Ethics; Technological Innovation.*

BIBLIOGRAPHY

Cardoso, Fernando Henrique, and Enzo Faletto. (1979). *Dependency and Development in Latin America,* trans. Marjory Mattingly Urquidi. Berkeley and Los Angeles: University of California Press.

Rosenberg, Nathan, and Claudio Frischtak, eds. (1985). *International Technology Transfer: Concepts, Measures, and Comparison.* New York: Praeger.

Sahu, Sunil K. (1998). *Technology Transfer, Dependence, and Self-Reliant Development in the Third World: The Pharmaceutical and Machine Tool Industries in India.* Westport, CT: Praeger.

Stepan, Alfred. (1978). *The State and Society: Peru in Comparative Perspective.* Princeton, NJ: Princeton University Press.

United Nations Development Programme (UNDP). (1999). *Human Development Report, 1999.* New York: Oxford University Press.

United States Government Accounting Office. (1998). "Technology Transfer." Report to Congressional Committees. Administration of the Bayh-Dole Act by Research Universities.

Vernon, Raymond. (1971). *Sovereignty at Bay: The Multinational Spread of U.S. Enterprises.* New York: Basic.

Vernon, Raymond. (1977). *Storm over the Multinationals: The Real Issue.* Cambridge, MA: Harvard University Press.

World Bank. (2000). *World Development Report, 1999–2000.* New York: Oxford University Press.

TECHNOSCIENCE

Technoscience refers to the strong interactions in contemporary scientific research and development (R&D) between that which traditionally was separated into science (theoretical) and technology (practical), especially by philosophers. The emphasis that the term *techno(-)science* places on technology as well as the intensity of the connection between science and technology varies. Moreover the majority of scientists and philosophers of science continue to externalize technology as *applications and consequences* of scientific progress.

Nevertheless they recognize the success and efficiency of technology as promoting realism, objectivity, and universality of science.

The prehistory of the concept of technoscience goes back at least to the beginning of modern science. Francis Bacon (1561–1626) explicitly associated knowledge and power; science provided knowledge of the effective causes of phenomena and thus the capacity for efficient intervention within them. The concept became clearer during the first half of the twentieth century. Gaston Bachelard (1884–1962) in *Le nouvel esprit scientifique* (1934; The new scientific spirit) places the *new scientific spirit* under the preponderant influence of the mathematical and technical operations, and utilizes the expression *science technique* to designate contemporary science. However the term techno(-)science itself was not coined until the 1970s.

The History of Techno(-)science

The first important occurrence of the term appears in the title of an article titled "Ethique et techno-science" by Gilbert Hottois, first published in 1978 (included in Hottois 1996). This first usage expresses a critical reaction against the theoretical and discursive conception of contemporary science, and against philosophy blind to the importance of technology. It associates technoscience with the ethical question, What are we to make of human beings? posed from an evolutionist perspective open to technical intervention.

Throughout the 1980s two French philosophers, Jean François Lyotard and Bruno Latour, contributed to the diffusion of the term in France and North America. For Lyotard technoscience realizes the modern project of rendering the human being, as argued from the work of René Descartes (1596–1650), a *master and possessor of nature*. This project has become technocratic and should be denounced because of its political association with capitalism. As a promoter of the postmodern, Lyotard thus facilitates diffusion of the term within postmodern discussions.

In *Science in Action* (1987), Latour utilizes the plural *technosciences* in order to underline his empirical and sociological approach. The technosciences refer to those sciences created by human beings in real-world socioeconomic-political contexts, by conflicts and alliances among humans and also among humans and nonhumans (institutions, machines, and animals among others). Latour insists on networks and hybrid mixtures. He denounces the myth of a *pure science*, distinct from technologies susceptible to good and bad usages. In reality it is less technology that Latour internalizes in the idea of science than society (and therefore politics), of which technologies are part in the same ways as other artifacts. He rejects any philosophical idea, whether ancient or modern, of a science that is supra- or extra-social and apolitical. The worldwide successes of the technosciences are a matter of political organization and will, and do not derive from some universal recognition of a rational and objectively true knowledge that progressively imposes itself. Latour has contributed to the success of the term technoscience in social-constructivist discussion since the 1990s.

The work of Donna Haraway illustrates well the diffusion of technoscience crossed with the postmodern and social-constructivist discussions in North America. Technoscience becomes the word-symbol of the contemporary tangle of processes and interactions. The basic ingredients are the sciences, technologies, and societies. These allow the inclusion of everything: from purely symbolic practices to the physical processes of nature in worldwide networks, productions, and exchanges.

In France, in continental Europe, and in the countries of Latin America, the use of the term technoscience has often remained closer to its original meaning that involves more ontological (as with German philosopher Martin Heidegger (1889–1976)), epistemological, and ethical questioning than social and political criticism. Indeed in a perspective that complements the one provided here, in *La revolución tecnocientífica* (2003; The technoscience revolution), Spanish philosopher Javier Echeverría provides an extensive analysis of technoscience as both concept and phenomenon. A political usage is not, however, rare, especially in France where there is a tendency to attribute to technoscience a host of contemporary ills such as technicism and technocracy, multinational capitalism, economic neo-liberalism, pollution, the depletion of natural resources, the climate change, globalization, planetary injustice, the disappearance of human values, and more, all related to U.S. imperialism. The common archetype of technoscience is Big Science, originally exemplified by the Manhattan Project, which closely associated science, technology, and the politics of power. In this interpretation, technoscience is presented from the point of view of domination, mastery, and control, and not from that of exploration, research, and creativity. It is technocratic and totalitarian, not *technopoiétique* and emancipating.

The Questions of Technoscience

What distinguishes contemporary science as technoscience is that, unlike the philosophical enterprise of science identified as a fundamentally linguistic and theoretical activity, it is physically manipulative, interventionist, and creative. Determining the function of a gene whether in order to create a medicine or to participate in the sequencing of the human genome leads to technoscientific knowledge-power-doing. In a technoscientific civilization, distinctions between theory and practice, fundamental and applied, become blurred. Philosophers are invited to define human death or birth, taking into account the consequences of these definitions in the practical-ethical plans, that is to say, in regard to what will or will not be permitted (for example, the harvesting of organs or embryonic experimentation).

Another example is familiar to bioethicists. Since the 1980s there has existed a line of transgenic mice (*Onco mice*) used as a model for research on the genesis of certain cancers. Here is an object at once natural and artificial, theoretical and practical, abstract and concrete, living and yet patented like an invention. Their existence and use in research further involves many different cognitive and practical scientific questions and interests: therapeutic, economic, ethical, and juridical. It is even a political issue, because transgenic mice are at the center of a conflict between the European Union and the United States over the patentability of living organisms.

The most radical questions raised by technosciences concern their application to the *natural* (as a living organisms formed by the evolutionary process) and *manipulated* (as a contingent creation of human culture). Such questions acquire their greatest importance when one takes into account the past and future (unknowable) immensity of biological, geological, and cosmological temporality, in asking, for example: What will become of the human being in a million years? From this perspective the investigation of human beings appears open not only to symbolic invention (definitions, images, interpretations, values), but also to techno-physical invention (experimentation, mutations, prosthetics, cyborgs). A related examination places the technosciences themselves within the scope of an evolution that is more and more affected by conscious human intervention. Both approaches raise questions and responsibilities that are not foreign to ethics and politics but that invite us at the same time to consider with a critical eye all specific ethics and politics because the issues exceed all conceivable societal projects.

GILBERT HOTTOIS
TRANSLATED BY JAMES A. LYNCH

SEE ALSO *Critical Social Theory.*

BIBLIOGRAPHY

Echeverría, Javier. (2003). *La revolución tecnocientífica* [The technoscience revolution]. Madrid: Fondo de Cultura Económica de España.

Haraway, Donna. (1997). Modest-Witness@Second-Millenium: Female-Man_Meets OncoMouse™. New York: Routledge.

Hottois, Gilbert. (1996). *Entre symboles et technosciences* [Between symbols and technosciences]. Seyssel and Paris, France: Champ Vallon and Presses Universitaires de France

Hottois, Gilbert. (2002). Species Technica [Species technica]. Paris: Vrin.

Latour, Bruno. (1987). Science in Action. Cambridge, MA: Harvard University Press.

Lyotard, Jean-François. (1988). Le postmodern expliqué aux enfants [The postmodern explanation of children]. Paris: Galilée.

Séris, Jean-Pierre. (1994). La technique. [The technique] Paris: Presses Universitaires de France.

TELEPHONE

Telephone technology allows a person to talk to nearly anyone in any place who has similar equipment. There are substantial ethical questions related to the uses and abuses of the telephone. Among other things, the telephone is a communication system that provides political leaders, pollsters, and social science researchers with some understanding of public attitudes and behaviors. It gives voice to the needs and wishes of citizens as they attempt to make their views known to governments and corporations. Additionally, the telephone is a conduit for the delivery of professional services. As a result of these aspects of what has been an everyday but rapidly changing technology, considerable attention has been devoted to the telephone from ethical, legal, and policy viewpoints.

Historical Development

The term *telephone* is based on the combination of the Greek words, *tele* ("distant" or "afar") and *phon* ("sound" or "voice"); it was first used in France in the 1830s to name a crude acoustic device. By the mid-1800s something akin to a pair of tin cans connected by a taut string was known in the United States as the "lover's telephone." In 1876 Alexander Graham Bell (1847–1922) won a patent for a device that has come to be known as the telephone.

Alexander Graham Bell testing his telephone invention in front of onlookers. Graham won a patent for the device in 1876. *(U.S. National Aeronautics and Space Administration.)*

The traditional telephone operates by converting the mechanical energy of sounds carried in the air (the speaker's voice) into electrical impulses for transmission to a receiver. The receiver reverses the process, changing the electrical impulses back into vibrations. Those vibrations are heard as sounds. The original telephones transmitted electrical impulses by wires. Radio and other portions of the electromagnetic spectrum subsequently supplemented or supplanted wires as digital forms replaced analog.

The uses of the telephone have expanded to include multiple forms of data transmission, including fax, photo, and video image formats. Ancillary services have been created and have been widely adopted, including answering machines, caller-ID boxes, and telephone-based security systems. The Internet owes much of its success to the ability of users to go online by means of telephone lines.

In the early period of the telephone myriad uses were explored, including the "broadcasting" of news, opera, weather reports, and religious services. Some contemplated services never materialized: Bell speculated that the telephone might be used to communicate with the deceased. Other services did not materialize because they were outdated before they could deployed: France's national telephone company conducted extensive research in the 1960s to see if the telephone touch-tone pad could be adapted to serve as a home calculator. Yet other services were initially innovative and popular, but then, as technology continued to advance, they were left in the backwater. The fax machine and the French Minitel system are examples of this phenomenon.

Ethical Issues

PRIVACY, SECURITY, AND SURVEILLANCE. Among the early ethical questions was the way the telephone was used to invade privacy in the household and give outsiders access to household members. In particular the telephone allowed outsiders to make social connections with the members of a household, thus violating rigid gender and class roles. Ethical questions relating to various roles in the household, along with the power relationships among those roles, have been exacerbated by the telephone. For example, teenagers and parents come into conflict over appropriate norms for telephone use.

The telephone often leads to disruption of household routines and may allow for social subversion through practical jokes and harassing or obscene phone calls. Women especially have been victimized by such calls, though a surprisingly large number of men have been as well. Although commentators see great net benefits arising from the telephone, they also recognize the moral dilemmas that result from the "distant presence" (a phrase popularized by Kenneth J. Gergen) the telephone allows. The American humorist Mark Twain (1835–1910) was an early acerbic critic of the way the telephone could disrupt trains of thought and ordinary social interaction. In addition, characteristic of early telephone technology was the large proportion of homes that shared local service party lines; this meant that neighbors could listen in to conversations and learn family secrets.

Larger questions of privacy surrounded systematic wiretapping conducted by both licit and illicit organizations. Only a few years after the telephone was invented numerous devices were built to allow not only tapping but also recording of telephone conversations. (Many of these microphone devices also can be used to listen in on in-room conversations.) A wide variety of practices legal and illegal, moral and immoral, could be identified and documented.

Police forces and other governmental agencies sometimes carried out large-scale wiretapping not only in pursuit of wrongdoers but also to monitor those perceived as opposing government policy. In what has become a well-established cycle of innovation, new ways to communicate were followed by new ways to penetrate those forms, followed by steps to enhance privacy. Often a variety of codes would be devised to hinder attempts to collect data and conduct surveillance. The question of the areas in which people had a "reasonable expectation" of privacy was brought to a head when the U.S. Supreme Court decided in *Katz* v. *United States* (389 US 347 [1967], docket number 35) that public phone booths were not eligible for systematic tapping by the police.

Although monitoring of workers has been a perennial workplace issue, the telephone gave that issue added impetus because it greatly expanded the ability of managers to tap into the conversations of employees. Telephone companies often have conducted extensive monitoring, sometimes to the point of abuse, when they have used their own technology to monitor employees' behavior and comments. Switchboard operators once were notorious for eavesdropping, though sometimes that allowed them to interrupt the execution of crimes. (Eavesdropping, as opposed to service monitoring or surveillance by officials, is generally prohibited everywhere.) Many companies, including especially telephone companies, have published rulebooks and etiquette guides directed to their employees and managers regarding eavesdropping. While these efforts presumably reduced the problem, they have not been sufficient to extinguish the practice.

TELEMARKETING AND RESEARCH. Telemarketing is the offering of goods or services through sales presentations on the telephone. Because it can be a low-cost, high-profit enterprise, its rapid proliferation has become a source of general annoyance to the targeted public. The Direct Marketing Association and the American Marketing Association instruct their members not to use approaches that might be considered illegal. Moreover, there are numerous laws that regulate telemarketing at the national and local levels. Major moral dilemmas are related to this situation.

On the one hand, there are the claimed rights of businesses to "freedom of commercial speech," which includes the freedom to communicate with potential customers and participation in "fair and efficient markets." (These rights are protected strongly in the United States.) These rights often are carried out with increasingly powerful telephone support technology and database-mining software. On the other hand, individuals have a right to be left alone and not to have information about them collected in secret and without their permission. (These rights are protected strongly in the European Union nations and not as well protected in the United States.) Despite such efforts on both the technological front (such as caller-ID and call blocking) and the legal front (such as the compilation of "do not call lists" and the regulation of times when sales calls may be made), this problem persists.

Social science research and public opinion surveys often are reliant on polling by telephone. Numerous agencies and associations, such as the American Sociological Association (ASA) and American Association for Public Opinion Research (AAPOR) have created codes of conduct for their members, and in some cases governments have stepped in to create regulations in this area. Criminal penalties can be imposed for collecting data improperly by telephone. Many institutional review boards (IRBs) at universities require that researchers demonstrate that they will protect the data and not cause psychological distress, and this applies to telephone surveys as well as to medical experimentation. In more extreme cases, such as at the University of Newcastle in Australia, researchers are required to notify the target population in advance with a written information sheet that warns that telephone contact will be made and includes complete contact information.

UNIVERSAL SERVICE, SOCIAL EQUITY, AND DEMOCRACY. An important ethical component of national and regional policies for telephone technology is equitable distribution. As Claude Fischer (1992) has noted, in its early years the telephone could be considered only a luxury. However, what was an expensive enhancement to lifestyle has in contemporary society become a near necessity for most people.

For much of the twentieth century national telecommunication policies were aimed at subsidizing low-income and rural populations by indirectly taxing (through higher rates) urban and nonpoor telephone subscribers. This was done under the rubrics of social equity and economic development. In fact, in the United States the promise of universal service at an affordable cost was accepted by the government in exchange for the granting of near-monopoly status to the American Telephone and Telegraph Company (AT&T). However, the initial moral clarity of those policies has been obscured as advanced telecommunication technologies have proliferated, especially in the case of the mobile phone.

Mobile phone. Mobile phones have a long and varied history that stretches back to the early 1970s. Due to their low establishment costs and rapid deployment, mobile phone networks have since spread rapidly throughout the world, outstripping the growth of fixed telephony. *(© Leland Bobbe/Corbis.)*

It is noteworthy that around the world hundreds of millions of subscribers have flocked to new mobile phone services. Those services allow subscribers to leapfrog the long waits and frequently high prices associated with wireline residential services. Moreover, cross-subsidization by ordinary telephone subscribers of low-cost services for schools and hospitals, as is the practice in the United States, means that many people with modest incomes are being penalized for the benefit of institutions in wealthy communities. (Mobile phone subscribers in the United States are exempt from these taxes.)

There can be little doubt that the telephone is an important adjunct to democracy on the level of political expression and as a bulwark against excessive governmental power. At the same time, terrorists and those seeking radical regime change can use the telephone to further their aims. In light of this situation many governments monitor telephone conversations and in some cases limit or prohibit mobile phone services. As instances, North Korea forbids civilian mobile phones on security grounds and Colombia's mobile phone networks were selectively turned off by the government in an effort to detect the location of cell phone-toting drug lord Pablo Escobar.

Public Use of Mobile Telephones

Each major advance in telephone technology has been accompanied by some social disruption. In most cases the disruptions have been transient. With the advent of the mobile telephone, however, high levels of conflict continue. These conflicts often may be understood in terms of what is known in psychology as the actor-observer paradox. The person who wishes to use the mobile phone (the actor) does so because he or she has good cause and with the expectation that others will understand and accept that necessity. However, the people around the user (the observers) view the situation differently. They feel that the mobile phone user is being selfish and self-indulgent and is failing to respect the conventions of polite society. The public use of mobile phones is likely to remain a source of normative conflict because the sources of irritation are not merely conventional but seem to go to the core of human cognitive processes. The result could be that as mobile phone users pursue the private pleasures of conversation there will be a reduction in civility and personal engagement in public places. Perhaps no better illustration of this process is the havoc wrought by drivers who are preoccupied by their mobile telephone conversations.

Provision of Professional Services

The ease and flexibility of telephone use have led many professional organizations to develop codes of conduct that allow their members to use the telephone, under appropriate conditions, to serve clients. This is the case with the many national and worldwide associations of lawyers, for instance. However, the potential for abuse also has led many organizations, such as the Legal Profession Advisory Council, to remind their members that whereas the telephone can be used to discuss and provide confidential information, both the professional and the client have to agree to this in advance. It further recommends that a scrambling device or other encryption technology be used. All advertisements for lawyers should bear the attorney's phone number prominently.

The question of recording telephone conversations is fraught with ethical and moral questions. In one instance (LEO 1738, 48/10 Va Lawyer Reg 23, April 13, 2000) the Virginia state bar association reexamined the subject of taping telephone conversations. That association concluded that all forms of wiretapping, along with one-party-consent recording of telephone conversations by lawyers, are prohibited. Although many people disagreed with that conclusion, it did arrive at the formulation that because wiretapping involves "deceit," the practice must be forbidden. This raises problems when, for instance, testers try to prove housing discrimination by pretending to be people other than who they are. The rules even make it unethical for an attorney who receives an obscene or threatening phone call to record it.

The American Medical Society counsels physicians that telephone advising and referral services should be used only to complement face-to-face interaction and that both the physicians and the clients should be well aware of the limitations of the medium. They urge that no physician make a clinical diagnosis or prescribe medications by telephone and at the same time be certain to elicit all-important information over the phone. They also should avoid generating large telephone bills that their patients or others have to pay.

Counseling by Telephone

Telecounseling has been defined as using the telephone for synchronous but distant interaction between counselors and clients for one-to-one conferencing. Obviously, such interactions are fraught with ethical issues. In response, the National Board for Certified Counselors (NBCC) says that its members should base the use of telecounseling on the needs and convenience of the client. The NBCC further stresses that telecounseling should only be a supplement to face-to-face counseling.

Confidentiality is an important consideration because it may be difficult to know precisely with whom one is speaking when one receives a telephone call. Thus, the American Psychological Association's guidelines warn counselors about privacy and confidentiality issues. The International Chiropractors Association of California has in its code of ethics the statement that its members "shall not discuss any patient information over the telephone with anyone without the patient's consent, preferably in writing." The International Association of Coaches instructs coaches to take precautions to ensure the confidentiality of telephone communications with clients.

In areas in which telephone counseling would be inappropriate professional codes of conduct underscore the importance of avoiding abuse. Thus, the Michigan Speech and Hearing Association urges that the telephone not be used for "diagnosis, treatment or re-evaluation of individual language, speech or hearing disorders." Medical and legal associations have guidelines that also are meant to avoid problems and underscore to their members that using the telephone may be construed as entering into a relationship with a client, with all the demands such a relationship entails.

More Complications Ahead

Because the telephone can obscure many of the ways in which people recognize each other or understand an evolving situation and can transcend distance, it opens new opportunities for ethically questionable or unethical behavior. In addition, as a result of the simplicity and power of the telephone, it has become a vital component of modern life. A variety of codes of conduct, laws, and corporate and governmental regulations have been developed to address these problems. However, these attempts have had incomplete success. Even as recent events are grappled with through norms and regulations, new telephone-based technologies that allow even more forms of use and abuse are complicating efforts to control telephone behaviors through technological countermeasures and moral and legal sanctions.

JAMES E. KATZ

SEE ALSO *Communication Ethics; Communication Systems; Monitoring and Surveillance; Networks; Privacy; Security.*

BIBLIOGRAPHY

Fischer, Claude. (1992). *America Calling: A Social History of the Telephone to 1940*. Berkeley: University of California Press. A profound analysis of technology's influence on social relationships and community. Fischer explores the integration of the telephone into society, thereby uncovering and illuminating important interplays between the communication processes and social structures.

Katz, James. (1999). *Connections: Social and Cultural Studies of the Telephone in American Life*. New Brunswick, NJ: Transaction. A detailed, empirical study of the ways telephone are used in ordinary (and extraordinary) circumstances. Explores norms and behaviors revolving around the telephone via methods including national surveys, interviews, and ethnographic observation.

Pool, Ithiel de Sola, ed. (1977). *The Social Impact of the Telephone*. Cambridge, MA: MIT Press. This path-breaking collection of historical and cultural studies on the telephone has become a classic and still has much to offer. It grew out of AT&T-sponsored lectures at MIT to celebrate the Centennial of the telephone's invention.

Ronnell, Avital (1989). *The Telephone Book: Technology-Schizophrenia-Electric Speech. Lincoln: University of Nebraska Press*. An eccentric but probing look at the deeper processes involved in the social and phenomenonological construction of the telephone. The volume is a wry postmodern achievement in both form and content.

TELEVISION

Along with the radio, television has become the primary means for broadcast communication and entertainment. As such it calls for ethical and political assessment.

What follows will thus focus on such assessments, noting a spectrum of views running from positive to negative in relation to both content and practice.

Background

The word *television,* a hybrid compound of the Greek *tele* (distance) and the English *vision,* names a technological invention from the 1920s in which electromagnetic waves are used to control a beam of electrons scanning a cathode-ray tube so as to create an image. The initially distinctive feature of this technology was that, unlike motion pictures but like radio, it could be personalized for home or individual use. Over the course of more than half a century the electronics underwent continuous modification: Vacuum tubes were replaced with transistors and then integrated circuits; the black-and-white cathode-ray tube became colored and was then replaced by a high-definition, flat, liquid crystal display; and analog transmission was transformed to digital. The information transmitted thus became increasingly rich in a technical sense.

The commercial development and regulation of television followed the pattern established by radio: Television was initially promoted by the same corporations, and existing regulatory agencies and frameworks were adopted to distribute a limited transmission spectrum among competing private interests. Some countries established national broadcast operations independent of or complementing private operations. But in all cases television viewers received programs free of charge, except for advertising time or taxes. With the advent of video recording systems, cable, and satellite television, however, transmission resources were greatly enlarged, and fundamental shifts took place within the industry that created pay-for-view television. Yet this further increase in technical information delivery and in regulatory regime change failed to alter the basic content, which has remained of two sorts: information and entertainment. Indeed, the TV is the centerpiece of home entertainment systems.

Moral Promise and Threat

From its post–World War II appearance, the promise of TV has been at once praised and criticized. As a new, more vivid and pervasive form of mass communication than anything that had preceded it (magazines, newspapers, radio, and movies) it was subject to intensified versions of both the hype of modernity, which sees technological innovation as inherently beneficial, and mass culture criticism, which argues technology's dangers and debasements. A love–hate relationship was manifest in tensions between promises of increased democratic enlightenment and worries about the commercialization of culture.

On the one hand, television brings diverse quality dramas into the home, and international news programs depict a variety of countries, cultures, and perspectives in a single broadcast. On the other, pop-culture programs, such as those on MTV, present fragmented images that draw from a multicultural mix of music, fashion, sexuality, and ethnic traditions. The moral significance of numerous "high" and "low" cultural programs can be attributed to their ability to deconstruct monolithic images and ideologies: "Implicit in pluriculture is a kind of *bricolage* relativism. One may pick and choose culture fragments, multiply choices, and in the process reflectively find one's own standards provincial or arbitrary—certainly no longer simply *a priori* obvious" (Ihde 1995, p. 155).

While traditional cultures find themselves forced to confront modern secular images, so too are provincial U.S. (and other Eurocentric) audiences forced to question their own identities when confronted with traditional religious images. Television thus presents viewers with the opportunity to engage the global "community of those who have nothing in common" (in Alphonso Lingus's formulation) such that they may become more reflective about the arbitrary nature of their own cultural identity. Any particular cultural position is but one of many such perspectives within the wider cultural arena. For example, the multiperspectival international coverage of the "War on Terrorism" suggests that the conflict between East and West cannot be adequately explained by the partial metanarratives of either side.

Criticism

For present purposes television criticism may be distinguished into three types: those not influenced by Marshall McLuhan (1911–1980), those influenced by McLuhan, and those reacting against or going beyond McLuhan. As the typology suggests, the ideas of McLuhan, who argued the primacy not of television content but of its formal properties, have played a central role. "The medium is the message" was the sound-bite summary of his theory in *Understanding Media* (1964).

Prior to or subsequently ignoring McLuhan have been studies focused on issues related to the content of television and the social influence of this content. Does television advertising work? Do the attitudes and opinions expressed on TV influence or just represent those of the viewers? In the 1950s concern often emphasized the impact of television on leisure and culture. In the early 2000s the concern shifted to the political or cultural biases of television programming. This tradition of criticism also distinguishes different genres—news, cultural programming, sports, soaps, and so on. Most television criticism in the mass media has been of this type, which thus represents the most common critical approach. Studies by Cecelia Tichi (1991) and Lynn Spigel (1992) are scholarly contributions to this tradition.

Among criticisms that have been influenced by McLuhan's work are more intellectual studies, some of which have become classic references. Examples include Tony Schwartz's *Media: The Second God* (1981), Neil Postman's *Amusing Ourselves to Death* (1985), and Joshua Meyrowitz's *No Sense of Place* (1985). More thickly analytic than McLuhan, but in the same vein, Stanley Cavell (1984) contrasts the basic experience of movies as viewing with that of television as monitoring. All successful TV formats—from sitcoms and game shows to sports coverage and news—are forms of monitoring. For Cavell it is no accident that the television receiver is called a monitor, and that TV is used to monitor everything from banks to parking lots.

Most representative of the reaction to McLuhan is the work of Brian Winston (1998), who originally titled his work *Misunderstanding Media*. For Winston television is not the radically new medium envisioned by McLuhan, but simply another instance of technological performance based on progressively developing scientific competence. Moreover, "there is nothing in the histories of electrical and electronic communication systems to indicate that significant major changes have not been accommodated by preexisting social formations" (p. 2). Building on but transcending McLuhan is the teletheory of Gregory L. Ulmer (1989) and the concept of the televisual as developed by Tony Fry (1993).

Cutting across these three types of criticism are negative and positive assessments that focus either on the physical aspects of the technology or its content/form. Although there is no proof that a person can become physically ill from watching television, conclusive scientific evidence does not exist that details what challenges to health are likely to arise from exposure to extremely low doses of low-level radiation over long periods of time. Indeed, critics suggest that there is no threshold of exposure below which radiation may not harmfully affect humans. From an environmental perspective, critics further note not only that the process of manufacturing televisions generates toxic problems, but also that the level of electronic waste is growing rapidly. This dilemma is exacerbated by the fact it is often less expensive and more convenient to replace rather than fix a malfunctioning television.

Negative assessments of the content of television programs vary. There are psychological worries about exposing children to violent and sexually charged programs, feminist and multicultural arguments about how television programs routinely stereotype women and other minorities in adverse ways, and sociopolitical concerns about the connection between television and political propaganda. Whereas the televised coverage of the Vietnam War in the 1960s facilitated a negative public reaction of the conflict because of its association with the "real" coverage of battlefield and civilian casualties, recent critical works that exemplify McLuhan's famous pronouncement that "the medium is the message," such as Jean Baudrillard's provocatively titled *The Gulf War Did Not Take Place* (1995) and Paul Virilio's *Strategy of Deception* (2000), suggest that the selective presentation of events during the Gulf War and the Kosovo conflict are indicative that people now live in a "hyper-real" time in which ever proliferating images are produced that are dissociated from reality. For example, during the Gulf War the impression that indiscriminate bombing and civilian causalities were minimized was fostered through the media's constant presentation of "smart bombs" that that destroyed only deliberately chosen and carefully delimited targets. A more recent argument, presented by Michael Moore in his Oscar-winning documentary *Bowling for Columbine* (2002), is that the media distortion of topics such as urban violence has produced a culture of fear in which American citizens routinely mistake deliberately sensationalized reporting for the presentation of unbiased facts.

In *Four Arguments for the Elimination of Television* (1978), Jerry Mander, a disillusioned advertising mogul, goes so far as to argue that because television is biased in favor of corporate interests and because it functions best when conveying simplified linear messages, it is beyond reform; the power of television to discipline people into accepting repressive control can be combated only by eliminating it completely. Mander also contends that television bolsters the tendency toward living in an artificial environment. This argument is given more in-depth philosophical examination by Albert Borgmann.

Ethical Criticism

Considering the sociological reports concerning how highly people esteem their televisions, Borgmann insists that the "telephone and television are the technological devices that have weakened literacy and impoverished the culture of the world" (1995, p. 90). Writing letters, telling stories, engaging in conversations, attending plays, reading to one another, and silently reading books and periodicals to oneself have all taken a backseat to watching television. Television routinely provides an alienating experience that disengages subjects from one another and inhibits genuine intersubjective connection by promoting self-oriented comportment. Whereas the scattered family once gathered around the "culture of the table," today TV dinners dominate. Not only is food reduced to a meal to be grabbed, but the festive and conversational context of dining—a focal practice—is lost. Seduced by the soothing presence of the television, people have come to experience engagement with others and with nature as exertion, as a cruel and unjust demand. When their favorite show is on, they do not want anyone to interrupt and pull them away from their passive contentment.

Borgmann grounds his negative assessment of television in an ontological distinction between two kinds of reality: *disposable devices* and *commanding things*. Disposable devices are readily available commodities that make technologically mediated experiences instantly available without the use of much skill. Indeed, learning to watch television requires little effort; young children ascertain how to do it, often without any formal instruction. Disposable devices thus belong to a world of pliable material; their emotional and moral significance is subjective and flexible. Their use, as Borgmann takes the example of television to illustrate, encourages a shallow life of distraction and isolation.

By contrast, commanding things are focal objects that express meaning on the basis of their own intrinsic qualities; the emotional and moral significance that people invest in them is largely based on the sense-bestowing capacity of the objects themselves. Commanding things direct one's attention because they require skill to use and we treat people who can adroitly operate them with respect. Whereas one does not value someone because they know how to operate a television, one admires musicians whose disciplined training allows them to create beautiful, memorable music. Furthermore, in contrast to the withdrawn and individualist behavior that disposable devices such as television encourage, commanding things further the end of communal engagement. One of the reasons why a person learns to use an instrument is to be able to extend the range of communication, to be expressive to others through the sounds that the instrument makes possible.

Assessment

Borgmann's criticisms, along with many others, have themselves been criticized as failures to appreciate the potential for enriching one's world through multivalent monitoring. From aesthetic installations of multiple television monitors to sports bars and space probe transmissions, television has the power to extend the human sensorium in ways not unlike the telescope and microscope. The ultimate promise of television may not be its utility to preexisting cultural ideals (such as democracy) but its performative presentation of scientific experience in ways that cannot help but insinuate science and technology ever more deeply into culture. To the extent to which science and technology may themselves be viewed as morally worthy projects, so too may television be viewed throughout its increasingly information-rich manifestations.

EVAN M. SELINGER

SEE ALSO *Advertising, Marketing, and Public Relations; Communications Ethics; Communication Systems; Entertainment; Globalism and Globalization; Popular Culture; Violence.*

BIBLIOGRAPHY

Baudrillard, Jean. (1995). *The Gulf War Did Not Take Place*, trans. Paul Patton. Bloomington: Indiana University Press.

Borgmann, Albert. (1984). *Technology and the Character of Contemporary Life: A Philosophical Inquiry*. Chicago: University of Chicago Press.

Borgmann, Albert. (1995). "The Moral Significance of the Material Culture." In *Technology and the Politics of Knowledge*, ed. Andrew Feenberg and Alastair Hannay. Bloomington: Indiana University Press.

Cavell, Stanley. (1984). "The Fact of Television." In his *Themes Out of School: Effects and Causes*. San Francisco: North Point Press.

Fry, Tony, ed. (1993). *RUA TV? Heidegger and the Televisual*. Sydney, Australia: Power Publications.

Heidegger, Martin. (1966). *Discourse on Thinking*. New York: Harper and Row.

Ihde, Don. (1995). "Image Technologies and Traditional Culture." In *Technology and the Politics of Knowledge*, ed. Andrew Feenberg and Alastair Hannay. Bloomington: Indiana University Press.

Mander, Jerry. (1978). *Four Arguments for the Elimination of Television*. New York: Morrow.

McLuhan, Marshall. (1964). *Understanding Media: The Extensions of Man*. New York: McGraw-Hill.

Mellencamp, Patricia, ed. (1990). *Logics of Television: Essays in Cultural Criticism*. Bloomington: Indiana University Press.

Meyrowitz, Joshua. (1985). *No Sense of Place: The Impact of Electronic Media on Social Behavior*. New York: Oxford University Press.

Newcomb, Horace, ed. (1976). *Television: The Critical View*. New York: Oxford University Press. A collection representative of early-generation TV criticism.

Postman, Neil. (1985). *Amusing Ourselves to Death: Public Discourse in the Age of Show Business*. New York: Viking.

Schwartz, Tony. (1981). *Media: The Second God*. New York: Random House.

Spigel, Lynn. (1992). *Make Room for TV: Television and the Family Ideal in Postwar America*. Chicago: University of Chicago Press. Cultural history.

Tichi, Cecelia. (1991). *Electronic Hearth: Creating an American Television Culture*. New York: Oxford University Press. Although the focus is on content, also influenced by McLuhan.

Ulmer, Gregory L. (1989). *Teletheory: Grammatology in the Age of Video*. New York: Routledge; 2nd edition, New York: Atropos Press, 2004.

Virilio, Paul. (2000). *Strategy of Deception*, trans. Chris Turner. London: Verso.

Winston, Brian. (1998). *Media Technology and Society: A History; From the Telegraph to the Internet*. London: Routledge. This is a "reworking and updating" of his *Misunderstanding Media* (1986).

TELLER, EDWARD

Edward Teller, 1908–2003. The Hungarian-American physicist—sometimes called the "father" or the "architect" of the hydrogen bomb—was for decades on the forefront of the nuclear question and in the 1980s was an advocate of the Strategic Defense Initiative (SDI), also known as "Star Wars." *(The Library of Congress.)*

Edward Teller (1908–2003) was born in Budapest, Hungary on January 15, emigrated to the United States in 1939, and became known publicly as the "father of the hydrogen bomb." From the late 1940s until his death, he defended the U.S. development of nuclear weapons and the ethics of nuclear deterrence; as a public policy adviser he argued for the peaceful use of nuclear power and advocated national missile defense. He died in Palo Alto, California (September 9).

Education and Hydrogen Bomb Development

Teller worked with many of the early physics greats in Europe between the two world wars, distinguishing himself first in atomic and molecular physics (the Inglis-Teller and the Jahn-Teller effects), and then in nuclear physics. After serving at several universities, he eventually established permanent residence at the Lawrence-Livermore National Laboratory, of which he was one of the principal founders. (Livermore was originally dedicated to military research and development, although its work is now more general.) Teller also served as a senior researcher at Los Alamos during World War II, although his efforts were directed more toward development of fusion (hydrogen) bombs rather than fission (uranium and plutonium) devices, which were the highest priority.

In the early postwar years Teller became a principal advocate for the development of the hydrogen bomb by the United States, on the basis of strong belief in the deterrence concept, and distinctly conservative political views, which made him unpopular among many physicists. A centerpiece of his political ideology lay with his extremely strong antipathy to Communism. It was his fear that the Soviet Union would develop fusion weapons first and then use them to blackmail North American and Western European countries, especially the United States, that drove him into advocating their development. Along with Stanislaw Ulam (1909–1984), he is credited with coming up with the scheme that led to successful development of the H-bomb.

Teller's advocacy of the H-bomb placed him in direct disagreement, even confrontation, with many of the leading weapons scientists, most notably J. Robert Oppenheimer, who had been the scientific director at Los Alamos. The confrontation reached its climax during security hearings for Oppenheimer in Washington, DC, in 1954. Whereas most of Oppenheimer's contemporaries acted as friendly and supporting witnesses, Teller was a notable exception. He did not state categorically that he was in favor of denying Oppenheimer clearance, but he did say that he would be uncomfortable having Oppenheimer privy to important weaponry secrets. Partly as a result of Teller's testimony Oppenheimer was denied clearance. This act led to what amounted to a permanent ostracization of Teller by the mainstream U.S. physics community, although he remained friendly with a number of important, loyal friends, including Hungarian colleagues.

Later Work and Assessment

Teller was an innovative, energetic, talented individual, well liked on a personal level by most who knew him. He was the source of innumerable ideas concerning both military and peaceful uses of atomic energy, though many of these turned out to be impractical. He was a strong advocate of the deterrence concept and a principal spokesperson for the concept of strategic missile defense, although his advocacy was diluted by his unwarranted claims concerning its effectiveness. He was a leader in "Project Plowshare" during the late 1950s and 1960s, whose goal was to utilize nuclear explosions for peaceful purposes. For example, he proposed creating artificial harbors and canals by this means, which he termed "geological engineering." None of these schemes was realized, and the idea eventually died.

Despite the contrary opinions of many distinguished scientists, including Albert Einstein as well as Oppenheimer, there appears to be little if any doubt that the Soviet Union would certainly have proceeded to build its own hydrogen weapons. Without U.S. equivalency, the twenty-first century world would likely be very different. In hindsight Teller's strong advocacy seems to have been warranted.

BENJAMIN BEDERSON

SEE ALSO *Atomic Bomb; Missile Defense Systems; Nuclear Ethics.*

BIBLIOGRAPHY

Blumberg, Stanley A., and Gwinn Owens. (1976). *Energy and Conflict: The Life and Times of Edward Teller*. New York: G. P. Putman's Sons.

Rhodes, Richard. (1995). *Dark Sun: The Making of the Hydrogen Bomb*. New York: Touchstone. Good general history.

Sanders, Ralph. (1962). *Project Plowshare: The Development of Peaceful Uses of Nuclear Explosions*. Washington, DC: Public Affairs Press.

Teller, Edward. (1947). "The Two Responsibilities of Scientists," *Bulletin of the Atomic Scientists* 1(December).

Teller, Edward. (1987). *Better a Shield than a Sword*. New York: Free Press. An argument for nuclear missile defense.

Teller, Edward. (2001). *Memoirs: A Twentieth Century Journey in Science and Politics*. Cambridge, MA: Perseus Publishing. For a very different take on Dr. Teller see the review of this book by Richard Rhodes in the *New York Times*, November 25, 2001.

TERRORISM

Terrorism was first used to define a systematic policy of violence during the French Revolution and has since undergone important transformations that have been topics of both scientific investigation and efforts at technological control. What is now called terrorism is an old practice that has acquired new dimensions as a result of science and technology in at least three respects: rationale, publicity, and weapons (and other means). Any adequate ethical or policy assessment of terrorism requires consideration of all three aspects of the problem.

Historical Aspects

Terrorism is an ill-defined but ethically charged term, which generally refers to the highly public, calculated use of violence, destruction, or intimidation to gain political, religious, or personal objectives. Yet in this sense many wars and even some police actions might be described as terrorist insofar as they seek to induce or exploit fear. Some observers also argue that there is little principled difference between official U.S. definitions of terror and counterinsurgency measures described in U.S. armed forces manuals (Atran 2003).

From certain Roman emperors to the Spanish Inquisition (beginning in the fifteenth century) and the French Revolution's Reign of Terror (1793–1794), early forms of terrorism were primarily conducted by the state or other parties with high political power such as the Catholic Church. The nineteenth century, however, witnessed the development of complementary efforts by individuals or small groups such as the small band of Russian revolutionaries known as Narodnaya Volya (People's Will) who grew impatient with the slow pace of tsarist reforms. Members of this group are among the few to refer to themselves as terrorists, and, aided by the development of powerful and affordable explosives, they assassinated Tsar Alexander II in 1881. The Fenian Brotherhood, an Irish-American group, planted explosives around London in the mid-1800s to protest the British occupation of Ireland, thus demonstrating one of the main objectives of many terrorist organizations, namely, to attempt to reacquire territory that they feel is legitimately theirs. On June 28, 1914, Gavrilo Princip, a member of the Serbian nationalist terrorist organization called the Black Hand, assassinated Archduke Francis Ferdinand of the Austro-Hungarian Empire, thus triggering the social and political upheavals of World War I.

World War II witnessed the uses of state terrorism by both the Allied and Axis powers. After the war, terrorism continued to broaden beyond the assassination of political leaders. Terrorist movements developed in certain European colonies to both pressure colonial powers and intimidate indigenous populations into supporting a particular group. After colonialism had waned in the 1950s and 1960s, terrorism continued in several areas and for a variety of purposes. These attacks often targeted civilians, as in the case of the murder of eleven Israeli athletes at the Olympic Games in Munich in 1972.

Although suicide terrorism has deep historical roots (Atran 2003), it has played a major role in Middle East politics since the early 1980s. Since at least 1993, suicide attacks by groups such as the Islamic Resistance Movement (Hamas) have continually thwarted peace efforts between Israel and Palestine. Although Islamic religious extremism is involved in many of these terrorist attacks, it should be noted that other religious groups have committed acts of terror. The same holds true for secular groups, such as the Liberation Tigers of Tamil Eelam in Sri Lanka.

In the 1990s, Osama bin Laden, a member of a wealthy Saudi family, rose to prominence as the leader of al-Qaeda (the Base), an Islamist terrorist organization. Determined to resist Western influence in Muslim countries, members of this group killed hundreds in bombings of U.S. embassies in Africa in 1998. Al-Qaeda members have been able to create a complex, networked organization capable of transcending national borders. Such capabilities allowed them to hijack commercial airplanes and crash them into the World Trade Center towers in New York City and the Pentagon in Washington, DC, on September 11, 2001. Passengers onboard a fourth plane forced it to crash in a Pennsylvania field. These attacks caused approximately 3,000 deaths and extensive social, psychological, and economic damage, and set off major political changes around the world, much of which bears on the use of science and technology both as potential security threats and as sources of counterterrorist measures.

Rationales

The justifications that terrorists give of their actions are perhaps even more difficult to consider than the definition of the actions themselves. It is easier—and initially appears more accurate—to describe terrorists as cowards or insane. But such a reaction runs the danger of misconstruing the phenomena and feeding into counterproductive responses.

Works by al-Qaeda and Theodore Kaczynski (the Unabomber) suggest that a major underlying rationale for some contemporary forms of terrorism is a condemnation of the dangers and depravity of modernity, including liberalism, capitalism, and a technological materialism divorced from spiritual or ethical guidance. Paul Berman (2003) traces much of the ideological impetus of al-Qaeda back to Egyptian Islamic fundamentalist groups and their "intellectual hero," Sayyid Qutb (1906–1966), who presented an extended critique of the modern world and the tyranny that technology holds over life. Qutb traced the source of error back to a split between the spiritual and material realms, which put humans out of touch with their own nature. He did not lament science but did decry the alienating effects of scientific "progress" (and the attendant consumerism) divorced from spirituality. The split between the secular and the sacred, he argued, was the fatal error that rendered the modern world inhospitable to a meaningful human existence and relationship with God.

Qutb's cultural critique also offered a revolutionary program to save humankind by calling for a small vanguard to establish sharia, the religious law of Islam, for all of society. Competing interpretations of the Koran and the meaning of Islam have created conflicts along the spectrum of liberal and extremist Muslims. For Berman Islamic terrorists are heirs to modern European fascism, with their ideals of submission, absolutism, and "the one instead of the many." William A. Galston (2003) suggests that such an interpretation erases key distinctions such as that between the meaningless self-annihilation of nihilists and the politically motivated acts of suicide terrorists. Furthermore, the thesis of liberalism versus totalitarianism reinforces the belief that terrorists "hate us for what we are, not what we do," which curtails critical scrutiny of policy decisions.

Kaczynski developed a related rationale in his manifesto, *Industrial Society and Its Future* (published by the *New York Times* and *Washington Post* in 1995). Whereas Qutb placed the problems of modernity in religious history and sought solutions in religious texts, Kaczynski appealed to human evolutionary history to explain modern social and psychological problems and relied on Western philosophers to buttress his critique. Nonetheless, both provided similar justifications for taking radical steps to undermine modern techno-industrial society. Alston Chase (2003) argues that (just as with Qutb) Kaczynski's writing cannot be simply dismissed as fringe lunacy or simple-minded Luddism. His ideas were shaped by real experiences as a mathematician at Harvard University in the late 1950s and early 1960s.

First, Kaczynski was subjected to dehumanizing psychology experiments at the hands of Henry A. Murray. Second, the climate of academia (and the wider culture) was saturated by the tenets of logical positivism, which held that ethical claims are meaningless, because science cannot prove them either true or false. Ethical and other values are purely matters of private emotion. As with Qutb, Kaczynski saw this separation of private (moral) and public (material) and other such fundamental schisms in modern industrial society as the root cause of unethical science and technology, vacuous consumerism, and massive human indignities and feelings of meaninglessness. Finally, Kaczynski held that science and technology had become servants of a military-industrial complex in ways that echoed the arguments of other critics such as the American mathematician Norbert Wiener (1894–1964). Such an argument justifies Kaczynski's rejection of the combatant/civilian distinction, because virtually all academic scientists and engineers could be perceived as caught up in a web of culpability. There is no doubt that acts of terror are objectionable, but this does not erase the possibility that their underlying rationale may at least be intelligible.

Although one major way to avoid considering the reasons that terrorists give for their actions is to reject terrorists themselves as irrational, another is to propose a sweeping historical thesis such as Samuel P. Huntington's "clash of civilizations" (1996). In response, Amartya Sen (2002) has argued that the "clash thesis" dangerously oversimplifies the heterogeneity of motives and objectives behind terrorist acts by reducing complex people and organizations to one dimension. Huntington's thesis paints a patina of coherence over the messy reality—that rationales for terrorism are diverse, complex, changing, and poorly understood. Context matters and terrorism cannot be reduced to a single "root cause" such as poverty, political conflict, or the intrusion of Western values on other cultures.

As an alternative to reliance on a large-scale historical thesis, it would perhaps be useful to undertake more detailed psychological and social scientific studies of terrorists and terrorist organizations. According to Scott Atran (2003), for instance, suicide terrorists have no appreciable psychopathology and are at least as educated and economically well-off as their surrounding populations, although there is a fairly strong negative correlation between civil liberties and suicide terrorism. In their studies attempting to uncover the causes of terrorism, Alan B. Krueger and Jitka Maleckova (2003) conclude that "any connection between poverty, education, and terrorism is, at best, indirect, complicated, and probably quite weak" (p. B10). They suggest that terrorism is a response to political conditions and feelings of indignity and frustration that are only weakly linked to economic circumstances. Marc Sageman (2004) similarly claims that people join terrorist organizations to escape a sense of alienation.

Atran also notes a correlation between U.S. involvement in international situations and terrorist attacks against the United States. Adolf Tobeña and Scott Atran (2004) suggest that understanding terrorists' motivations requires research both on social conditions and individual traits. Hector N. Qirko (2004) proposes a model from evolutionary psychology to explain suicide terrorism. He suggests that this non-kin altruistic behavior can be explained in terms of inclusive fitness, because institutions that train suicide terrorists essentially create "fictive kin."

Contemporary terrorists are usually young males who feel that they have no alternative path to influence and power and that their voice will otherwise be ignored. Humiliation, despair, and loss of economic or social advantage are factors that often play into motivations to join terrorist movements. In many Muslim areas, expanding youth populations cannot find opportunities because of rigidly authoritarian regimes. For many, the allure of martyrdom becomes a strong case for carrying out suicide missions. Indeed Nasra Hassan (2001) reports that there is an excess of young recruits hoping for martyrdom.

Publicity

A primary terrorist objective is the creation of fear in a targeted population in order to use the psychological impact of actual or threatened violence to effect political change. The capability to cause terror has been multiplied not just by more powerful weapons, but also by the expanded media coverage of terrorist acts made possible by innovations in communication technologies. Knowledge of terrorist acts is much more immediate, vivid, and widely disseminated than ever before.

Before the advent of mass media and modern communication technologies, acts of terror were committed in crowds in order to gain publicity. This led Brian M. Jenkins (1974) to describe "terrorism [as] theatre," which was vividly confirmed by the September 11 attacks, designed in part to provide billions of television viewers with images symbolizing the weakness of the United States. Timothy McVeigh, who bombed the Alfred P. Murrah Federal Building in Oklahoma City in 1995, chose that target for the open space surrounding it, which allowed for extensive television coverage. The Colombian leftist terrorist group known as the Revolutionary Armed Forces of Colombia (FARC) has its own radio broadcasts, and there are more than 4,000 terrorist websites (Wright 2004). Terrorists have adapted strategies with the emergence of satellite networks such as the Arabic news network Al Jazeera and the video capabilities of the Internet to expand their abilities to gain publicity.

Brigitte L. Nacos (1994) has explored the relationship between terrorism and the media, and suggested that the media unintentionally help terrorists achieve goals of publicity, recognition, instability, and respect. Focusing on the Iranian hostage crisis (1979–1981) and the downing of Pan Am Flight 103 (1988), Nacos argued that terrorists successfully manipulated the linkages between the news media, public opinion, and presidential decision-making by staging spectacles of terror. The opposite view is that media attention harms terrorist causes. Images of death and destruction focus attention not on the group's message but on its method, which can delegitimize its cause and alienate potential supporters.

What is not controversial, however, is the fact that media attention can and often has shaped the outcome of terrorist activities. It can disrupt counterterrorist operations and influence the dynamics of hostage situations. Terrorist groups increasingly target the media, which attracts attention and shapes coverage. The decision by managers of two U.S. newspapers (as urged by the Federal Bureau of Investigation) to publish the Unabomber's manifesto led to his identification and capture. Nacos argued, however, that this was a shameful act of government acquiescence to mass-media pressure, which might eventually encourage more terrorism. The mass media holds wider powers too, in the sense that its public representations partially define what counts as terrorism and what counts as legitimate acts of violence.

Such issues raise questions about the responsibility of the media in covering terrorism. Excessive coverage may further terrorist causes and encourage more attacks, but it is also true that too little coverage would not fulfill the media's goal of informing the public. One specific example of this dilemma is posed by the occasional audio and videotapes released by bin Laden. How much coverage should he be granted? An example of self-imposed limits on media coverage emerged in the aftermath of the 2003 U.S.-led invasion of Iraq, when the major media organizations declined to air images of beheadings performed by terrorists. But the explosion of media outlets, especially on the Internet, makes it easier for terrorists to publicize their message.

Media coverage of terrorism also raises the important ethical issue of tradeoffs between freedom of the press and security interests. Democratic governments must walk a fine line to find the proper balance for controlling media actions. In the 1980s the British government banned the broadcasting of statements by members of terrorist organizations and their supporters. Margaret Thatcher, the then prime minister of Britain, justified this policy by claiming that the surest way to stop terrorism was to cut off "the oxygen of publicity." Some argue that coverage of vulnerabilities in U.S. national security (e.g., the susceptibility of nuclear power plants to terrorist attacks) might also help terrorists prioritize future acts.

Finally, the publicity received by Islamic fundamentalist groups has given the impression that they commit the majority of suicide terrorist acts. But Robert A. Pape (2003), in a quantitative study of the 188 documented acts of suicide terrorism from 1980 to 2001, concluded that this impression was false. The leading instigator of suicide attacks was the Tamil Tigers in Sri Lanka, a secular Marxist-Leninist group that was responsible for seventy-five of the incidents.

Weapons and Other Means

As in many other areas of interaction between science, technology, and society, the most dramatic transformation in contemporary terrorism is new technological means. These means come in two forms: means of communication among terrorists that facilitate their planning and execution, and means in the form of weapons. The thousands of deaths resulting from the September 11 attacks signal terrorists' abilities to manipulate modern technologies to cause ever greater devastation. Contemporary terrorist attacks highlight the fact that not just the use of individual technological instruments is at stake. Developed societies' dependency on centralized, complex technological systems looms as a source of vulnerability that gives terrorists enormous power.

Lawrence Wright (2004) uses the March 2004 Madrid train bombings by al-Qaeda to detail the importance of the Internet to terrorist organizations. He argues that the Internet serves two interrelated purposes. First, it is a vehicle for strategic and tactical goals such as planning and organizing attacks, raising funds, and training recruits. The Internet and other communication technologies (e.g., cell phones and satellite phones) allow for highly coordinated international attacks. Al-Qaeda even publishes two online magazines that feature how-to articles on kidnapping and other terrorist tactics. Coded communications are used, and web sites are continually moved in order to avoid detection.

The second purpose served by the Internet is more fundamental. Muslim immigration in Europe is creating massive social and psychological disruptions. Many young Muslims have trouble adapting to their new situations and are confused about whether their adopted homelands are part of "the land of believers" or "the land of impiety." The Internet provides a virtual community and a compassionate, responsive forum that "stands in for the idea of the *ummah*, the mythologized Muslim community" (Wright 2004, p. 49). This virtual community strengthens feelings of common identity and provides mutual emotional support to combat feelings of alienation. Arabic satellite channels are being replaced by the Internet as the main conduit of information and communication among a growing global "jihadi subculture."

Marc Sageman (2004) sees further implications of the new Internet culture. Al-Qaeda, for example, is a nonhierarchical network, which increasingly uses bottom-up, self-selected recruitment strategies (rather than top-down selection) as a result of emerging Internet communities. Various levels of adherents form according to different interpretations of the ideology and purpose of al-Qaeda. Top-down control is diminished, as leaders no longer approve all attacks. After losing its Afghan sanctuary, the leadership of al-Qaeda is more reliant on such semi-independent cells in diverse regions. Sageman sees such local cells as the wave of the future, a theory supported by the Madrid bombings, which were carried out by a semi-independent cell. Because of the Internet, al-Qaeda is becoming a virtual community (not dependent on any one geographical locale) in the global space of the Internet. It is a "virtual Islamist state that is trying to find a place for itself in the actual world" (Wright 2004, p. 53). The cohesiveness of this virtual community presents fundamental questions about its legitimate recognition in the international arena.

The use of the Internet and other communications technologies has sparked a technological arms race as government entities develop their own innovations to track and monitor terrorist activities. Government intervention such as shutting down web sites that are judged to support terrorism has sparked controversies about the proper limits to free speech (e.g., should instructions on bomb making be available online?).

Terrorists also use technologies in the form of weapons, which span the spectrum from simple to complex. Nasra Hassan (2001) explains that the materials used to build suicide bombs (nails, gunpowder, light switches, acetone, etc.) are not only readily available but so affordable that the most expensive part of some Palestinian suicide missions is the transportation to the site of the attack. Similarly, very little expertise or high-tech equipment is needed to make effective agricultural bioterrorist weapons (Wheelis, Casagrande, and Madden 2002). Timothy McVeigh used an ammonium nitrate and fuel oil (ANFO) bomb, which was composed of many simple and readily available components (e.g., fertilizer) but was most likely fairly complicated to construct. So-called dirty bombs (combinations of TNT or ANFO explosives with highly radioactive materials) are similar in that radioactive materials are relatively easy to procure (significant quantities have even been found in scrap yards), but constructing and deploying an effective dirty bomb capable of widely dispersing radiation is difficult (Levi and Kelly 2002).

Nuclear weapons are extremely difficult to build and nuclear material is rare and hard to refine, but political unrest in nations possessing them has increased fears that terrorists could acquire existing nuclear weapons. The term *loose nukes* refers to nuclear weapons, materials, or knowledge that could fall into terrorist hands. The black market in uranium and plutonium and poorly paid Russian scientists are of special concern. Al-Qaeda has repeatedly attempted to purchase highly enriched uranium, and states that sponsor terrorism continually try to build nuclear weapons. The threat of nuclear terrorism raises the old "nuclear dilemma" former U.S. President Dwight Eisenhower noted in the 1950s, namely, how to ensure atomic power is used to promote peace rather than threaten war. Fear surrounding these possibilities also spreads rumors of new weapons, such as "red mercury," which could make nuclear fusion weapons easier to build. Controversy surrounds the nature and very existence of red mercury, however (Edwards 1995).

Biological and chemical agents have also been used to kill and terrorize targeted populations. At least one British officer gave blankets used by smallpox patients to Native Americans during the French and Indian War (1754–1763), and reports exist of similar acts by land speculators and settlers. In 2001 an unidentified terrorist mailed letters laced with anthrax to U.S. senators and media icons. Five people died as a result. In the late 1980s Saddam Hussein used a combination of chemical agents including sarin, mustard gas, and possibly VX to kill as many as 5,000 and wound another 65,000 Kurds in northern Iraq.

In addition to both simple and more complex weapons, terrorists have adapted other technologies to serve as weapons. The most dramatic example is the use of commercial airplanes and skyscrapers by terrorists on September 11, 2001. It could also be argued, however, that terrorists even use television as a psychological weapon by creating images that induce fear.

Perhaps the most frightening reality raised by contemporary terrorist acts is the inherent vulnerability of complex sociotechnical systems. As Langdon Winner (2004) argues, life in modern civilization increasingly depends on large-scale, complex, geographically extended, and often centralized technological systems. The Y2K scare vividly raised the specter of vulnerability, as citizens, governments, and businesses alike realized how fragile such highly integrated and tightly coupled systems are. Examples include information and computer networks, dams and water purification systems, nuclear power plants, the energy transmission and distribution infrastructure, the communications infrastructure, chemical plants, gas pipelines, railroads, the mail system, food supply chains, huge fields of monoculture crops, and the containerized cargo system.

The human demands and material costs of policing these systems are, in the long term, unsustainable. Totalitarian societies have "hardened" their technologies to provide the necessary surveillance and protection, but this destroys civil freedom. Reliable engineering can solve only some of the problems. The only alternative left for free, democratic societies, Winner argues, is to embrace an attitude of trust. Citizens expect that key technologies will always work reliably. The relationship is reciprocal as it informs the structure and operation of technological systems themselves. The upshot is that "Many key components are built in ways that leave them open to the possibility of inadvertent or deliberate interference" (p. 156).

When this attitude of openness and trust is undermined by a sense of vulnerability and dread, rights and democratic institutions are threatened. Fears of cyber-, bio-, eco-, and other terrorist plots lead to a society that begins to treat all citizens as suspects, because anyone could potentially cause massive damage given the vulnerability of high-density populations dependent upon tightly integrated systems of all sorts.

Winner speculates that "Although seldom mentioned in the mass media, the ultimate fear driving public and private policies in the post 9/11 [era] is an awareness that seemingly secure, reliable structures of contemporary civilization are, taken together, an elaborate house of cards" (p. 167). This taps into our deepest fears about technology: that the powers we seek to control will come back to destroy us. Winner presents a suite of options based on the premise of designing technical systems that are more loosely coupled and "forgiving." Environmental design and bioregionalism provide models for shifting to locally available resources and decentralized systems.

The vulnerability of sociotechnical systems presents a curious reversal of the technological and power asymmetries in the relationship between terrorists and the groups they attack. The latter are generally regarded as privileged in terms of technology and power, whereas the former must take recourse to terrorist tactics precisely because of their position of weakness. Certainly, many of these groups are oppressed. But power in this dynamic is revealed as a two-way, nonhierarchical affair. The massive vulnerability of technological systems (and the fact that many technologies are becoming easier to manufacture on small scales partially because of the wide dissemination of knowledge) gives to individuals and small groups an inordinate amount of power to inflict damage and spread terror.

ADAM BRIGGLE
CARL MITCHAM

SEE ALSO *Aviation Regulatory Agencies; Biological Weapons; Building Destructions and Collapses; Chemical Weapons; Fire; Information Ethics; International Relations; Security; Terrorism and Science.*

BIBLIOGRAPHY

Atran, Scott. (2003). "Genesis of Suicide Terrorism." *Science* 299(5612): 1534–1539.

Berman, Paul. (2003). *Terror and Liberalism*. New York: Norton.

Chase, Alston. (2003). *Harvard and the Unabomber: The Education of an American Terrorist*. New York: Norton.

Edwards, Rob. (1995). "Cherry Red and Very Dangerous." *New Scientist* 146(1975): 4–5.

Elshtain, Jean Bethke. (2003). *Just War against Terror*. New York: Basic.

Galston, William A. (2003). "Why They Hate Us." *Commonweal* 130(11): 22–24.

Gilbert, Paul. (1994). *Terrorism, Security, and Nationality: An Introductory Study in Applied Political Philosophy*. London: Routledge.

Hassan, Nasra. (2001). "An Arsenal of Believers." *New Yorker* 77(36): 36–41.

Huntington, Samuel P. (1996). *The Clash of Civilizations and the Remaking of World Order*. New York: Simon and Schuster.

Jenkins, Brian M. (1974). *Terrorism and Kidnapping*. Santa Monica, CA: Rand.

Krueger, Alan B., and Jitka Maleckova. (2003). "Seeking the Roots of Terrorism." *Chronicle of Higher Education*, 6 June, B10–B11.

Levi, Michael A., and Henry C. Kelly. (2002). "Weapons of Mass Disruption." *Scientific American* 287(5): 76–81.

Nacos, Brigitte L. (1994). *Terrorism and the Media: From the Iran Hostage Crisis to the World Trade Center Bombing*. New York: Columbia University Press.

Pape, Robert A. (2003). "Dying to Kill Us." *New York Times*, 22 September, A17.

Qirko, Hector N. (2004). "'Fictive Kin' and Suicide Terrorism." *Science* 304(5667): 49–51.

Sageman, Marc. (2004). *Understanding Terror Networks*. Philadelphia: University of Pennsylvania Press.

Sen, Amartya. (2002). "Civilizational Imprisonments." *New Republic* 226(22): 28–33.

Tobeña, Adolf, and Scott Atran. (2004). "Individual Factors in Suicide Terrorism." *Science* 304(5667): 47–49.

Wheelis, Mark; Rocco Casagrande; and Laurence V. Madden. (2002). "Biological Attack on Agriculture: Low-Tech, High-Impact Bioterrorism." *BioScience* 52(7): 569–576.

Winner, Langdon. (2004). "Trust and Terror: The Vulnerability of Complex Socio-technical Systems." *Science as Culture* 13(2): 155–172.

Wolin, Richard. (2003). "Are Suicide Bombings Morally Defensible?" *Chronicle of Higher Education*, 24 October, B12–B14.

Wright, Lawrence. (2004). "The Terror Web." *New Yorker* 80(21): 40–53.

INTERNET RESOURCE

Kaczynski, Theodore. (1995). *Industrial Society and Its Future*. Available from http://www.unabombertrial.com/manifesto.

TERRORISM AND SCIENCE

When the U.S. Department of Homeland Security (DHS) was proposed in 2002, President George W. Bush (b. 1946) noted that "in the war against terrorism, America's vast science and technology base provides us with a key advantage." What he failed to mention is that science and technology are also major sources of vulnerability to terrorist attacks, requiring decisions about censorship of publication and restriction of access to sensitive areas and materials. Thus terrorism poses special problems for the scientific and technical community in two respects: how to limit terrorist access to sensitive knowledge and technology, and what scientific research and technological developments to pursue in the interests of countering terrorist threats. Although scientists and engineers must bring their professional ethical responsibilities to bear on both tasks, it is equally important that decision makers understand the related limitations of science and technology.

Limiting Terrorist Access

Because of their multiple use capabilities, scientific knowledge and technological devices can be used by terrorists for purposes other than those originally intended. Preventing such misuse presents policy makers and the scientific and engineering communities with two challenges. First, they must insure that knowledge and information are not inappropriately disclosed. Second, they must secure existing and proposed technologies (e.g., nuclear power plants) and research materials (e.g., pathogens). In general, policies in the first case involve restricting the availability of sensitive information by the government, scientists, or both. Actions in the second case generally involve containment, monitoring, and restriction of access. Both actions raise tensions between the goals of security and scientific freedom and openness in the creation and exchange of knowledge and products. Striking the proper balance between these competing goods has taken on heightened importance since the terrorist attacks of September 11, 2001, and the responses by the governments of the United States and other nations.

The situation is made more complex by the notion that some degree of scientific freedom is necessary for national security, because it facilitates the creation of new knowledge and artifacts that may be useful in preventing or responding to terrorist attacks. Especially in the biomedical field, circumstances are further complicated by the potential twin effects of secrecy and restricted access. In some cases, these effects may protect public health by preventing terrorist from acquiring sensitive information or dangerous pathogens. In others, they may harm public health by preventing the development of cures and vaccines or inhibiting the coordination of response efforts to disease outbreaks. In some cases, the potential benefits of researching pathogens to mitigate the effects of terrorist attacks may not be worth the risks. This has sparked controversies about the creation and siting of biosafety laboratories that handle dangerous pathogens.

The free creation and exchange of knowledge by scientists can present dangerous, unintended consequences for society. A paper by Ronald Jackson and other researchers found that the insertion of IL-4 genes into mousepox viruses resulted in near total immunosuppression (Jackson, Ramsay, Christensen, et al. 2001). This advanced valuable knowledge about immune system functioning, but it also evoked fears that terrorists could use such knowledge to engineer hyper-virulent viruses. Similarly, the journal *Science* published a paper in 2002 that showed how to assemble a poliovirus from readily available chemicals (Cello, Aniko, Eckerd 2002). The threat of terrorist acts has caused political leaders and members of the scientific community to question whether such knowledge should be created, and if so, how its publication and exchange should be regulated.

In *New Atlantis* (1627), Francis Bacon (1561–1626) imagined the self-censoring activity of scientists in recognition of the fact that politically authorizing experimental science entails societal risks. The twentieth century provided several examples of tradeoffs between security and openness in the pursuit of knowledge. The Manhattan Project that produced the first atomic bomb cultivated a culture of secrecy. A similar culture developed among researchers studying microwaves during World War II. During the Cold War, the U.S. government attempted to constrain information exchange in some areas of mathematics and the physical sciences that may have aided Soviet nuclear weapons development (Monastersky 2002). Physicist Edward Teller (1908–2003) and others eventually persuaded policy makers that openness, rather than secrecy, was the best tactic for security during the Cold War.

In 1975, an international group of scientists held the Asilomar conference to debate the proper use and regulatory oversight of recombinant DNA research. During the late 1970s, the National Security Agency (NSA) regulated cryptographers developing new algorithms, but the two groups eventually agreed to a system of voluntary submission of papers for review. In 2002, the U.S. government began to withdraw from public release more than 6,600 technical documents dealing mainly with the production of germ and chemical weapons. In a controversial move, the U.S. national policy for the restriction of information that may threaten national security was altered in the wake of the September 11 attacks to include restrictions on publication of federally-financed research deemed to be "sensitive but not classified" (Greenberg 2002).

As these examples illustrate, limitations on research and the availability of technical knowledge can come in the form of self-imposed screening mechanisms by the scientific community or government regulation. The Asilomar conference, for example, led to a suite of self-policing mechanisms within the scientific community, including the decentralized system of Institutional Biosafety Committees (IBCs). This same mechanism has been proposed by the National Science Advisory Board for Biosecurity (NSABB) as a way to prevent the misuse of biological research by terrorists. The NSABB also works to develop codes of conduct for researchers and laboratory workers, which underscores the importance of ethical conduct by individuals, especially where no rules exist or where the precise meaning of rules is unclear. Some professional associations and journals, including *Science* and *Nature*, have instituted procedures to give special scrutiny to papers that raise security concerns (Malakoff 2003). Putting such control in the hands of journal editors has caused some to argue that an advisory group like the Recombinant DNA Advisory Committee (RAC) would be a better mechanism.

Mitchel Wallerstein (2002) points out that the dangers posed by terrorists acquiring sensitive science and technology information differ from the state-related threats that were of primary concern during World War II and the Cold War. Terrorists generally do not seek out and would not be able to use the results of most basic research, but states may possess the intellectual and financial capital necessary to turn basic research into weapons. Daniel Greenberg (2002) contends that terrorists do not rely on new science. Rather, readily accessible information that has long been available suffices to fulfill most of the goals of terrorist organizations.

Biological weaponry is the area of science that could most directly benefit terrorist organizations. Wallerstein writes, "Information that improves knowledge of dangerous pathogens, their safe handling, and their weaponization increases the likelihood that such weapons could be produced covertly on a small scale" (p. 2169). His general conclusion is that restrictions on scientific and technical communications need occur only on a much smaller scale than during the Cold War. In fact, many echo his conclusion that sensitive research is a very narrow slice of the scientific world, which allows for severe but highly targeted restrictions.

Restricting the publication of information deemed sensitive and controlling access to technologies and research materials can help achieve security goals, but not without costs (Knezo 2002a). Some impacts are relatively minor, such as new standards for the construction and management of laboratories. Other impacts are more severe, including the impact of national security policy measures on the research process. Tightened laboratory access policies, publication rules, and visa restrictions may reduce the number of applications by foreign students to U.S. universities and colleges. This could hamper cross-cultural understanding. According to State Department rules, consular officials may deny visas for study in the United States in sixteen categories specified on the Technology Alert List to students from countries listed as "state sponsors of terrorism." Additional exemptions to the Freedom of Information Act (FOIA) and the withdrawal of information from federal agency websites have also sparked concerns about constraints on legitimate scientific work and academic freedoms.

Economic losses are also a concern about some legislative responses to security risks posed by science and technology. Instituting security and tracking measures in academic laboratories entails additional costs for researchers. Restrictions on foreign researchers can damage technological developments and economic productivity. The U.S. Immigration and Customs Enforcement (ICE) agency operates "Project Shield America" to prevent the illegal export of sensitive munitions and strategic technology to terrorists. It is intended to prevent terrorism, but may also entail losses to economic competitiveness.

Science and Technology to Counter Terrorism

Since the September 11 attacks, science and technology have increasingly been advertised as ways to prevent terrorist attacks as well as reduce vulnerabilities and minimize impacts of such attacks (e.g., Colwell 2002). This is in part a response by scientists and engineers to the sizeable increases in homeland security and counterterrorism research and development (R&D).

The National Research Council's Committee on Science and Technology for Countering Terrorism issued a report in 2002 that described the ways in which science and engineering can contribute to making the nation safer against the threat of catastrophic terrorism. It outlined both short-term applications of existing technologies and long-term research needs. The report recommended actions for all phases in countering terrorist threats, which can be roughly ordered as awareness, prevention, protection, response, recovery, and attribution. Different threats pose different challenges and opportunities across these phases. For example, nuclear threats must be addressed at the earliest stages, whereas biological attacks are more difficult to preempt, but more opportunities exist for technological intervention to mitigate their effects.

Scientific research and technological innovations can improve performance of all phases, from threat analyses and vulnerability assessments to post-attack investigations and restoration of services. For example, the Bush administration established BioWatch, a nationwide system of sensors to detect the presence of certain pathogens, and a public-health surveillance system that monitors the databases of eight major cities for signs of disease outbreaks. Early warning systems can detect the presence of certain pathogens by utilizing computer chips and antibodies or pieces of DNA (Casagranda 2002). Explosives-detection technologies have also been spurred since September 11, 2001 in order to bolster airline security.

Other examples include the use of biometrics (e.g., fingerprints and retinal signatures) to develop national security identity cards. The shipping industry is slowly adopting new security measures such as sophisticated seals and chemical sensors. Other researchers are developing strategies for securing information systems. Military infrared countermeasures for surface-to-air missiles may be used on civilian aircraft. Technologies for decontamination, blast-resistant walls, and protective gear for first responders are other components of research programs. Increasing flexibility and innovating measures to isolate failing elements could increase security of more complex technical systems such as transportation and communication infrastructures. Researching and developing broader applications of renewable energy can harden the energy infrastructure. Social scientists and psychologists also provide research for understanding causes and motivations of terrorists as well as the dynamics of terrorist group formation. Some (e.g., Susser, Herman, Aaron 2002) have demonstrated that, because terrorists choose targets to maximize psychological impact, mental health must be considered a top response priority.

With all of these potential applications of science and technology, decision makers need to address questions about how to coordinate, organize, prioritize, and evaluate investments to serve the goals of security and public health. Genevieve Knezo (2002b) reported that prior to September 11, 2001, the Government Accountability Office (GAO) and other authorities had questioned whether the U.S. government was adequately prepared to conduct and use R&D to prevent and combat terrorism. Partially in response to the need to better coordinate counterterrorism efforts (including R&D), the cabinet-level Department of Homeland Security (DHS) was created by legislative act in 2002. This incorporated half of all homeland security funding within a single agency. In addition to legislative activity, new advisory bodies such as the NSABB have been formed to guide the creation of new rules and development of new institutions to maximize the benefits of science and technology while minimizing unintended negative impacts.

Since September 11, 2001, established institutions have benefited from significantly increased funding for homeland security and public health research. For example, in 2002 President Bush proposed a 2,000 percent budget increase for the National Institute of Allergy and Infectious Diseases (NIAID) from pre-September 11 levels. Other institutions and agencies have either received additional funding (especially the National Institutes of Health) or made attempts to restructure their priorities to take advantage of shifts in R&D funding priorities (Congressional Research Service 2002; American Association for the Advancement of Science 2004).

Investments in science to reduce terrorist threats raise several ethical issues. First, the scale of vulnerabilities outstrips resources to reduce them, which raises equity issues in the process of prioritizing investments. For example, bioweapons detectors are too expensive to deploy on every street corner, so locations must be prioritized. Likewise, not all areas pose equal risks from terrorist attacks, so efforts need to be targeted to match threats.

Second, Arthur Caplan and Pamela Sankar (2002) note the increase in "research protocols that call for the deliberate exposure of human subjects to toxic and noxious agents" (p. 923). Such dilemmas are not new, as many trials on U.S. Navy and Army crew members took place in the 1960s in an effort to document the effects of biological and chemical weapons. Many research subjects were neither informed of the details of the study nor issued protective gear (Enserink 2002). Such research needs clear guidelines and unequivocal justification for its relevance to national security. Professional ethical issues also arise when unemployed scientists and engineers face financial incentives to aid terrorist organizations (Richardson 2002).

Third, the integrated nature of socio-technical systems raises considerations of equity and civil liberties. For example, forty percent of all containerized cargo that arrives in the Long Beach harbor in Los Angeles is destined for the U.S. interior. How should the burden of increased security costs be distributed? Furthermore, the process of hardening these systems can reduce access and curtail certain civil liberties (Clarke 2005).

Finally, several analysts have criticized dominant U.S. counterterrorism science policies as ineffective. Bruce Schneier, security technologist and cryptographer, argues that managers too often seek technological cure-alls and rarely consider the consequences of system failures (Mann 2002). For example, all security systems require secrets, but they should be the components that are most easily changed in case system integrity is breached. Biometric identity devices that use fingerprints can centralize so many functions that they create "brittle" systems that fail poorly in case they are stolen. New banking account numbers can be issued in case of fraud, but not new fingerprints. Schneier contends that in airline security the only effective measures are the low-tech solution of reinforcing cockpit doors and the non-technical fact that passengers now know to fight back against hijackers. Both measures pass Kerckhoffs' principle, which occurs when a system remains safe even when almost all of its components are public knowledge. Schneier also holds that security systems are at their best when final decision-making responsibility is given to humans in close proximity to the situation, not computers. Security systems should be ductile, small-scale, and compartmentalized to mitigate the effects of inevitable failures.

Stephen Flynn (2004) focused less on the inherent limitations of technology as a means of countering terrorism; rather he critiqued government R&D prioritizations. Flynn argued that some high-tech solutions such as digital photographs of container loading processes, internal emissions sensors in cargo containers, and GPS tracking devices can improve security, but they have not been given adequate funding.

The 2002 report by the Committee on Science and Technology for Countering Terrorism openly recognizes the fact that science and technology are only one part of a broad array of strategies for reducing the threat of terrorism that includes diplomacy, cross-cultural learning, and economic, social, and military policies. Furthermore, as the U.S. experience in the Vietnam War and the Soviet experience in the 1980s invasion of Afghanistan demonstrate, technological superiority does not guarantee victory. Success in the war on terror is measured by accomplishments, not R&D budgetary numbers.

From communism to environmental problems and the challenges posed by a globalizing economy, science and technology have often been put forward as ways to protect national interests and secure prosperity (Jenkins 2002). Scientists, engineers, and politicians often define problems in ways that call for technical solutions, but they must be held accountable for such problem definitions. Scientists and engineers especially must exercise ethical responsibility by not unduly exaggerating arguments that their research will serve societal goals.

Assessment

The two sections of this entry are interrelated in that increased scientific research on counterterror measures will create new knowledge and opportunities for terrorist exploitation, which will create new challenges for securing that knowledge. Given that security, health, and civil liberties are at stake in decisions about science and terrorism, it is important that measures be taken to involve and inform citizens. This entry has focused on actions by the U.S. government because it plays a leading role in matters of science and terrorism. But other countries and international coalitions face similar ethical dilemmas and policy choices. Private companies own many of the infrastructures that are targets for terrorist attacks, so regulations may be required to induce the private sector to invest in counterterrorism technologies that may not have commercial markets. Some scientific research, however, may have viable market applications, meaning that some of the R&D burden can be privatized, which raises other ethical issues that partially mirror those involved in the privatization of war.

ADAM BRIGGLE

SEE ALSO *Biological Weapons; Building Destructions and Collapses; Chemical Weapons; Fire; Information Ethics; International Relations; Security; Terrorism.*

BIBLIOGRAPHY

Caplan, Arthur L., and Pamela Sankar. (2002). "Human Subjects in Weapons Research." *Science* 298(5595): 923.

Casagrande, Rocco. (2002). "Technology against Terror." *Scientific American* 287(3): 83–87.

Cello, Jeronimo, Paul V. Aniko, and Wimmer Eckard. (2002). "Chemical Synthesis of Poliovirus cDNA: Generations of Infectious Virus in the Absence of Natural Template." *Science* 297(5583): 1016–1018.

Clarke, Richard A. (2005). "Ten Years Later." *Atlantic Monthly* 295(1): 61–77. Imagines future scenarios of terrorist attacks and government reactions.

Enserink, Martin. (2002). "Secret Weapons Tests' Details Revealed." *Science* 298(5593): 513–514.

Committee on Science and Technology for Countering Terrorism, National Research Council. (2002). *Making the Nation Safer: The Role of Science and Technology in Countering Terrorism.* Washington, DC: National Academy Press.

Flynn, Stephen. (2004). *America the Vulnerable: How Our Government Is Failing to Protect Us from Terrorism.* New York: HarperCollins.

Greenberg, Daniel S. (2002). "Self-Restraint by Scientists Can Avert Federal Intrusion." *Chronicle of Higher Education* October 11: B20.

Jackson, Ronald J., Alistair J. Ramsay, Carina D. Christensen, et al. (2001). "Expression of Mouse Interleukin-4 by a Recombinant Ectromelia Virus Suppresses Cytolytic Lymphocyte Responses and Overcomes Genetic Resistance to Mousepox." *Journal of Virology* 75(3): 1205–1210.

Jenkins, Dominick. (2002). *The Final Frontier: America, Science, and Terror.* London: Verso. Presents the argument that changes in technology have created a situation where all citizens are vulnerable to catastrophic terrorist attacks.

Malakoff, David. (2003). "Researchers Urged to Self-Censor Sensitive Data." *Science* 299(5605): 321.

Mann, Charles C. (2002). "Homeland Insecurity." *Atlantic Monthly* 290(2): 81–102.

Monastersky, Richard. (2002). "Publish and Perish?" *Chronicle of Higher Education* October 11: A16–A19. Focuses on the dilemma of scientific openness and national security.

Richardson, Jacques G. (2002). *War, Science and Terrorism: From Laboratory to Open Conflict.* London: Frank Cass. Sees the connection between science and terrorism largely as an outgrowth from the partnership between science and the military and asks to what extent science is promoted by actual or threatened armed conflict and whether war is an extension of science by other means.

Susser, Ezra S., Daniel B. Herman, and Barbara Aaron. (2002). "Combating the Terror of Terrorism." *Scientific American* 287(2): 70–77.

Wallerstein, Mitchel B. (2002). "Science in an Age of Terrorism." *Science* 297(5590): 2169.

INTERNET RESOURCES

American Association for the Advancement of Science. (2004). "Defense and Homeland Security R&D Hit New Highs in 2005; Growth Slows for Other Agencies." Available from http://www.aaas.org. A summary of AAAS estimates and analyses of appropriations in the FY 2005 omnibus bill and final FY 2005 appropriations bills for federal R&D.

Colwell, Rita R. (2002). "Science as Patriotism." Available from http://www.sciencecoalition.org/presskit/articles/puboped/colwell_jan302002.pdf. Paper presented at the Annual Meeting of the Universities Research Association, Washington DC.

Congressional Research Service. (2002). "Science and Technology Policy: Issues for the 107th Congress, 2nd Session." Available from http://www.ncseonline.org.

Knezo, Genevieve. (2002a). "Possible Impacts of Major Counter Terrorism Security Actions on Research, Development, and Higher Education." CRS Report for Congress. Available from http://www.fas.org.

Knezo, Genevieve. (2002b). *Federal Research and Development for Counter Terrorism: Organization, Funding, and Options* CRS Report RL31202. Abstract available from http://www.pennyhill.com/index.php?lastcat= 200&catname= Terrorism&viewdoc=RL31202.

THEODICY

Theodicy is a concept developed by Gottfried Wilhelm Leibniz (1646–1716) to justify the existence and absolute perfection of God despite the evil that exists in the world. The term appeared in 1710 in the title of Leibniz's work *Theodicy—Essays on the Goodness of God, of the Freedom of Man, and the Origin of Evil,* and with it he coined an optimistic variant *par excellence* on theories of evil. Insofar as science and technology are often interpreted as responses to evil, theodicy is related to their modern emergence.

Background and Emergence

Theories of evil have been developed by Plotinus (204–270), Augustine (354–430), and others in which evil is seen as necessary for universal harmony. Within the framework of the complex theological discussions on the origin of evil, Leibniz's theodicy denies both the idea of God as a malevolent creator of the world (a position taken by certain Gnostics) and the refutation of this theory by Origen (c. 185–254) and Augustine who, in postulating human freedom, attributed moral responsibility for all the evils of the world to human beings, in the form of sin.

Leibniz's particular approach was to interpret perfection as the state of a thing when it attains its highest level of being. This definition highlights God's perfection. From the quantitative point of view, God has all perfections; from the qualitative point of view, these perfections reach their highest form in him. God is therefore omniscient and omnipotent. Despite the impressions that evil, injustice, and suffering give us of the world, God's perfection is necessarily expressed in his creation.

This theory is, paradoxically, a key philosophical element of transition to modernity, a vital bridge to the new philosophies that emerged in the second half of the eighteenth century: the philosophy of history, philosophical anthropology, and aesthetic philosophy. The advance of these philosophies is tied to a new understanding of human nature that rejects the naturalism of seventeenth century thought, as well as traditional Christian theology. All the images of the human that developed in the eighteenth century were optimistic in ways reflecting theodicy—as can be illustrated in moral humanity (Anthony Ashley Cooper Shaftesbury [1671–1713]), rational humanity (Jean-Jacques Rousseau [1712–1778], Immanuel Kant [1724–1804]), economic humanity (Adam Smith [1723–1790]), and perfectible humanity (Condorcet [1743–1794]).

Although the idea of a human fall did not immediately disappear, a new concept began to replace it—not exactly of human greatness, but of the ability of humans to do what was necessary to make the world better for the human species. To understand this situation is to recognize the significance of Leibnizian theodicy for modern science and technology, as well as for ethics in the era of modernity. Leibniz's theodicy was both necessary for and representative of the modern world, insofar as it gave expression to a vision of the human condition as one which, aided by science and technology, was no longer characterized by powerlessness, suffering, and evil. These were henceforth looked at outside Leibniz's own metaphysical framework as being essentially surmountable.

Collapse and Continuity

With the Lisbon earthquake of 1755, Leibniz's justification of God in the face of worldly evil collapsed, in a complex historical context where science began progressively to replace religion as the cultural frame of reference. Nevertheless, the semantic core of Leibniz's arguments, that to compensate for evil is in fact the purpose the divine creator had before him, held firm. As Odo Marquard (1989, pp. 38–63) argued, Leibniz provided the teleological framework in which science and technology could become both means and ends. In Leibniz's theology that basic principle is "*malum* through *bonum*": God does not make up for evil with good, but evil is rehabilitated by the good it pursues. Tolerance in the face of evil is justified by having the highest good as the end in view, insofar as evil is the condition that makes the good possible.

In this sense, the principle of theodicy is that the ends justify the means. With the collapse of Leibnizian theodicy in its original form, human beings take the place left vacant by the omnipotent creative will and theodicy is transformed into anthropodicy or human progress. Humanity as an end in itself is free to use everything else as mere means, inheriting God's role in order to realize and complete theodicy in history. Every goal achieved became a new means toward another end.

As a result of this teleological sequence of means and ends, what came to predominate was not the possible uses of the means, but the very means themselves. The ends no longer justified the means, the means justified the ends. This logic is linked to the cost/benefit compensation criterion of utilitarianism: Every good has its price. As Thomas Robert Malthus (1766–1834) wrote in his *Essay on the Principle of Population* (1798): "There is evil in the world, not in order to produce despair, but rather activity." This idea is equally present in other modern thinkers such as Bernard Mandeville (1670–1733): "There are 'private vices' [*malum*], but they are 'public benefits' [*bonum*-through-*malum*]."

The Example of Cournot and Teilhard

Among those who developed philosophies of history guided by an optimistic approach or who believed in humanity's ascending progress to an ideal state were the Frenchmen Antoine-Augustin Cournot (1801–1877), a teacher of mathematics and author of several works on the philosophy of history, and Pierre Teilhard de Chardin (1881–1955), a Jesuit priest, paleontologist, and philosopher of nature. Though sometimes neglected, these two thinkers developed unusual and powerful syntheses that reflect the subtle and penetrating influence wielded by the Leibnizian idea of an omnipotent creative will. Their work had significant repercussions during their own lifetimes, and their theoretical constructs are still surprisingly topical in the twenty-first century: Cournot as a prophet of post-historical technological civilization, Teilhard as the prophet of transhumanism.

For the century in which he lived, Cournot was the thinker who developed with the greatest persistence a philosophy of history in which science and technology take pride of place. His philosophy of history is based on a series of binary opposites: chance and necessity, reason and instinct, passions and interests. With these concepts, his reading of history was finalistic, and he argued for the likelihood or even the inevitability of what has come to be called "the end of history," a partly Hegelian premise that was revived at the end of the twentieth century in a world that claimed the end of ideology, of utopia, of politics, of the human. Hermínio Martins (1998), who has emphasized the importance of Cournot for the philosophy of technology, argues that Cournot's "end of history" semantics do not imply a form of necessitarianism, in the sense of extinction or termination, but more correctly exhaustion, completion, fulfillment, or consummation.

Cournot's temporal interpretation of collective human existence is based on a system of three great time-phases, as found in the work of Auguste Comte (1798–1857) and Karl Marx (1818–1883), and closely related to different kinds of discourse. The first phase has been labeled "ethnological" and is characterized by the subordination of reason to instinct, of the planful to the unreflective; habit and custom predominate, and are accompanied by natural or human disasters. The second stage is the phase of history itself. This is defined by an increase in rationality in thought and action, and by a combination of passions and interests as the springs of action with sufficient power to give rise to colossal events, of which the French Revolution is an example. The third and terminal phase is the closest possible approximation to the ideal, which humanity will never be able to attain. In this phase, "political faiths" decline, as occurred during the French Revolution, and give way to the peaceable play of economic interest and the *doux commerce*.

This third stage establishes a post-historic society that conquers nature by systematic scientific discovery, technological invention, innovation, and economic growth. Cournot anticipates positions that were further developed in the twentieth century, such as Joseph Schumpeter's routinization of economic innovation and what Alfred North Whitehead calls the "invention of invention," but does not show any significant concern with the possible intrinsic limits of scientific progress, which might bar further fundamental technological advance.

Teilhard's approach to human history also embodies finalism, and the role of scientific and technological advance within it, although his vision embraces different domains from those of Cournot. Teilhard's arguments have roots in the philosophy of Henri Bergson (1859–1941), and are part of the new theology of history that seeks to protect theology from the temptation of rationalist hermeneutics. Nonetheless, it did not shy away from dealing with "earthly realities," such as the relationship between humans and nature, the carnal nature of human beings, scientific humanism, and the theology of science. Teilhard's thinking embodied these contributions, and added a lively intuition of the evolutionist and voluntarist scientific and technological type that aroused serious suspicions in Rome. Contravening some basic postulates of Christianity, he argued for the "spiritual value of matter," and developed a conception in which humankind, with its artistic achievements, technological artifacts, and religions, is part of an overall evolutionary scheme in which there exists a progressive manifestation of biochemical complexity on the path to a growing unified consciousness.

In the tradition of the omnipotent creative will, Teilhard argued that perfection lies in the progress not of individuals, but of humanity as a whole, on a path toward unification with God who, being in essence supernatural, is at the same time the natural outcome of evolution. In his main work, *The Phenomenon of Man* (1959), he develops a suggestive synthesis of science and religion, in the context of a view of the universe as a system that develops from one phase to another with ever-higher forms of consciousness.

Teilhard's speculations anticipated those who favor a transhuman future which appears possible and desirable. These transhumanists are convinced that the new computational technologies are creating a collective human intellect, a kind of cognitive and mental hyperextension of the human mind. Cournot, by contrast, thought that organic life would remain fundamentally inaccessible to mathematical and experimental science, while postulating that increasing knowledge of inanimate nature would be sufficient to ensure technical perfectibility and material progress.

JOSÉ LUÍS GARCIA

SEE ALSO *Leibniz, G. W.; Progress.*

BIBLIOGRAPHY

Anderson, Perry. (1992). *A Zone of Engagement*. London: Verso.

Cournot, Antoine-Augustin. (1861). *Traité de l'Enchaînement des Idées Fondamentales dans les Sciences et dans l'Histoire* [Treatise on the Chain of Fundamental Ideas in Science and History]. Paris: Hachette.

Cournot, Antoine-Augustin. (1875). *Matérialisme, Vitalisme, Rationalisme* [Materialism, Vitalism, Rationalism]. Paris: Hachette.

Leibniz, Gottfried Wilhelm. (1952 [1710]). *Theodicy—Essays on the Goodness of God, of the Freedom of Man, and the Origin of Evil*, ed. Austin Farrer, trans. E.M. Huggard. London: Routledge & K. Paul.

Marquard, Odo. (1989). *Farewell to Matters of Principle: Philosophical Studies*, trans. Robert M. Wallace with the assistance of Susan Bernstein and James I. Porter. New York: Oxford University Press.

Martins, Hermínio. (1998). "Technology, Modernity, Politics." In *The Politics of Postmodernity*, ed. James Good and Irving Velody. Cambridge, UK: Cambridge University Press.

Ruyer, Raymond. (1930). *L'Humanité de l'Avenir d'après Cournot* [The Humanity of the Future according to Cournot]. Paris: Alcan.

Teilhard de Chardin, Pierre. (1959). *The Phenomenon of Man*, trans. Bernard Wall. New York: Harper.

THERAPY AND ENHANCEMENT

It is common, in classifying interventions, to sort them into those that are therapeutic, that is, directed at diminishing the harms suffered by a patient, and those that are enhancing, that is, directed at increasing the goods experienced by a patient. At least three independent but related questions can be raised about the therapy/enhancement distinction: (1) Can the two terms *therapy* and *enhancement* be defined clearly, reliably, and accurately? (2) Assuming they can be satisfactorily defined, under what circumstances is it morally justified for a physician to engage in either activity? (3) Assuming they can be satisfactorily defined, what implications does labeling an intervention as therapeutic or enhancing have on the issue of whether the cost of the intervention should be borne in part or in whole by third-party funding agencies?

Defining Therapy and Enhancement

The distinction between therapy and enhancement can be most clearly made by first having available a clear definition of a third term: *malady*. The following definition of a malady, adapted from Gert, Culver, and Clouser 1997 (p. 104) classifies all clear cases of maladies as maladies and does not classify as a malady any condition that is clearly not a malady.

> An individual has a malady if and only if (s)he has a condition that is not normal for a person in his (her) prime, other than his (her) rational beliefs or desires, such that (s)he is suffering, or is at a significantly increased risk of suffering, a nontrivial harm or evil (death, pain, disability, loss of freedom, or loss of pleasure) in the absence of a distinct sustaining cause.

Therapies are interventions whose intention is to reduce or eliminate the harms that are a defining characteristic of maladies. If an intervention is not directed toward reducing or eliminating the harms associated with a malady, then it is not a therapy. Enhancements are interventions directed toward increasing the personal goods experienced by another person, such as abilities (including knowledge), freedom, and pleasure. If an intervention is not directed toward increasing another's personal goods, then it is not an enhancement. These definitions seem to correctly classify all cases of therapies and enhancements.

An extensive project ("The Enhancement Project") sponsored by the Hastings Center concluded that the two terms could not be defined clearly and could thus serve only as "conversation starters." In the words of the project coordinator, "Like many distinctions, the treatment/enhancement distinction is permeable, unstable, and can be used for pernicious purposes" (Parens 1998, p. 25). In contrast, the present authors think the two terms can be defined clearly and that one advantage of clear definitions is that they decrease the likelihood of any pernicious applications of the terms defined.

There are inevitable borderline cases. For example, how should one classify the administration of growth hormone to a child destined to be very short but who shows no evidence of an endocrinopathy? There is disagreement about this question, but not because of any avoidable vagueness in the definitions given here. Instead the disagreement is about whether this condition is a malady. If it is not, then administering growth hormone is not a therapy; if it is, then it is a therapy. Both Eric T. Juengst (1998) and Norman Daniels (1994) also use the concept of malady in distinguishing between therapies and enhancements, although Daniels's definition of malady differs from the one given here.

The Moral Justifiability of Administering Therapies and Enhancements

There is a general consensus that it is ethically justified to administer interventions when certain conditions are met. First, the intervention must be a rational one for the patient to choose under his or her circumstances. Second, patients must give valid consent to an intervention: They must be given adequate information about the intervention, must not be coerced into consenting, and must be fully competent to consent. If these conditions are met, then it is ethically justified to administer an intervention. If one of them is not met, then it may or may not be ethically justified to administer the intervention.

If an intervention can be accurately predicted to cause only an increase in the personal goods experienced by an individual, and the individual gives a valid consent to the intervention, then there is nothing morally problematic about administering the enhancement. What often makes enhancements problematic is that there is uncertainty about whether there might be significant harms that will, sooner or later, accompany the enhancement. Breast augmentation surgery may result in abscesses or in later disfiguring and irreversible structural lesions. Exogenous growth hormone administration might result in later endocrinopathies or even tumors. Mood-altering drugs might result in short-term tranquility or euphoria but long-term deleterious psychic (or neurochemical) effects. Even in cases of enhancements with possible risks, unless it would be irrational for the adequately informed competent patient to choose to have the enhancement, it seems morally justified to administer the enhancement if the patient has validly consented to it.

One moral problem that arises concerning enhancements is not the moral acceptability of enhancing with valid consent, but whether the resources spent developing enhancements detract from the resources that are available for therapy. Except when the harms suffered are trivial and the goods involved are extraordinary, it is almost universally acknowledged that it is more important to prevent or relieve harms than to promote goods. Thus if the enhancements that are developed and marketed decrease the resources that are available for therapy, then it might be argued that it is not morally acceptable to develop and market such enhancements. It is very doubtful, however, that preventing the development of enhancements would increase the resources used for therapy, so that it is not clear how much force this argument would have.

Another moral problem concerning enhancement is that it is sometimes used to gain an unfair advantage over others, such as the case of athletes who take prohibited drugs to gain a competitive edge. The problem here, however, is not with enhancements themselves but with their use to gain an unfair advantage. It might be claimed that the existence of enhancing drugs provides such a strong temptation that merely making them available is morally problematic. But most enhancing drugs are also used therapeutically and, in fact, were originally developed for therapeutic use. That enhancing drugs are sometimes used unfairly is no more of an argument against their morally acceptable use than the fact that automobiles are sometimes used in committing a crime is an argument against their morally acceptable use. Other arguments against the use of enhancements, such as that they cause envy, create social pressure for their use, and increase the disparity between people, are also arguments against elite colleges, expensive cars, and personal trainers.

A rhetorically powerful but completely mistaken argument against enhancement is that it is not natural. This argument has no force because almost the entire world humans now live in is not natural, if by *natural* one means independent of human artifice. Even most of the trees and plants humans use are not natural. Medicine is not natural. Before abandoning traditional ways of acting and doing, whether natural or artificial, it is certainly important to ensure that the undesirable unintended consequences will not overwhelm the desired consequences. The larger the change the more caution is appropriate, especially if the desired consequences are not the prevention or relief of evils, but only the promotion of goods, such as germ-line genetic engineering that is used solely for enhancing.

HUMAN GENETIC THERAPY AND ENHANCEMENT. An important application of the therapy/enhancement distinction occurs with genetic therapy and genetic enhancement, and examples of both processes may well proliferate in the future. It is important to distinguish germ-line genetic engineering from somatic-cell genetic engineering. Both involve directly altering the genetic structure of an organism, but somatic-cell genetic engineering, which is done by altering the somatic cells of an organism, is not intended to have any consequences for the descendents of that organism. Germ-line genetic engineering alters the genetic structure of an organism in ways that will or may have consequences for all of its descendents. Gene therapy is genetic engineering aimed at eliminating the genetic cause of (a) a serious malady or (b) a significantly increased risk of suffering that malady. Genetic enhancement is genetic engineering aimed at providing an organism with new or improved traits that are deemed useful or desirable by those doing the altering. Genetic engineering for plants and nonhuman animals is almost always genetic enhancement. Gene therapy is now being considered for human beings, but there is already talk of genetic enhancement for human beings.

If somatic-cell genetic engineering does not have any consequences for future generations, it is not considered controversial. Unlike the genetic engineering that is used in plants and animals, somatic-cell gene therapy alters only the genetic structure of the individual who receives the somatic-cell gene therapy; the altered genetic structure is not passed on to that individual's offspring. Although it is possible for somatic-cell genetic engineering to affect the germ line, this is not yet considered a serious risk, and so its effects are thought to end with the individual treated. Unless some argument is provided to show that somatic-cell genetic engineering has serious risks, there is no stronger reason not to have somatic cell gene enhancement than not to have plastic surgery to improve the appearance of normal people. Indeed, it is hard even to imagine an argument against somatic-cell gene enhancement that is not also a general argument against any kind of technological enhancement.

The moral controversy that is the main subject here concerns whether there is any morally significant difference between germ-line gene therapy and germ-line gene enhancement with regard to human beings. In what follows, gene therapy and gene enhancement will always refer to germ-line gene therapy and germ-line gene enhancement. Gene therapy is regarded by some as the best way to correct severe genetic defects such as thalassemia, severe combined immunodeficiency, or cystic fibrosis. One argument is that because there is no nonarbitrary line between therapy and enhancement, acceptance of gene therapy, even to cure a serious genetic malady, makes it impossible not to accept gene enhancement as well.

This argument is used both by those who are opposed to genetic engineering of any kind, and those who favor gene enhancement. The former argue that because scholars are unable to draw a nonarbitrary line between gene therapy and gene enhancement, people should protect themselves against the latter by not even beginning with the former. The latter argue that because it is clear that one ought to accept gene therapy, one ought to also accept gene enhancement. Nevertheless, the objection that gene therapy will lead to gene enhancement presupposes that there is something intrinsically morally wrong with gene enhancement. No one has yet provided a strong theoretical argument that shows that genetic enhancement to produce greater size, strength, or intelligence, or increased resistance to toxic substances, is morally problematic. Yet neither is it clear that one ought to accept gene therapy or that there is no morally significant distinction between gene therapy and gene enhancement.

In fact, it is possible to draw a nonarbitrary line that distinguishes gene therapy and gene enhancement because there is an adequate definition of a genetic malady, related to the above general definition of a malady:

> An individual has a genetic malady if and only if (s)he has a genetic condition that is not normal

> for a person in his (her) prime, other than his (her) rational beliefs or desires, such that (s)he is suffering, or is at a significantly increased risk of suffering, a non-trivial harm or evil (death, pain, disability, loss of freedom, or loss of pleasure) in the absence of a distinct sustaining cause.

Genetic conditions such as hemophilia, cystic fibrosis, and muscular dystrophy all share features common to other serious maladies, such as cancer, high blood pressure, and tuberculosis and so fit the definitional criteria of malady. Genetic conditions that do not meet the definitional criteria of a malady should obviously not be counted as a malady, and gene engineering for these constitutes gene enhancement. Examples of genetic nonmaladies might include blue eyes, widow's peak, freckles, O blood type, or curly hair.

Nonetheless, it is inevitable that there will be some genetic conditions about which there will be disagreement concerning their malady status. The number of such conditions is small, however, and the disagreement is based on the nature of maladies, not on vagueness in the malady definition. Borderline conditions, such as short stature or mild obesity, will be conditions about which people disagree on their malady status because it is not clear whether these conditions significantly increase the risk of suffering nontrivial harms. Because such borderline conditions are not very serious in the medical sense, they are quite unlikely to be candidates for gene therapy, at least initially. For all practical purposes gene therapy would be limited to the clear cases of genetic maladies. Indeed, the moral argument against gene enhancement, outlined below, is also an argument against genetic engineering for mild or borderline cases of genetic maladies.

The moral argument against gene enhancement is fairly straightforward. It is not morally acceptable to cause harm or a significant risk of harm to some people simply in order to create benefits for some other people. It is sometimes morally acceptable, however, to cause harm or a significant risk of harm to some people in order to prevent more serious or more certain harm to others. The government is allowed to quarantine people, that is deprive them of their freedom, even without their consent, if failure to quarantine would cause serious harm, as in the sudden acute respiratory syndrome (SARS) epidemic of 2003. This restriction of freedom, however, would not be justifiable simply in order to provide benefits to people. Gene enhancement does, at present, pose an unknown but possibly significant risk of harm to the descendants of the person who is being genetically enhanced. This genetic enhancement is not done to prevent a more serious or certain harm to this person. Therefore genetic enhancement is not morally justified. As noted, this same argument can be used against gene therapy for mild or borderline cases of genetic maladies. With regard to serious genetic maladies, this argument does not have the same force, for in these cases, the harm being prevented is more serious and certain than any harm that might be created. This does create a morally significant difference between gene therapy and gene enhancement.

Another completely different kind of argument can be given that leads to the same conclusion. Gene therapy simply aims to replace a defective gene with a nondefective allele of the same gene. If the technique for replacing genes is perfected, which at present it is not, then there is little or no chance that some unknown harmful side effect will result. The genetic structure of the organism will be identical in the relevant respect to the genetic structure of the majority of the human species. With gene enhancement, however, a new gene is being introduced with far greater chance of unknown harmful side effects. There are many genetic effects that do not show up for many generations. The identical gene inherited from the mother may have different effects when inherited from the father. There are expanding genes (triplet repeats) that do not have any effect until after several generations. Gene enhancement could create harms for the third or fourth generation, when it may not even be possible to track these individuals. This is another morally significant difference between gene therapy and gene enhancement.

Because preimplantation screening can eliminate almost all of the genetic maladies that would be eliminated by gene therapy, it seems clear that the primary reason for engaging in any kind of genetic manipulation is gene enhancement. Thus, although there is a morally significant difference between gene therapy and gene enhancement, given that the alternative of preimplantation therapy has less risks than gene therapy, it may be that there is at present no moral justification for engaging in either of these practices.

NONHUMAN GENETIC THERAPY AND ENHANCEMENT. As previously noted, genetic engineering is practiced on plants and nonhuman animals, and indeed has a long history in the nondirect forms of selective breeding and hybridization. In these cases what is almost always of interest is not genetic therapy for the good of the organism but genetic enhancement for the good of human users. On the basis of all the arguments already given, there is no reason to make a general objection to the genetic enhancement of plants and nonhuman animals.

Reimbursements for Therapies and Enhancements

Discussions of the therapy/enhancement distinction are sometimes linked to the question of third-party reimbursement for the two kinds of interventions. It may be assumed that therapies should be reimbursed and enhancements should not (see Parens 1998 for a discussion of these arguments). While there may be a societal consensus that most therapies should be reimbursed and that most enhancements should not, this is a contingent and not an invariant relationship.

Suppose two new managed-care companies start up and offer somewhat different ranges of benefits. Company A pays not only for essentially all therapies but also for most borderline cases whose therapy/enhancement status is a matter of dispute, and even pays for a few enhancements that are clearly specified in the terms of the contract. Company B pays only for therapies and states ahead of time that they will not reimburse for borderline conditions (which they might list) and will not reimburse for any enhancements whatsoever. Company A's premiums are higher, while company B is offering a lower cost, less-inclusive policy. Neither company is acting unethically or in an unjust fashion.

If, however, the issue concerns medical plans that are financed by taxes, then there may be an argument that only therapies, and not enhancements, should be covered. Yet even in this case, there is no obvious way to determine which, if any, borderline cases should be covered. In democratic societies decisions about government-financed medical treatments should reflect the prevailing public consensus, as determined through democratic political processes.

BERNARD GERT
CHARLES M. CULVER

SEE ALSO *Bioethics; Human Cloning.*

BIBLIOGRAPHY

Brock, Dan W. (1998). "Enhancements of Human Function: Some Distinctions for Policymakers." In *Enhancing Human Traits*, ed. Erik Parens. Washington, DC: Georgetown University Press. Discusses circumstances in which it is ethically justified for a health insurance company not to reimburse the treatment of a disease and to reimburse the giving of some enhancements.

Daniels, Norman. (1994). "The Genome Project, Individual Differences, and Just Health Care." In *Justice and the Human Genome Project*, ed. Timothy F. Murphy and Marc A. Lappé. Berkeley and Los Angeles: University of California Press.

Gert, Bernard. (2000). "Thinking about Huxley's *Brave New World:* Was It Wrong to Create a Genetic Hierarchical Society? Is It Wrong to Prevent One?" In *Etica ricerca biologica* [The ethics of biological research], ed. Cosimo Marco Mazzoni. Florence, Italy: Leo S. Olschki. Reprinted in *Ethics and Law in Biological Research*, ed. Cosimo Marco Mazzoni. Boston: Kluwer Academic, 2002. Explores the issue of whether genetic enhancement should be allowed.

Gert, Bernard; Charles M. Culver; and K. Danner Clouser. (1997). *Bioethics: A Return to Fundamentals.* New York: Oxford University Press. Contains an extensive discussion of the criteria for a valid consent and the criteria for justified paternalistic interventions.

Gert, Bernard; Edward M. Berger; George F. Cahill Jr.; et al. (1996). *Morality and the New Genetics.* Boston: Jones and Bartlett. Contains a detailed discussion of the concept of a genetic malady.

Juengst, Eric T. (1998). "What Does Enhancement Mean?" In *Enhancing Human Traits*, ed. Erik Parens. Washington, DC: Georgetown University Press.

Parens, Erik. (1998). "Is Better Always Good? The Enhancement Project." In *Enhancing Human Traits*, ed. Erik Parens. Washington, DC: Georgetown University Press.

THOMAS AQUINAS

Thomas of Aquino (ca. 1225–1274), a philosopher and theologian, was born into an aristocratic family at Roccasecca, near Naples, Italy. He joined the Dominican order in 1245, taking a *licentia docendi* at Paris in 1256. He later taught at Paris, Rome, Orvieto, and Naples. Thomas died at the Cistercian abbey of Fossa Nuova on March 7 and was canonized in 1323 by Pope John XXII. The *Summa contra Gentiles* was completed about 1264. His longest and most influential work, the *Summa Theologiae*, was unfinished at the time of his death.

Ethics and Politics

Thomas was the foremost contributor to the thirteenth-century recovery of Aristotle. His achievement in ethics lies chiefly in the application of a Christianized version of Aristotle to politics and law. In most respects he departs from the Augustinian orientation of previous generations that found the present world sin-laden and disordered and its politics harsh and coercive.

Thomas accepted the rational, humane, ordered world depicted by Aristotle. There is no tension between the acquisition of present goods on earth and the achievement of eternal ones in heaven so long as the former are directed toward and subordinated to the

Thomas Aquinas, ?–1274. Aquinas was an Italian theologian and philosopher of the Dominican Order of the Catholic Church and is regarded as one of the greatest and most influential thinkers of the Church. He had an important influence on the intellectual awakening that occurred in western Europe during and after his lifetime. *(© The National Gallery, London/Corbis.)*

latter. Human beings have a final ethical end—eternal blessedness—that transcends all earthly ends, but earthly happiness is also possible and desirable. God has equipped human beings with the rational capacity to pursue earthly as well as heavenly goods, and although sin has impaired the will, it has not obliterated reason. Thomas believes, as Augustine (354–430) did not, that humans are capable, under proper governance, of cooperating with one another to achieve a common good.

For Thomas human beings are by nature political animals; government is not merely a consequence of sin. Even if the Fall of Adam had not occurred, no individual would be able to acquire all the necessities of life unaided; only cooperation can secure the benefits of divisions of labor. However, there are many ways to achieve human ends, and so a community must be guided toward the common good by just and wise rule. The best government is a "mixed" constitution of the kind that Aristotle called *politeia*. Kingship may be the most efficient form of rule, but it is also the most likely to deteriorate into tyranny. It therefore must be tempered by elements of democracy and aristocracy. A king should choose the best people as his counselors, and what he does should be ratified by the people. Thomas follows Aristotle in supposing that a government in which as many people as possible participate will be the most stable because it will commend itself to all sections of the community.

Law and Ethics

In the *Summa Theologiae* Thomas develops a typology of law as eternal, natural, human, and divine. This theory has a Platonic starting point insofar as law is defined as a rational pattern or form. In the political realm law thus serves as a "rule and measure" for citizens' conduct. When citizens obey the law, they "participate" in that order in the way a table "participates" in the rational pattern or form of a table.

Because God is the supreme governor of everything, the rational pattern or form of the universe that exists in God's mind is law in the most comprehensive sense: the law that makes the universe orderly and predictable. This rational pattern is what Thomas called eternal law, and to it everything in the universe is subject. The eternal law is similar in content to what science now calls the laws of nature.

Inasmuch as humankind is part of the eternal order there must be a portion of the eternal law that relates specifically to human conduct. This is the *lex naturalis*, the "law of [human] nature": an idea present in Aristotle to which Thomas gave extensive elaboration. In developing his natural law theory Thomas restored human reason to a central place in moral philosophy. For Thomas, as for Aristotle, human beings are preeminently reason-using creatures. The law or order to which people are subject by their nature is not a mere instinct to survive and breed. It is a moral law ordering people to do good and avoid evil, have families, live at peace with their neighbors, and pursue knowledge. It is natural in that humans are creatures to whom its prescriptions are rationally obvious. To all humans, pagans included, these precepts simply "stand to reason" by virtue of a faculty of moral insight or conscience that Thomas called *synderesis*.

However, humans act on the principles of natural law with the assistance of more particular and coercive provisions of what Thomas called human law. The natural law is too general to provide specific guidance. Part of this specific guidance can come from the moral virtues that equip people to achieve practical ends: prudence, justice, temperance, and fortitude. However, these personal guidelines are developed and reinforced by human or positive laws that that help cultivate such good habits. These particular, positive rules of behavior include civil and criminal laws of the state as formulated by practical reason, or what Aristotle called *phronesis,* in the light of the general principles of natural law and have a morally educative function. Human laws that are not based on natural law—laws that oppress people or fail to secure their good—have more the character of force than that of law. Obedience may be called for if disobedience would cause greater harm, but people are not obliged to obey unjust laws. Individuals may exercise independent moral judgment; they are not simply subjects but rational citizens.

The fourth kind of law—divine law—is part of the eternal law but, unlike human law, is not derived from rational reflection on more general principles and historical circumstances. It is a law of revelation, disclosed through Scripture and the Church and directed toward people's eternal end. Human law is concerned with external aspects of conduct, but salvation requires that people be inwardly virtuous as well as outwardly compliant. The divine law governs people's inner lives: It punishes people insofar as they are sinful rather than merely criminal.

Applying Thomism

The strongest implications of Thomas's thought for ethics, science, and technology are found in the doctrine of natural law and the underlying idea of human equality. For instance, Pope Leo XIII in his encyclical *Rerum Novarum* (1891) drew on law theory to criticize the conditions of labor under industrial capitalism. Insofar as it requires people to do good, avoid evil, pursue knowledge, and live at peace with their neighbors, the natural law suggests that governments should support scientific and technological research intended to have beneficial outcomes. By the same token, it supports the principle that governments should not sponsor such research when it involves the development of weapons of mass destruction or the exploitation of some human beings by others.

Natural law doctrine implies as well that governments should not harm, but seek to preserve, the physical environment of humankind: the natural world that God created and over which humans properly exercise dominion. In regard to biological and medical science, the idea of human nature as a repository of value implies a distinction between laudable biomedical research, which is a work of charity beneficial to the human race, and unacceptable research involving the manipulation or distortion of human nature. In this connection Thomas often is cited in support of the Catholic Church's prohibition of artificial (as distinct from natural) methods of contraception.

Finally, it may be noted that Thomas's insistence on citizen participation in government speaks against any suggestion that political decisions should be made by technocratic elites of scientists and engineers rather than by those who will be affected by those decisions. Thomas presided over a thorough revaluation of the capacity of human beings for autonomous moral action and hence for responsible political participation. In effect, he reinvented the Aristotelian ideal of citizenship after its long medieval eclipse, and that reinvention would apply today to scientific and technological decision making.

R. W. DYSON

SEE ALSO *Aristotle and Aristotelianism; Christian Perspectives; Just War; Natural Law; Virtue Ethics.*

BIBLIOGRAPHY

Chesterton, G. K. (1974). *Saint Thomas Aquinas: The Dumb Ox.* New York: Image. A popular and uncritical biography, but useful for purposes of orientation.

Dyson, R. W., ed. *Political Writings/Thomas Aquinas.* Cambridge, UK, and New York: Cambridge University Press. A comprehensive selection of passages in translation, with detailed notes and introduction.

Finnis, John. (1998). *Aquinas: Moral, Political and Legal Theory.* Oxford, UK: Oxford University Press. A comprehensive and recent scholarly treatment of Thomas's thought on ethics, politics and law.

McInerny, Ralph M. (1982). *Ethica Thomistica: The Moral Philosophy of Thomas Aquinas* Washington DC: Catholic University of America. A clear exposition and summary of Thomas's moral philosophy; still regarded as a standard textbook on the subject.

O'Connor, D. J. (1967). *Aquinas and Natural Law.* London: Macmillan.

THOMISM

Thomism is a philosophical system of thought based on the writings of Thomas Aquinas, from his death in 1274 to the present. As a philosophy Thomism may be viewed as a moderate realism developed within medieval and Renaissance scholasticism that has been in continuous dialogue with alternate systems of thought in the modern and contemporary periods. The focus here is on Thomism specifically as it relates to science, technology, and ethics in the present.

Notion and Relevance

Thomas of Aquino (1225–1274) was a Dominican who studied under Albert the Great (c. 1200–1280) in Paris and Cologne and then taught at the University of Paris and in various Italian cities. Thomas was a prolific writer, known in his own day as a commentator on Aristotle, who adapted his thought to explicating the Catholic faith. Thomas was himself competent in the science of nature in the Aristotelian sense, and owed much to Albert's knowledge of the biological and psychological sciences. The relevance of both Albert and Thomas to modern science and its problems has been explored extensively by three contemporary Dominicans, Benedict M. Ashley, William A. Wallace, and James A. Weisheipl (1923–1984).

Modern science differs from *scientia* as understood in the Thomistic tradition, where it is defined as true and certain knowledge acquired by demonstration through prior knowledge of principles and causes. Modern science makes a lesser epistemic claim, only to knowledge acquired by hypothetico-deductive reasoning yielding conclusions with a high degree of probability but that fall short of certitude. Mathematical logic is instrumental for science, but science itself remains fallible and revisable. For Thomists this is too pessimistic. They would say that philosophers of science should rediscover the epistemology of Aristotle's *Posterior Analytics*, and rather than basing their reasoning on logic alone, could also focus on concepts provided by the philosophy of nature developed within the Aristotelian tradition (Wallace 1996).

For Thomism's relevance to technology a balanced view is that of a former Dominican and Wallace student, Paul T. Durbin. Durbin insists, first, that technology in the present day is essentially related to science, and second, that an identifiable social group is the carrier of technology. Thus the term *technology* can be taken to cover this scientific and technical community, including its inner structure and functions, its products, its particular values, and its implicit view of human nature. The term *philosophy of technology* then means a set of generalizations or a systematic treatment, in philosophical language, of one or another or all of the above social phenomena.

With regard to ethics, of the three terms—*science*, *technology*, and *ethics*—the last has the most explicit and enduring relationship to Thomism. There ethics is seen as the philosophical study of voluntary human action, with the purpose of determining what types of activity are good, right, and to be done, or bad, wrong, and not to be done, so that human individuals might live well. As a philosophical study, ethics treats information derived from a person's natural experience of the problems of human living. The term ethics is etymologically connected with the Greek *ethos*, meaning customs or behavior, and is the same as moral philosophy, similarly connected with the Latin *mores*, also meaning customs or behavior. It is a practical science in the sense that its objective is not simply to know, but to know which actions should be done and which should be avoided, so as properly to translate knowledge into action. Thus understood, only one thesis on ethics is listed among various theses seen as essential to Thomism. This states that humans have by nature the right to cooperate with others in society in the pursuit of personal happiness in the common good, and that this pursuit of happiness is guided by conscience, laws both natural and positive, and virtues both private and public. Briefly, Thomistic ethics is a virtue ethics that infers from nature what humans ought to do or be to achieve their proper perfection.

Historical Overview

Albert and Thomas wrote in the medieval period of high scholasticism. Albert was the first to appreciate the importance of the newly imported Greek-Arabic learning for science and philosophy, and he set himself to making encyclopedic summaries for his students, which earned for him the title "the Great" in his own lifetime. He had many followers among German Dominicans, including Meister Eckehart (c. 1260–1327) and Theodoric of Freiberg (c. 1250–1310), the second of whom worked out the first correct theory of the rainbow. But Albert's work bore principal fruit in the monumental synthesis elaborated by his pupil Thomas. Called the "Angelic Doctor," Thomas brought natural philosophy and metaphysics into the heart of theology to develop the unique synthesis known as Thomism. Its major teachings are that first matter is pure potentiality and its first actuation is by substantial form; that the human rational soul is the unique substantial form of the human body, endowed with powers that are really distinct from it; that human knowledge originates with the senses but is capable of attaining universals; and that humans can reason to the existence of God and some of God's attributes from the visible things of the world.

In later scholasticism Thomism became the official doctrine of the Dominican Order, where it was championed by Harvey Nedellec (1250 or 60–1323), John of Naples (d. 1330), and Jean Capréolus (c. 1380–1444). The Renaissance was the period of great commentaries on Thomas known as "Second Thomism," when Dominicans exerted strong influence at Paris and Salamanca as well as northern Italy. The more famous of the figures of Second Thomism were Thomas de Vio Cajetan (1469–1534), who debated the German religious reformer Martin Luther on the Eucharist; Francisco de Vitoria (1486?–1546), who developed the theory of natural law during Spain's period of colonial expansion; and Vitoria's colleague Domingo de Soto (c. 1494–1560), whose work foreshadowed to a degree Galileo Galilei's law of falling bodies (Wallace 2004). The same period saw the foundation of the Jesuits, who were initially trained as Thomists but then developed their own versions of Thomism. Jesuits and Dominicans later entered into prolonged controversy over the efficacy of God's grace on human free will and God's foreknowledge of human free actions, and were convinced that many modern evils stem from false philosophy, to which Thomas's thought would supply a needed corrective.

Developmental Thomism

The period from the mid-sixteenth to the late nineteenth century saw little development within Thomism. The system itself had received strong endorsement by the Council of Trent (1545–1563), and, as what may be referred to as Scholastic Thomism, it was taught in Catholic seminaries as a philosophical preparation for the study of theology. It was often seen as the "perennial philosophy," an integrated system that gave enduring answers to central questions about reality and knowledge. And it was largely unaffected by the scientific revolution of the seventeenth century, which was mainly concerned with physical sciences that seemed to have little relevance to Catholic teaching.

This situation changed dramatically after the issuance in 1879 of the encyclical *Aeterni Patris* of Pope Leo XIII (1810–1903), which gave rise to a movement known variously as neo-scholasticism or neo-Thomism (or, among Dominicans, "Third Thomism.") The stimulus came from the labors of medieval historians such as Maurice De Wulf (1867–1947) and Martin Grabmann (1875–1949), who had recovered works of medieval thinkers and focused attention on Thomas's thought as containing answers to pressing contemporary problems. With Pope Leo's endorsement, Thomism underwent extensive development in the twentieth century and came in dialogue with other philosophical movements. Arguably it is the most extensively developed systematic philosophy in the present day.

In this expanded sense, the term *Thomism* has itself undergone a change of meaning. An "ism" need not refer exclusively to an original system of thought. It might also refer to a system of thought that has taken on new meaning in light of developments that were unforeseen and unknown by its originator. In this alternate sense René Descartes could not be a Cartesian nor could Immanuel Kant be a Kantian. This sense would apply to those who came after them and assimilated new knowledge into their syntheses in ways consistent with the principles they had established, while rejecting matter that had been superseded in the interim. This is obviously a more speculative enterprise, but it is in this sense that one might speak of one or more developmental Thomisms.

Types of Thomism

The development of overriding importance is the growth of modern science in its classical and contemporary senses and how this affects Thomism as a whole. Allied to this are three subsidiary developments that may be characterized as different types of Thomism. Of these, two have already achieved the status of movements, namely, Existential Thomism, which arose from confrontation with existentialist thought, and Transcendental Thomism, which arose from the confrontation with Kantianism and other forms of idealism seen in the works of Continental philosophers. A third, resulting from the confrontation with Anglo-American philosophy, may be described as Analytical Thomism, though it is not yet regarded as a movement.

EXISTENTIAL THOMISM. The two philosophers most identified with this movement were the Frenchmen Jacques Maritain (1882–1973) and Étienne Gilson (1884–1978), both former students of Henri Bergson (1859–1941). Maritain became interested in the thought of Thomas after being converted to Catholicism. His most lasting achievements have been in the area of epistemology, in elucidating the different degrees of knowledge and their interrelationships, so as to constitute an integral, Christian humanism. He also made substantial contributions to social and political philosophy and to constructive critiques of modern culture and art. In his theoretical philosophy he stressed the authentic existentialism of Thomas, maintaining the primacy of existence in a realist philosophy of being, and seeing this as also providing the basis for an understanding of knowledge and of love.

Gilson did his early work on Descartes, which led him to a study of medieval philosophy and of Thomism in particular. He saw the philosophy of the Middle Ages as a Christian philosophy, one that, while keeping the orders of faith and reason distinct, considers Christian revelation as an indispensable auxiliary to reason. In Thomas he found a metaphysics of existence that conceives God as the very act of being (*Ipsum Esse*) and creatures as beings centered on the act of existing (*esse*). His disciples regarded his existential metaphysics as a corrective to the essentialism that had insinuated itself in Renaissance and rationalist versions of Thomistic thought.

TRANSCENDENTAL THOMISM. The roots of this movement can be traced to Désiré Mercier (1851–1926) and Maurice Blondel (1861–1949), and to the efforts of two Jesuits, Jean-Pierre Rousselot (1846–1924) and Joseph Maréchal (1878–1944), to rehabilitate critical philosophy in light of the teachings of Thomas. Maréchal's thought passed through several phases, but in a later formulation he proposed the act of judgment as an affirmation of absolute reality that objectifies the form or concept and so grasps it as being. Then, beyond the concept, the intellect is made aware of a further intelligibility by its own tending, in a dynamism unleashed by the concept itself, toward something infinite and absolute—actually the infinite act of existing that is God. The intellect thus "constitutes" its object as belonging, in a finite and participatory way, to the realm of the real.

Maréchal's innovative views gained new insights from dialogues with phenomenology by two German Jesuits, Karl Rahner (1904–1984) and Emerich Coreth (b. 1919), and by analyses of modern science by a Canadian Jesuit, Bernard Lonergan (1904–1984). From these have emerged a new metaphysics in which the being investigated is that which occurs in consciousness. So Coreth writes of an immediate unity of being and knowing in the very act of knowing, and Lonergan looks upon being as whatever is to be known by intelligent grasp and reasonable affirmation, and so extrapolates from the being of consciousness to the being of the cosmos. For Rahner an analysis of the performance of the human spirit discloses an innate drive to being as absolute and really existing, which itself is human nature as "spirit in the world" or finite transcendence. They elaborate these insights in various ways through the use of what is called a transcendental method.

ANALYTICAL THOMISM. Like phenomenology, analytical philosophy is more a method or way of doing philosophy than it is a philosophy itself. Bertrand Russell (1872–1970) was one of its pioneers, and after him came the logical positivists, with their anti-metaphysical programs, and finally a more relaxed conception of linguistic analysis, culminating in the work of Ludwig Wittgenstein (1889–1951). One of Wittgenstein's students, Elizabeth Anscombe (1919–2001), along with her husband Peter Geach (b. 1916) were the first analysts to attend to Thomism in their writings. A related thinker is Alasdair MacIntyre (b. 1929), whose work in Aristotelian politics and virtue ethics brought him to the study of Thomas. Also noteworthy is the work of John N. Deely, a former Dominican and student of Weisheipl, who recovered the work on semiotics of the early-seventeenth-century Thomist John Poinsot, known in the Dominican Order as John of St. Thomas. By the early twenty-first century, the most distinctive contributor to the emerging movement is John J. Haldane, of the University of Aberdeen, who has published extensively in the philosophy of mind and the philosophy of God from a Thomist perspective.

Areas of Continuing Research

Thomists in the United States seem more inclined to pursue the analytical route than the other two movements, and have two main areas of research. The first focuses on an analysis and critique of scientific concepts with reference to the Aristotelian-Thomistic heritage, particularly the latter's use of first matter and transient entities to develop a view of creation and evolution that concords with recent theories of cosmogenesis (the origin of the cosmos). The second focuses on problems in bioethics, particularly through a recovery of Thomas's teaching on delayed hominization as this relates to the study of homogenesis.

On the theme of cosmogenesis, this line of research associates God's creative act at the beginning of time with the "big bang" theory of cosmic origins (Wallace 2002). Time began some 13 billion years ago by the production by God, ex nihilo (out of nothing), of the primordial mass-energy of which the universe is now composed. Along with the act of creation, God as prime mover also initiated the "big bang," releasing the enormous energy of the primitive mass for the formation of the natures now found in the universe. These are, in order, transient natures, inorganic natures, plant natures, animal natures, and human nature. They correspond to the stages of evolution commonly accepted among scientists: the period of fundamental particles impelled at high energy; that of element and compound formation; the two periods of biogenesis, wherein first plants and then animals were generated; and finally that of hominization, when *Homo sapiens* first appeared. All of these stages except the last were accomplished by a natural process Thomas referred to as "the eduction of [substantial] form from the potency of first matter" (*Summa Theologiae* I, q. 90, a. 2).

The final stage of cosmic evolution would then be hominization, the appearance of humans with a special type of substantial form, an immaterial (and immortal) soul. Here there is a break in the line of causality extending back to creation, because, according to Catholic teaching, such a soul cannot be educed from the potency of matter. Up to this point the entire process of evolution can bring organisms to a level just below that of thought and volition, but they cannot progress to the final stage. Here God's creative act is again required. This second input of divine causality is the production, ex nihilo, of the immaterial souls of the first humans, tailored to match the ultimate disposition of first matter, as this has been prepared, over billions of years, for their reception.

With regard to bioethics, an important advance has been in the recovery of Thomas's teaching that the beginning of human life is a gradual process: that the human soul is not infused into the incipient organism at fertilization but rather is prepared for by a succession of substantial forms that dispose first matter for the reception of an intellective soul (Wallace 1995). Less well known is his speculation that the reverse process may occur at the ending of human life, namely, that the human soul may depart from the body well before all signs of life have disappeared from it. Both views are opposed to the notion of immediate hominization, commonly taught in Catholic circles, namely, that human life begins at fertilization, when the rational soul is infused by God into the body, and terminates at death, when the same human soul departs from the body.

With regard to human generation, Thomas followed Aristotle in holding that the conception of a male child was not completed until the fortieth day after intercourse, whereas that of the female child was not completed until the ninetieth day. The details of Thomas's treatment, now referred to as delayed hominization, were worked out on the basis of Aristotle's teaching as developed by medieval commentators, particularly Avicenna (980–1037). Little empirical evidence was available to support the various steps of the argument. In the early twenty-first century, however, the human reproductive process is being studied intensively, and much evidence can be brought to bear on the problem of hominization.

Catholic theologians have advanced two lines of argument that generally favor Thomas's solution. The first, proposed by Norman M. Ford (1988), is based on the possibility of twinning in the formation of the fetus and is essentially an argument from individuation. This would propose that the definitive individuation of the human fetus does not occur until fourteen days after conception, and thus that the intellective soul, and so the human person, need not be present before that time. The second argument, advanced by Joseph F. Donceel (1970), is based on the organ systems required first for sensitive life and then for the exercise of reason, which would involve the senses, the nervous system, the brain, and especially the cortex. The time when such organ systems are present in the human fetus must be ascertained by embryology. This probably occurs somewhere between several weeks and the end of the third month after conception, and so it is possible, on this theory, that human animation does not occur before this time.

Both of these conclusions, if accepted, would have far-reaching implications for future work in human genetics. Because the Catholic Church has thus far not taken a definitive position on the precise time when the human soul is present in the developing organism, the question remains open to discussion.

WILLIAM A. WALLACE

SEE ALSO *Christian Perspectives; Thomas Aquinas; Virtue Ethics.*

BIBLIOGRAPHY

Ashley, Benedict M. (1985). *Theologies of the Body: Humanist and Christian.* St. Louis, MO: Pope John Center.

Deely, John N. (1990). *Basics of Semiotics.* Bloomington: Indiana University Press.

Donceel, Joseph F. (1970). "Immediate Animation and Delayed Hominization." *Theological Studies* 31(1): 76–105.

Durbin, Paul R. (1968). *Philosophy of Science: An Introduction.* New York: McGraw-Hill.

Durbin, Paul R. (1986). "Ferment in Philosophy of Science: A Review Discussion." *The Thomist* 50 (1986): 690–700.

Ford, Norman M. (1988). *When Did I Begin? Conception of the Human Individual in History, Philosophy, and Science.* Cambridge, UK: Cambridge University Press.

Furton, Edward J., and Louise A. Mitchell, eds. (2002). *What Is Man, O Lord? The Human Person in a Biotech Age.* Boston: National Catholic Bioethics Center.

John of St. Thomas. (1985). *Tractatus de Signis: The Semiotic of John Poinsot,* ed. John N. Deely. Berkeley and Los Angeles: University of California Press.

Kretzmann, Norman, and Eleonore Stump, eds. (1993). *The Cambridge Companion to Aquinas*. Cambridge, UK: Cambridge University Press.

Wallace, William A. (1989). "Nature and Human Nature as the Norm in Medical Ethics." In *Catholic Perspectives on Medical Morals*, eds. Edmund D. Pellegrino, John P. Langan, and John Collins Harvey. Dordrecht, Netherlands: Kluwer Academic.

Wallace, William A. (1995). "St. Thomas on the Beginning and Ending of Human Life." In *Sanctus Thomas de Aquino Doctor Hodiernae Humanitatis*. Studi Tomistici, 58. Libreria Editrice Vaticana: Pontificia Accademia di S. Tommaso, pp. 394–407.

Wallace, William A. (1996). *The Modeling of Nature: Philosophy of Science and Philosophy of Nature in Synthesis*. Washington, DC: Catholic University of America Press.

Wallace, William A. (2000). "Thomas Aquinas and Thomism." In *The History of Science and Religion in the Western Tradition: An Encyclopedia*, ed. Gary B. Ferngren. New York and London: Garland.

Wallace, William A. (2002). "*Fides et Ratio:* The Compatibility of Science and Religion." In *What Is Man, O Lord?* eds. Edward J. Furton and Louise A. Mitchell. Boston: National Catholic Bioethics Center.

Wallace, William A. (2004). *Domingo de Soto and the Early Galileo: Essays on Intellectual History*. Collected Studies Series, CS 783. Aldershot, UK: Ashgate Publishing Ltd.

Wallace, William A., and James A. Weisheipl. (1967). "Thomas Aquinas, St." In *New Catholic Encyclopedia,* Vol. 14.

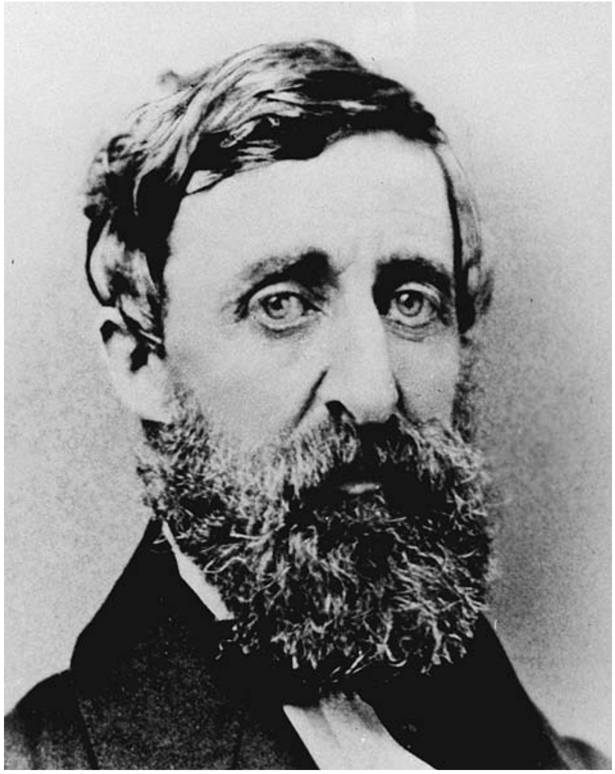
Weisheipl, James A. (1967). "Thomism." In *New Catholic Encyclopedia,* Vol. 14, continued in "Scholasticism, 3," 12: 1165–1170.

Weisheipl, James A. (1974). *Friar Thomas d'Aquino: His Life, Thought, and Work.* Garden City, NY: Doubleday.

Weisheipl, James A., ed. (1980). *Albertus Magnus and the Sciences: Commemorative Essays, 1980.* Toronto: Pontifical Institute of Mediaeval Studies.

THOREAU, HENRY DAVID

Henry David Thoreau (1817–1862) was born in Concord, Massachusetts, on July 12, and died there of tuberculosis on May 6, two months shy of his forty-fifth birthday. He is best known as the author of *Walden* (1854), an account of the two years (1845–1847) he spent living in a cabin he built on the shores of Walden Pond (outside Concord), and "Civil Disobedience" (originally delivered as a lecture entitled "The Rights and Duties of the Individual in Relation to Government"), a polemical political essay describing the events surrounding, reasons for, and consequences of his arrest for nonpayment of taxes.



Henry David Thoreau, 1817–1862. Thoreau was an American writer, a dissenter, and, after Emerson, the outstanding transcendentalist. He is best known for his classic book, *Walden*. *(The Library of Congress.)*

Thoreau is often portrayed as an anti-modern romantic, placing him in strong opposition to the modernizing forces of science and technology. There is good evidence for this portrait scattered throughout his work. He wrote as an advocate of nature, and frequently suggested that the artifacts of civilization violated the goods and principles found in nature. For example, in his first book, *A Week on the Concord and Merrimack Rivers* (1849), he claimed that he would prefer to destroy the dams on the rivers and free the fishes; in a late essay, "Walking" he famously declared that "in Wildness is the preservation of the World" (Thoreau 1893, p. 275). He wrote in *Walden* of the need for people to simplify their lives ("Simplicity, simplicity, simplicity!" [Thoreau 1985, p. 395]), and many have interpreted this as an injunction to turn away from the world of modern science and technology in order to restore a more independent, even primitive lifestyle.

Despite the occasional evidence in support of this understanding of Thoreau's teaching, however, there is good reason to believe it is not a true picture of either his life or his intentions as an author. Any reader of Thoreau's books, essays, or fourteen volume *Journal* will be struck by his preoccupation with observing the natural world. He was a skilled, committed, and lifelong naturalist, and he provided field reports and specimens to the foremost biologist in the United States at the time, Louis Agassiz of Harvard University. He was also something of an archaeologist, gathering one of the most extensive collections of American Indian artifacts of his generation. Equally important *Walden* can be read as a philosophical commentary on modern economics, suggesting Thoreau's interest in social science. Thoreau was skilled as a surveyor and a carpenter, and proved his genius as a technologist by developing a new formula and manufacturing process for the graphite in the pencils manufactured by his family's business, which made these the highest quality pencils produced in the United States at the time. Thoreau's biography and writings reveal a man with a much more sophisticated view and knowledge of modern science and technology than is often acknowledged. While it is true that Thoreau often juxtaposed modern science and technology with what he took to be the wisdom or laws of nature, this does not preclude his being a serious natural and social scientist.

In fact Thoreau's complaint was not with science or technology in themselves, both of which he admired (and tried successfully to practice) in their proper place, but with the uncritical exercise and use of both. Although he was a skilled naturalist and technologist, he was most importantly a literary artist and a moralist. The message of *Walden* is not that modern science and technology are bad, but rather that they are bad as human beings currently practice them. This complaint is inspired by a concern for liberty, and is built on the fear that people are using science and technology to build wealth even if it costs them their freedom. He complained that people "have become the tools of their tools" (Thoreau 1985, p. 352) and that they would be more likely to learn "beautiful housekeeping" and "beautiful living" (p. 353) if they were willing to cultivate a more thoughtful poverty and independence. Ultimately Thoreau was a critic not of science and technology, but of the modern political economy and the way it employed these tools. His fear was that people were becoming morally ignorant about the cultivation of a good human life even as they were becoming scientifically and technically proficient.

As a social critic Thoreau has inspired many in the modern environmental movement who share his fear that society uses science and technology to war against nature rather than to learn to live in peace and harmony with it. Thoreau continues to be one of the most powerful literary voices in America. He is a reminder of the need to continually probe the purposes and ends to which science and technology are employed.

BOB PEPPERMAN TAYLOR

SEE ALSO *Environmental Ethics; Environmentalism; Freedom; Nature; Science, Technology, and Literature.*

BIBLIOGRAPHY

Buell, Lawrence. (1995). *The Environmental Imagination: Thoreau, Nature Writing, and the Formation of American Culture.* Cambridge, MA: Harvard University Press.

Harding, Walter. (1966). *The Days of Henry Thoreau.* New York: Alfred A. Knopf.

Neufeldt, Leonard N. (1989). *The Economist: Henry Thoreau and Enterprise.* New York: Oxford University Press.

Richardson, Robert D. (1986). *Henry Thoreau: A Life of the Mind.* Berkeley and Los Angeles: University of California Press.

Taylor, Bob Pepperman. (1996). *America's Bachelor Uncle: Henry Thoreau and the American Polity.* Lawrence: University Press of Kansas.

Thoreau, Henry David. (1893). *Excursions.* Boston: Houghton Mifflin.

Thoreau, Henry David. (1985). *A Week on the Concord and Merrimack Rivers; Walden, or Life in the Woods; The Maine Woods; Cape Cod.* New York: Library of America.

THREE GORGES DAM

The Three Gorges Multipurpose Water Control Project on the Yangtze River in China is one of the largest engineering projects in history. When complete, it will rival the Great Wall in technical and cultural significance. Unlike the Great Wall, however, and in accord with contemporary notions of scientific and technological decision making, the Three Gorges Dam has been the subject of considerable ethical and environmental assessment.

Historical Background and Description

The Yangtze River originates at 6,000 meters (20,000 feet) in the mountains of Tibet and then flows for 6,300 kilometers (3,900 miles) east through central China, passing through Nanjing, the capital of Jiangsu Province, before emptying into the East China Sea, through the port of Shanghai. From Shanghai, for the first 2,500 kilometers up the lower river is generally broad, calm,

and navigable, serving as a major transportation artery as it flows through the traditional rice basket of China. At Yichang there is a series of three, sheer-cliffed gorges, Xiling, Wu, and Qutang, that stretch up river for another 1,000 meters.

The idea of building the dam was first proposed by Sun Yat-sen in 1919, but it was not until 1994, with the backing of Deng Xiaoping, that construction actually began.

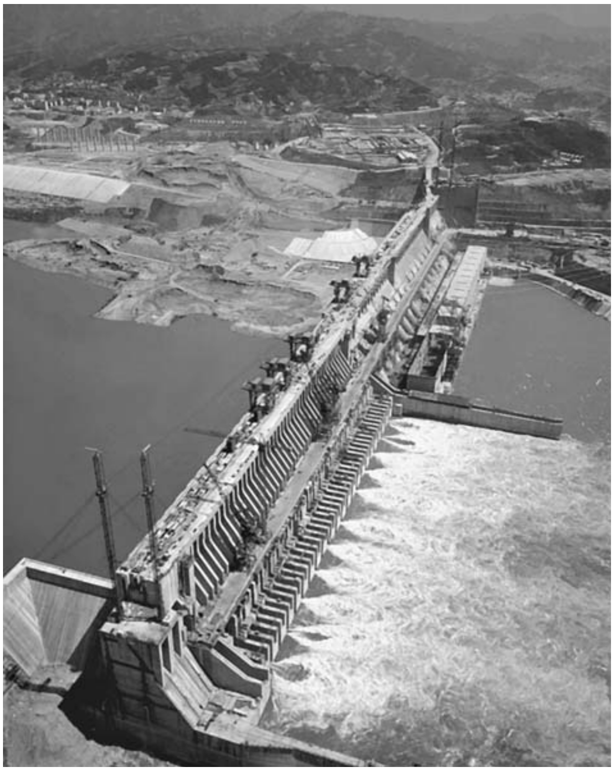
The project consists of three parts: the dam itself, hydroelectric stations located on each side of the dam, and navigation locks on the left side of the dam. When finished, the dam at the mouth of Xiling Gorge will be 185 meters high, 3,035 meters long at the top, and will create a reservoir that stretches 600 kilometers through each of the gorges in turn, with a surface area of 10,000 square meters and a volume of 39.3 billion cubic meters. It will provide flood control, generate electric power, and improve navigation.

Ethical Issues

The Three Gorges Dam project has been subject to three basic criticisms. It has been judged by the World Bank as economically unsound, by many environmentalists as ecologically destructive, and by some social scientists as socially and culturally disruptive. All of these issues have been discussed at length, and efforts have been made to address the objections.

Because of the negative judgment of the international financial community, China has raised the money for construction from its own resources. At the same time, it has tried to structure the project so that in the long term the investment will benefit Chinese economic development.

The Three Gorges Dam will indeed have significant ecological and social consequences. The ecological impact is justified not only by great social but also significant environmental benefit. When completed, for instance, the dam will provide for extensive flood con-



The Three Gorges Dam on the Yangtze River at Yichang, in China's Hubei Province. *(AP/Wide World Photos. Reproduced by permission.)*

trol on a river that has caused major disasters on an average of every ten years in the past. It will also produce 18.2 million kilowatts of electricity, the equivalent of ten standard coal-fired power plants that would together burn more than 50 million tons of coal each year, create 2 million tons of sulphuric oxide, 10,000 tons of carbon monoxide, and 370,000 tons of nitrous oxide, which would severely pollute the environment there. The dam will use an otherwise wasted, and sometimes destructive, energy source, water, to supply clean electricity for industrial and economic development.

But the Three Gorges project is also a means for scientific and technological collaboration at both the national and international levels, and thus an opportunity to exercise human self-realization or achievement by bringing science and technology together to cause a beneficial transformation of nature. The project is in fact utilizing and developing advanced construction techniques, and will install the highest quality power generation equipment available. On site concrete formulation takes place in Japanese machines, the hydroelectric generators come from Europe, and so on.

Finally the design of the Three Gorges Dam has been the subject of extensive ethical discussion and aims to contribute to the contemporary ideal of sustainable development. Where possible, biological preserves have been established to protect threatened species and to preserve water quality. Although more than 1 million people along the river are being relocated, they are being provided with new and better housing than they had in the past. Additionally efforts have been made to preserve materials of archeological value.

The Three Gorges Dam project is thus a major learning experience in China. It is teaching an important lesson in relating science, technology, and ethics.

FAN CHEN
YINGHUAN ZHAO

SEE ALSO *Dams; Ecology; Environmental Ethics; Pollution; Water.*

BIBLIOGRAPHY

"A Brief Introduction to the Three Gorges Dam Project," 2nd edition. *People's Daily*, November 5, 1997.

Chetham, Deirdre. (2002). *Before the Deluge: The Vanishing World of the Yangtze's Three Gorges*. New York: Palgrave Macmillan. A historical and personal story by a Chinese scholar with more than twenty years experience on the Yangtze.

Hersey, John. (1956). *A Single Pebble*. New York: Knopf. A fictional story about a civil engineer from the West who travels up the Yangtze in order to develop a Three Gorges Dam proposal, in the process discovering the rich historical traditions that any such project would disrupt.

Winchester, Simon. (1996). *The River at the Center of the World: A Journey Up the Yangtze and Back in Chinese Time*. New York: Henry Holt.

INTERNET RESOURCES

"The historical review of the Three Gorge Project". Available from http://www.people.com.cn.

"Will Rare Underwater Plants Become Extinct?" Available from http: //www. jxnews.com.cn.

Ziyun, Fang, and Yongbai Chen. "The Practice and Research of Environmental Protections of the Three Gorge Project." Available from htpp://www.emcp.acca21.org.cn.

THREE-MILE ISLAND

On March 28, 1979, a series of events took place at the nuclear reactor at Three Mile Island, Unit 2 (TMI-2), near Harrisburg, Pennsylvania, that resulted in an accident in which a significant fraction of the nuclear reactor core melted and a small amount of radioactivity was released to the environment. After more than twenty years of government-stimulated development of the nuclear power industry and in the context of increasing public objections, that accident became the focus for an intensely polarized debate about the wisdom of further construction of nuclear reactors. The accident at the Three Mile Island nuclear power station has taken on a key historical role in discussions concerning science, technology, and ethics.

Reactor Design

Understanding the accident requires a general understanding of the way the TMI-2 reactor worked. TMI-2 was a pressurized water reactor. A simple diagram of the system is shown in Figure 1.

The fission process—splitting the atom, with the release of energy—occurs in the reactor core. This generates heat, and so the core is cooled with water under high pressure, which is needed to prevent the water from boiling. The reactor is contained in a thick (ten inches) steel-walled reactor vessel. Two loops circulate the water. The primary loop carries the pressurized water through the reactor, where it is heated, to a device called a steam generator. In the steam generator heat is transferred from the primary loop to water in a secondary loop, which is not under pressure, and thus is converted to steam. Water in the primary loop does not mix with water in the secondary loop. Radioactivity in the primary loop never mixes with water in the secondary loop. The cooled water in the primary loop then is pumped back to the reactor for reheating. The steam produced in the secondary loop is piped to a turbine, where it hits turbine blades and causes them to spin. The turbine is connected to a generator that produces electricity. The steam then condenses below the turbine and is pumped back to the steam generator for its own reheating.

The primary loop is contained inside a steel-lined, steel-reinforced concrete building in which the walls are three to five feet thick. This containment building, as shown in Figure 1, is designed to prevent or at least minimize radiation leakage to the environment in case of a serious accident. It is a requirement in the United States that all commercial reactors be built inside a containment building. This is part of the "defense-in-depth" philosophy that has been required from the beginning in the design of commercial nuclear power plants in the United States.

The Accident

The accident began at 4:00 A.M., when maintenance activities caused secondary loop pumps to shut down, leading to a buildup of heat in the primary loop. The reactor shut down automatically, but the pressure in the primary loop increased significantly. As is shown in Figure 1, a pressurizer outside the reactor vessel monitors the primary loop. If the pressure gets too high, a valve opens and radioactive water escapes to the drain tank below the reactor.

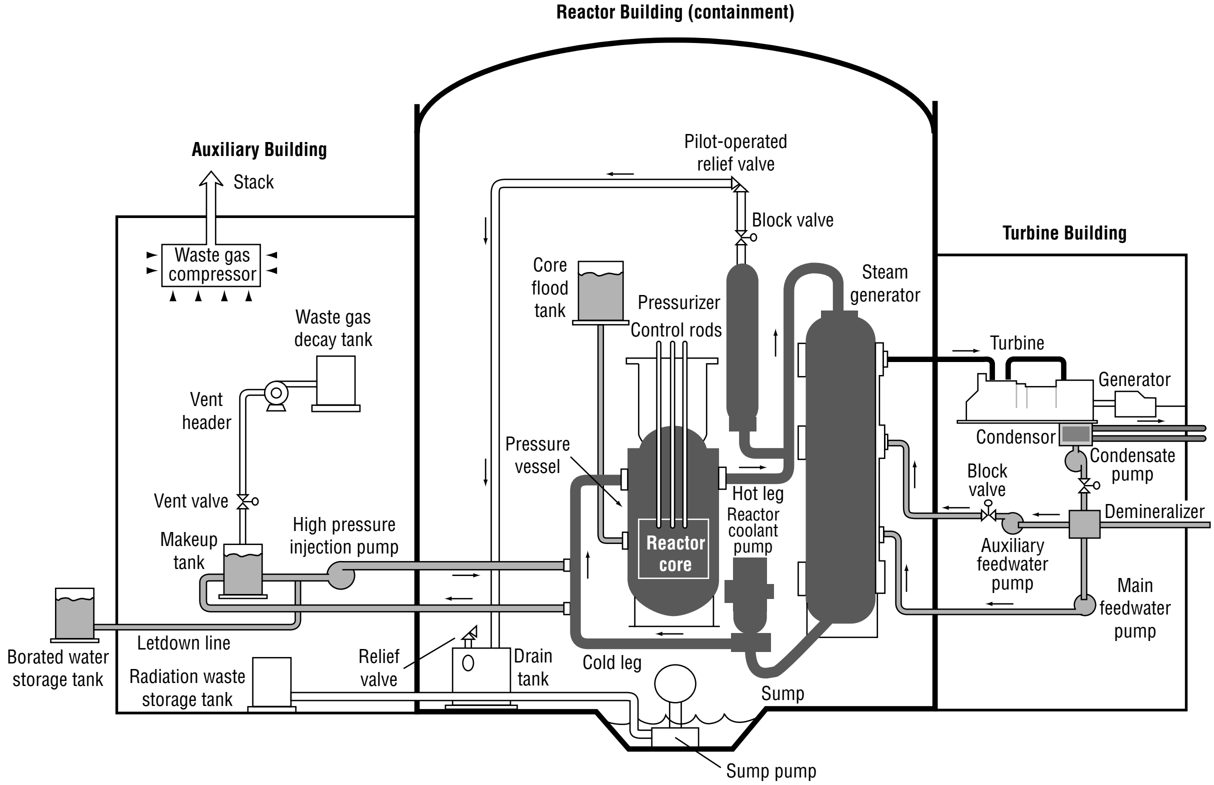
This is what happened at TMI-2. When the pressure returned to normal, the operator sent an electrical signal to the motor that closes the valve. An indicator light showed this action was taken, causing the operator to believe the valve had closed. Unfortunately the indicator did not show the actual valve position, which was partially stuck open. One of the changes resulting from the accident is an indicator that actually shows closure of the valves. Another sensor in the control room showed high pressure in the reactor drain tank, which indicated a leak, but this indicator was located behind a seven-foot-high instrument panel.

Alarms and warning lights began to go off in the control room, indicating problems in different systems. This confused the operators and made it difficult to diagnose the problem and choose the appropriate corrective action. Water continued to leak through the open valve from the primary loop to the basement, where it overflowed from the reactor drain tank onto the basement floor. It then was pumped to tanks in the adjacent auxiliary building. When those tanks overflowed, radioactive water spilled onto the floor of the auxiliary building, enabling the radioactive gas xenon, an inert gas that is not incorporated into the body tissue, to escape from the building through the ventilation system. This resulted in a low-level exposure to residents in surrounding communities.

Even when a reactor is shut down, residual radioactive fission products in the reactor core continue to produce heat that must be removed. An emergency cooling system turned on automatically and started pumping water into the primary loop. The operators, however, thinking that the valve on the pressurizer was closed and noting that the water level indicator in the pressurizer showed that the pressurizer was full, throttled back and then shut down the emergency cooling system because they feared that the primary loop would overfill with water and cause a dangerous overpressure in the loop.

FIGURE 1

Schematic Diagram of TMI-2



SOURCE: Adapted from *IEEE Spectrum* 16 (November 1979): 43–45. In Walker (2004), p. 72.

Schematic diagram of TMI-2. (© *IEEE 2004.*)

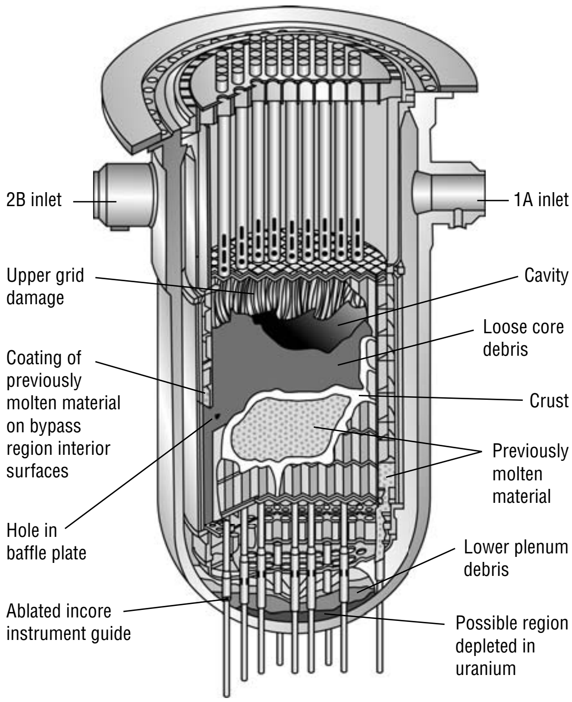
Actually, the pressure was dropping in the primary loop because of the open valve, and boiling of the remaining water began to occur. The large pumps for the primary cooling water began to vibrate heavily because they were filling with steam from the boiling water. Those pumps were shut down to prevent them from being damaged. Although the primary loop water was boiling off, with the steam going through the open valve, serious damage to the core still would have been avoided if the emergency core cooling system had continued operating.

After about 100 minutes enough water had leaked from the core through the open pressurizer valve that the top of the core was no longer covered with cooling water. The temperature in the uncovered parts of the core began to rise. The fuel is contained in tubes called cladding made of a zirconium alloy, and the uncovered tubes began to react with the steam, releasing hydrogen. Some of that hydrogen escaped into the containment building and later underwent a rapid burn (mild explosion) that caused some equipment damage. Some of the hydrogen accumulated in the top of the vessel that held the reactor and inhibited reactor cooling for several days. It also led to concern by some Nuclear Regulatory Commission (NRC) staff members that the hydrogen might explode. (It turned out that this was not possible because of an oxygen shortage in the system.) Because of uncertainty about the condition of the reactor two days after the accident began Pennsylvania Governor Richard Thornburgh advised pregnant women and preschool-age children within a five-mile radius of the plant to evacuate.

After 142 minutes the cause of the leak was determined, and a backup valve for the pressurizer was closed, stopping the loss of water. However, by that time about one-third of the primary loop water had escaped. Because of concern that introducing cold water into the intensely heated core would cause the fuel elements to fracture, the emergency core cooling system was not restarted until four and a half hours after the accident began.

FIGURE 2

Three Mile Island-2 Core End-State Configuration



SOURCE: Osif, Barrata, and Conkling (2004), plate 27.

Condition of the reactor core after the accident. (*Courtesy of the Pennsylvania State University Engineering Library*.)

As the core overheated and the cladding underwent chemical reactions as well as melting, the core structure began to lose strength and the top of the fuel elements collapsed into a pile, some of which heated to the melting temperature of the fuel, creating a large molten mass in the center. Some of that molten fuel eventually spilled over the side of the core and accumulated below the core. Altogether approximately 50 percent of the core melted. Fortunately, there was sufficient cooling water to prevent the molten fuel from rupturing the reactor vessel. Except for the radioactivity in the cooling water that leaked into the drain tank and then was pumped into the auxiliary building, from which there were small gaseous releases to the environment, almost all the radioactivity was contained within the containment building. The final state of the core at the end of the accident is shown in Figure 2.

Health Effects

The Nuclear Regulatory Commission, the Environmental Protection Agency (EPA), the Department of Health, Education and Welfare, the Department of Energy, and the state of Pennsylvania conducted studies on the health effects of the accident. All those studies concluded that the dose any member of the public received was far less than the natural background radiation. There was no increase in cancer in the surrounding communities.

Some nongovernmental groups and university researchers rejected those reports. Although the accident led to no generally accepted radiation injuries to the public or to workers, it did cause an emotional trauma to the local citizens and indeed to the nation. Without question it led to a loss of public confidence in nuclear power.

Lessons and Changes

Analysis of the accident revealed several significant operations problems in the industry as well as oversight problems at the NRC. Of particular importance was the finding that operator error had resulted from a lack of understanding of how the system behaved, a lack of information at the control panel to help operators make a correct diagnosis, and a control panel design that promoted confusion rather than understanding. Other issues in the accident included poor communication between the reactor site and NRC headquarters, ineffective communication with the public and the press, and an inadequate communication system for the NRC and industry to inform operators of safety problems identified at other plants. For example, the operators did not know that a similar stuck valve incident had occurred at another reactor eighteen months earlier.

In response the industry created an operations oversight organization called the Institute for Nuclear Power Operations (INPO). Among its activities are plant visits by expert teams on a regular basis (twelve to eighteen months), assistance to plant operators to improve their skills, and the creation of the National Academy for Nuclear Training, which accredits nuclear training programs in maintenance and operations to assure high standards. Simulators that replicate the behavior of the plant now exist at each site and are used to train operators on normal operations and accident scenarios. A key goal of INPO is the promotion of a culture at nuclear power plants that emphasizes "safety first" as the basis of decision making.

Finally, the NRC and industry used information from the accident to develop computer models that describe the progression of serious accidents. There are now emergency centers that conduct regular emergency exercises, including the use of local community response teams of emergency workers and fire fighters. All these efforts have transformed the U.S. nuclear industry and its regulation and have resulted in remarkable improvements in safe operations as well as economic performance, both of which were needed.

In the United States the nuclear power industry had developed rapidly in the 1960s and 1970s, with different companies involved and with diverse designs and changes in design with each new reactor. The power output of the reactors increased quickly from the early small reactors, with the belief that there would be an "economy of scale" with larger units. The regulatory process developed in parallel with industry growth, and changes in regulations were made as experience was gained and plants got larger. As a result each reactor was unique, and it was difficult to maximize learning in construction, operation, and maintenance. This contrasts with both the French and the Japanese nuclear power industries, which were initiated later and chose one or a small number of designs for their reactors, which contributed to facilitated learning in building and operations.

Accident Cleanup

Cleanup of the accident included the processing and storing of radioactive contaminated water in the auxiliary and reactor buildings and removal of contaminated building materials and the reactor core to a safe storage site at the Idaho National Engineering Laboratory (INEL). This was a lengthy, expensive, and contentious process. Numerous technical challenges, many of them first of a kind, had to be overcome. Those challenges included (1) building and operating systems to treat the radioactive water; (2) inspecting damage to the core, which revealed a collapse of the top five feet of the reactor material into a rubble bed, with a five-foot-thick section of solidified melted fuel below; (3) development and use of tools to break up the solidified section of the core so that it could be loaded into casks and shipped to INEL; (4) solving a biological growth problem that caused clouding of the water; and (5) the development and use of robotic equipment to decontaminate the reactor building basement. In addition to finding solutions to the technical problems, NRC approval was needed for each step in the cleanup. This often resulted in delays, partly because the NRC frequently sought general public input and acceptance.

Some of the contentious issues that arose delayed the cleanup. One was the venting of radioactive gas from the containment building to allow worker entry and building cleanup to begin. Two raucous public meetings were held before NRC approval of the plan. The public was angry, fearful, and mistrusting, and assurances that radiation exposure to the public would be negligible fell on deaf ears. The venting took place from June 28 to July 11, 1980, and was monitored by the NRC, the EPA, a state agency, the utility company, and a citizen's group. Radiation exposure was determined to be negligible.

Another issue was more technical and involved the use of a crane above the reactor vessel to remove the vessel head to allow access to the fuel. The conditions inside the containment were junglelike, including high humidity and even rain. Extensive maintenance was performed on the crane to ready it for use, but one engineer, Richard Parks, wanted to do a full load test before attempting to lift the multiton vessel head. When management decided against this, Parks went directly to the NRC with his concern and was fired for whistle-blowing by the general contractor, Bechtel. The NRC sided with his concern, and testing was performed before the head was lifted.

Additional public concerns arose about shipping canisters of highly radioactive waste off-site to INEL and about the disposal of the decontaminated water after the rest of the cleanup had been completed. The simplest and least expensive solution would have been to release the water gradually to the river. This would not have presented any hazard to the public, but there was strong citizen opposition to putting the water into the Susquehanna River. In the end the utility agreed to evaporate the water. That operation was completed in August 1993 after a two-and-a-half-year process.

It took approximately eleven years to complete the cleanup and place the building in a monitored shutdown state. The cost was approximately $1 billion. This does not include the cost of replacement electricity or the cost related to TMI-1 being shut down for six years before it was allowed to restart. The cost to the industry was also substantial because the NRC required numerous modifications to the safety systems of all pressurized water reactors as well as changes to operating procedures. Although those changes did enhance plant safety in most cases, making changes in response to a crisis is generally more expensive and undoubtedly drove up the cost of nuclear power generation in the 1980s.

Ethical and Policy Issues

Several ethical and policy issues have arisen regarding the safety of nuclear power plants and whether another accident might occur. The first issue is whether electric power generation companies might put economics before safety. Although the industry has found that the safest plants are also the most economical, decisions to keep a plant operating even though conservative safety considerations suggest it should be shut down occasionally still occur. One example was the Davis-Besse plant in Ohio in 2002, where evidence of continuous corrosion of the reactor vessel was not investigated thoroughly until the corrosion completely penetrated the head. Fortunately, the steel liner was able to hold the reactor pressure until the problem was discovered. The public will have to judge whether the safety record of the industry and the oversight of the NRC are sufficient to justify the continued operation of nuclear power plants.

Second, and perhaps more significant in the early twenty-first century, is whether, in light of potential terrorist attacks against nuclear power plants, the nation should continue to use nuclear power, which in 2000 supplied approximately 20 percent of the electricity consumed in the United States. Could a group of terrorists breach all safety systems and cause a significant radiation injury to the public? After the terrorist attacks of September 11, 2001, security has been enhanced at each nuclear site, including the hiring of additional guards. Also, studies have been made on the effect of an airplane crash into the containment building and other parts of the plant. These studies suggest that the use of standard evacuation procedures would be sufficient to prevent any serious injury to the public. Nonetheless, some public officials and critics of nuclear power lack confidence in the results and believe nuclear power plants should be eliminated.

There are, however, national security and environmental benefits of nuclear power that must be considered. Nuclear power does not require the use of imported fossil fuels such as oil or future imports of natural gas. Furthermore, there are no emissions of sulfur oxides, nitrous oxides, or carbon dioxide as there are with the burning of fossil fuels. Indeed, nuclear power is already the dominant method of avoiding carbon dioxide emissions in the nation. Any replacement of the 20 percent of electricity generated by nuclear power could increase the cost of electricity generation, reduce the reliability of the electrical grid system, and/or increase pollutants emitted to the environment. Nuclear power may be critically needed to reduce the potential consequences of global warming. Also, as the price of natural gas rises and as it is recognized that natural gas may be able to serve as a substitute for oil in transportation, nuclear power may be the most cost-effective means for producing electricity, especially for electrical generation that has a minimum of environmental consequences.

EDWARD H. KLEVANS
DARRYL L. FARBER

SEE ALSO *Chernobyl; Nuclear Ethics; Nuclear Regulatory Commission.*

BIBLIOGRAPHY

Knief, Ronald Allen. (1992). *Nuclear Engineering: Theory and Technology of Commercial Nuclear Power*, 2nd edition. Washington, DC: Hemisphere. A technical account of the accident contained in a text on commercial nuclear power. Has a good summary of the lessons learned.

Osif, Bonnie A.; Anthony J. Baratta; and Thomas W. Conkling. (2004). *TMI 25 Years Later*. University Park: Pennsylvania State University Press. Written for the general public; provides a good summary of how nuclear power plants work as well as a description of the accident, its causes, and responses to it.

President's Commission on the Accident at Three Mile Island. (1979). *The Need for Change, the Legacy of TMI: Report of the President's Commission on the Accident at Three Mile Island*. Washington, DC: Author. (Also available in paperback and hardcover from Pergamon, Elmsford, NY, 1979.) The first and most important analysis of the accident, with particular emphasis on the failures of the NRC, along with ample discussion of problems in the nuclear industry. The authors identified needed improvements and made numerous specific recommendations to improve the industry and its regulation.

Rees, Joseph V. (1994). *Hostages of Each Other: The Transformation of Nuclear Safety since Three Mile Island*. Chicago: University of Chicago Press. The history of the Institute for Nuclear Power Operations. The primary emphasis is on the industry's response to the TMI-2 accident.

Walker, J. Samuel. (2004). *Three Mile Island: A Nuclear Crisis in Historical Perspective*. Berkeley: University of California Press. A well-documented book that describes the accident in great detail, summarizing what happened each day from Wednesday, when the accident started, to the Monday after the accident, when the most intensive crisis phase was over. Effectively captures the human dynamics involving the NRC, the governor of Pennsylvania, and state offices. Also continues the story of the accident through the reviews that followed.

TILLICH, PAUL

Born in Starzeddel, Germany, on August 20, Paul Johannes Tillich (1886–1965) explored the theological

Paul Tillich, 1886–1965. The American Protestant theologian and philosopher ranks as one of the most important and influential theologians of the 20th century. He explored the meaning of Christian faith in relation to the questions raised by philosophical analysis of human existence. *(Harvard University News Office.)*

and philosophical depths of contemporary culture. His experiences as a German army field chaplain in World War I shook Tillich's confidence in Western civilization, leading him to question its cultural and religious assumptions. In a series of professorships culminating in an appointment at the University of Frankfurt he spelled out his "theology of culture," exploring the unconscious, self-evident faith implicit in ostensibly secular social thought and structures. After he was dismissed from his professorship on April 13, 1933, by the Nazi government, on November 3 of that year Tillich arrived in the United States, where he held positions at Union Theological Seminary, Harvard University, and the University of Chicago. He died on October 22 in Chicago.

Tillich understood technology as an adjusting of means to an end. That process is present in animal behavior such as the building of a nest, but human technology transcends organic processes by making tools for unlimited use. Tillich called the technical forms closest to natural processes "unfolding" technologies, for example, cattle breeding; those technical forms conserve and develop the potentialities implicit in natural forms. "Realizing" technologies such as musical instruments represent the direct expression of spirit in symbolic productions. "Transforming" technologies, exemplified by machines, destroy living connections by imposing purposes that are not implicit in natural forms.

Tillich defined science (*Wissenschaft*) as any methodologically disciplined cognitive approach to reality. In the subject-object structure of knowing, science separates itself from its object. For Tillich modern science is also a form of controlling knowledge or technical rationality because of its intimate connection to technological application.

Science and technology are "ambiguous," Tillich argued, both creative *and* destructive. They provide liberation from superstition and debilitating work but are enslaving in other ways. This shadow side of science and technological development arises not from their essential structures but from their isolation from wider contexts of meaning and their domination (what Tillich calls imperialism) over other ways of knowing and acting. In this fallen state of autonomy they achieve a quasi-religious status as "scientism" and "technicism." Along with capitalism they form a trinity of social forces that determine the religious situation of modernity.

The fulfillment of scientific and technological possibilities cannot come from their subjection to political or religious authority, however. That would constitute the imposition of "heteronomy," or determination from outside. Science must be free to question every presupposition, Tillich argued, or it loses its character as science. The creative potential of science and technology must proceed though an autonomy aware of its own depth to become "theonomous," or transparent to the ground of being (God), and thus reunited with broader conceptions of the meaning of life.

Ambiguity as the mixture of creativity and destructivity pervades technological production as the tools that liberate humanity also subject humankind to the rules of the making of those tools. Ambiguity is manifest in humanity's limited ability to adapt itself to limitless technical productivity, including atomic weapons. It is revealed in the emptiness created by the production of gadgets, which represent means that become their own end. It is manifest in an objectification of both natural objects and persons that transforms both into things. Neither the external restrictions of heteronomy (including religious determination) nor the fallen autonomy of running ahead indefinitely in a meaningless world is adequate to overcome these ambiguities.

Scientism and technicism must be overcome by what Tillich calls *theonomy*. Theonomy does not prescribe particular technological objects but instead calls for the creation of technical *Gestalten* (wholes) that people can love for the form and meaning embodied in them. It does this through production that follows rather than precedes human needs and maintains the intrinsic power in things. It would not halt scientific inquiry into the nature of the atom, for example, but would ban the destructiveness of inventions such as the atomic bomb by limiting the desire to create such devastation. Theonomy demands that people be treated as a ends rather than means, overcoming technological structures of dehumanization. It resists the attempt to control knowledge or monopolize the cognitive function, influencing science indirectly by determining the attitude and style of scientific creations.

Science is ambiguous in that the observer remains estranged from objects, examining them for the sake of domination. It proceeds through observation and conclusion. However, the observed changes, in the process of being observed, result in the discovery not of the "real" but of an encountered reality. Science carries unexamined assumptions into arguments that may influence its discoveries, with every statement about an object adopting concepts that require further definition, ad infinitum.

Autonomous reason, without the depth of reason (the true-itself), is driven to solve its dilemmas by combating relativism with absolutism, formalism with emotionalism, and subjectivism with objectivism. In theonomy, however, reason is grounded in the depth of reason, leading toward a more inclusive pattern of participation and insight, delving not only into the nature but also into the ultimate meaning and existential significance of things. Science tends toward a nominalistic form of methodological reductionism that is manifest in empiricism and positivism. Cut off from the depth of reason, scientism creates its own quasi-religious myth of a meaningless universe that swallows everything, including scientific passion. Theonomy, however, rejects an "objective" approach that loses its objectivity by grasping only one element of an object and not the whole, reducing reality to its own terms.

Contemporary technological society is ambiguous, Tillich states, just like the technological era that brought it into being. The task of a theonomous technological society would be to move autonomy to its own depth, making things and structures transparent to the ground of their being, thus making them not only useful but significant components of a meaningful world.

Few modern theologians have attempted the broad and deep conversation Tillich carried on with political, social, economic, and cultural phenomena. His distinctively neoclassical style of thought, however, is more intelligible to those steeped in the European intellectual traditions than to those grounded in pragmatic American thought. The theologian and ethicist Reinhold Niebuhr (1892–1971), in contrast, is more accessible to readers in the United States. For those who can negotiate his prose, however, Tillich provides a systematic and comprehensive ethical, philosophical, and theological assessment of modernity, from art and architecture to space travel.

J. MARK THOMAS

SEE ALSO *Christian Perspectives*.

BIBLIOGRAPHY

Thomas, J. Mark. (1987). *Ethics and Technoculture*. Lanham, MD: University Press of America. This book reviews the evaluation of technological society in the thought of Talcott Parsons, Herbert Marcuse, Martin Heidegger, and Paul Tillich, arguing that the presuppositions of each thinker determine the terms of his social and ethical judgment.

Thomas, J. Mark. (1990). "Are Science and Technology Quasi-Religions?" In *Research in Philosophy and Technology*, vol. 10, ed. Frederick Ferré. Greenwich, CT: Jai Press. This essay uses thought within the "civil religion" debate and the work of Paul Tillich to analyze the proposition that science and technology constitute quasi-religions. It concludes that they are not quasi-religions but that scientism and technicism are.

Tillich, Paul. (1956). *The Religious Situation*. New York: Meridian. Originally written in 1926, this book explores the religious situation of modernity as it has been determined by the divine trinity of science, technology, and capitalism.

Tillich, Paul. (1963). *Systematic Theology*, vol. III. Chicago: University of Chicago Press. The third and final volume of Tillich's system explores the ways in which theonomy overcomes the ambiguities present in every dimension of finite life, including technological and scientific endeavors.

Tillich, Paul. (1988). *The Spiritual Situation in Our Technical Society*, ed. J. Mark Thomas. Macon, GA: Mercer University Press. This collection of essays brings together Tillich's writings on science and technology from his earliest German period (1927) until almost the end of his career (1963). It organizes those essays in five parts, describing the situation in technical society; the structure and meaning of science and technology; science, technology and human self-interpretation; dehumanization in technical society; and the symbols and ambiguities of a technical society.

TOCQUEVILLE, ALEXIS DE

Politician and author Alexis de Tocqueville (1805–1859), who was born in the village of Tocqueville in France on July 29 and died on April 16, is best known for his two politically minded books, *Democracy in America* (1835–1840) and *The Old Regime and the Revolution* (1856). Tocqueville was born into an aristocratic family and lived as an aristocrat. He had no children and no strong desire to perpetuate his family's noble name. His passion was to promote human liberty in democratic times, to keep alive what was best about the old aristocracies in societies devoted to the democratic understanding of justice. Tocqueville's political career was undistinguished, but he deserves to be remembered for his literary legacy.

Democracy in America, the outgrowth of an extended visit to the United States from May 1831 until February 1832, remains the best single book written on democracy and the best book written on America. It has in many ways become more true over time, as America has become more democratic. Tocqueville presents democracy not just as a form of government but as a way of life; the democratic ways of thinking, feeling, and acting, he correctly thought, had infused and would gradually continue to infuse themselves into every aspect of American and modern life.

Alexis de Tocqueville, 1805–1859. Tocqueville was a French political thinker and historian who championed liberty and democracy. *(The Library of Congress.)*

Tocqueville's explicit discussion of democratic science, technology, and ethics occurs in Part 1 of *Democracy* Volume 2, where his subject is the democratic mind. There he describes Americans as Cartesians without ever having read a word of Descartes. They are habitual skeptics; they view all claims of personal authority as nondemocratic claims to rule. Skeptical of the soul, Americans act feverishly on behalf of the body and its enjoyments. So they prize scientific knowledge far less for its own sake than for its applications or technological effects. The Americans dismiss the proud and pure desire to know characteristic of theoretical science as an aristocratic prejudice. Democratic peoples subordinate pleasures of the mind to those of the body.

Tocqueville himself embraces neither the aristocratic nor democratic views of science, but adopts the position of an umpire determining what is true and false about each partial or extreme view. The pride associated with the ruling class in an aristocracy leads scientific inquirers to confine themselves to the haughty and sterile pursuit of abstract truths. All scientific advances find their roots in such fundamental inquiry, but aristocrats inconsiderately or unethically neglect what applied science might do to improve ordinary human life.

Democrats, Tocqueville adds, are so selfishly enthralled with the benefits of technology that they neglect to provide for pure or theoretical inquiry. Democracies characteristically do not have a class that possesses the leisure required for the theoretical sciences; the mind needs relatively calm or unagitated social circumstances to achieve its possible perfection. The theoretical life is rarely possible for members of a merely middle class, for free beings who must work to earn a living.

For minds in democratic times, the most magnificent products of human intelligence are methods that quickly produce wealth and machines that reduce the need for human labor and the cost of production. Those who direct democratic nations, Tocqueville contends, must use their influence and power to go against the democratic grain by raising those minds on occasion "to the contemplation of first causes," to elevate them sometimes with the magnificence of the theoretical life. Their failure to do so might mean the near disappearance of scientific geniuses such as Blaise Pascal (1623–1662) and even the gradual decline of scientific progress itself. A nation with no theoretical passion at all might end up wallowing in the scientific stagnation characteristic of the China that Europeans discovered. The technical genius of America finally depends on the perpetuation of a way of life that disdains mere technology in the name of truth.

Tocqueville also worried about the effect of a democratic technological orientation on the souls of most human beings. He writes that if he had lived in an unjust, poor, and otherworldly aristocratic age, he would have attempted to turn people toward the study of physical science and the pursuit of material wellbeing. But in a democracy, people are readily pushed by social circumstances in that technological direction; there is no longer any need to promote applied science. Instead, the need is to raise souls in the direction of heaven, greatness, a love of the infinite, and the love of immaterial pleasures. The democratic danger is that "while man takes pleasure in [the] honest and legitimate search for well-being, he will finally lose the use of his most sublime faculties, and that by wishing to improve everything around him, he will finally degrade himself" (*Democracy in America,* Volume 2, Part 2, Chapter 14). So any comprehensive scientific claim for the truth of materialism—for the idea that there is no truth at all to claims for the soul's immortality—should be condemned by thoughtful human beings in democratic times as probably untrue and certainly pernicious.

Tocqueville was also a critic of the effect of applied science on language in democratic times. Language becomes progressively more vague and impersonal; human action is described using words more appropriate to mechanical motion. Precise personal distinctions and assertions become suspect, and metaphysics and theology slowly lose ground. Instead of saying, "I think," those who aim to influence democratic opinion say, "studies show." Having rejected personal authority, people in democratic times are far less skeptical concerning impersonal scientific claims about the various *forces* that shape their lives. Having freed themselves from aristocratic tyranny, people are seduced by the expertise of *schoolmasters* whose despotism is milder but exceedingly meddlesome. A democratic danger is the loss of any conception of free will or personal liberty; people will too easily be governed both by the claims of impersonal expertise and public opinion determined by no one in particular.

Tocqueville's significance is his account of all of modern life in terms of democracy. Many of his observations and fears anticipate, for instance, Martin Heidegger's account of all of modern life in terms of *technology*, and certainly modern democracy would be impossible without the liberation of technological progress for the most part from moral and political concerns. But Tocqueville emphatically refuses to equate technological progress with human progress. His judgments about democratic progress are friendlier to democracy and more judicious than Heidegger's. Democratic thought is partly true and partly not, and there is no reason to believe that people will not be able to correct some of its excesses in the directions of truth and liberty.

PETER AUGUSTINE LAWLER

SEE ALSO *Democracy; Freedom; Skepticism.*

BIBLIOGRAPHY

de Tocqueville, Alexis. (2000). *Democracy in America,* trans., ed., and introduced by Harvey C. Mansfield and Delba Winthrop. Chicago: University of Chicago Press.

Lamberti, John-Claude. (1999). *Tocqueville and the Two Democracies,* translated by Arthur Goldhammer. Cambridge, MA: Harvard University Press.

Lawler, Peter Augustine. (1993). *The Restless Mind: Alexis de Tocqueville on the Origin and Perpetuation of Human Liberty.* Lanham, MD: Rowman and Littlefield.

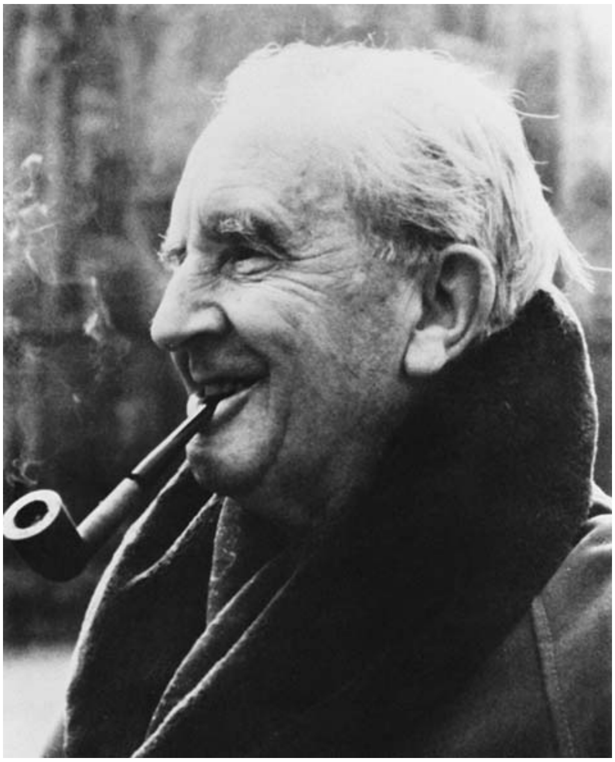
Manent, Pierre. (1996). *Tocqueville on the Nature of Democracy,* trans. John Waggoner. Lanham, MD: Rowman and Littlefield.

TOLKIEN, J. R. R.

Born in Bloemfontein, South Africa on January 3, fantasist, philologist, and critic John Ronald Reuel Tolkien (1892–1973) served in France during World War I and saw action at the Battle of the Somme. He completed his undergraduate studies at Exeter College, Oxford, in 1915, and from 1920 until 1924 was Reader and Professor of English Language at Leeds University. In 1925 Tolkien was elected Rawlinson and Bosworth Professor of Anglo-Saxon at Oxford University and Fellow of Pembroke College. In 1945 he was elected Merton Professor of English Language and Literature at Oxford. He published *The Lord of the Rings* in three volumes from 1954 to 1955 and retired from his professorship in 1959.

Man and Nature vs. Technology

In a 1951 letter to an editor, Tolkien commented that *The Lord of the Rings* and *The Silmarillion* (1977) were primarily concerned with "the Fall, Mortality, and the Machine." He explained that *the Machine* (or *magia,* magic) were plans or devices that dominated, either by



J. R. R. Tolkien, 1892–1973. Tolkien gained a reputation during the 1960s and 1970s as a cult figure among youths disillusioned with war and the technological age; his continuing popularity evidences his ability to evoke the oppressive realities of modern life while drawing audiences into a fantasy world. *(AP/Wide World Photos.)*

destroying the environment or by controlling the wills of people (Carpenter 2000, pp. 145, 146). His Middle-earth writings (*The Hobbit* [1937], *The Silmarillion*, *The Lord of the Rings*, the posthumously published *Unfinished Tales* [1980], and the twelve-volume *History of Middle Earth* [1982–1996]), can be understood as at least a partial response to a modern world that was embracing industry and technology. Tolkien believed the Machine (technology) was destroying his beautiful, rural, Edwardian countryside (represented in *The Hobbit* by the peaceful Shire) with wars, factories, cars, railroads, and pollution, and he saw no end in sight. He passed on his distaste for mechanization to his hobbits in the prologue of *The Lord of the Rings*: "They [hobbits] do not and did not understand or like machines more complicated than a forge-bellows, a water-mill, or a hand-loom . . ." (Tolkien 1994, p. 1). His two major villains in the story, Saruman and Sauron, are dependent on machines and use them to dominate and destroy the countryside. His descriptions of the realm of Mordor, with its desolate, scarred plains and history of being a stronghold of evil, were taken from his experiences on the battlefield.

Tolkien was not opposed to technology in itself, but he despaired of the motives behind it, which he saw as primarily concerned with speed, *immediacy*, and the desire for power and control. He compared the Machine with art, which created new worlds of the mind and imagination, and complained that labor-saving machines only added more and less effective work. He lamented that the *infernal combustion* engine had ever been invented, and expressed doubts that it could ever be put to rational use. He also disliked the fact that the Machine was increasingly associated with English daily life. He once owned a car, but found it difficult to drive in Oxford's traffic congestion, and commented that the *spirit of Isengard* (the evil Saruman's fortress) had led planners to destroy the city in order to accommodate more cars and traffic. Near the end of World War II he sarcastically suggested the war had been conducted by bureaucrats (*the big Folk*) who viewed most of it in *large motor-cars*.

Some critics suggested that *The Lord of the Rings* was an allegory and protest of atomic power and the dangers inherent in nuclear warfare. Tolkien emphatically denied this, saying that the story (which predated the nuclear age) was not about atomic power, but power exerted for domination. In his view nuclear physics could be used for domination, but it should not be used at all, and he further emphasized that the story was really about *Death and Immortality*. But he was stunned and outraged when he learned of the dropping of the atomic bomb on Hiroshima. He called the scientists who developed the bomb *lunatic physicists* and raged that it was idiocy to "consent to do such work for war-purposes, calmly plotting the destruction of the world!" (Carpenter 2000b, p. 116).

Tolkien's conservative Christian (Roman Catholic) beliefs contributed substantially to his attitudes about technology. In his seminal essay "On Fairy Stories" (1939, originally a lecture at the University of St. Andrews), he stated that human beings were *subcreators* who were created by God in his image to use their gifts wisely and in accordance with his wishes. The inclination of modern society toward domineering technology was, for Tolkien, a denial of God as creator. He called *The Lord of the Rings* a "fundamentally Christian and Catholic work" (Carpenter 2000b, p. 172), and his view of Christianity saw the universe as a place of conflict between good and evil.

Translation of *The Lord of the Rings* Into Film

In late 1957 Tolkien was approached by a group of American businessmen who gave him drawings and a story-line for a proposed animated film version of *The Lord of the Rings*. He wrote a member of the group a scathing letter of denunciation, explaining that the proposal and script, in whole and detail, was totally unacceptable, and that he did not want his story *garbled*. The early twenty-first century film versions of *The Lord of the Rings* have received generally favorable notices, particularly on the Internet and from young people. But several Tolkien scholars have written of their displeasure at the crass commercialization of the films, and the many liberties taken with characters and events. The films have been marketed by deploying the latest technology to sell to younger fans, and Tolkien's complex fantasy has been simplified into a visually stunning, character-driven action story with emphasis on spectacle rather than content.

Tolkien's son Christopher, the literary executor of his father's estate, did not disapprove of the film, but voiced doubts about the transformation of *The Lord of the Rings* into dramatic form. Tolkien, no doubt, would voice his displeasure over the films, and contend that technology has been used to reproduce and garble his narrative. He was resigned to the use of the Machine as a self-destructive tool of the modern world, which desired, in his view, to eliminate tradition and the past. He expressed his resignation in 1956, just a year or so after the publication of the final volume of *The Lord of the Rings*: "If there is any contemporary reference in my story at all it is to what seems to me the most widespread assumption of our time: that if a thing can be done, it must be done" (Carpenter 2000b, p. 246).

PERRY C. BRAMLETT

SEE ALSO *Anglo-Catholic Cultural Criticism; Christian Perspectives; Science Fiction; Science, Technology, and Literature.*

BIBLIOGRAPHY

Carpenter, Humphrey. (2000a). *J. R. R. Tolkien: A Biography*. Boston: Houghton Mifflin. The standard biography of Tolkien. The author was given unrestricted access to all Tolkien's papers and interviewed his friends and family.

Carpenter, Humphrey, ed. (2000b). *The Letters of J. R. R. Tolkien*. Boston: Houghton Mifflin.

Curry, Patrick. (1998). *Defending Middle-Earth—Tolkien: Myth & Modernity*. London: HarperCollins. Defends Tolkien's work from escapist and reactionary charges and maintains that *The Lord of the Rings* addresses the global realities and problems associated with the misuse of technology and destruction of the environment.

Purtill, Richard L. (1984). *J. R. R. Tolkien: Myth, Morality and Religion*. San Francisco: Harper & Row. Examines the religious and ethical ideas in Tolkien's work, with particularly trenchant chapters on the nature and role of myth and the art of storytelling.

Schick, Theodore. (2003). "The Cracks of Doom: The Threat of Emerging Technologies and Tolkien's Rings of Power." In *The Lord of the Rings and Philosophy*, ed. Gregory Bassham and Eric Bronson. Peru, IL: Open Court Publishing.

Tolkien, J. R. R. (1994). *The Lord of the Rings*. Boston: Houghton Mifflin.

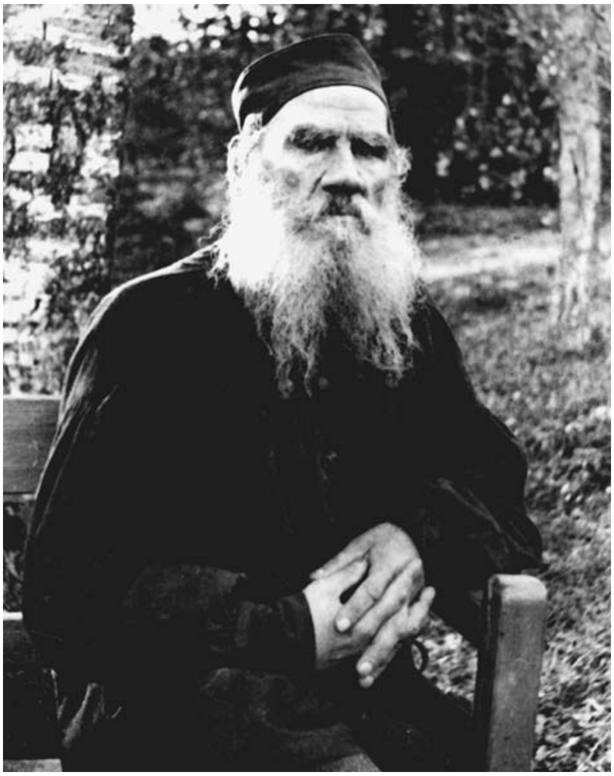
OTHER RESOURCES

J. R. R. T.—A Film Portrait of J. R. R. Tolkien. (1992). Produced by Helen Dickinson. Directed by Derek Bailey. 110 minutes. Visual Corporation Limited. Videocassette. This is a video, the first made on Tolkien, with valuable contributions from Tolkien himself, his son Christopher, and noted Tolkien scholar Tom Shippey.

TOLSTOY, LEO

Lev Nikolaevich (Leo) Tolstoy (1828–1910) was born at Yasnaya Polyana, the Tolstoy family estate a hundred miles south of Moscow on August 28. He died on November 20 at a nearby railroad station, having fled in the night from an increasingly contentious marriage and a set of familial relationships that had been hardened in large part by Tolstoy's attempts to apply his radical moral beliefs to his own life. In the intervening eighty-two years Tolstoy became perhaps the most prominent novelist in an age and place of great authors as well as a vociferous critic of science and modernization.

Tolstoy's international fame rests primarily on two novels, *War and Peace* (1865–1869) and *Anna Karenina* (1875–1877). His fictional works also include short masterpieces such as "The Death of Ivan Ilyich" (1886), "The Kreutzer Sonata" (1889), and "Master and Man" (1895). In addition he wrote autobiographical accounts of his childhood (*Childhood, Boyhood, Youth* [1852–1857]) and his experiences as a soldier in the Crimean War (*Sevastopol Sketches* [1855]). With regard to issues of science, technology, and ethics Tolstoy's most relevant writings include a variety of short, passionate nonfiction works, particularly "What I Believe" (1884), "What Then Must We Do?" (1887), "On the Significance of Science and Art" (1887), "What Is Art?" (1898), and "I Cannot Be Silent" (1908), all of which address a confluence of moral and intellectual errors he perceived in modern life and thought at the turn of the twentieth century.



Leo Tolstoy, 1828–1910. Tolstoy was a Russian novelist, reformer, and moral thinker, notable for his influence on Russian literature and politics. *(The Library of Congress.)*

Tolstoy directed his most trenchant criticisms at the insensitive intellectuality of the urban elites, which he considered distant from the natural values of the land and its laborers; the modern Western adherence to science and its methods; and thinkers such as Auguste Comte (1798–1857), Georg Hegel (1770–1831), and simplistic interpreters of the philosopher Immanuel Kant (1724–1804) who built positivist historical and scientific doctrines on what he considered rickety evidence.

Despite his turn toward the simplicity of peasant agricultural values and the teachings of the Gospels, Tolstoy's commitment to a questioning, empirical worldview was deep. Tolstoy was never interested in a vague and disconnected mysticism. Those who consider themselves capable of circumscribing the infinite multiplicity of the world with their "scientific" theories were deluding themselves, he argued. People are not incapable of knowing or perceiving many of the causes or influences on which the natural and human world has been founded; it is simply that there are far too many influences, causes, and effects for people to remember and record, and to be able to integrate the available material in a scientifically conclusive manner. Positivistic science rests on a lack of respect for the multiplicity of the natural and human worlds. Assuming too much about human capabilities to know and understand is, in the world of social action and belief, morally dangerous.

Like his contemporary Fyodor Dostoevsky (1821–1881), whom he never met, Tolstoy was broadly concerned with the spiritual future of the human race. He attempted to confront the gradual movement away from traditional values with an almost Aristotelian emphasis on the permanent relationships of things, promoting the universality of natural and religious values of love and labor to which he believed the human heart responds. Although the West now knows him as the writer of large and perhaps infrequently read novels, his influence on writers and political dissidents such as Mohandas Gandhi (1869–1948) and Alexander Solzhenitsyn (b. 1918) has been enormous, and his thought provides resources for ethical assessments of science and technology that have not yet been explored fully.

GLENN R. WILLIS

SEE ALSO *Russian Perspectives.*

BIBLIOGRAPHY

Bayley, John O. (1967). *Tolstoy and the Novel.* New York: Viking Penguin. Regarded by some as the finest, most incisive one-volume study of Tolstoy and his literary legacy.

Berlin, Isaiah. (1978). "The Hedgehog and the Fox" and "Tolstoy and the Enlightenment." In *Russian Thinkers.* New York: Penguin. Berlin's syntheses of historical and intellectual currents in nineteenth century Russia are accessible and brilliant. "The Hedgehog and the Fox" may be his most famous essay. Berlin's analyses of Tolstoy's influence on his own epoch, and the epoch's influence on Tolstoy, are unsurpassed.

Troyat, Henri. (2001). *Tolstoy,* trans. Nancy Amphoux. New York: Grove/Atlantic. Troyat's biography of Tolstoy is a new translation from the French. The dominant Tolstoy biography in Europe, it is an aspiring work of literature in itself.

Wilson, A. N. (2001). *Tolstoy: A Biography.* New York: Norton. Written by a prolific English literary biographer and novelist; more analytic in tone than Troyat's biography.

TOOLS AND MACHINES

Tools and machines are almost universally thought of as beneficial, which would make their invention morally praiseworthy. Indeed, without tools it is difficult to see how human beings could survive, and the increasing adoption of machines shows that most people see them as salutary contributions to human affairs. Although isolated tools or particular machines may on occasion be criticized for their negative impacts, this is done mostly to improve technological implements or to reform their uses. Nevertheless, one may note important distinctions between tools and machines as such, and how these distinctions, independent of any particular uses, may be ethically significant.

Distinctions

What is the difference between a tool and a machine? This question is complicated by lexicographic shifts over time. The Greek and Latin words for machine (*mechane* and *machina*) name a kind of tool (*organum* or *instrumentum*) for lifting heavy weights. Classical mechanics identified six basic types of such machines: the lever, wedge, wheel and axle, pulley, screw, and inclined plane. Machines, unlike other tools, presented a conundrum: How do they enable human users to lift weights that would otherwise be beyond their power to move?

Unlike with a stick used for poking or scratching, which serves as a straightforward extension of some human operation, determining how machines work is more difficult. Aristotle's *Mechanical Problems* was an early attempt to solve the mystery concerning how machines do what they do, that is, how they work or operate. What happens is that all six simple machines function as machines by transforming a smaller force exerted over a longer distance into a greater force exerted over a shorter distance by means of a structured redirection of the force in question.

But machines in this premodern sense are just one kind of tool. All tools, even simple machines, require two types of direct human inputs: energy and guidance. The hammer is swung with the arm and guided by hand–eye coordination. By contrast, machines in a modern sense require only one type of direct human input: guidance. The difference is that between a human-powered and -guided bicycle and a human-guided car; a person does not pedal a car, but simply drives it.

After human beings have constructed them or found natural objects with properties such that they can be used as tools, any use will involve some energy and guidance from a user. The guidance, precisely because it constitutes the introduction of intelligence, involves skill. In this sense the skillful use of tools is different from the more passive use of other artifacts such as baskets, chairs, and houses. The coordination of human power inputs, as when a group of men operates a battering ram, and the substitution of animal and other nonhuman sources of power such as wind for human power, foreshadow the development of machines in the modern sense.

The standard definition for the modern machine is: "a combination of resistant bodies so arranged that by their means the mechanical forces of nature can be compelled to do work accompanied by certain determinate motions." Alternatively, a machine is an "assemblage of resistant bodies, connected by movable joints, to form a closed kinematic chain with one link fixed and having the purpose of transforming motion." (Both definitions are from Franz Reuleaux, who in the late 1800s formulated the modern science of mechanics.) Mechanics, or the science of machines, analyzes the ways forces are compelled and transformed to do work in terms of their structures (statics) and functional operations (dynamics).

Functions and Uses

Tools and machines have internal operations or workings that can be used for many different purposes. These operations are commonly analyzed in modular terms: Gears slow down or speed up motion. A cam transforms reciprocal into rotary motion. Although how tools and machines operate or function does not fully determine their uses, they place boundary conditions on or for possible uses. Indeed, when an inventor applies for a patent on a new machine, the inventor is required to specify both its (external) use and how (internally) it is designed to operate or function so as to make possible the intended use. Engineering design thus considers both extrinsic use and internal structure and operation, and is successful when it unites the two.

But just as with the tool–machine distinction, so that between function and use is difficult to nail down. In many instances the word *function* can be replaced by the words *working*, *operation*, or even *use*. One must be careful in speaking about functions not to create an imaginary ontological substance that is nothing more than projected use. But to say that the machine operations or functions of pounding, drilling, or rotating are the uses of pounding, drilling, or rotating shifts attention from the structure of the machine and how it works to the intentions or purposes of the user.

For engineers who focus on machines, then, machines and their component parts are as often distinguished by operations or functions as by uses. Indeed, it is precisely in this sense that classical machines are distinguished from tools. The machine works to increase force across decreasing distance in ways that other tools do not. Moreover, the working or functioning of tools as tools depends on human energy and skillful guidance; modern machines work or function with only human guidance. Because of this, using machines requires less human work and, by placing greater and greater power in human hands, makes consciousness or forethought an ethical imperative. One does not have to be nearly as conscious about what is going on when riding a bicycle as when driving an automobile.

In general the experience of using machines is different from that of using tools in terms of the decline in human energy input and a corresponding increase in human mental input. This transformation of the use experience is of ethical significance and is independent of any particular use. It is true no matter what kind of machine one is operating and what one is producing with it or where one might be traveling in it. No matter what kind of machines are involved, machine users are morally obligated to think more than tool users about what is going on. To some extent this shift in the character of the use experience may also be described as setting the pattern for living in a machine-dominated technological world.

CARL MITCHAM
ROBERT MACKEY

SEE ALSO *Animal Tools.*

BIBLIOGRAPHY

Mitcham, Carl. (1994). *Thinking through Technology: The Path between Engineering and Philosophy*. Chicago: University of Chicago Press. See especially chapter 7, "Types of Technology as Object."

Reuleaux, Franz. (1876). *The Kinematics of Machinery: Outlines of a Theory of Machines*, trans. and ed. Alex B. W. Kennedy. London: Macmillan. Translation of *Theoretische Kinematik: Grundzüge einer Theorie des Maschinenwesens*, 1875.

TOTALITARIANISM

• • •

Totalitarianism is defined as a political system or regime in which the government seeks total control of society. This requires breaking down all the intermediate associations of civil society or turning them into agencies of the government, so that all that exists are, on the one hand, atomistic individuals and, on the other, the unity of the state.

Totalitarian systems have significant implications for science, technology, and ethics. Totalitarian governments rely on communications technology to spread an official ideology and to monitor subjects, while totalitarian control of the economy creates major hurdles to technological invention and innovation. Scientists face numerous ethical challenges in totalitarian systems, from ideological conditions often imposed on their research (a rejection of *Jewish science* in Germany and the promotion of Trofim Lysenko's genetics of the inheritance of acquired characteristics in the Soviet Union) to the kinds of projects on which they may be required to do research.

Features of Totalitarianism

The two classic scholarly examinations of totalitarianism are Hannah Arendt's *The Origins of Totalitarianism* (1951) and Carl Friedrich and Zbigniew Brzesinski's *Totalitarian Dictatorship and Autocracy* (1956). Friedrich and Brzesinski identify totalitarianism as a unique political order, opposed to democracy yet distinct from authoritarianism and dictatorship, and characterized by six key features. The first is an official ideology. In totalitarian systems, this ideology includes a blueprint for remaking society, either in ethnic or racial terms (as in the case of *fascism*) or in class terms (as in the case of communism) as well as justification for the monopoly of political power.

The second basic feature is a single mass political party, usually with a single leader, with a monopoly of political power. This group is part of the total penetration of society by the rulers. Other rival group identities in society—religious organizations, voluntary associations, other political parties—are either destroyed or brought under the control of the party.

The third characteristic is the existence of a secret police force and rule through the development of terror in the population. Because the leaders of the political system seek to penetrate and remake society, they are ruthless in dealing with political and cultural opponents. Any autonomous organization of activities is seen as a threat and all who are not active in their support of the ruling party are possible targets of harassment by the secret police. Even active, and loyal, party members are not immune, however. The purges of the Communist Party under Stalin, for example, were aimed at party members who were deemed not diligent enough in their identification and condemnation of potential threats to the system.

The fourth feature is its monopoly over the means of communication. Although it is impossible to control all forms of communication, totalitarian regimes seek to limit the autonomous flow of information. Control over information is a crucial component in solidifying the ideology in the minds of the population—facilitating the establishment of legitimacy for the leaders, justifying its monopoly of political power, and creating support for its social blueprint.

The fifth characteristic, highlighted by Friedrich and Brzezinski, is the monopoly over weapons in society. This is not a feature unique to totalitarian systems (many democracies control access to weapons by the general population). It is, however, a necessary feature of totalitarian control.

The final feature is a centrally controlled economy. Control over the economy serves three purposes. First it assures the social blueprint; economic development can be structured in the way most supportive of the plan for remaking society, and the workplace can be used as an arena for socializing the masses in support of the system. Second it assures access by the state to the resources it requires to maintain power at home and expand its influence abroad. Finally, and perhaps most important, a centrally planned economy makes people dependent on the state. Thus, while arguably economically inefficient, a planned economy is politically efficient.

Arendt proposed a similar description of totalitarianism, emphasizing its ability to *atomize* the population (controlling the ability of the population to engage in group activities autonomous from the party or the state) and its effective use of ideology. The development of a mass adherence to official ideology is essential for the formation of legitimacy in totalitarian systems. Control over communications—particularly the educational system and mass media—made the development of such adherence theoretically possible.

Totalitarianism in Practice

In practice totalitarianism has never achieved the complete penetration and control of society. Although people were careful in public, and often went through the motions of participating in state-sponsored mobilization efforts, they led separate public and private lives. Terror crept into the private lives of individuals—one had to be extremely leery of speaking ill of the government even among one's good friends—but people also partook in the activities of normal life: shopping, attending the ballet, walking in the park, and so on.

Because the ideal differed from the reality of totalitarian life, some political scientists and many social historians (see, for example, writings by Sheila Fitzpatrick and Stephen Cohen) criticized the totalitarian model for overemphasizing politics, underemphasizing the role of society, and assuming a system of tight, top down control devoid of political and social conflict. The totalitarian model of politics assumed that everyone was completely controlled and atomized, and that leaders never responded to society. But in the Soviet case, leaders sometimes appealed to constituencies, and policies were, at times, sparked by initiatives from below.

The three examples in the real world that came closest to approaching the totalitarian ideal have been Adolph Hitler's Nazi Germany (1933–1945), Joseph Stalin's Soviet Union (1929–1953), and, more recently, the Taliban-run system in Afghanistan. None of these, however, achieved full realization of the totalitarian ideal. These three cases provide helpful examples of three forms of totalitarianism: fascism, communism, and Islamism. Friedrich and Brzezinski argue that fascist and communist dictatorships were basically alike, though one can identify different points of emphasis between the two forms of government. Fascism is a form of totalitarianism that emphasizes racial and/or ethnic superiority, engages in militarism, and argues for the need for a dominant state to develop the capacity of the superior race and/or ethnic group. According to Barrington Moore (1966), fascism develops as the result of an alliance among the state, the land-owning elite, and the industrial bourgeoisie. Communism emphasizes the remaking of society to eliminate economic exploitation through state control of the means of production. Moore argues—ironically, given Karl Marx's prediction of workers' revolutions in the most economically developed countries—that communism developed where the lack of a middle class and the presence of a large and disgruntled peasantry allowed revolutionary leaders to seize control of the government in the name of destroying the old economic order. In both forms of totalitarianism in practice, increasing control over the economy and society were justified through the claim that one or more groups (for example, capitalists or Jews) were *enemies* of the people.

Islamism is a more recent variant of totalitarianism. Its ideology is anti-western, critical of modernization, and emphasizes the dominance of Islamic law—as interpreted by the leaders—over society.

Science, Technology, and Ethics

The totalitarian goal to penetrate and remake society completely has significant implications for science and technology. The control and monitoring that characterized totalitarianism shaped the practice of science dramatically. In the ideal totalitarian system, scientists are less free than in any other type of system to pursue their research as they see fit. Scientific research and related technological advances become the property of the party-state. This situation poses ethical dilemmas for scientists. On the one hand, the likelihood that the fruits of their labor could be used in unpleasant ways by the state creates a disincentive for scientists. On the other hand, working through the official scientific channels is the only way for such scientists to conduct their research. Thus, although in practice scientists in systems with totalitarian features conducted pioneering research, such scientists were limited both by the imperatives of the totalitarian ideology and by their personal ethical concerns about the consequences of their research.

Technology is a necessary tool in the transformation of tyranny into totalitarianism. Friedrich and Brzezinski emphasize technology in their discussion of totalitarianism, arguing that this type of political system could only have arisen in an era of modern technology. They highlighted the role of technology in allowing control over communications and making possible large scale economic planning, as well as in facilitating the monitoring of everyday life by the secret police. Totalitarian governments direct scientists to develop such technology.

Though technology is a necessary part of a modern totalitarian state, technology was not easily absorbed into the totalitarian system in practice. Not all technological products of scientific research found a receptive audience in the party-state bureaucracy. The economic planning approach that was a feature of the Soviet system, for example, made it difficult to incorporate technology. Many economic planners feared the introduction of new technology because of the uncertainty that accompanied the introduction. As a result, when there was a clear goal to increase production, and when this increase could be achieved through the addition of more inputs into the system (extensive growth), the totalitarian planning system worked fairly well. As the global economy moved in the direction of growth resulting from technology-driven improvements in efficiency (intensive growth), the Soviet planning system lagged behind.

Finally technologically-conditioned improvements in communication posed serious problems for totalitarian systems. While technology made monitoring of large numbers of citizens possible in the middle part of the twentieth century, the growth of fax machines, personal computers with printers, cellular telephones, and Internet connections by the early twenty-first century, provided citizens in dictatorial countries with access to information from outside the country and enabled them to compose and spread antigovernment messages quickly and relatively anonymously. Technology may allow Big Brother more ways to monitor citizens, but it also provides citizens more opportunities to engage in subversive activities.

LOWELL W. BARRINGTON

SEE ALSO *Arendt, Hannah; Authoritarianism; Conservatism; Fascism.*

BIBLIOGRAPHY

Arendt, Hannah. (1951). *The Origins of Totalitarianism*. New York: Harcourt, Brace.

Cohen, Stephen. (1985). *Rethinking the Soviet Experience: Politics and History since 1917*. New York: Oxford University Press.

Easton, David. (1965). *A Framework for Political Analysis*. Englewood Cliffs, NJ: Prentice-Hall.

Fitzpatrick, Sheila. (1986). "New Perspectives on Stalinism." *Russian Review* 45(October): 357–373.

Friedrich, Carl, and Zbigniew Brzezinski. (1956). *Totalitarian Dictatorship and Autocracy*. Cambridge, MA: Harvard University Press.

Moore, Barrington, Jr. (1966). *Social Origins of Dictatorship and Democracy: Lord and Peasant in the Making of the Modern World*. Boston: Beacon Press.

TOURISM

The ancient Greek philosophers thought that leisure was a necessary component of human flourishing even though freedom from the demands of necessity was possible only for a few people. Modern industrialized countries have achieved economies that for many of their members facilitate leisure, or, as Thorstein Veblen (1857–1929) suggested, the "non-productive consumption of time" (Veblen 1994 [1899], p. 43). In this context tourism is a form of unproductive consumption that is peculiar to the technologically advantaged. Tourism, however, also has become a major stimulus to economic production.

Purpose and Effects

Tourism is travel based on desires to relax, sightsee, appease curiosity, satisfy a sense of adventure or an adventurous self-image, compete with one's peers or colleagues, re-create images of paradise or luxury or the exotic, and escape. Tourism affects the economies and cultures of destination sites in both positive and negative ways. Those locales may organize their production activities around the satisfaction of tourists' demands for leisure, fantasy, adventure, or knowledge, activities that may operate to the detriment of local cultures.

As with any human relations involving production and consumption, even an activity centered on leisure, tourism thus calls for ethical and philosophical reflection. Only recently, however, has the phenomenon of tourism become a subject of ethical consideration, largely through its connection to other concerns, such as environmental degradation (to which "ecotourism" is one response), economic development, and cultural impacts.

Distinctions

The word *tourism* is derived from the Latin *tornus* and before that the Greek *tornos*, referring to a tool for making a circle (the word *turn* comes from the same root). Taking a tour thus implies circumnavigating, and the term *tourism* initially had depreciatory connotations of superficiality. In the early twenty-first century the connotations are more complex.

Tourism must be distinguished from other kinds of and motivations for travel. Economic and political migration, for example, is not new, but its increased extent is considered a significant element of globalization (Held, McGrew, Goldblatt, and Perraton, 1999). Contemporary economic migration includes the journeys made by migrant laborers and travel for business purposes in a postindustrial age of transnational corporations and labor markets, prompted also by international disparities in wealth and movement, especially between less developed countries and Organization for Economic Cooperation and Development (OECD) countries. Political migration includes refugees from crisis or conflict areas. Tourism, in contrast, has no material imperative, although one could argue that advertising and the media create a perceived necessity for tourism.

Flâneurism, a form of consumption activity that is much closer to tourism, is leisurely and detached urban promenading among the crowds, allowing spontaneous perceptual encounters to determine the directions of one's movements and thoughts. Although the expression came from the poet Charles Baudelaire (1821–1867), the philosopher Walter Benjamin (1892–1940) is perhaps the preeminent exponent of flâneurism through his writings on walking in Paris (Benjamin 1999). Voyeurism suggests a disengaged onlooker without a commitment to the local environment and thus overlaps with many common tourist practices. At its most benevolent voyeurism is the observation or immersion experience of other cultures in a way that allows one to extricate oneself when the experience becomes uncomfortable or problematic. The observation or experience, though perhaps immersive, allows a relatively easy exit from the situation, unlike the case for members of the local culture. There is a fine line between "authentic," engaged traveling and voyeurism.

Tourism is first and foremost an industry. It is one of the largest modern industries, accounting for hundreds of billions of dollars per year, and is the most significant industry for many countries. According to the World Tourism Association, which became an executing agency of the United Nations Development Programme in 1976, tourism grew from 456 million international travelers in 1990 to more than 700 million in 2002. Tourism appeared as both a word and a phenomenon in the early 1800s in association with increases in the means of transportation brought about by the construction of roads and highways, advances in carriage technology, and the building of the railroads. The current growth in tourism is due largely to the same processes and technologies that drive and constitute globalization and its consequences, including ease and frequency of transport and the growth of information and communications technologies. Economically advantaged people increasingly seek more far-flung and diverse destinations for vacation and pleasure.

The idealized motivation driving some forms of tourism is, as the Spanish-American philosopher George Santayana (1863–1952) suggested, that "there is wisdom in turning as often as possible from the familiar to the unfamiliar: it keeps the mind nimble, it kills prejudice, it fosters humor" (Santayana 1968, p. 15). Arguably, however, tourism today is much more epistemically ordered even when it takes on authenticity-seeking or adventurous forms.

Varieties of tourism or leisure travel have been distinguished in regard to the authenticity of the experience of other cultures and places (see Boorstin 1961). Dean MacCannell (1999 [1976]) suggests that actual gradations in the search for authenticity resist polar categorizations of tourism as authentic or inauthentic. Rather, destination places, tourist objectives and perceptions, local expectations and dependencies, “staged authenticity” (MacCannell 1999 [1976], title of chapter 5), and the dynamic nature of cultural activities and artifacts render such categories indistinct. The global journeying that through the years has created “backpacker meccas” in places such as Goa (India), Kathmandu (Nepal), and Lamu (Kenya) may seem a more authentic quest for rich cultural experiences in comparison to sheltered resort vacationing (enclave tourism), in which the actual place or culture is insignificant. Authenticity, however, is framed by the tourist’s cultural expectations as much as it is a property of the experience of foreign destinations. The “inauthentic,” moreover, may involve a relatively benign mutual exploitation or exchange between tourists and locals.

Ethical Issues

The paradox of the authenticity-seeking traveler is that the more tourists vacation in a particular place, the more a tourism infrastructure is developed and the more that place comes to resemble the tourist’s home, causing local cultural and environmental deterioration. Pico Iyer (1989) has written about the unusual juxtapositions and hybrids of different cultures one finds across the globe as a result of the forces of globalization and tourism. This paradox creates a dilemma regarding whether to visit a place or to tour at all. The question for anthropologists and environmentalists is whether it is appropriate to visit a fragile culture or a pristine environment when one’s visitation contributes to its alteration. Furthermore, as a tourist destination becomes more developed and attracts increasing numbers of visitors, many tourists may look elsewhere for less-traveled destinations. As a consequence they may perpetuate the same cycle, and some overdeveloped areas ultimately may witness a decline in the visits on which their economies depend.

From the perspective of those who welcome the local tourist industry may provide much-needed income and infrastructure development, but the cycle of unmanaged tourism development ultimately places those economic benefits at risk. Although income is generated locally from the industry, the distribution of benefits is uneven, and there may be severe damage to local cultures, other parts of local economies, and the natural environment. Such considerations have generated antitourism and protourism positions, with the former generally concerned with the environmental and cultural impact and the latter with economic development.

Tourism raises specific and clear ethical and cultural concerns in regard to some of its manifestations, for example, sex tourism and reality tourism, with the latter involving poor or oppressed people inviting visitors to observe and experience their living conditions (an example of voyeurism). Opponents of tourism point to increased child labor, greater crime rates, and increased prostitution.

Tourism may contribute indirectly to resource conflicts and tensions with traditional land-use practices in addition to eroded cultural values and commodification of traditional practices. Economically it can lead to increased prices for basic goods for local people and higher costs for infrastructural development, diverting resources from other critical social sectors. Environmentally tourism may lead to the depletion of natural resources and pollution (air pollution, sewage, solid waste) in addition to problems such as coral reef anchoring, trampling, construction and deforestation, and disruption of ecosystem processes. Other common foci of criticism include the large amounts of fuel burned by airliners transporting tourists to and from their destinations, the construction of golf courses in environmentally fragile areas, and the aesthetic pollution of overdevelopment.

Proponents of tourism point to new infrastructure development for residents, greater civic participation, and reinvigoration of cultural traditions in addition to the mutual understanding and respect that may result from cultural exchange. Tourism may contribute to state revenues and foreign exchange earnings, increase employment opportunities, and help local economies grow. Environmentally tourism may contribute to new investments in conservation efforts, lead to regulatory measures and improved management practices, and provide new forms of employment. It also may indirectly involve the development of better technologies for conservation programs through technology transfer and the growth of science-based programs for environmental management.

The distinction between negative and positive effects depends principally on the specific contexts, rendering the prospects of a global management program extremely challenging. Environmental impacts, however, can have a far-ranging effect beyond the particular tourism context. This contributes another dimension to already complex ethical questions of obligations beyond borders, especially in a globalizing era.

The expansion of ecotourism is a major response to such concerns over environmental and cultural degradation and an attempt to invigorate local economies that otherwise are dependent on environmentally unsustainable practices. In some cases such practices are directly related to the tourism industry (for example, deforestation in the Himalayas for wood-fire cooking); in others the practices may be the sole (and sometimes illegal) source of income (such as rain forest logging).

Ideally, the goals of ecotourism are to combine ecological and cultural awareness with sustainable local economies and resource use and preserve local cultural identities and values. Ecotourism may include what is sometimes referred to as "scientific tourism." This form of tourism may range from volunteer fieldwork in the collection of scientific data to tourism accompanied by an ecologically informed guide. The growth of ecotourism in some areas, however, often represents a superficial assuaging of tourists' environmental concerns and expectations rather than an actual advance in conservation practices. Cheating on the ecotourism designation is common in some areas in the form of advertising regular activities, accommodations, or management practices as "eco-friendly" to attract unsuspecting tourists concerned about ecological impact. This has prompted efforts to certify and monitor ecotourism companies. Nevertheless, genuine ecologically benign tourism, even if it is possible, seeks to attract tourists to fragile places, thus re-creating the paradox mentioned above.

More recently these collective considerations have found expression in international forums. The World Tourism Organization (WTO), which is affiliated with the United Nations, has drafted a "Global Code of Ethics for Tourism" (1999). The code consists of ten general principles intended to guide "stakeholders" and supplement the tourist industry's emphasis on the market and private enterprise aspects of tourism. The WTO seeks to encourage "sustainable tourism," encompassing some of the considerations raised above. The United Nations Environmental Programme also attempts to integrate tourism considerations with international agreements such as the United Nations Convention on Biological Diversity.

The intersection of facilitating technologies, economics, and culture, along with environmental impacts, generates ethical considerations and dilemmas involving tourism. The new directions of tourism remain to be seen as globalization proceeds. Some places focus on the tourist industry to boost economies whose other industries may be stagnating or nonexistent. However, as a result of the fickle nature of tourism and its potential for the destruction of local environmental and cultural resources there is urgent cause for concern over dependency on tourism, particularly in developing countries. Ecotourism may provide only a temporary answer to economic and ecological realities without a more closely regulated and monitored industry or different global economic arrangements. If tourism is inevitable, perhaps the best option is the development of a global regime of "sustainable tourism." The Kingdom of Bhutan may provide an educative example, as it limits the numbers of visitors per year in the name of sustainable environmental and cultural considerations while trying to sustain economic well-being.

These issues perhaps may be overcome through shared, direct experience of places such as the Nepalese Himalayas, the biodiverse rain forests in Costa Rica, and the coral reefs of the South Pacific or of the peoples of New Guinea, Lapland, and central Africa. Perhaps what is needed is an ethics of tourism that is attentive to character, obligations, equity, and rights so that the benefits of tourism may flourish without doing harm. Perhaps there is also a need for a practical ethics of tourism that can admit that sometimes it is better not to be a tourist at all.

THOMAS C. HILDE

SEE ALSO *Benjamin, Walter; Consumerism; Science, Technology, and Society Studeis.*

BIBLIOGRAPHY

Benjamin, Walter. (1999). *The Arcades Project,* trans. Howard Eiland and Kevin McLaughlin. Cambridge, MA: Belknap Press.

Boorstin, Daniel J. (1961). *The Image: A Guide to Pseudo-Events in America.* New York: Harper and Row.

Fussell, Paul. (1980). *Abroad: British Literary Traveling between the Wars.* Oxford: Oxford University Press.

Held, David; Anthony McGrew; David Goldblatt; and Jonathan Perraton. (1999). *Global Transformations.* Stanford, CA: Stanford University Press.

Iyer, Pico. (1989). *Video Night in Kathmandu and Other Reports from the Not-So-Far East.* New York: Vintage.

MacCannell, Dean. (1999 [1976]). *The Tourist: A New Theory of the Leisure Class.* Berkeley: University of California Press.

Santayana, George. (1968). "The Philosophy of Travel." In *The Birth of Reason and Other Essays,* ed. Daniel Cory. New York: Columbia University Press.

Smith, Mick, and Rosaleen Duffy. (2003). *The Ethics of Tourism Development.* New York: Routledge.

Veblen, Thorstein. (1994 [1899]). *The Theory of the Leisure Class*. New York: Penguin.

World Tourism Organization. (2002). *Tourism Market Trends*. Madrid: Author.

INTERNET RESOURCE

World Tourism Organization. (1999). "Global Code of Ethics for Tourism." Available from http://www.world-tourism.org/projects/ethics/principles.

TOXIC CHEMICALS

SEE *Arsenic; Chemical Weapons; Regulatory Toxicology*.

TOXIC METALS

SEE *Heavy Metals*.

TOXICOLOGY

SEE *Regulatory Toxicology*.

TOYS

SEE *Robot Toys*.

TRADEOFFS

Tradeoffs occur under constraints similar to zero-sum games in which one participant's gain (or loss) is balanced by another's loss (or gain). A tradeoff is an exchange that occurs as a compromise, giving up one set of interlocked advantages and disadvantages in order to gain another, more desirable set. The benefits that are foregone in a particular case are often referred to as the opportunity-costs of that decision. Many personal and policy decisions regarding scientific research, technological development, and the use of technological products, processes, or systems depend either consciously or unconsciously on accepting tradeoffs. In many cases so-called ethical criticisms of science and technology are themselves criticized as ignoring the need for tradeoffs. Analysis of the concept of tradeoffs is thus an important feature of any general appreciation of relations between science, technology, and ethics.

Examples in Science and Technology

Human life is saturated with tradeoffs because time is a limiting resource. People can only perform a limited number of activities and thoughts in a given period of time. Usually, the routine of life masks the tradeoffs made and opportunity costs incurred.

ECONOMICS AND SCIENCE. People are perhaps most aware of tradeoffs in financial choices because money is another limiting resource. For example, with the money I have, I can choose between buying a car and taking a vacation. As Kenneth Arrow (1974) noted, much of economics involves saying "this or that, not both" (p. 17).

Budget allocation scenarios present important instances of tradeoffs in science as well. For example, the National Institutes of Health (NIH) experienced annual increases of fifteen percent between 1998 and 2003. Such large growth was justified by the potential health benefits of new advances in biomedical research, but some complained that the physical sciences and engineering suffered as a result of this prioritization. Other tradeoffs occur further downstream in the allocation of these funds through competitive grant processes. At the NIH, for example, decisions must be made about which diseases to prioritize and which researchers and facilities are most qualified to carry out that research. Indeed, this illustrates a more general point that prioritization is one way of dealing with tradeoffs, and the failure or inability to set priorities is a failure or inability to appreciate the reality of tradeoffs.

ENGINEERING. Tradeoffs are essential to both the internal operations of engineering and architecture as well as their social interactions. According to Edward Wenk (1986), "The most demanding skill in engineering design may . . . be the *acute weighing of tradeoffs*" (p. 53). Different materials have different advantages and disadvantages for a given project and competing goals such as beauty, efficiency, responsiveness, and durability must be traded off against one another.

But tradeoffs in the design and implementation of technology are not an insular affair, limited only to considerations of material and design constraints. Another important factor in engineering tradeoffs is the public perception of risk. Engineers must incorporate safety margins and/or redundancy into their designs in order to reach socially acceptable levels of risk. These extra measures impose additional costs and other constraints, which can lead to declines in efficiency or functional performance.

Wenk demonstrated how political and financial aspirations can be traded off against safety in the use of technology. In the 1980s several highway bridges collapsed, but the problem was not poor design or age. Rather, political leaders caved into the pressure from trucking lobbies to permit greater truck weights by relaxing load limits. Citing the costly but failed U.S. federal bailout of railroads and the persistent pursuit of the Strategic Defense Initiative despite signs of systematic problems, he wrote, "the more massive a technology, the greater seems to be the political momentum for implementation and the greater the difficulty in identifying the tradeoffs occasioned by its accomplishment" (p. 38). Wenk also speculated about the influence of political concerns on the ill-fated *Challenger* shuttle. It was launched on the morning of the State of the Union address, which may have affected the managerial decisions about how to treat warnings of a possible failure of the O-rings. These cases point out the ethical responsibility of engineers when political considerations are traded off against safety concerns.

APPLICATIONS. Yet Wenk's most important point is that every choice involving science and technology presents tradeoffs because technological innovation and implementation are not unqualified goods. There are disadvantages to go along with the advantages and costs to go along with the benefits. This symmetrically implies that forgoing or somehow altering the pursuit and application of knowledge presents benefits as well as costs. For example, participants in the lengthy Environmental Impact Statement (EIS) process concerning the construction of a wind farm in Nantucket Sound, Massachusetts, were weighing many tradeoffs, including the one between clean energy and the beauty of a relatively pristine seascape.

The case of chlorofluorocarbons (CFCs) is another example. Industrial and political leaders were at first unaware that the use of CFCs involved tradeoffs between human and environmental health and the conveniences of widespread and cheap refrigeration. The international decision to phase out the use of CFCs was another tradeoff between the costs of such a large-scale economic transition and improved human and environmental health. Companies that produce hazardous wastes face tradeoffs between the costs of containing and storing that waste and the potential liability for damages to human and environmental health. As they attempt to minimize costs, the risks to health usually increase (Sewall 1990). Another example stems from the threat of terrorist attacks and the resulting tradeoffs between national security and scientific freedom of inquiry. In these cases, decisions must be made by public leaders, but many tradeoffs involving the use of technology are made by individuals. For example, those who choose general over commercial aviation accept the tradeoff of increased cost and risk for greater convenience.

RISKS. John Graham and Jonathan Wiener (1995) argued that as technology has come to saturate modern life, government has increasingly adopted the role of reducing risks to environmental and human health. They point out that risk tradeoffs often confound these efforts, as well-intentioned efforts to reduce some risks can turn out to increase others. Efforts to counter a "target risk" can generate "countervailing risks," which are commonly known as side effects (medicine), collateral damage (military tactics), or unintended consequences (public policy). If decision makers are well informed, they may be able to reduce overall risk by choosing "risk-superior" options, but sometimes risk tradeoffs are unavoidable.

Risk tradeoffs occur at both personal and societal levels. For example, a woman dealing with menopause can take hormonal replacement therapies to ward off the risk of osteoporosis and chronic pain, but in so doing she may increase the risk of uterine and breast cancer. Similarly, visiting a hospital can reduce risks from trauma and illness, but it can also lead to other illnesses. On a social level, decision makers must choose when to chlorinate drinking water, which kills harmful microbes but may add a cancer risk. Spraying hot water on the beaches of Prince William Sound, Alaska, after the 1989 *Exxon Valdez* oil spill reduced risks to nearby otters and birds, but may have harmed the longer-term ability of the ecosystem to recover by killing certain marine organisms and microbes. Grahm and Wiener proposed a risk tradeoff analysis framework to help decision makers grasp the entire portfolio of risks that science and technology can present within a given decision.

Tradeoffs as an Explanatory Concept

The notion of tradeoffs is important not only in decision making but as an explanatory term in several scientific disciplines, including economics and evolutionary biology. British economist Lionel Robbins called economics the study of human behavior as a relationship between ends and scarce means that have alternative uses. Indeed, microeconomics rests largely on the math of constrained maximization (for example, Lagrange multipliers). Robbins' definition of economics shows its close connection to ethics and politics as all involve the assessment of social institutions and the consequences of alternative decisions. The ethics of political-economics derives from the fundamental tradeoffs posed by scarcities of land, labor, and capital. Even social programs that do achieve their goals leave society with fewer available resources to further values in other policy areas. Steven Rhoads (1985) stated "spending and regulatory decisions that use scarce resources . . . incur costs in terms of forgone alternatives (that we no longer have the capacity to undertake) elsewhere" (p. 11). But economic activity is not entirely a zero-sum game. For example, comparative advantage can increase overall output and welfare if countries specialize their production processes and engage in trade. Similarly, although many tradeoffs exist between environmental protection and economic growth, there are several cases where environmentally friendly practices are also most cost-effective.

Rhoads (1985) noted that economists and engineers often clash in their understanding of opportunity-costs and tradeoffs. Engineers, he argued, have a narrower conception that revolves around materials selection, whereas economists account for all social costs. The former ask about tradeoffs between using steel and reinforced concrete in building projects, whereas the latter consider ways to solve the problem without building at all. Their differences also point out contrasts in the meaning of efficiency. Engineers push for the implementation of the latest technological innovations, whereas economists account for the tradeoffs involved in replacing older technologies. The former is the path to increasing technological efficiency, whereas the latter implies that economic efficiency takes wider social costs into account.

Although it is true that economic transactions are not always zero-sum games, there can be a tendency by some to underemphasize the importance of tradeoffs in some areas. The broken window fallacy, for example, states that when a child breaks the baker's window, he or she actually spurs economic activity. After all, the baker must buy a new window, which gives money to the window-maker to spend on new shoes, etc. However, "hidden costs" are ignored in this calculus. The money spent by the baker on a new window would have been spent on shoes. Now, for the same cost, instead of a window and shoes the baker only has a window.

The Panglossian attitude of the broken window fallacy has also been attacked in evolutionary biology. Stephen Jay Gould and Richard Lewontin (2001) critiqued the dominant adaptationist program, which atomizes an organism into its traits. It then explains that an organism cannot optimize each trait without imposing expenses on others: "The notion of 'trade-off' is introduced, and organisms are interpreted as best compromises among competing demands" (p. 77). Organisms are presented as the result of an optimization problem, where "each trait plays its part and must be as it is" (p. 77). Gould and Lewontin borrowed the metaphor of spandrels to argue that organisms must be analyzed as integrated wholes with "Baupläne," or phyletic and developmental constraints. These constraints, they contended, are more important in explaining evolutionary change than selective forces. The plurality of tradeoffs between selective pressures, random forces, and various constraints, rather than strictly between selective forces, expands the relevant foci of analysis.

Ethical Analysis

Tradeoffs can be abstracted into a taxonomy of competing goods, including equity, efficiency, freedom, and security (see Okun 1975). Indeed public policy, by virtue of being public, tends to require tradeoffs due to a plurality of views and interests. Science and technology play major roles in several policies that make tradeoffs among social priorities, between costs and risks, between various sectors of the population, and between long- and short-term timescales (Wenk 1986).

The latter tradeoff has become increasingly important as technological capacities have increased our power to create negative consequences deep into the future. This tradeoff is often posed as one between short-term gains and obligations to future generations, although the degree to which this is an ethical concern in any given circumstance is usually contested. Technology-induced displacements of the workforce also seem to create tradeoffs between long-run, aggregate gains and short-term, localized losses.

The development, use, and regulation of technologies pose many other ethical dilemmas in the form of tradeoffs. Some of the most charged issues involve tradeoffs between economic growth and human health and safety. For example, regulations on pollution emissions and synthetic chemicals protect health and safety, especially of workers who come in close contact with those pollutants and chemicals. Similarly, traffic laws and regulations on automobiles ensure some measure of safety. Theoretically, banning pollution, chemicals, automobiles, and other dangerous technologies could save millions of lives annually. Yet even marginally increasing restrictions on certain emissions (let alone banning them) can bring major tradeoffs that pose the difficult question of how much a human life is worth. Rhoads (1985) cited a proposed 1980 benzene emission standard by the U.S. Environmental Protection Agency (EPA) that would have imposed large costs on industry but would not prevent a case of leukemia until 37,000 years had passed. The estimated cost of saving one life was $33 billion. Rhoads argued that decision makers can minimize opportunity-costs by investing money in other areas (for example, traffic safety) where saving lives costs much less.

Cases such as this raise the question of how risks should be measured (for instance, what toxicological dose-response model) and how they are perceived by different elements of society. They also highlight the fact that the tradeoff concept itself depends upon a consequentialist ethic. One must be willing to base a decision on the consequences of alternative course of action to even participate in the logic of tradeoffs. A deontologist who believes it to be immoral to jeopardize human life no matter what the consequences will not accept the tradeoffs mentioned above. They would argue that $33 billion is not too much to pay to save a human life, because protecting human life is considered an inviolable duty.

Another important insight is that individuals may make different decisions about tradeoffs depending on how they encounter information. For example, Norman Augustine (2002) presented his students a hypothetical opportunity of investing in a new product that would create millions of jobs and enhance the quality of life for most people. He received an enthusiastic response, but then he adds that the product would kill a quarter of a million people every year. None of the students remained interested in investing, and most said the product should be banned. He then tells them that he is referring to the automobile. Tradeoff decisions clearly depend on cultural norms, personal experiences, and the socio-psychology of risk perception as much as they do on a rational tabulation of relative costs and benefits (see Slovic 2000).

Whether performed consciously or unconsciously, every time new knowledge is sought and new technologies are applied, a tradeoff has been made. In many cases, the bundle of benefits and costs chosen is obviously more desirable than the forgone alternatives. However, in other instances there may be considerable disagreement on whether and how to proceed. These cases pose challenging questions of who should make such decisions and how they should be made.

Decision makers have several tools for making tradeoff decisions. On the technical end, a tradeoff calibration can be used, which involves filling lookup tables by balancing different objectives. For example, this tool can help an engineer who wishes to increase torque while restricting nitrogen oxide emissions. Economic tools include risk-cost-benefit analyses, revealed preferences, and expressed preferences (for example, contingent valuation and willingness-to-pay surveys). Psychological tradeoff analyses show cross-cultural differences in the interactions between an individual's moral reasoning and the consequences of decisions (see for example Swinyard et al. 1989). More strictly governmental tradeoff analysis techniques include advisory panels and institutions dedicated to assessing decisions and assigning accountability for successes and failures. Decision makers can be guided through the oftentimes high-stakes tradeoffs presented by science and technology by specialized assessment institutions such as the U.S. Office of Technology Assessment (OTA), which existed from 1972 to 1995.

Decision making is inherently forward-looking, so one of the biggest challenges posed by many tradeoffs involving science, technology, and society is uncertainty about likely future outcomes of alternative decisions. Increasing information is often a worthwhile means to reduce uncertainties and increase foresight, but this must also be accompanied by decision-making structures capable of synthesizing that information. Furthermore, uncertainties will remain. For example, regulating toxic chemicals involves tradeoffs between costs and acceptable risks. But the situation is complicated by uncertainties in modeling dose-response functions, ecological interactions, and economic impacts. Eliminating these uncertainties is often impossible, at least on the time-scales required by decision makers.

Therefore, many tradeoff decisions must be made not between two (or more) well-characterized competing bundles of advantages and disadvantages, but rather between two (or more) dimly understood future scenarios. Partially for this reason, Edward Wenk (1986) argued that tradeoffs require anticipatory governments capable of assessing different alternatives and their probabilities. He also insisted that tradeoffs involving science and technology call for participation by an "attentive public" not just political, commercial, and scientific elites. Such assessments raise the fundamental question of which alternative will make us better off. Thus, they are the responsibility of all citizens, not the domain of any particular expertise.

ADAM BRIGGLE

SEE ALSO *Consequentialism; Double Effect and Dual Use; Risk Ethics; Unintended Consequences.*

BIBLIOGRAPHY

Arrow, Kenneth. (1974). *The Limits of Organization.* New York: Norton.

Augustine, Norman R. (2002). "Ethics and the Second Law of Thermodynamics." *The Bridge* 32(3): 4–7. Also available as a publication from the National Academy of Engineering, Washington, DC.

Gould, Stephen Jay, and Richard C. Lewontin. (2001). "The Spandrels of San Marco and the Panglossian Paradigm: A Critique of the Adaptationist Programme." In *Conceptual Issues of Evolutionary Biology*, 2nd edition, ed. Elliot Sober. Cambridge, MA: MIT Press.

Graham, John D., and Jonathan Baert Wiener, eds. (1995). *Risk versus Risk: Tradeoffs in Protecting Health and the Environment*. Cambridge, MA: Harvard University Press. A collection of nine case studies in risk tradeoffs with an introduction and conclusion by the editors, in which they abstract out the main issues, critically analyze them, and offer some ways to resolve risk tradeoffs.

Okun, Arthur M. (1975). *Equality and Efficiency: The Big Tradeoff*. Washington, DC: The Brookings Institution. Explores the question of to what extent governments should pursue economic equality and notes four major tradeoffs involved in this pursuit, which are weighed against the tradeoffs of allowing the market to function based solely on efficiency.

Rhoads, Steven E. (1985). *The Economist's View of the World: Governments, Markets, and Public Policy*. London: Cambridge University Press. Contains sections on opportunity cost (pp. 11–24) and benefit-cost analysis (pp. 124–142) that are most relevant to tradeoffs.

Sewell, Kenneth S. (1990). *The Tradeoff between Cost and Risk in Hazardous Waste Management*. New York: Garland. Provides a conceptual framework to evaluate these tradeoffs and applies it to a case study in Massachusetts.

Slovic, Paul (2000). *The Perception of Risk*. Sterling, VA: Earthscan Publications.

Swinyard, William R., Thomas J. Delong, and Peng Sim Cheng. (1989). "The Relationship between Moral Decisions and their Consequences." *Journal of Business Ethics* 8: 289–297. Proposes a tradeoff analysis framework to elucidate the way in which these decisions are made.

Wenk, Edward Jr. (1986). *Tradeoffs: Imperatives of Choice in a High-Tech World*. Baltimore: Johns Hopkins University Press. One of the best single overviews of the topic. Examines the decisions that must be made as technology intersects with culture, politics, and individual lives.

TRANSACTION-GENERATED INFORMATION AND DATA MINING

The term *transactional information* was first employed by David Burnham (1983) to describe a new category of information produced by tracking and recording individual interactions with computer systems. Unlike most human interactions, those processed by computer systems are easily recorded and aggregated to yield knowledge about individual behaviors that would have otherwise been more difficult to acquire and often less complete. Known as transactional-generated information (TGI), it is information acquired from commercial and noncommercial transactions involving individuals in many increasingly computerized day-to-day activities. Examples of commercial transactions include withdrawing money from an ATM machine or credit-card shopping; examples of noncommercial transactions include checking books out of a library or participating in an online educational program. TGI can be contrasted with but does not exclude more traditional information such as a person's age, place of birth, education, work history, and so forth.

The Special Character of TGI

The practice of collecting information about persons is hardly new. Governments have collected census data since the Roman era. But through the twentieth century, the few records that existed about individuals contained information about when and where they were born, married, worked, or owned property. Information about the day-to-day transactions of individuals was rarely, if ever, collected and stored. Even if it had been collected, it would have been difficult to process and store. Armies of clerks would have been needed to sort through this information and huge warehouses or repositories would have been required to store the physical records. Those conditions changed, of course, with the advent of computers and electronic databases.

Additionally much traditional information about persons is gathered in ways that require conscious acts of disclosure on the part of those providing it. When individuals fill out census forms, they are generally aware of providing information about themselves to a government agency. By contrast, with TGI data subjects are not always consciously aware they are providing information about themselves to some data collector. When motorists use the convenience of an Intelligent Highway Vehicle System, such as E-ZPASS, they seldom realize that a transaction occurs each time they pass a toll plaza. Not only is a motorist's pre-paid account with E-ZPASS debited, but the exact time of passing through the toll booth is electronically recorded and stored.

Cookies

Next consider a kind of *on-line* transaction involving typical Internet users, who may have no knowledge that TGI is being collected. Via programs called *cookies*, TGI is routinely gathered about users who visit web sites. Cookies technology enables web site owners to collect certain kinds of data about users who access their sites, including information about the user's Internet Protocol (IP) address and Internet Service Provider (ISP). This information is stored in a text file placed on the hard drive of the user's computer and then retrieved from that computer and resubmitted to the web site the next time the user accesses it. It provides the operator of a web site with information about a user's on-line browsing preferences. Transactions involving the use of cookies to exchange data between users and web sites typically occur without the knowledge and consent of users.

Since their implementation on the web in the 1990s, the use of cookies technology has been controversial. The owners and operators of on-line businesses and Web sites, who defend the use of cookies, claim that they are performing a service for repeat users of a web site by customizing a user's means of information retrieval. For example, they point out that cookies technology enables them to provide a user with a list of preferences for future visits to that Web site. Defenders of cookies also note that users can elect to disable cookies via an option provided on their web browsers.

Privacy advocates, on the other hand, argue that because cookies technology involves the monitoring and recording an individual's activities while visiting a Web site, as well as the subsequent downloading of that information onto a user's PC (without informing the user), the use of cookies clearly cross the privacy line. They also point out that many web sites do not permit users to disable cookies, and they note that users must first be aware of cookies before they can opt out (i.e., reject cookies) on web sites that allow them to do so. Some privacy advocates also worry that information gathered about a user via cookies can eventually be acquired by on-line advertising agencies, which could then target that user for on-line ads.

Merging and Mining TGI

Because TGI exists in the form of electronic records, it can be easily exchanged between databases in a computer network; these records can also be *merged*. *Computerized merging* is the technique of extracting information from records about individuals (or groups of individuals) that reside in two or more databases, which are often unrelated, and then integrating that information into a composite file.

Information gathered about an individual's on-line activities and preferences via Internet cookies can also be merged with information about an individual's transactions in off-line activities in physical space to construct a general profile. In 1999 DoubleClick.com, an on-line advertising firm that used cookies technology to amass information about Internet users, proposed to purchased Abacus, an off-line database company. DoubleClick's pending acquisition of Abacus was criticized by many privacy advocates who feared that the on-line ad company would combine the information it had already acquired about Internet users (via cookies) with the records of some of those same individuals that resided in the Abacus database.

DoubleClick would have been able to merge web profiles with off-line transactional data about consumers. In January 2000, however, DoubleClick was sued by a woman who complained that her right to privacy had been violated by that company. The woman filing the suit claimed that DoubleClick's business practices were deceptive because the company had quietly reversed an earlier policy in which it provided only anonymous data about Internet users (acquired from cookies files) to businesses. Because of public pressure, DoubleClick backed off its proposal to purchase Abacus. However, because of the controversy surrounding the DoubleClick incident, many realized for the first time the kinds of privacy threats that can result from the merging of electronic data. And even though the DoubleClick-Abacus merger did not materialize, the danger of future mergers of this type remain.

In addition to being merged, TGI can also be *mined*. *Data mining* is a computerized technique used to reveal non-obvious patterns in data that otherwise would not be discernible. Data-mining technology also generates new classifications or categories (of individuals), which are not always obvious to the individuals who populate them. Some of these newly discovered/created categories or groups suggest *new facts* about individuals who constitute these groups. For example, a young executive with an impeccable credit history could, as a result of data-mining technology, end up being identified as a member of a (newly generated) category of individuals who are perceived to be high-credit risks because of certain patterns found in aggregated data, despite the fact that the particular person's credit history is unblemished. That is, a data-mining program might associate the young executive with a group of individuals who are likely to start their own businesses in the next three years and then file for bankruptcy within the next five years.

Because of concerns about the ways in which electronic records can be exchanged between two or more databases, various privacy laws have been enacted at the federal and state levels. For example, the Health Insurance Portability and Accountability Act (HIPPA) of 1996, enacted into law on April 14, 2003, provides protection for personal medical records. And the Video Protection Act (also known as the "Bork Bill" because it was passed through the U.S. Congress in the aftermath of Judge Robert Bork's nomination to the U.S. Supreme Court) protects consumers from having records of their video rentals from being collected and exchanged. However, these laws primarily aim at protecting personal information that is: (a) *explicitly* identifiable in electronic records, and (b) considered *intimate* or *confidential*.

Information acquired via data mining fits neither category. First, as noted, it is derived from *implicit* patterns in data, which without data-mining technology, would not be accessible to data collectors. Second the kind of personal information generated in the data-mining process is often considered non-intimate or non-confidential because it is derived from information acquired through transactions in which individuals engage openly and in public places.

The use of courtesy cards in supermarket transactions might initially seem innocuous from the perspective of personal privacy. The items purchased are typically transported in an open shopping cart that is visible to anyone in the store so there is nothing confidential or intimate about the activity. However a record of courtesy card purchases can be used to generate a consumer profile. This profile reveals patterns that identify, among other things, the kinds of items purchased and the time of day/week an individual typically shops. Such information is useful to *information merchants* who use it to target consumers in their advertising and marketing campaigns. Furthermore information in a consumer profile can be used to make judgments about personal lifestyles, health, spending habits, and more. Indeed such a profile may be created even when the aggregated data on which it is based is inaccurate because the courtesy card was loaned to another person.

The new forms of information produced by TGI and data mining thus present special challenges to privacy. First individuals may not be aware of the degrees to which their activities are being tracked by a constellation of computer system interactions and their interactions analyzed by data mining techniques. The lack of knowledge in these regards is itself an ethical issue that deserves to be addressed by general education and disclosure statements associated with the particular computer systems. Second because it is easy for such TGI and data mining products to include inaccuracies that may have substantial if subtle impacts, it may be necessary to consider possibilities for personal review or disclosure when TGI is used to influence decision making.

HERMAN T. TAVANI

SEE ALSO *Computer Ethics; Internet; Privacy.*

BIBLIOGRAPHY

Burnham, David. (1983). *The Rise of the Computer State*. New York: Random House. One of the earliest accounts of how computer databases could be used by government agencies to store and exchange information gained about individuals from their electronic transactions.

Fulda, Joseph S. (2004). "Data Mining and Privacy." In *Readings in CyberEthics*, 2nd edition, ed. Richard A. Spinello and Herman T. Tavani. Sudbury, MA: Jones and Bartlett Publishers. This anthology comprises fifty readings; Fulda's article succinctly describes how privacy concerns involving data mining differ from other computer-related privacy issues.

Johnson, Deborah G. (2004). "Computer Ethics." In *Academy and the Internet*, ed. Helen Nissenbaum and Monroe E. Price. New York: Peter Lang. This anthology comprises twelve readings; Johnson's article provides an overview of computer-ethics issues, including a discussion of specific privacy concerns involving TGI.

Tavani, Herman T. (1999). "Informational Privacy, Data Mining, and the Internet." *Ethics and Information Technology* 1(2): 137–145. Examines how privacy issues arising from data mining differ from those associated with traditional data-retrieval techniques; also illustrates how mining data from the Internet differs from data mining in off-line contexts such as "data warehouses."

Tavani, Herman T. (2004). *Ethics and Technology: Ethical Issues in an Age of Information and Communication Technology*. Hoboken, NJ: John Wiley and Sons. Comprises eleven chapters that cover a wide range of computer-ethics issues, including an extensive discussion of data mining and cookies in Chapter 5: "Privacy and Cyberspace."

TRANSPLANTS

SEE *Organ Transplants.*

TREAT, MARY

• • •

Accomplished amateur botanist and entomologist, Mary Treat (1830–1923), born in Trumansville, New York, on September 7, was a popular chronicler of the plant, insect, and bird life that shared her small Vineland, New Jersey, home. Treat, who was considered a peer and valued correspondent by countless scientists (including Asa Gray (1810–1888), Charles Darwin (1809–1882), Gustav Mayr (1830–1908), and Auguste Forel (1848–1941)), was widely acknowledged as an authority on insectivorous plants, harvesting ants, and burrowing spiders. She is credited with discovering two species of spider, as well as rare fern and plant species. The recognition she received for her scientific research distinguishes her in the history of women in the sciences. It is her investigations into the nest-making actions of birds and insects, however, that illuminates her concern with ethics and the effects of human action in the natural world.

Treat's scientific nature essays, first published in *Harper's* and the *Atlantic Monthly,* then collected in *Home Studies in Nature* (1885), reflect the shift in scientific investigation prompted by the publication of Darwin's *Origin of Species* (1859). Treat described a world in which the landscape of morality changed significantly, where humans no longer resided securely at the apex of creation. Treat agreed with Darwin's notion of nature "red in tooth and claw"; she saw instances of struggle, violence, chance, and adaptation all around her. Yet Treat, unlike many other American intellects of the time, refused to see nature exclusively in these terms. Instead, she advocated a sophisticated brand of Darwinian evolution—one that incorporated ideas expressed in Darwin's *Descent of Man* (1871) and *The Expression of Emotions in Man and the Animals* (1872)—to explain how animals and insects construct their domestic spaces in the face of their struggle to survive.

Treat revised the model of nature she inherited from the tradition of women nature writers preceding her—nature is not simply a model for human behavior, nor is it something that exists solely for humans to control. Instead, as she learned from her reading of Darwin, nature is composed of separate but interrelated communities; the moral sense, as Darwin notes, comes into being with the social instincts that animals develop as they learn to live in a community. Treat focused her scientific studies on how birds and insects build their nests and observed that they, like humans, exercise reason in the construction of their homes. These observations led her to question the supposed difference between human and non-human, and she used nest construction to demonstrate kinship through reason. Humans, or at least those whom Treat called "good observers" of nature, cannot deny this kinship with non-human communities and are, as a result, obligated to act in an ethical way toward nature.

Treat did not escape the anthropocentric observer position common to many women writing about nature in the nineteenth century, but like her mid-twentieth century counterpart Rachel Carson, she used what she saw (and how she saw it) to justify her call for the ethical treatment of all inhabitants of nature.

TINA GIANQUITTO

SEE ALSO *Darwin, Charles; Environmental Ethics; Sex and Gender*.

BIBLIOGRAPHY

Bonta, Marcia Myers. (1995). *American Women Afield: Writings by Pioneering Women Naturalists*. College Station: Texas A&M University Press.

Creese, Mary. (1998). *Ladies in the Laboratory? American and British Women in Science, 1800–1900*. Lanham, MD: The Scarecrow Press.

Norwood, Vera. (1993). *Made from This Earth: American Women and Nature*. Chapel Hill: University of North Carolina Press.

Treat, Mary. (1885). *Home Studies in Nature*. New York: American Book Company.

TRUST

Trust of science and technology and of the people who conduct research and invent, design, develop, manufacture, operate, maintain, and repair technology is essential to the development of science and technology. When the trust proves unwarranted, however, the result can be disaster in forms varying from harm to health and safety, to persistent distortions of knowledge, to theft of credit or property that cripples cooperation necessary to support the growth of knowledge and development of technology. A deeper question is what it means for science and technology, and the people responsible for them, to be trust*worthy*.

The Concepts of Trust and Trustworthiness

Although Sissela Bok (1978) discussed trust as a moral resource beginning in the 1970s, the question of the morality of trust relationships—the conditions under which, from a moral point view, one ought to trust—was not explicitly discussed until a decade later by Annette Baier (1986). Two earlier essays were important in laying the foundation for this major turn in the discussion. Ian Hacking (1984) provided a devastating assessment of game theoretic approaches to solving problems of trust, such as the Prisoner's Dilemma. Baier (1985) herself previously had argued for broadening the focus in ethics from obligations and moral rules to the subject of whom one ought, as a moral matter, to trust and when. As Kathryn Addelson (1994) points out, Baier's change of focus establishes a general perspective on ethical legitimacy that is shared by all, rather than privileging the perspective of those who make, instill, and enforce moral rules.

As Baier (1986) argues, trust involves both confidence and reliance. If people lack other options, they may continue to rely on something, such as the water supply, even when they no longer trust it. Similarly, people may have confidence in something, or confidence in their expectations concerning it, without relying on it. To rely only where one can trust is a fortunate circumstance.

Baier's general account of the morality of trust illuminates the strong relation between the trustworthy and the true. A trust relationship, according to Baier, is *decent* insofar as it stands the test of disclosure of the premises of each party's trust. For example, if one party trusts the other to perform reliably only because the truster believes the trusted is too timid or unimaginative to do otherwise, disclosure of these premises will give the trusted party an incentive to prove the truster wrong. Similarly if the trusted party fulfills the truster's expectations not through trustworthiness but only through fear of detection and punishment, disclosure of these premises will lead the truster to expect that the trusted would defect, if able to do so undetected.

Although explicit discussion of moral trustworthiness is relatively recent, both professional ethics and the philosophy of technology have given considerable attention to the concept of (prospective) responsibility. Because being trustworthy is key to acting responsibly in a professional capacity, or to being responsible in the virtue, as contrasted with causal, sense, the literature on responsibility provides at least an implicit discussion of many aspects of trustworthiness.

Niklas Luhmann (1979) has shown how trust simplifies human life by endowing some expectations with assurance. It is prohibitively difficult and time-consuming to consider all possible disappointments, defections, and betrayals by those persons or circumstances on which one relies; all possible consequences of those disappointments; and all actions that might prevent those disappointments or change their effect. Trust reduces that burden. In a later work, Luhmann urged a different distinction between confidence and trust: that *trust* be used only when the truster has considered the alternatives to trusting. Luhmann's discussion of the distinction between trust and confidence highlights the element of risk in trusting. Risk or vulnerability does characterize situations in which trust is necessary, in contrast to those in which one's control of the situation makes trust unnecessary. However the notion of reliance in Baier's definition of trust as confident reliance does capture the sense of vulnerability. One's vulnerability in reliance does not require consideration of the alternatives to such reliance.

The risk taken in trusting does leave the truster liable to disappointment (or worse), whether that trust is of persons, objects, or circumstances (such as, that the temperature will go below freezing overnight). However only if one's trust is in agents capable of recognizing intention, can one be let down. Furthermore, although one may disappoint without intending to, one must at least be aware of behaving in the way that turns out to disappoint in order to be said to have let someone down. So if Alice does not know she is waking Bob each morning by closing the garage door, she cannot be said to have let him down by not waking him today. Because science and technology do not arise except through human intervention, the focus of this entry is on trust in people, individually or acting as a group.

Trustworthy Professionals

For the professionals behind science and technology to behave in a responsible or trustworthy manner requires both technical competence and moral concern—specifically a concern to achieve a good outcome in the matter covered, which is sometimes called their fiduciary responsibility, the responsibility of a person in a position of trust. The moral and technical components of professional responsibility led sociologist Bernard Barber (1983) to speak of these as two *senses* of trust. However if the public is to trust the members of the science and engineering professions, it is not in two senses. Rather the public trusts the professional to achieve some outcome for which both competence and concern are required. For researchers, the outcome typically centers on the accurate report of the methods and results of research, a report that fairly acknowledges any contributions of others. For engineers, it typically centers on the provision of a technology that performs its function and does not pose unnecessary threats to safety.

For engineers the competence and concern are engineering competence and concern for such social goods as public safety, confidentiality of information, fairness in competition, the public understanding of science and technology, protection of the environment, and the quality and performance of the technology in question. Engineering codes of ethics enjoin engineers not to take on work beyond their competence, so at least for engineers technically incompetent performance is also recognized to be a moral failing. In contrast, researcher investigators generally do not regard undertaking research beyond one's competence as a *moral* failing, although certain incompetencies, such as those that result in harm to experimental subjects or to public health, might be.

Because the exercise of professional responsibility characteristically draws on a body of specialized knowledge that is brought to bear on the promotion or preservation of another's welfare, to trust a person to fulfill a professional responsibility is to trust that professional to perform in a way that someone outside of the profession cannot entirely specify, predict, or often even recognize. The point is not captured in the frequent suggestion that trust is necessary because the trusting party cannot control or monitor the trusted party's performance. It would do the layperson little good to have full knowledge of the plans for a medical device or an experiment, or even the ability to guide the actions of the science and engineering professionals. Although laypeople might be able to recognize some acts of gross negligence, they would not know the implications of most of what they saw or how to improve the professional's performance. For this reason, from the point of view of the public, there are no good alternatives to having trustworthy professionals. In her 2001 Gifford Lectures, Onora O'Neill (2002) makes the same point that nothing can guarantee trustworthiness and emphasizes the burden that what she calls the *culture of suspicion* places on officials and professionals, such as medical researchers.

The question of whether scientists and engineers are responsible for the ultimate uses of the knowledge and technology they create is sometimes called the *end use question*. Caroline Whitbeck (1998) has argued that for scientists and engineers to be entrusted to prevent evil end uses of their products and discoveries those uses must be intended as well as foreseeable, because, for example, it would be impossible to forego the creation of all the many useful tools from hammers to pokers, to kitchen knives to hatchets that one can foresee can also be used as weapons.

It is arguably unreasonable to say that scientists and engineers are untrustworthy (more specifically, negligent), if they fail to consider *unforeseeable* uses and consequences. Indeed National Academy of Engineering President William Wulf (2004) draws attention to technological systems, such as computer systems, that are so complex that failures in them are inherently unpredictable, so it would not be possible for engineers to predict them. Criteria for trustworthy behavior or policies regarding such systems have yet to be settled.

The application of standards of professional responsibility in science and engineering is complicated by the fact that not all scientific and engineering professions have the same developed understanding of themselves as professions. Although U.S. engineering societies formulated ethical codes and guidelines from the early decades of the 1900s, attention to the professional responsibilities of research investigators has only received broad attention since the mid-1980s. However trust and trustworthiness became a central theme in those discussions in the 1990s (Whitbeck 2004). An international perspective provides even greater variation although the so-called Washington Accord, an agreement that recognizes equivalency of accredited engineering education programs in participating countries, is leading to more uniformity.

Trustworthy Policies

Some questions about the ethical implications of science and technology are policy questions, sometimes called *macro issues*. Although people can and do praise and blame particular individuals for formulating, adopting, implementing, or carrying out policies regarding science and technology, in a democracy these are societal decisions. Policy decisions run the gamut from decisions about what research and development should be given public support or even legally permitted, to what can be used as research material (for example, embryonic stem cells), to how and when to prevent or clean up toxic and nuclear contamination, to whether and how to control the social consequences of new technologies, such as privacy invasions on the Internet.

Typically such policy questions must be decided under conditions of significant uncertainty. Often the nature of the possible outcomes as well as the likelihood of various outcomes are unknown. Such uncertainties lead to misgivings about the pace of innovation and discovery. Technology is said to create new options, but technological advance also forecloses options. For example, after the introduction of the automobile, one could no longer choose to keep a horse and buggy in the city. Furthermore its consequences may contradict expectations. For example, historian Ruth Cowan (1983) found that household appliances did not reduce housework but raised the standards for that work. The relationship between science and technology and the societies in which they develop is extremely complex. Therefore the extent to which the frequent criticism of modern life in technologically developed societies is most properly directed at science and technology (or at least the pace of their development); at social factors, such as market forces affecting their development; or at human tendencies to use and abuse power in general is likely to continue to be disputed.

CAROLINE WHITBECK

SEE ALSO *Virtue Ethics*.

BIBLIOGRAPHY

Addelson, Kathryn. (1994). *Moral Passages: Notes toward a Collectivist Ethics*. New York: Routledge. Addelson presents a collectivist account of responsibility and ethics.

Baier, Annette. (1986). "Trust and Antitrust." *Ethics* 96: 232–260. Reprinted in Baier's *Moral Prejudices*. Cambridge, MA: Harvard University Press, 1994. Baier discusses the subject of trust and the curious neglect of this subject in most of moral philosophy. She gives an account of what it is to trust and a partial account of when it is immoral to expect or fulfill trust.

Barber, Bernard. (1983). *The Logic and Limits of Trust*. New Brunswick, NJ: Rutgers University Press. This work examines trust in various contexts including professional practice and business. As a sociologist, Barber delineates professions from non-professions in terms of their social status, rather than in terms of their claim to provide ethical guidelines for their practice.

Bok, Sissela. (1978). *Lying*. New York: Vintage Books. Bok addresses the subject of trust, one of the few philosophers to do so before Baier and provides a model of what was to become known as practical (as contrasted with "applied") ethics.

Cowan, Ruth Schwartz. (1983). *More Work for Mother: The Ironies of Household Technology from the Open Hearth to the Microwave*. New York: Basic Books. Cowan's history of household technology demonstrates supposed labor-saving household technology raised the standards for housework, rather than reducing the time spent performing it.

Hacking, Ian. (1984). "Winner Take Less: A Review of *The Evolution of Cooperation* by Robert Axelrod." *New York Review of Books*, June 28, pp. 17–21. Hacking praises *The Evolution of Cooperation* and criticizes twentieth-century modes of philosophizing that seeks to force-fit human life to logical models that fail to do justice to notions such as cooperation.

Ladd, John. (1979). "Legalism and Medical Ethics." In *Contemporary Issues in Biomedical Ethics*, ed. John W. Davis, Barry Hoffmaster, and Sarah Shorten. Clifton, NJ: Humana Press. Ladd here develops his philosophical position on the primacy of the notion of responsibility in practical ethics and the secondary status of rights and obligations/duties.

Luhmann, Niklas. (1979). *Trust and Power*. New York: John Wiley & Sons. Luhman's principle work on trust examines the relationship between trust and confidence and discusses the function of trust in human life.

O'Neill, Onora. (2002). *A Question of Trust: 2002 BBC Reith Lectures*. Cambridge, UK: Cambridge University Press. O'Neill examines what she regards as the current climate of suspicion and argues for a better appreciation of the evidence of trustworthiness.

Whitbeck, Caroline. (1998). *Ethics in Engineering Practice and Research*. NewYork: Cambridge University Press. Examines the notions of responsibility, trust, and trustworthiness in engineering and science.

Whitbeck, Caroline. (2004). "Trust and the Future of Research." *Physics Today* 57(11): 48–53.

Wulf, William A. (2004). "Keynote Address." In *Emerging Technologies and Ethical Issues in Engineering: Papers from a Workshop, October 14–15, 2003*. Washington, DC: National Academies Press. Wulf, President of the National Academy of Engineering, reviews the accomplishments of engineers in the twentieth century and their challenges in twenty-first century, including the moral and ethical responsibilities associated with the impact of engineering on society.

INTERNET RESOURCE

Washington Accord. Available from http://www.washingtonaccord.org. Internet site of the Washington Accord.

TURING, ALAN

Alan Mathison Turing (1912–1954), the founder of modern computer science and an important World War II cryptanalyst, was born in London on June 23. He died near Manchester, England, on June 7. His short life illustrates the ethical conflicts and ambiguities of scientific and technological aspirations.

Basic Creativity

Turing's early life was characterized by an intense enthusiasm for science that was only weakly supported by his upper-middle-class family. In 1931 he became an undergraduate at Cambridge University and read mathematics, demonstrating a rapidly emerging originality. At age twenty-four he settled an important problem in the foundations of mathematics, using a method that had much wider implications. Turing developed a precise way to characterize the concept of the "effectively calculable." This consisted of the "Turing machine," as the logician Alonzo Church immediately dubbed Turing's construction when reviewing it in 1937.

A Turing machine is an imaginary device with a finite number of possible configurations, a finite table of instructions for moving from one configuration to another, and the capacity to read, erase, and write a set of finitely many different symbols on a tape. With this structure Turing captured the idea of a finite mechanism, which he compared with the finite capacity of the human mind. By allowing unlimited space and time for working out the machine's operations, Turing was able to argue that such a device could encompass everything that could be achieved by a human calculator following a definite rule. Church endorsed Turing's argument that the concept of "effectively calculable" had been given a natural and convincing definition in terms of being computable by a Turing machine, a proposition now known as the Church-Turing thesis.

More recently there has been discussion of whether there could be, in the real universe or an imaginary one machines capable of operations beyond the scope of a Turing machine, and this debate has generated controversy about the correct interpretation of the Church-Turing thesis (Floridi 2003). At the time, however, Church simply characterized "computable" by reference to what could be done by any kind of machine of a finite size, and Turing similarly referred to that term as being synonymous with *mechanical*.

What is not in dispute is the fact that the Turing machine is still definitive as the foundation for computer science. By attacking an abstruse problem in the most rarefied and philosophical aspects of mathematics Turing arrived at the principle behind the dominant technology of the late twentieth century. Indeed, it was Turing who, seeing the practical potential of his ideas in 1945, was a leading designer and promoter of the electronic computer and its software.

However, this was possible only because of world events between 1938 and 1945 that gave Turing unique insight into practical computation and the promise of digital electronic technology. During the World War II Turing was the chief scientific figure in the successful British effort to decipher coded German communications, a project that became a joint Anglo-American operation after 1941. Turing's ingenious logical methods and theory of information measuring were used throughout the communications war, especially in the section he personally headed, which was responsible for reading U-boat signals.

By 1945 Turing thus possessed unrivaled theoretical and practical experience in the emergent field of information processing. He was disappointed by the practical progress of his plans at the National Physical Laboratory, the British government establishment to which he was appointed. He soon left to take up another, also disappointing, position at Manchester University. However, those short-term setbacks illustrated the fact that Turing's interest was never in the economic potential of computers but only in the long-term scientific question of what he called intelligent machinery, now usually referred to as artificial intelligence.

Alan Turing, 1912–1954. The British mathematician was noted for his contributions to mathematical logic and to the early theory, construction, and use of computers. *(Photo Researchers, Inc.)*

Is the computer in principle capable of rivaling human thought? That question was hinted at even in Turing's prewar references to human memory and states of mind but became much more prominent after 1945. In that period Turing went much further than he had in 1936, arguing that the computer could emulate all aspects of human thought, not merely those corresponding to a human being following a definite method. At that time he also spoke frequently about the physical basis of mental operations and informally described his work as "building a brain."

Contested Issues

A crucial element in Turing's argument is that the computer is a practical form of a universal machine that is capable of performing any algorithm. According to this argument, if the function of the brain can be described as any sort of definite process, in principle a computer can simulate it. It is not suggested that the architecture of the brain should resemble that of a digital computer. Another vital part of Turing's argument is that programs that modify themselves can be considered as learning from experience. He expected them to show the features of surprise and originality that characterize the apparently "nonmechanical" aspects of human thought. Turing's famous 1950 paper (reprinted in Boden 1990) introduced the "imitation game," now called the Turing test, in an attempt to make an objective comparison between computational and human processes.

Interest in these issues has never flagged. The arguments of Roger Penrose (1989) have supplied important new ingredients. It is noteworthy that the interpretation of Gödel's theorem and the quantum-mechanical nature of matter, which are central to Penrose's arguments, are also issues that Turing found important and difficult to address.

The Turing test for intelligence can be accused of having been set up to evade questions of consciousness and responsibility: It is the problem of mind made into a game perhaps in the way codebreaking made it possible to think of World War II as a fascinating and exciting but bloodless game. In real life Turing struck everyone as a person of great integrity, not as a superficial or insensitive person. However, he did not offer an ethical view in his writing on mind and machines. It was the same with the war in which he played so important a role: Turing never spoke about motivation or political allegiance, though his actions showed a strong commitment to the defeat of Nazi Germany. His moral speech was generally directed against anything "phony." In this he was like G. H. Hardy, the Cambridge champion of pure mathematics, but whereas Hardy hated war and rejoiced if his work was "useless" for it, Turing applied mathematics to more effect in war than perhaps anyone else ever had.

After 1950 Turing devoted himself mainly to a mathematical theory of biological growth and form, a quest roughly parallel with the elucidation of DNA. This time he stated a motivation: to defeat the religious "argument from design" and vindicate the power of scientific explanation. However, in 1952 Turing was arrested as a homosexual, and after the ensuing trial he was sentenced to receive injections of estrogen, which was the advanced "scientific" treatment of that period. Turing rose to the crisis with a staunch defense of his personal liberty and equality that has become a standard of European human rights but in his time was an isolated position. He was even more isolated because of his unique access to sensitive Anglo-American military secrets. At the height of Cold War paranoia in June 1954 Turing found his life impossible. He died by taking cyanide.

That period has been dramatized for the stage and television (Whitemore 1986) in scenes in which a fictional Turing gives speeches to an audience, but the real person left his life without a word about the major ethical conflicts he faced. Although Turing was a farsighted and original thinker on fundamental scientific questions and an extraordinary personality, in his silence and unwillingness to pontificate he bore witness to a particular view of scientific practice.

ANDREW P. HODGES

SEE ALSO *Artificial Intelligence; Computer Ethics; Turing Tests; von Neumann, John.*

BIBLIOGRAPHY

Boden, Margaret A. (1990). *The Philosophy of Artificial Intelligence*. Oxford, UK: Oxford University Press. Classic papers, beginning with Turing's.

Davis, Martin. (2000). *The Universal Computer: The Road from Leibniz to Turing*. New York: Norton. A vivid exposition of Turing's 1936 work as the culmination of symbolic logic.

Floridi, Luciano. (2003). *Blackwell Guide to the Philosophy of Computing and Information*. Oxford, UK: Blackwell.

Hardy, G. H. (1940). *A Mathematician's Apology*. Cambridge, UK: Cambridge University Press. A classic essay on the ethics of mathematics from Turing's Cambridge background.

Hodges, Andrew. (1983). *Alan Turing: The Enigma*. London: Burnett; New York: Simon & Schuster. New editions: London, Vintage 1992; New York, Walker 2000.

Penrose, Roger. (1989). *The Emperor's New Mind: Concerning Computers, Minds, and the Laws of Physics*. Oxford and New York: Oxford University Press. A serious challenge to Turing's theory of mind that shares Turing's materialist assumptions and base in mathematics.

Whitemore, Hugh. (1986). *Breaking the Code*. New York: Samuel French. A stage dramatization of Turing's life.

INTERNET RESOURCE

Hodges, Andrew. Alan Turing Website. Available at http:/www.turing.org.uk. Covers all aspects of Turing's life and work.

TURING TESTS

Turing tests are procedures to test the functional equivalence of people and computers. They generalize the thought experiment proposed by the British mathematician Alan M. Turing (1912–1954) in his pioneering 1950 paper, "Computer Machines and Intelligence," to answer the question, Can machines think?:

> [T]he "imitation game" . . . is played with three people, a man (A), a woman (B), and an interrogator (C) who may be of either sex. The interrogator stays in a room apart from the other two. The object of the game for the interrogator is to determine which of the other two is the man and which is the woman.
>
> In order that tones of voice may not help the interrogator the answers should be written, or better still, typewritten. The ideal arrangement is to have a teleprinter communicating between the two rooms.
>
> We now ask the question, "What will happen when a machine takes the part of A in this game?" Will the interrogator decide wrongly as often when the game is played like this as he does when the game is played between a man and a woman? These questions replace our original, "Can machines think?" (Turing 1950, pp. 433–434)

Turing's proposed test has been very influential in the philosophy of mind and cognitive science. Variations apply as well to some issues in the ethics of technology. Consider four cases.

A Moral Problem

First, Turing's original test had a moralizing aspect. A tricky game is needed to arrive at a fair test of human versus machine ability because humans are prejudiced against machine intelligence. Turing's blind test combats this prejudice. Note that in Turing's imitation game, computers serve two roles: as potential artificially intelligent interlocutor and as filtering media. This second role has become more significant with the spread of networked computer-mediated communication. As Turing noted, when people communicate only by typing, many cues drop out, and it is not immediately obvious who is male or female. Indeed, in a long-running Internet implementation based on Turing's original male–female game gender turns out to be very difficult to detect (Berman and Bruckman 2001). The spread of the Internet has made this filtering and uncertainty, which might be termed a "Turing effect" of computer-mediated communication, practically important. Its equalizing and liberating aspect is summed up by Peter Steiner's 1993 *New Yorker* cartoon caption: "On the Internet, nobody knows you're a dog." So too do age and rank in organizations drop away in chat rooms and e-mail, creating one of the moral risks of Internet anonymity: adults posing as children and vice versa. Indeed, the recent winners of the annual Loebner metals for best Turing test performance have been chatbots (Loebner Prize Internet site).

Machines with Moral Standing?

Second, and more speculatively, were a computer program to pass Turing's original test for intelligence, this success might have moral implications. For Roger Penrose, ownership of a device that passed the test "would involve us in *moral responsibilities* [because] to operate [such a] computer to satisfy our needs without regard to its sensibilities would be reprehensible." This could be morally equivalent to slavery. "Turning off the computer, or even perhaps selling it, when it might have become attached to us, would present us with moral difficulties" (Penrose 1989, p. 8). Of course, this argument assumes human-level intelligence sufficient for moral standing. A broader account of moral standing leads to an extension of Turing's test.

Third, there is the direct ethical extension of the Turing test. Instead of testing for intelligence, one could test for moral standing itself. Arguably, a computer program that could discuss ethically complex issues indistinguishably from a person should be granted moral standing (Allen, Varner, and Zinser 2000). Variations on this theme of testing for moral personhood via indistinguishability is common in science fiction. For example, in Ridley Scott's 1982 film *Blade Runner,* humans and computer-based "replicants" are indistinguishable by any nonphysical (invasive) Turing test.

Problems with Turing Tests

These Turing test applications disclose some of its problems: (a) The original version tests for communicative ability, but ethics (and perhaps intelligence) arguably requires the ability to *act* as well as to communicate. (b) Turing tests make playing a game (the imitation game) the criteria for intelligence or ethics, respectively. But the ability to deceive is neither necessary (think of naive but intelligent agents) nor sufficient (think of programmed con artists) for moral considerability. (c) More generally, experience with computers because Turing makes it obvious that people tend to overestimate the abilities of computer programs. Notwithstanding such problems, the Turing test remains ethically salient, invoking core moral ideals of fairness and the equivalence of the indistinguishable to challenge prejudice about the unique status of human abilities.

Human versus Machine: Chess

Fourth and again quite practically, there are indirect ethical questions about the human values challenged by machine performance of activities once thought to be open only to humans. The most noted example is the game of chess and the victories of IBM's Deep Blue computer system over grandmaster Gary Kasparov in 1996 and 1997. This can be considered, loosely, a real-world Turing test, whereby master level chess ceased to be a realm in which humans could be distinguishable from machines.

Predictably Deep Blue's success led to a strategic retreat, distinguishing easily (we say now!) mechanizable formal games such as chess from "really difficult" tasks embedded in thick human contexts. Subsequently the Internet search engine Google introduced automated news editing, and reviewers claimed that its editing service was indistinguishable from that of normal human editors. It remains open whether people will view these tests as raising the value of what machines can now do or lowering it. The initial reaction to Deep Blue's victory suggests the latter.

PETER DANIELSON

SEE ALSO *Artificial Intelligence; Robots and Robotics; Turing, Alan.*

BIBLIOGRAPHY

Allen, Colin; Gary Varner; and Jason Zinser. (2000). "Prolegomena to Any Future Artificial Moral Agent." *Journal of Experimental and Theoretical Artificial Intelligence* 12(3): 251–261. Thorough consideration of ethical aspects of the Turing Test.

Berman, Joshua, and Amy Bruckman. (2001). "The Turing Game: Exploring Identity in an Online Environment." *Convergence* 7(3): 83–102. Reports on a research platform for experimenting with online Turing Tests.

Millican, P & A. Clark, eds. (1996). *Machines and Thought: The Legacy of Alan Turing*. Oxford, UK: Clarendon Press. A collection of leading articles on the Turing Test emphasizing cognitive science and philosophy of mind.

Penrose, Roger. (1989). *The Emperor's New Mind: Concerning Computers, Minds, and the Laws of Physics*. Oxford: Oxford University Press. A well-known scientist considers one ethical aspect of the Turing Test.

Turing, Alan M. (1950). "Computing Machinery and Intelligence." *Mind* 59: 433–460. Turing's original article. See also under Internet Resources below.

INTERNET RESOURCES

The Loebner Prize. Available at http://www.loebner.net/Prizef/loebner-prize.html.

Turning, Alan M. (1950). "Computing Machinery and Intelligence." Available from http://www.loebner.net/Prizef/TuringArticle.html. Online reproduction of Turning's original article.

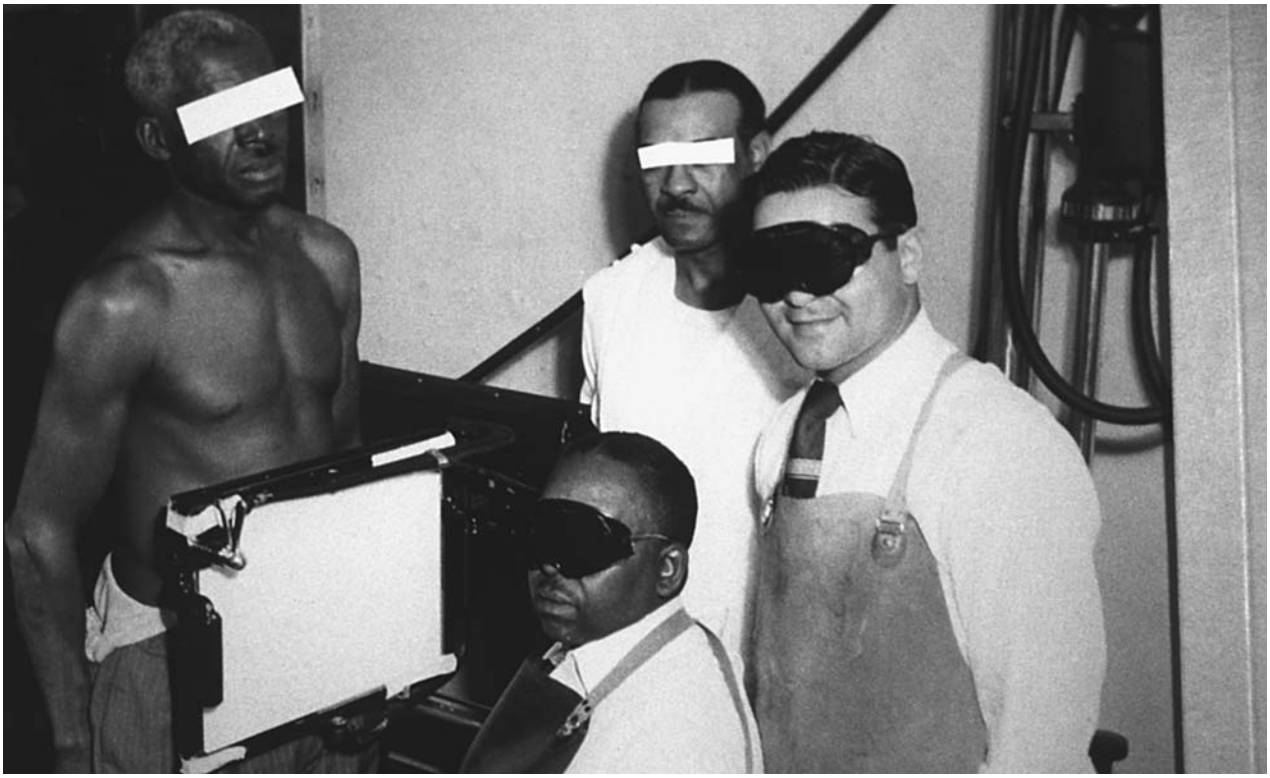
The Turning Test Page. Available from http://cogsci.ucsd.edu/~asaygin/tt/ttest.html#onlineref. Contains links to many Turning Test papers.

TUSKEGEE EXPERIMENT

From 1932 to 1972 the U.S. Public Health Service (PHS) tracked the nonmedicated course of syphilis, a disease that is caused by the bacterium *Treponema palladium*, among 399 patients and 201 controls at Tuskegee Institute (now Tuskegee University). In the region around Tuskegee in Macon County, Alabama, the PHS, in conjunction with the county health department and the Rosenwald Foundation, initially began a survey and small treatment program for African-Americans with syphilis.

The study goals and research methods soon shifted in response to financial limitations, and the project became the longest nontherapeutic observational study on human beings in medical history, manifesting major violations of basic human rights and ethical precepts. The legacy of government-sanctioned refusal to treat syphilis continues to influence the reluctance of African-Americans and other ethnic minorities to participate in government-funded clinical trials, contribute to organ and tissue donation campaigns, support biomedical research initiatives, and be involved in routine preventive medical care programs.

Throughout forty years of untreated observations infected poor rural African-American men intentionally were denied effective therapy as their disease progressed. Indeed, the premise of the study entailed nontreatment until the participating men died and could be autopsied to document the effects of syphilis on their tissues and organs. U.S. government health professionals withheld the standard treatment for syphilis in the early years of the project, injections of arsenic-based salvarsan and



Doctors taking an x-ray of a Tuskegee subject. *(© Corbis Sygma.)*

topical applications of mercury or bismuth ointments; study participants never received clear advice about their disease state. When penicillin became the therapeutic agent of choice, study participants continued to be denied access to this known cure and their unremediated infections progressed.

Ongoing participation in the study by the men and their families was secured through the deception that they were receiving valuable medical care. Although the PHS provided the bulk of the medical personnel for this study, participant's primary contact throughout the years was with the Tuskegee-trained, PHS employed African-American nurse.

Permission for the study was obtained from key officials, including the U.S. surgeon general, the president of Tuskegee Institute, the medical director of Tuskegee Institute's John A. Andrew Hospital, and public health officials of Macon County. However, at no point were the basic human rights of the study participants protected. There was no voluntary, informed consent of the men under study and no opportunity to end the experiment at will, and the participants continued to be deceived throughout the study. The project, often called America's Nuremberg, reflected the convergence of scientific insensitivity and arrogance, racial injustice and dehumanization, and socioeconomic class–based duplicity in the victimization of the study participants.

Target participants in the study were syphilitic African-American men in the later stages of the disease. In these less contagious stages untreated syphilis still causes serious cardiovascular abnormalities, neurological disorders, blindness, and death in infected individuals. Lack of treatment through participation in the study caused 28 to 100 men to die, and it has been estimated that the withholding of medical care adversely affected 22 wives, 17 children, and 2 grandchildren who subsequently contracted syphilis. The impact of intentional nontreatment of the men who were studied on rates of offspring miscarriages, stillbirths, infant mortality, and infants born with serious syphilis-related mental and physical problems remains unknown. Additionally, the degree of infertility among women sexually affiliated with the study's untreated syphilitic men has not been quantified.

The study was continued at a time when Jim Crow racism and segregation dominated interethnic interactions in the American South and when patients with sexually transmitted diseases faced social and medical discrimination. In the United States syphilis was both a medical problem and a metaphor for immorality and indecency. The PHS study focused on a nonrepresentative cohort of poor, uneducated African-American men residing in a remote location. Their selection was compatible with the emergence of U.S. eugenic programs.

Syphilis historically had been a significant social scourge in much of the Western world; the development of effective treatments for treponemal disease increased public confidence in the capacity of science to develop innovative technological solutions for persistent social problems and suggested that this dreaded sexually transmitted disease could become rare. Tracking its natural history in an expendable group was for some people a "tolerable" breach of ethics.

The government study was exposed publicly in 1972. In 1997 U.S. President Bill Clinton apologized on behalf of the nation to the few surviving victims. Ten million dollars in lawsuit-generated reparations was distributed among six hundred study participants and their descendants in partial compensation for their suffering.

FATIMAH L.C. JACKSON

SEE ALSO *Human Rights; Race; Sociological Ethics.*

BIBLIOGRAPHY

Jones, James H. (1993 [1981]). *Bad Blood: The Tuskegee Syphilis Experiment.* New York: Simon and Schuster.

TWO CULTURES

The term *two cultures* refers to a failure of scientists and humanists to comprehend the content, nature, and implications of each other's intellectual activities. An issue that goes back at least to the rise of modern science as a distinct practice and the romantic criticism of some of the results of the scientific worldview, it received international attention when Charles Percy Snow (1905–1980) considered the breakdown in a 1959 lecture, "The Two Cultures and the Scientific Revolution."

Snow, who had experience as a novelist and a scientist, coined the phrase to deplore a widening *gulf of mutual incomprehension* between *literary intellectuals* and natural scientists. The division between cultures represented a dilemma over the role of science and technology in human affairs and led to the failure to address the three *menaces* of nuclear weapons, overpopulation, and the gap between rich and poor. Although he recommended broadening education for both groups, Snow ultimately implied that solving these problems simply required more science and technology. Accordingly Snow accused literary intellectuals of being anti-scientific: While scientists held *the future in their bones,* the literati (whose ideas, Snow believed, unduly influenced western policy makers) were *natural Luddites.*

Critics, notably Frank R. Leavis, criticized Snow for being anti-cultural: In reducing humanistic knowledge to the equivalent of factual information, Snow undermined the capacity for *reflexive* ethical inquiry. In "A Second Look" (1964), Snow acknowledged that his phrase ignored the emergence of a *third culture* of social scientists that studied *the human effects of the scientific revolution.* Snow's phrase, imprecise in excluding *third* groups and in reducing *culture* to a set of conditioned responses, nevertheless calls attention to the problem of specialization and the disagreements about the proper function of science and technology that have persisted to this day.

Exchanges such as the *science wars* demonstrate that in many respects intellectual chasms have only continued to widen. Moreover, public policy debates over the relations among science funding, technology development, and the common good are often indicative of clashing worldviews reminiscent of Snow's two cultures. Within academe, most often in engineering and science curricula, occasional multidisciplinary and interdisciplinary programs do allow students to analyze and even synthesize humanistic and scientific paradigms; these offset to some extent the trends of increased specialization and balkanization. Public science agencies have likewise paid increasing attention to the ethical and societal implications of their research and development activities.

Efforts to integrate the two cultures can potentially balance technological goals with humanistic ones, but they can also be superficial and even counter-productive if they treat humanistic contributions as afterthoughts. Moreover the problem is not simply one of social groups; engineers, for example, tend to be the main advocates of appropriate technology. The gap, however, will continue to widen as specialized knowledge continues to be valued over broader, more integral understanding. A modern educational grounding in the fundamental concepts and practices of technical and humanistic traditions would be ideal. At the very least, interdisciplinary efforts that critically engage values and assumptions on both sides are indispensable if there is to be communication, understanding, and collaboration across the various intellectual divides.

ERIK FISHER

SEE ALSO *Governance of Science; Interdisciplinarity; Science Policy.*

BIBLIOGRAPHY

Brockman, John, ed. (1995). *The Third Culture*. New York: Simon and Schuster.

Leavis, Frank R. (1963). *Two Cultures? The Significance of C. P. Snow*. New York: Pantheon. Leavis, a literary critic, maintains the primacy of the humanities, not science; contains "An Essay" by Michael Yudkin.

Snow, Charles P. (1998). *The Two Cultures*. Cambridge, UK: Cambridge University Press. This reprint includes Snow's original lecture "The Two Cultures and the Scientific Revolution" (1959) and his "Second Look" (1964); the introduction by Stefan Collini presents the Snow-Leavis debate in light of precursors such as that between T. H. Huxley and Matthew Arnold.

U

UNCERTAINTY

The privative concept of uncertainty is more important in science, technology, and ethics than its positive root, certainty. (There is no entry in the encyclopedia on certainty.) This is the case for two reasons: Uncertainty is more common than certainty, and the implications of uncertainty for human action are more problematic than certainty. Uncertainty in science or engineering appears to call for an ethical assessment; uncertainty in ethics is a cause for moral concern. Nevertheless before discussing uncertainty, it is useful to begin with some considerations of certainty, the positive notion from which it is derived.

Certainty and Uncertainty in History

Concern for certainty as a distinct issue emerges at the same time as modern natural science. In premodern philosophy and science, it is difficult to find any term or concept that is strictly analogous. The Latin *certus,* the etymological root of certainty, is from the verb *cernere,* meaning to decide or determine; the Greek cognate *krinein* means to separate, pick out, decide, or judge. This sense remains in English when speaking of *a certain X,* indicating one item picked out from a group.

The concept of certainty in something approaching the modern sense is first given extended analysis in relation to religious faith. Faith, according to Augustine, is more certain than other forms of knowledge. Thomas Aquinas replies (*Quaestiones disputatae de veritate,* q. 14) that faith is psychologically but not epistemologically more certain than knowledge. Falling between knowledge and opinion in its degree of certainty, faith is defined as "an act of the intellect assenting to divine truth at the command of the will moved by the grace of God" (*Summa theologiae* II-II, q. 1). Moreover the certainty of faith provides a basis for moral judgment that is more secure than any provided by natural knowledge. Through faith, ethics takes on obligations of a stronger character than would otherwise be possible.

From theology, certainty becomes an issue for science when philosophers such as Francis Bacon and René Descartes argue for seeking cognitive certainty not through faith but through new methodologies. As interpreted by John Dewey in *The Quest for Certainty* (1929), "The quest for certainty is a quest for peace which is assured, an object which is unqualified by risk and the shadow of fear that action casts" (Dewey, p. 7). But the effort to secure such certainty and security that was originally undertaken through religious acceptance or propitiation of the gods is, in the early twenty-first century, commonly sought by means of technology and science. Extending Dewey, it is noteworthy that significant worries about lacks of certainty only became prominent as the new methods began to succeed so as to raise expectations of still further achievement. Thus has the pursuit of certainty through science and technology acquired a sense of ethical obligation.

The quest for certainty implies the presence of uncertainty, so that although this could not have been said prior to the modern period, it is now common to describe all human action as taken in the context of uncertainty. Insofar as this is the case, uncertainty is a locus of ethical discourse and conflict. Yet there are two forms of uncertainty in the modern sense that are most basic. Although often thought of as incomplete knowledge and applied to propositions, uncertainty can also be a psychological state. This distinction is important because perceived uncertainties may or may not reflect the actual state of incompleteness in knowledge. Perceptions of uncertainty may themselves be uncertain.

Uncertainty in Science

Characterizing and quantifying uncertainty is a core activity of science. Uncertainty emerges from research methodologies themselves, from the inherent characteristics of the processes and phenomena being studied, from incomplete or imperfect understanding, and from the contexts within which human beings seek to understand their surroundings. These sources of uncertainty may be understood, but they can never be eliminated. Uncertainty is always present to some degree in scientific knowledge, and in our formal knowledge of the world. This phenomenon is most famously embodied in Heisenberg's Uncertainty Principle, which states that the location and momentum of subatomic particles—the fundamental components of existence—can never simultaneously be known with complete accuracy.

Uncertainty is conceptually and practically distinct from fallibilism, or the notion that all scientific knowledge may turn out to be false. While both uncertainty and fallibility are attributes of knowledge, uncertainty refers to the accuracy of knowledge; fallibility to the provisional nature of knowledge. As Heisenberg's Uncertainty Principle illustrates, even if some knowledge (in this case, the uncertainty principle itself) were not provisional, uncertainty would still exist.

If, by contrast, the world were largely deterministic—that is, if its behavior could be explained through comprehensible and invariant cause and effect relations—then uncertainty could be eliminated, at least in theory. In practice, determinism can be approximated in some important human activities. Engineered systems, for example, can be designed as closed systems whose functional behavior is dictated by well-tested, scientific laws (laws of gravity, thermodynamics, and more), tested in laboratories, and supported by experience. Thus, for example, a bridge, or electronic circuit, or nuclear reactor, may operate with high reliability for decades. Eventually, however, the apparently closed system is breached—by corrosion, contamination, earthquake, or terrorism, among others—and the behavior of the system can no longer be thought of as deterministic or certain. The embeddedness of all engineered systems in larger social and natural systems dictates that uncertainty will eventually be introduced into engineering.

Uncertainties can be known with accuracy in closed systems that display random, or aleatory, behavior. Once the laws governing such system behavior are well elucidated, aleatory uncertainties cannot be further reduced. The obvious example is a game of dice or cards, where probabilities of particular outcomes can be determined from relatively simple statistical methods due to the known behavior of six-sided dice or fifty-two-card decks. Random behavior, and thus aleatory uncertainty, also exists in nature (for example, radioactive decay, Brownian motion), and can be approximated by some living systems (such as growth of bacteria in a medium) over limited periods of time, and often described by simple mathematical relations. Aleatory uncertainty is a property of random behavior in closed systems; it is inherent in the system itself.

For open systems whose governing laws cannot be fully elucidated, which includes all social and many technological and natural systems, uncertainty is said to be epistemic—a consequence of incomplete knowledge about cause-and-effect relations. In such cases—that is, most of the real world—uncertainty is a characteristic of both the system itself, and the psychological state of those who are assessing the uncertainty. Most problems at the interface of science, uncertainty, and ethics, are problems of epistemic uncertainty.

Epistemic uncertainties are most typically measured and expressed in probabilistic terms. Probabilities may be determined through frequentist approaches based on statistical analysis of past events or phenomena, or through subjectivist approaches, such as eliciting expert opinions, or surveying the scientific literature on a given subject. It is important to keep in mind that probability distributions derived from subjectivist approaches are distributions of beliefs about events, not of actual event occurrences.

Epistemic uncertainties also may be expressed in qualitative terms (such as *likely*, *unlikely*, and *doubtful*), or nonprobabilistically as ranges in values (for example, as error bars on a graph). Quantitative, nonprobabilistic uncertainties can also be derived from a comparison of the differences among outputs from different mathematical models ("model uncertainty").

Uncertainty in some complex systems or problems can be successfully addressed with frequentist approaches, because observational experience is sufficient to allow rigorous statistical treatment. Insurance companies, for example, set premiums using population-based data on life expectancy, morbidity, and frequency of auto accidents, among others. Engineers use data from tests and historical performance to estimate probabilities of failures in technological systems. Weather forecasts take advantage of a long history of careful observation of meteorological events. In such cases, uncertainty estimates can be refined and sometimes reduced on the basis of ongoing experience. It is important to recognize, however, that frequentist estimates of uncertainty are not necessarily accurate indicators of future probabilities, because in open systems, past behavior, however well documented, does not necessarily foretell future behavior. For example, 100-year flood levels, which are based on historical records and used in the United States for planning and insurance purposes, derive from the false assumption that climate behavior does not vary on time scales of more than a century (Pielke 1999).

Contextual Origins of Uncertainty

Uncertainty is a crucial concept in human affairs because knowledge of the future is always imperfect, and decisions are therefore always made in the face of uncertainty about their outcomes. From this perspective, the word uncertainty refers most generally to the disparity between what is known and what *actually is* or *will be*. Uncertainty, that is, reflects an incomplete and imperfect characterization of current conditions relevant to a decision, and the incomplete and imperfect knowledge of the future consequences of the decision. Logically, then, one way to improve the success of a decision should be to characterize, and if possible reduce, the uncertainty relevant to that decision, and considerable resources in science are devoted to this task. But significant obstacles stand in the way of this goal.

Many, perhaps most, of the important decisions faced by society have one or more of the following attributes: (1) the problem cannot be characterized in terms of easily measured outcomes in a well-defined population; (2) sufficient or relevant historical data are not available to allow frequentist approaches; (3) the dynamics of system behavior are incompletely and imperfectly understood; (4) the system is open; (5) numerous disciplines can contribute relevant understanding; and (6) different interests or values define the problem in different ways. For these reasons, most uncertainties in human affairs are epistemic, and most must be assessed through subjectivist methods. In all such cases, estimates of uncertainty are themselves both uncertain and strongly conditioned by the social context within which they are generated and used.

Less uncertainty can be an attribute of less knowledge. Continual research into and experience with complex, open systems should be expected to reveal new questions and new intricacies that may add to uncertainty over time. New knowledge does not necessarily translate into a greater ability to make well-constrained statements about cause-and-effect relations relevant to human decisions. The archetypal example of this phenomenon is the climate change controversy, where ongoing research into the operations of the earth system and its interactions with human activities is continually introducing new variables and parameters, new appreciation of existing complexities, and new areas of scientific disagreement. While the observation of global warming is robust, and the rising impact of climate on society well documented, continued investigation into the causal relations between these two observations yields an ever expanding array of possible causal agents, and growing intricacy in the relations among agents.

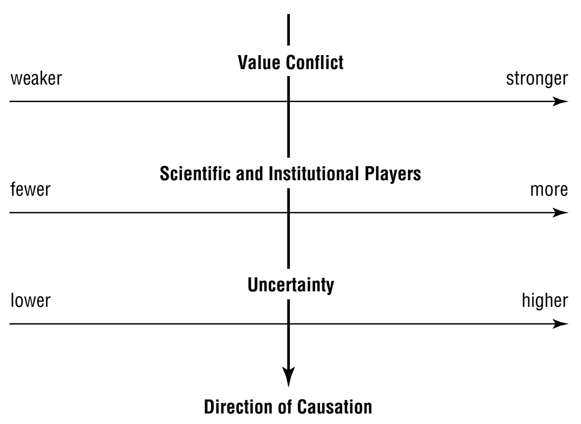
A conventional view of this problem describes a *cascade of uncertainty*, where the more modest uncertainties embodied in the understanding of relatively simple systems or phenomena are introduced into and magnified at the next level of complexity, which in turn introduces its own, perhaps greater, uncertainties (Schneider and Kuntz-Duriseti 2002). The importance of this notion lies especially in the fact that simpler systems are generally farther away from real world problems. Thus it is hard enough to understand and reduce the uncertainties surrounding greenhouse gas behavior in the atmosphere, but if the concern is the impacts of those gases on society via changes in regional climate, then uncertainties cascade beyond comprehension or control.

This view of the problem locates uncertainty in the complexity of natural and social systems being studied, but uncertainty also arises from the conduct of these studies. Science is not a unitary activity; multiple disciplinary approaches often yield multiple perspectives that do not fit together to yield a seamless picture of nature, but rather create multiple and sometimes even conflicting pictures (Dupré 1993). For example, plant geneticists and those in related fields commonly evince greater certainty than ecologists that genetically modified crops will be beneficial to humanity and the environment. These differences derive in part from different ways of understanding nature. Plant geneticists, employing reductionist approaches to crop engineering, are thus confident about their ability to control crop behavior. Ecologists, in contrast, study complex systems where small variations in conditions are often seen to have large and unpredictable impacts.

Lying beneath these epistemological differences are likely to be ethical tensions between one worldview where control of nature yields human benefit and another where pretensions to control can be futile and dangerous. For complex issues where relevant knowledge comes from multiple disciplines, estimates of

FIGURE 1

Political Origins of Uncertainty



SOURCE: Courtesy of Daniel Sarewitz.

uncertainty may thus partly be a reflection of competing disciplinary perspectives, and the ethical commitments entailed in those perspectives. These relations are likely to be reinforced by behavioral attributes of scientists. In particular, experts typically underestimate uncertainty in their own area of expertise (Kahneman et al. 1982) while locating the sources of uncertainty in disciplines other than their own (Pinch 1981).

Uncertainty estimates may strongly reflect institutional and political context. Consider, for example, that the U.S. National Aeronautics and Space Administration (NASA) initially estimated the reliability of its space shuttle fleet at 0.9997, or one failure every 3,333 launches (Pielke 1993). Since then two shuttles out of 112 total launches have self-destructed during flight, yielding a historical reliability of 0.98—thirty times less than the initial estimate. High certainty about shuttle reliability could exist when experience with shuttle flights was small, and knowledge was limited. Yet high certainty was also consistent with the political interests of NASA, and with the institutional incentives in the agency, which rewarded launching shuttles, not grounding them. Another illustration comes from medical science, where a number of studies have shown that clinical trials directly or indirectly supported by pharmaceutical companies often yield more favorable assessments of new therapies—greater certainty about positive results—than trials that are not tied to the private sector in any way (Angell 2000). The point here is not that scientists are engaging in fraudulent research in an effort to bolster desired conclusions, but experimental design and interpretation of data are partly matters of judgment, and judgment may be influenced by the incentives, priorities, and culture of one's work environment.

Additional examples from such areas as climate change science (van der Sluijs et al. 1998), earthquake prediction (Nigg 2000), oil and gas reserve estimates (Gautier 2000), and nuclear waste disposal (Metlay 2000) show that uncertainty estimates are strongly dependent on institutional and political context, and that opening up the research process to additional scientific and institutional perspectives often leads to significant changes in perceived uncertainty.

Uncertainty and Values

Important decisions in human affairs create winners and losers relative to the status quo ante, and thus implicate competing interests and values. In areas of decision making that include a significant scientific component, such as the environment, public health, and technological risk, uncertainty provides the space for disputes between competing interests and values to play out, because those who hold contesting positions can make conflicting or disparate science-based claims about the consequences of particular courses of action. Thus, for example, supporters of genetically modified foods can point to the potential for gains in crop productivity, and opponents can point to the threat of diminished crop genetic diversity. This is a self-reinforcing process: As value disputes grow more heated, they bring out the latent uncertainties associated with a problem or decision by expanding the realm of phenomena, disciplinary perspectives, and institutional and political players relevant to the problem. These relations are schematically illustrated in Figure 1.

So long as uncertainty is understood simply in terms of the incomplete but ever-improving knowledge of the world, reduction of uncertainty will be prescribed as a path toward resolving political disputes. But when uncertainty is also recognized as an outgrowth of the contexts within which scientific inquiry is structured and carried out, the path begins to look Sisyphean. Indeed the contextual diversity of science is the manifestation of, not the solution to, the conflicting values that underlie political debate. These observations suggest that the taming of uncertainty must depend not on the capacity of science to characterize and reduce uncertainty, but on the capacity of political processes to successfully resolve value disputes that underlie the choices that humans face.

DANIEL SAREWITZ
CARL MITCHAM

SEE ALSO *Precautionary Principle; Reliability of Technology: Risk; Technical and Social Dimensions; Unintended Consequences.*

BIBLIOGRAPHY

Angell, Marcia. (2000). "Is Academic Medicine for Sale?" *New England Journal of Medicine* 342: 1516–1518. How interests and uncertainty interact in clinical medicine.

Dewey, John. (1984). *John Dewey: The Later Works, 1925–1953;* vol. 4: (1929) *The Quest for Certainty: A Study of the Relation of Knowledge and Action*. Carbondale: Southern Illinois University Press.

Dupré, John. (1993). *The Disorder of Things: Metaphysical Foundations of the Disunity of Science*. Cambridge, MA: Harvard University Press. Why science does not provide a unified explanation of nature.

Gautier, Donald L. (2000). "Oil and Gas Resource Appraisal: Diminishing Reserves, Increasing Supplies." In *Prediction: Science, Decision Making, and the Future of Nature*, eds. Daniel Sarewitz; Roger Pielke Jr.; and Radford Byerly Jr. Covelo, CA: Island Press. Uncertainty and predictions of hydrocarbon reserves.

Kahneman, Daniel; Paul Slovic; and Amos Tversky. (1982). *Judgment under Uncertainty: Heuristics and Biases*. New York: Cambridge University Press. Classic treatment of uncertainty and human decision making.

Metlay, Daniel. (2000). "From Tin Roof to Torn Wet Blanket: Predicting and Observing Groundwater Movement at a Proposed Nuclear Waste Site." In *Prediction: Science, Decision Making, and the Future of Nature*, eds. Daniel Sarewitz; Roger Pielke Jr.; and Radford Byerly Jr. Covelo, CA: Island Press. Uncertainty and nuclear waste storage.

Nigg, Joanne. (2000). "Predicting Earthquakes: Science, Pseudoscience, and Public Policy Paradox." In *Prediction: Science, Decision Making, and the Future of Nature*, eds. Daniel Sarewitz; Roger Pielke Jr.; and Radford Byerly, Jr. Covelo, CA: Island Press. Uncertainty and earthquake prediction.

Pielke, Roger A., Jr. (1993). "A Reappraisal of the Space Shuttle Program." *Space Policy* 9: 33–157.

Pielke, Roger A., Jr. (1999). "Nine Fallacies of Floods." *Climatic Change* 42: 413–438. How misunderstanding uncertainty can lead to flawed public policies.

Pinch, Trevor J. (1981). "The Sun-Set: The Presentation of Certainty in Scientific Life." *Social Studies of Science* 11: 131–158. How scientists perceive uncertainty.

Schneider, Stephen H., and Kristin Kuntz-Duriseti. (2002). "Uncertainty and Climate Change Policy." In *Climate Change Policy: A Survey*, eds. Stephen H. Schneider; Armin Rosencranz; and John O. Niles. Washington, DC: Island Press. Natural science perspective on uncertainty in climate change science.

van der Sluijs, Jeroen; Josee van Eijndhoven; Simon Shackley; and Brian Wynne. (1998). "Anchoring Devices in Science for Policy: The Case of Consensus around Climate Sensitivity." *Social Studies of Science* 28(2): 291–323. Social science perspective on uncertainty in climate change science.

UNINTENDED CONSEQUENCES

Human activities often produce consequences very different from those intended. Indeed this is a theme of classical tragedy and much premodern argument about the indeterminacy of human affairs. Sociologist Robert K. Merton was one of the first to subject "The Unanticipated Consequences of Purposeful Action" (1936) to systematic analysis, noting the influences of the need to act in spite of uncertainties, the allocation of scarce resources such as time and energy, and how personal interests shape perspectives and decisions. Advances in science and technology seem particularly likely to change the world in unanticipated ways. Innovations are by definition something new and are likely to involve unknowns. Innovations may be used in unplanned ways that trigger surprising results. The more complex a system, the harder it is to anticipate its effects. Unintended consequences can shift the cost-benefit analysis of a new technology, theory, or policy; distribute costs and benefits inequitably; or lead to other direct or indirect social problems. Such consequences raise questions of responsibility and liability; decision making under uncertainty; equity and justice; and the role of individual citizens, corporations, universities, and governments in managing science and technology.

Types of Unintended Consequences

Unintended consequences occur in many forms, although the categories are neither entirely discrete nor universally recognized. *Accidents* are usually immediate and obvious, and result from problems such as mechanical failure or human error, such as the disastrous 1986 explosions, fires, and releases of radiation at the nuclear rector in Chernobyl, Russia.

Side effects are additional, unanticipated effects that occur along with intended effects, such as gastrointestinal irritation resulting from aspirin taken to relieve pain. *Double effects*, meaning simply two effects, often refer to simultaneous positive and negative effects, as in the aspirin example. Many medical side effects are well documented, such as the devastating effects of diethylstilbestrol (DES) and thalidomide and the ability of bacteria to develop resistance to antibiotics (Dutton et al. 1988).

Surprises could apply to any unintended consequence, but the term is more specifically used, along with *false alarms*, to describe errors in prediction. A false alarm is when a predicted event fails to occur, such as the millennium computer bug, whereas a surprise is an unexpected event, such as the 2004 Indian Ocean tsunami (Stewart 2000).

Henry N. Pollack (2003) refers to *inadvertent experiments,* in which human actions unwittingly allow and sometimes force society to consider the effects of its actions. He cites the hole in the ozone layer and climate change as classic examples. Historians of science and technology also have noted the occasional benefits of *serendipity* in both discovery and invention.

More provocatively science and technology sometimes have the reverse of their intended effects. In the 1970s Ivan Illich (1973) among others argued that scientific and technological development, after crossing a certain threshold, may exhibit a counterproductivity, producing new problems even as it solves old ones. Extending this notion into political theory, Ulrich Beck (1986) argues that unintended consequences in the form of *boomerang effects* are transforming politics into a concern for the just distribution not of goods but of risks.

With a more individualist focus, Edward Tenner identifies *revenge effects* as the "ironic unintended consequences of mechanical, chemical, biological, and medical ingenuity" or, more anthropomorphically, as "the tendency of the world around us to get even, to twist our cleverness against us" (Tenner 1997, p. 6). He further divides revenge effects into *rearranging effects,* that shift the locus or nature of a problem, such as urban air-conditioning making the outside air hotter; *repeating effects,* that have people "doing the thing more often rather than gaining time to do other things"; *recomplicating effects* such as the annoying loops of voice mail systems; *regenerating effects,* in which a proposed solution such as pest control makes a situation worse; and *recongesting effects,* such as the human ability to clog space with debris from space explorations (Tenner 1997, p. 10).

Direct effects are those that occur fairly quickly, with no intervening factors. *Indirect effects* are likely to take longer to develop and may involve interactions with other factors; *latent side effects* also refer to impacts that occur later in time. *Secondary effects* are the next level of impacts resulting from direct effects; they generally impact people or places other than those a product or activity is intended to affect; these may also be called *ripple effects*. The secondary effects of smoking on nonsmokers have been well documented. *N-order effects* are even more removed from the direct effects. *Cumulative effects* are additive. Combinations of substances, particularly pesticides or medicines, are sometimes called *cocktail effects*, especially in the United Kingdom. *Interaction effects* are those resulting from a combination of two or more factors that act on or influence each other to produce a result different from either acting alone.

The military uses the term *collateral damage* to describe injuries to people and property other than intended targets, such as the destruction of the Chinese Embassy during the 1999 North Atlantic Treaty Organization (NATO) bombing campaign in Yugoslavia. Civilian casualties are often framed as collateral damage because ethical principles of noncombatant immunity proscribe the deliberate injury of civilians.

Economists often refer to unintended consequences as *externalities,* "An action by either a producer or a consumer that affects other producers or consumers, yet is not accounted for in the market price" (Pindyck and Rubinfeld 1998, p. 696). Pollution is usually considered an externality, as its effects on human health, safety, and quality of life are often not factored into industrial costs. Externalities may require management such as government imposed regulations, subsidies, or market-based mechanisms to prevent economic inefficiencies. Externalities such as pollution or hazardous wastes often impose unequal burdens on the poor or powerless, raising questions about equity and environmental justice.

Unintended consequences are different from *unanticipated consequences,* in which effects may be suspected or known to be likely but are not part of the intended outcome. Some anticipated consequences may be ignored if they interfere with the interests of decision makers or seem relatively minor; cumulative or interactive effects may make them more serious. Knowledge about effects, or effects that should have been anticipated, may be important in deciding who, if anyone, should be held legally, politically, or morally responsible for unintended outcomes.

Causes and Effects

Unintended consequences of science and technology can have many causes. Design flaws may lead to project failure. Materials may not meet expectations. Assumptions may prove incorrect.

Human factors frequently trigger unintended consequences. Human errors, sometimes interacting with technical failures and environmental stresses, often cause accidents, such as the 1984 release of poisonous gas from Union Carbide's pesticide plant in Bhopal, India (Jasanoff 1994). People often use science and technology in unexpected ways. What appears to be operator error may be the result of an overly complex or inherently unsafe technology. Additionally safety measures such as seat belts sometimes may actually increase hazards as people compensate by taking more risks, illustrating a phenomenon known as *risk homeostasis*.

Unintended consequences may have social, economic, or behavioral as well as physical causes and impacts, especially when transferred from one culture to another. Anthropologists, for instance, have well documented the often unintentionally destructive outcomes of technology transfer across cultures (Spicer 1952). The movie *The Gods Must Be Crazy* (1981) depicts a comic version of this phenomenon. Effects may be catastrophic, even when the transfer is only from laboratory to market place.

Richard A. Posner (2004), for instance, distinguishes four types of catastrophe, all but one resulting from the unintended consequences of science and technology. The exception is a natural catastrophe. The other categories are accidents from the products of science and technology, such as particle accelerators or nanotechnology; unintended side effects of human uses of technology, such as global climate change; and the deliberate triggering of destruction made possible by dangerous innovations in science and technology, which can be considered technological terrorism. Posner also notes "the tendency of technological advance to outpace the social control of technology" (Posner 2004, p. 20), an instance of cultural lag.

Not all unintended consequences are bad; many innovations have beneficial side effects, and effects can be mixed. For example, 2004 studies on some pain relievers, such as Vioxx or Celebrex, suggest that they may reduce cancer risks while enhancing risks of heart attacks. From the perspective of social scientist Michel de Certeau creative, unintended uses may actually serve as a means for the assertion of human autonomy; using products in ways unintended by the designer is a way of resisting technological determination. Some writers see occasional benefits even in negative unintended consequences. Fikret Berkes and Carl Folke suggest that in some cases, "breakdown may be a necessary condition to provide the understanding for system change," although crisis cannot be allowed to reach the point where it imperils the survival of the system (Berkes and Folke 1998, p. 350). Complexity theorists have even argued the emergence of new forms of spontaneous order from unintended chaotic situations.

Managing Unintended Consequences

How should unintended consequences be managed? Some impacts may be avoided with more careful planning in the design and implementation of innovations, but many writers assume that unexpected negative consequences are inevitable, *normal accidents* (Perrow 1984), and advocate systems that either minimize such effects or try to manage them.

Unintended consequences often cross temporal and spatial boundaries. When effects cross physical or political barriers, unintended consequences raise questions about responsibility. Indeed, one ethical response to such technological changes in the scope and reach of human action is to argue for the articulation of a new *imperative of responsibility* (Jonas 1984). How does one country hold another responsible when pollution or other effects cross borders? This is a major question in climate change, where industrialized countries have been the major human source of greenhouse gases but developing countries will suffer the most severe impacts expected, such as sea rise and increased and prolonged regional droughts. In some limited cases national tort law provides compensation for injuries caused by actions taking place outside the borders of the sovereign state. International law is even more problematic, since there is no sovereign providing enforcement, and countries must rely on their ability to reach international agreements to deal with novel and intractable problems such as the hole in the ozone.

Conventional methods of dealing with risk, such as insurance, legal remedies, and emergency procedures, were not designed to deal with the current spread of side effects. When effects occur much later in time they affect future generations, raising issues of *intergenerational* equity. Is it fair to leave a seriously degraded and hazardous world for future generations?

Three types of errors may be made at the more mundane level of managing unintended consequences (Tenner 1997). *Type I errors* are those where unnecessary preventive measures are taken, such as keeping a safe and effective product off the market. *Type II errors* occur when an important protective measure is not taken, such as allowing the use of a very harmful product. *Type III errors* involve displaced risks, new risks created by protective measures, such as the economic effects of unnecessary environmental regulations.

David Collingridge describes the essential problem with technology, the *dilemma of control:* "Attempting to control a technology is difficult, and not rarely impossible, because during its early stages, when it can be controlled, not enough can be known about its harmful social consequences to warrant controlling its development; but by the time those consequences are apparent, control has become costly and slow" (Collingridge 1980, p. 19) He proposes "a theory of decision making under ignorance" to make decisions more "reversible, corrigible, and flexible" (p. 12). He works within the *fallibilist tradition,* which "denies the possibility of justification, and sees rationality as the search for error and the willingness to respond to its discovery" (p. 29). Collingridge advocates a decision process that allows errors to be identified quickly and managed inexpensively. Options should be kept open so that changes can be made as new information becomes available, but this becomes more difficult the longer a technology is in use.

Others have suggested similar systems. Aaron Wildavsky talks about the *resilience* of systems and advocates a gradual system of response as new information becomes available. Steve Rayner (2000) also stresses the importance of developing resilience to improve society's ability to deal with surprises. Sheila Jasanoff (1994) advocates planning in both the anticipation of and the response to disasters. Kai Lee (1993) and Berkes and Folke (1998) propose using *adaptive management* to build resilience into the management of natural resources.

Arguing that science and technology themselves can play multiple roles, not only as a source of risks but as means to help identify and prevent problems, as well as to develop adaptation measures to ease negative impacts, Posner (2004) recommends the use of *cost-benefit analysis* to evaluate risks, saying it is an essential component of rational decisions. He also recognizes that uncertainties create many ethical, conceptual, and factual problems and suggests several methods for coping. Some application of the *precautionary principle*, or the *better safe than sorry* approach to decisions, may be appropriate as a variation of cost-benefit analysis in which people choose to avoid certain risks.

John D. Graham and Jonathon B. Wiener (1993) describe the *risk tradeoffs* that are inevitably faced in protecting human health and the environment; minimizing one risk may actually increase other *countervailing risks*. In some cases, reducing one risk will cause other *coincident risks* to decrease, as well. The authors propose a *risk trade-off analysis* to reveal the tradeoffs likely in any decision, and examine ethical as well as scientific issues. Factors to be considered in evaluating risks include "magnitude, degree of population exposure, certainty, type of adverse outcome, distribution, and timing" (Graham and Wiener 1993, p. 30). Consideration of these factors before making a decision may make it possible to reduce but not eliminate surprise effects.

Corporations, think tanks, universities, or other private institutions may not consult the public about their scientific and technological decisions. Even government-sponsored research and regulation typically involve little public participation. Yet the public is usually the intended user of innovations and bears many of the benefits and burdens of both intended and unintended consequences. Questions for a democratic society include whether the public should play a larger role in decisions regarding science and technology, how meaningful public involvement can be achieved, and how public opinions should be balanced with scientific expertise. Greater public involvement would increase the diversity of interests and values brought to an analysis of and debate about the risks and benefits of innovations in science and technology.

Science and technology funding raise questions about the optimal allocation of public and private funds. Funding rarely is devoted to assessing risks of innovations. Funding to develop solutions to one problem may end up creating other unintended consequences. Should funding agencies require more analysis of possible consequences of funded projects, and should the agencies be held partially responsible for consequences?

Conclusion

The unintended consequences of science and technology are ubiquitous and complex in the contemporary world. They raise important questions about the kind of society in which humans choose to live in, including issues relating to allocation of scarce societal resources; the types and levels of risks society is willing to tolerate; the attribution of responsibility and liability; the right to compensation for injury, the equitable distributions of societal costs and benefits; and the role of individuals, corporations, governments, and other public and private institutions in the control of science and technology.

MARILYN AVERILL

SEE ALSO *Enlightenment Social Theory; Normal Accidents; Precautionary Principle; Uncertainty.*

BIBLIOGRAPHY

Beck, Ulrich. (1986). *Riskogesellschaft: Auf dem Weg in eine andere Moderne* [Risk society: Towards a new modernity]. Frankfurt am Main: Suhrkamp. English version, translated by Mark Ritter (London: Sage Publications, 1992). Beck maintains that the changing nature of risks is transforming the developed world from an industrial society to a risk society in which the side effects of industrialization increase in frequency and severity and force society to focus more on risk production than on wealth production.

Berkes, Fikret, and Carl Folke, eds. (1998). *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience*. Cambridge, UK: Cambridge University Press. This edited volumes presents case studies of the interactions of social and ecological systems in response to environmental change. Authors focus on the nature of the problems faced, responses to those problems, and lessons to be learned.

Collingridge, David. (1980). *The Social Control of Technology*. New York: St. Martin's Press. Focusing on the social effects as well as the social control of technology, Collingridge describes the problem of control when undesirable effects are not known until change has become more difficult. He proposes a theory of decision making under ignorance so that decisions can be modified as new information becomes available.

De Certeau, Michel. (1984). *The Practice of Everyday Life*, trans. Steven F. Rendall. Berkeley: University of California Press.

Dutton, Diana D.; Thomas A. Preston; and Nancy E. Pfund. (1988). *Worse than the Disease: Pitfalls of Medical Progress*. Cambridge, UK: Cambridge University Press.

Graham, John D., and Jonathon Baert Wiener. (1993). *Risk vs. Risk: Tradeoffs in Protecting Health and the Environment*. Cambridge, MA: Harvard University Press. This book describes the many tradeoffs that must be made in attempting to manage risks, including risks relating to unintended consequences. It provides case studies of tradeoffs that have been made, analyzes the problems inherent in such tradeoffs, and suggests ways to manage risks more effectively and democratically.

Illich, Ivan. (1976). *Medical Nemesis: The Expropriation of Health*. New York: Pantheon Books. In this work, Illich criticized the medical establishment as a major threat to health, claiming that even though more money is being spent on healthcare, fewer benefits are being realized.

Jasanoff, Sheila. (1994). "Introduction: Learning from Disaster." In *Learning from Disaster: Risk Management after Bhopal*, ed. Sheila Jasanoff. Philadelphia: University of Philadelphia Press. Authors from a variety of disciplines seek to identify lessons to be learned from the 1984 lethal gas leak from a plant in Bhopal, India. The book discusses the problems with transplantation of technologies across cultures and the way culture, politics, and other human factors shape approaches to risk management.

Jonas, Hans. (1984). *The Imperative of Responsibility: In Search of an Ethics for the Technological Age*. Chicago: University of Chicago Press. Viewed as Jonas' most important work. Here he reflects on the challenges brought to society by nuclear weapons, chemical pollution, and biomedical technologies.

Lee, Kai. (1993). *Compass and Gyroscope: Integrating Science and Politics for the Environment*. Washington, DC: Island Press. Sustainable development; civic science, and adaptive management are discussed within the context of the controversies over salmon populations in the Columbia River Basin. Lee recommends that science be coupled with public debate in addressing environmental problems.

Merton, Robert K. (1936). "The Unanticipated Consequences of Purposive Social Action." *American Sociological Review* 1(6): 894–904.

Perrow, Charles. (1999). *Normal Accidents: Living with High Risk Technologies*. Princeton: Princeton university press.

Pindyck, Robert S., and Daniel L. Rubinfeld. (1998). *Microeconomics*, 4th edition. Upper Saddle River, NJ: Prentice Hall.

Pollack, Henry N. (2003). *Uncertain Science . . . Uncertain World*. Cambridge, UK: Cambridge University Press.

Posner, Richard A. (2004). *Catastrophe: Risk and Response*. Oxford: Oxford University Press. Posner Addressed Risks that could actually threaten the future of human life on earth; several of these Potential disasters are the unintended outcomes of innovations in science and technology. He calls for interdisciplinary policy responses to address these potential catastrophies.

Rayner, Steve. (2000). "Prediction and Other Approaches to Climate Change Policy." In *Prediction: Science, Decision Making, and the Future of Nature*, ed. Daniel Sarewitz, Roger A. Pielke Jr., and Radford Byerly Jr. Washington, DC: Island Press.

Spicer Edward H., (1952). *Human Problems in Technological Change: A Cashbook*. New York: John Wiley. Includes Lauriston Sharp's widely referenced case study on "Steel Axes for Stone Age Australians."

Stewart, Thomas R. (2000). "Uncertainty, Judgment, and Error in Prediction." In *Prediction: Science, Decision Making, and the Future of Nature*, ed. Daniel Sarewitz, Roger A. Pielke Jr., and Radford Byerly Jr. Washington, DC: Island Press.

Tenner, Edward. (1997). *Why Things Bite Back: Technology and the Revenge of Unintended Consequences*. New York: Vintage Books. Unintended consequences are at the center of this book, which describes how and why technology, when combined with human behavior and institutions sometimes seems to turn on the society that produced it. Extensive examples are provided relating to medicine, the environment, computers, and the spread of pests.

UNION OF CONCERNED SCIENTISTS

The Union of Concerned Scientists (UCS) is a nonprofit alliance of more than 100,000 scientists and citizens that works to promote environmental and global security solutions based on sound science. UCS scientists, engineers, and analysts collaborate with colleagues across the country to conduct technical studies on renewable energy options, cleaner cars and trucks, the impacts of and solutions to global warming, the risks of genetically engineered crops, deforestation, invasive species, nuclear power plant safety, missile defense, the security of nuclear material, and other issues. Research results are shared with policy makers, the news media, and the public in order to shape public policy, corporate practices, and consumer choices.

Founding and Finances

UCS was founded in 1969 out of a movement at the Massachusetts Institute of Technology, where an ad hoc group of faculty and students joined together to protest the misuse of science and technology. They put forth a Faculty Statement—the genesis of UCS—calling for greater emphasis on the application of scientific research to environmental and social problems, rather than military programs.

UCS derives approximately 50 percent of its operating revenue from foundations, 40 percent from membership, and 10 percent from planned giving and other sources. Member and foundation support has grown steadily over the years, and in the early twenty-first century UCS has an operating budget of nearly $10 million. More than 75 percent of the operating budget is applied directly to program work.

Historical Development

In its early work, the UCS focused on nuclear weapons, weapons-related research, and nuclear power plant safety. In April 1969, it released its first report, *ABM ABC,* criticizing President Nixon's proposed Safeguard anti-ballistic missile system. UCS's ongoing opposition helped build public support for the ABM Treaty, signed by the United States and the Soviet Union in 1972. In 1979, when Three Mile Island Unit II experienced a near meltdown, UCS provided crucial independent information to the media and the public seeking to understand the accident and the risks to neighboring communities.

In the early 1980s, when the Reagan administration proposed a missile defense program called the Strategic Defense Initiative (SDI), also known as "Star Wars," UCS mobilized swift and sweeping opposition in the scientific community to the SDI program, and analyzed its technical and strategic drawbacks, providing a crucial counterweight to the claims and promises of its proponents.

In 1987, UCS successfully sued the Nuclear Regulatory Commission to strengthen safety enforcement at nuclear power plants. Four years later, UCS forced the shutdown of the Yankee Rowe nuclear plant in Massachusetts due to safety concerns.

UCS kicked off its new climate change campaign in 1990, when 700 members of the National Academy of Sciences signed UCS's Appeal by American Scientists to Prevent Global Warming. In 1992, some 1,700 scientists worldwide, including a majority of Nobel laureates in the sciences, issued the World Scientists' Warning to Humanity. UCS Chair Henry Kendall, a Nobel laureate in physics, wrote and spearheaded the statement, an unprecedented appeal from the world's leading scientists on the destruction of the earth's natural resources.

In 1993, UCS pioneered new analytical techniques to demonstrate the breadth of renewable energy resources in twelve Midwestern states. The attention and commitment to clean energy that the research generated continues into the twenty-first century. UCS also launched a new program the same year, focusing on sustainable agriculture and biotechnology. The program's first report, *Perils Amidst the Promise,* analyzes the ecological risks of the commercialization of transgenic (genetically engineered) crops. Two years later, in response to grassroots pressure generated by UCS, the U.S. Environmental Protection Agency imposed new transgenic crop standards.

The UCS Clean Vehicles program, which was launched in 1991, had a number of major policy victories in the mid- to late-1990s. UCS led the successful campaign to open the market to clean, nonpolluting cars in California in 1996. The state's low-emission vehicle (LEV) standards, which include zero-emission vehicle (ZEV) production requirements, have been adopted by several states in the northeastern United States. In 1998, UCS helped convince California to require SUVs, light trucks, and diesel cars to meet the same tailpipe emissions standards as gasoline cars. *Greener SUVs,* a 1999 report demonstrating numerous "off the shelf" technologies available to automakers to cost-effectively increase the gas mileage of their cars and trucks, has provided a technical basis for the environmental community's efforts to raise national fuel economy standards.

Success and Shortcomings

UCS has secured some major policy victories in the early twenty-first century. Its 2000 report *Countermeasures,* which demonstrated that the proposed national missile defense system could be defeated by missiles equipped with simple countermeasures, convinced President Clinton not to deploy the system. In 2001, UCS issued the first-ever analysis of antibiotic use in livestock feed, demonstrating that widespread overuse threatens the efficacy of drugs used in human medicine. And UCS continues to play a key role in shaping California environmental policy; in 2002, the state passed the first global warming emission rules for cars and light trucks, and the nation's strongest renewable energy standard (20% by 2017). The U.S. Senate also passed a 10 percent renewable energy standard in 2002, the first-ever renewable energy legislation of its kind in Congress.

USC's advocacy of forward-thinking solutions on environmental and arms control issues have prompted some national media label to UCS a "liberal" group and has also made it a target of criticism of various groups invested in the status quo. Despite these challenges, UCS has forged relationships with leaders, on both sides of the aisle, who understand that independent scientific analysis has an important role to play in the decisions about public health, safety and the environment.

Since its inception, however, the Union of Concerned Scientists has played an influential role in environmental and security policy development. It has brought independent scientific analysis to pressing issues facing the global society and effectively communicated these findings to the public and policy makers to demonstrate their meanings at the national, regional, and community level. UCS believes scientists can and should play an important role informing public policy choices. As long-time UCS board chair Henry Kendall put it, "If scientists do not speak out, significant opportunities are lost" (Kendall 2000, p. 1).

SUZANNE SHAW

SEE ALSO *Federation of American Scientitsts; Nongovernmental Organizations; Professional Engineering Organizations.*

BIBLIOGRAPHY

Kendall, Henry W. (2000). *A Distant Light: Scientists and Public Policy*. New York: AIP Press/Springer.

INTERNET RESOURCES

Union of Concerned Scientists. "History." Available from http://www.ucsusa.org/ucs/about/page.cfm?pageID=767.

UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION

The United Nations Educational, Scientific and Cultural Organization (UNESCO) was conceived within the United Nations (UN) Charter, which was ratified on October 24, 1945. In the view of its founders, it was to revive within the new UN system, the International Institute of Intellectual Cooperation (IIIC), created, in 1924, by the League of Nations' International Committee on International Cooperation (ICIC). The institute had counted among its members such eminent world personalities as Albert Einstein, Henri Bergson, Sigmund Freud, Marie Curie, Gabriela Mistral, Aldous Huxley, Miguel de Unamuno, Paul Valéry, and Rabindranath Tagore. The UNESCO Constitution was adopted on October 24, 1945, by thirty-seven countries, By October 2003, it was composed of 190 Member States and six Associate Members.

At the outset, some of its more influential members were of the opinion that UNESCO should be the world organization in which "intellect would be allowed to have more scope and real power in the things of this world" (an expression used by Valéry, a leading member of the first French delegation to the new organization, who had also represented France in the old IIIC). It was thought that this approach could better protect the institution from excessive dependence on changing political pressures. The same concerns could explain why, at the outset, the members of the Executive Board were conceived to be more than just representatives of their respective governments; they would be chosen by the General Conference (the highest organ of UNESCO) on the basis of their personal qualifications and independence of mind, as had been the case with the IIIC. But because of political considerations, the practice moved in a different if not opposite direction. Accordingly, the UNESCO Constitution was amended in 1992 to make it clear that the representatives on the Board would always follow the instructions of their respective governments.

UNESCO's five original fields of competence were placed under the headings of education, exact and natural sciences, social sciences, culture, and communication. To these were later added intersectoral activities that embrace both the sciences and culture as well as fundamentally multidisciplinary projects such as the Protection of the World and Cultural Heritage and collaboration with other organizations of the UN system and with international nongovernmental organizations (NGOs).

Education

UNESCO's first publication was a report titled *Fundamental Education: Common Ground for All Peoples* (1946). Although, ten years later, a working party of the General Conference proposed a new definition of this concept ("to help people who have not obtained such help from established educational institutions to understand the problems of their environment and their rights and duties to acquire a body of knowledge and skills for the progressive improvement of their living conditions and to participate more effectively in the economic and social development of their community"), the term *fundamental* or *basic* education stopped being used, on the ground that it was liable to confer official status on a "cut-rate" educational goal that would run counter to the goal of universal primary education.

The pursuit of a world model of schooling based on the experience of industrially developed countries had often exacerbated the difficulties of the poorer populations in developing their vernacular modes of learning. Therefore, at the World Education Forum (held in Dakar, Senegal, in 2000), UNESCO adopted a new approach under the name Education for All. This program was designed to reach six goals by the year 2015: (1) expand early childhood care and education, (2) improve access to and complete free schooling of good quality for all children of primary school age, (3) greatly increase learning opportunities for youth and adults, (4) improve adult literacy rates by 50 percent, (5) eliminate gender disparities in schooling, and (6) improve all aspects of educational quality (UNESCO, "World Education Forum").

Since 1964 UNESCO has taken a similar approach in working toward its goal of eradicating literacy in the world. At the 1965 World Conference of Ministers of Education in Tehran, the organization introduced the notion of "functional literacy," a conception in which learning to read and write was no longer regarded as an end in itself, but was more closely linked to the exercise of rights, responsibilities, and aptitudes in the professional, social, civic, and cultural fields. Despite some technically impressive results, these massive interventions did not succeed in absorbing the residual number of some 900 million "illiterate" persons who live in the world. Even the UN Literacy Decade Program, launched in 2003, seems to have accepted that despite the intensification of the efforts aimed at accelerating the literacy campaigns, the number of the illiterate will still be of the order of 820 million by 2010.

Natural Sciences

The International Hydrological Programme and the Man and the Biosphere Programme are two of the most important UNESCO programs in the field of natural sciences.

INTERNATIONAL HYDROLOGICAL PROGRAMME (IHP). IHP aims to provide technical training and policy advice required to manage water resources efficiently, fairly, and in an environmentally sound manner. The program is also involved in developing tools and strategies to prevent water conflicts from erupting between and within states.

UNESCO hosts the secretariat of twenty-three UN partners, which constitute the World Water Assessment Programme. The *U.N. World Water Development Report* (WWDR) provides a comprehensive, up-to-date overview of this resource. The first edition of the report, *Water for People, Water for Life* was launched on World Water Day, May 22, 2003, at the Third World Water Forum in Kyoto, Japan.

MAN AND THE BIOSPHERE (MAB) PROGRAMME. MAB is a most innovative program. In 1968, four years before the UN Conference on the Human Environment in Stockholm, UNESCO held the Conference on the Biosphere in Paris with a view to reconciling the environment and "development." The term *biosphere* was used to designate all living systems covering Earth and the processes allowing them to function. MAB got underway in 1971 as an intergovernmental interdisciplinary activity aimed at developing scientific knowledge about the rational management of natural resources and their conservation in the light of the different types of human activity and the world's different land systems. More than 10,000 researchers from some 110 countries participated in this worldwide effort. More than 400 "biosphere reserves" have also been created that work as "living laboratories," each testing ways of managing natural resources while fostering economic development.

OTHER MAJOR ACTIVITIES IN THE NATURAL SCIENCES. The list of UNESCO's other activities in the natural sciences includes the following:

Intergovernmental Oceanographic Commission (IOC): This coordinating body of UN agencies and institutes monitors ocean conditions to improve weather forecasts, predict the onset of El Niño, and provide early warnings of tsunamis and storm surges. IOC also helps build the Global Ocean Observing System, which weaves together data from special buoys, ships, and satellites to better understand the links between ocean currents and climate.

International Geoscience Programme: Formerly called the International Geological Correlation Programme (IGCP), this joint endeavor of UNESCO and the International Union of Geological Sciences (IUGS) was launched in 1972. It maintains active interfaces with disciplines such as water, ecological, marine, atmospheric and biological sciences. As an international forum for multi-disciplinary geo-environmental research, it is designed to help scientists in more than 150 countries assess energy and mineral resources, while expanding the knowledge base of Earth's geological processes and reducing the risks of natural disasters in less-equipped countries.

Environment and Development in Coastal Regions and Small Islands (CSI): The CSI platform for intersectoral action was initiated in 1996 to contribute to environmentally sustainable, socially equitable, culturally respectful and economically viable development in small islands and coastal regions. The program is based upon three complementary and mutually reinforcing approaches: field-based projects on the ground; UNESCO chairs and University Twinning (UNITWIN) arrangements; and a multi-lingual, Internet-based forum on "wise coastal practices for sustainable human development."

The CSI platform has generated two cross-cutting projects: the Local and Indigenous Knowledge Systems (LINKS) project and the Small Islands Voice (SIV) project. The LINKS project focuses on this interface between local and indigenous knowledge and the Millennium Development Goals of poverty eradication and environmental sustainability. It addresses the different ways that indigenous knowledge, practices and worldviews are drawn into development and resource management processes.

Social and Human Sciences

Often perceived as the conscience of the United Nations, UNESCO is further mandated to develop ethical guidelines, standards, and legal instruments in the field of science and technology—specifically bioethics. The ongoing revolution in science and technology has indeed given rise to some fears that unbridled scientific progress poses a threat to the culturally established ethics of world societies in dealing with their life and their human and natural environment. UNESCO's Programme on the Ethics of Science and Technology was designed to place such progress in the framework of ethical reflection rooted in the cultural, legal, philosophical, and religious heritage of the various human communities. This program includes the Bioethics Programme, the International Bioethics Committee (IBC), the Intergovernmental Bioethics Committee (IGBC), and the World Commission on the Ethics of Scientific Knowledge and Technology.

BIOETHICS PROGRAMME. Created in 1993, this program has been a principal priority of UNESCO since 2002. With its standard-setting work and the multicultural and multidisciplinary forums it has helped to organize, the program has played a leading institutional role at the international level. The Bioethics Programme oversees the activities of the IBC and the IGBC.

UNIVERSAL DECLARATION ON THE HUMAN GENOME AND HUMAN RIGHTS. The first major success of the Bioethics Programme came in 1997, when the General Conference adopted the Universal Declaration on the Human Genome and Human Rights. The only international instrument in the fields of bioethics, this landmark declaration was also endorsed by the UN General Assembly in 1998. Adopted unanimously and by acclamation by the twenty-ninth session of the General Conference, the declaration serves as a legal reference and a basis for reflection on such critical issues as human cloning. In the early twenty-first century, work was underway to evaluate the impact of the declaration worldwide, in accordance with the Guidelines for the Implementation of the Declaration (1999), and to develop a new international declaration on human genetic data.

INTERNATIONAL BIOETHICS COMMITTEE. Created in 1993, this body, composed of thirty-six independent experts named by UNESCO's Director General, follows progress in the life sciences and its applications in order to ensure respect for human dignity and freedom. As the only internationally recognized global body for in-depth bioethical reflection, the IBC acts as a unique forum for exposing the issues at stake. It does not pass judgment on one position or another. Instead, it invites each country, and particularly the lawmakers therein, to decide between the different positions and to legislate accordingly.

INTERGOVERNMENTAL BIOETHICS COMMITTEE. The IGBC, created in 1998, comprises thirty-six member states whose representatives meet at least once every two years to examine the advice and recommendations of IBC. It informs the IBC of its opinions and submits these opinions along with proposals for follow-up of the IBC's work to the Director General for transmission to member states, the Executive Board, and the General Conference.

WORLD COMMISSION ON THE ETHICS OF SCIENTIFIC KNOWLEDGE AND TECHNOLOGY (COMEST). Also created in 1998, this commission formulates the ethical principles that provide noneconomic criteria for decision makers concerning sensitive areas such as sustainable development; freshwater use and management; energy production, distribution, and use; outer space exploration and technology; and issues of rights, regulations, and equity related to the rapid growth of the information society.

From the 1999 World Conference on Science, COMEST also received a mandate to pursue research and come up with recommendations on instilling ethics and responsibility into science education. As a first step toward fulfillment of this mandate, COMEST organized a Working Group on the Teaching of Ethics. This group was asked to give the necessary advice on how to integrate awareness and competence in the field of ethics and responsibility of scientific education and research in the training of every young scientist. The report of the group, endorsed in December 2003, includes a survey of existing programs, an analysis of their structure and content, and detailed curriculum advice on how to integrate into scientific education both ethics and training in the history, philosophy, and cultural impact of science.

MANAGEMENT OF SOCIAL TRANSFORMATION (MOST) PROGRAMME. The list of the programs started by UNESCO with a view to setting ethical frameworks for the advancement of scientific discoveries cannot be completed without mentioning MOST, a program aimed at extending UNESCO's new ethical approach to the larger social transformations linked to globalization. Through this program, which was created in 1993, UNESCO seeks to conduct studies on issues such as urban development and governance through a range of grassroots projects, consultations, and academic networks. MOST increasingly focuses on research to help national and local governments develop appropriate governance policies and structures in multicultural societies, even addressing such issues as social inclusion and the eradication of poverty.

A Critical Assessment of UNESCO's Activities

UNESCO has often been criticized for having failed to act as "the conscience" of the people composing the United Nations and, in the particular field of science and technology, to fully implement its mandate to contain their unbridled development within internationally accepted ethical principles. Such criticisms need to be assessed against philosophical, structural, and institutional limits to UNESCO actions.

A first limit is the fact that the "conscience" attributed to UNESCO is nothing but a metaphor. It represents, at best, the hopes placed by the world populations in the performance of its organizational mandate. In practice, however, an insurmountable gap exists between these populations and the politicians, experts, and economists who often act in their name in the way that each side perceives how science, technology, education, and communication affect their lives. For the latter side, composed of the dominant groups of power and knowledge, ethics have seldom had the same meanings as have been conferred to it by the overwhelming number of humans suffering from the so-called fallouts of modern economic and technological development.

A second serious limit to attempts by UNESCO—or any other similar organization—to humanize science and technology or to curtail their unbridled advancement, stems from the very nature of these institutions. Ethics, by definition, poses questions of morality and of adherence to a set of humanly and socially defined *moral* values, whereas the advancement of science and technology remains solely defined by the state of the art in knowledge and performance. As Jacques Ellul (1954) has argued, technology, in particular, is not neutral. It tends to colonize the very behavior and worldview of the subjects it serves. The same way that an unbridled economy tends to "dis-embed" itself from the society that needs it, technologies such as human cloning or genetic engineering create for themselves an autonomous or transcending "ethics" that tends to defy that of a historically defined culture.

The twin set of reasons mentioned above have been quite detrimental to the hopes raised by UNESCO in the implementation of its "grand design" to act as the "conscience of the world." In their greatest majority, the delegates composing its General Conference and its Executive Board were led, more or less, to defend the passing interests of their respective governments rather than uphold the spirit of its constitution. Some of the more politically or financially powerful members of the organization did not even hesitate to openly impose on it their particular views, regardless of their obligations. On the other hand, the power of experts and specialists defending the dominant discourse in the fields of governance, development, market economy, science, and technology have had a steady repressive effect on the growth of different forms of resistance to that power. The result has been that, despite the fact that UNESCO can be credited with some important technical and legal achievements in its fields of competence, these have fallen far short of fulfilling the hopes that the people of the world had placed in its potentialities.

MAJID RAHNEMA

SEE ALSO *Education; Human Rights; International Relations; United Nations Environmental Program.*

BIBLIOGRAPHY

Bose, Frédéric. (2002). *Tell Me About: UNESCO*. Paris: UNESCO/Nouvelle Arche de Noé Editions.

Conil-Lacoste, Michel. (1994). *The Story of a Grand Design: UNESCO 1946–1993: People, Events, and Achievements*. Paris: UNESCO Publishing.

Dutt, Sagarika. (2002). *UNESCO and a Just World Order*. New York: Nova Science Publishers.

Ellul, Jacques. (1964). *The Technological Society*, trans. John Wilkinson. New York: Knopf, 1964. Revised edition, New York: Knopf/Vintage, 1967.

Stenou, Katérina. (2000). *UNESCO and the Issue of Cultural Diversity: Review and Strategy, 1946–2000: A Study Based on Official Documents*. Paris: UNESCO Publishing.

INTERNET RESOURCE

United Nations Educational, Scientific and Cultural Organization (UNESCO). "World Education Forum." Available from http://www.unesco.org/education/efa/wef_2000.

UNITED NATIONS ENVIRONMENTAL PROGRAM

As "the voice for the environment" in the United Nations system, the United Nations Environment Programme (UNEP) speaks on behalf of generations not yet born and acts as a clearinghouse for scientific information. It works with other U.N. entities as well as international organizations, national governments, nongovernmental organizations, and the private sector, reporting on the changing state of the world environment, tracking the causes of change, and working collaboratively to develop responses to those changes. Based in Nairobi, Kenya, UNEP has six regional offices and centers, including the Global Resource Information Database and the World Conservation Monitoring Center. Its Division of Technology, Industry, and Economics is headquartered in Paris. UNEP also hosts several secretariats that were formed in response to the passage of international treaties, conventions, and protocols relating to the environment.

Origins

At the time of the first Earth Day celebration in 1970 there was growing awareness of the transnational threats posed by pollution but no international body to advocate for global environmental health. That void was filled in 1972 in Stockholm, Sweden, at the United Nations General Assembly Conference on the Human Environment, which established UNEP.

Delegates to the conference, which was convened to examine the relationship between the environment and development, agreed that humankind had the fundamental right to "freedom, equality, and adequate conditions of life, in an environment of a quality that permits a life of dignity and well-being" and that human beings bear "a solemn responsibility to protect and improve the environment for present and future generations" (*Declaration of the United Nations Conference on the Human Environment,* Stockholm, June 1972).

However, agreement was not forthcoming about how to balance concern for the environment and development to achieve those ends. Officials from developing countries worried, for example, that the resource-protection policies suggested by many of the delegates would hinder economic development in poor nations. At the urging of developing-world leaders such as Indira Gandhi, philosophical statements about "loyalty to the earth" were displaced by practical considerations of economic growth.

From Stockholm onward UNEP has tried to set a course that both is visionary and grapples with the realities of life. To that end it has underscored the fact that poverty, hunger, and misery in the developing world must be addressed if an environmental agenda is to be successful, emphasizing the need for economic growth that would allow developing countries to make progress without repeating the environmentally disastrous mistakes of the industrialized world. The term *sustainable development* came into use in the 1980s to describe that approach.

Areas of Concern

In the 1980s UNEP defined several areas of environmental concern, including climate change and atmospheric pollution; pollution and the shortage of freshwater resources, along with the deterioration of coastal areas and oceans; and land degradation, including desertification and the loss of biological diversity.

AIR. Since the first book on air pollution was written in the seventeenth century, the situation has gotten decidedly worse. There is still urban air pollution, and with it concern about sulfur dioxide, nitrogen oxides, carbon monoxide, ozone, and suspended particulate matter. Every day nearly one billion people in urban areas breathe air with unacceptable levels of pollution. The problem has widened to include the depletion of the stratospheric ozone layer caused by chloroflourocarbons, acid rain that burns forests with heavy doses of sulphur dioxide and nitrogen oxides, and climate change, which is melting glaciers and raising sea levels at an alarming rate and has been studied in a concerted way since 1980 by UNEP's World Climate Programme. UNEP's efforts to improve understanding about the sources of atmospheric pollution and climate change helped bring about the entry into force of a Global Convention (Vienna 1985) and a Global Protocol (Montreal 1988) for the protection of the ozone layer. UNEP collaborated with other groups in the development of the Climate Change Convention that was signed in 1992.

WATER. As far back as 1977 at the United Nations Water Conference delegates were alarmed about rising levels of water consumption and pollution. The conference's Mar del Plata Action Plan challenged the international community to create an integrated long-term plan for water management. The first step was taken in 1985, when UNEP launched the Programme for Environmentally Sound Management of Inland Waters (EMINWA) in an effort to protect the world's supplies of fresh water.

Oceans and seas, which cover 70 percent of the earth's surface, are another area of concern, particularly with regard to coastal development, discharges of municipal and industrial waste, and the overexploitation of water through the use of long-line and drift nets. In the early twenty-first century more than 120 countries take part in UNEP's Regional Seas Programme, which encourages research, monitoring, and the control of pollution and the development of coastal and marine resources.

LAND. The degradation of drylands, which is known as desertification, is an increasingly severe problem that affects more than a sixth of the world's population. Caused mostly by agricultural and grazing practices that ignore the fragility and productive limits of the land, desertification also is brought about by prolonged drought. More humid areas are at risk of degradation as a result of urbanization, unsustainable agriculture, and deforestation, which clears more than 11 million hectares (27.2 acres) of forest per year. In 1977 UNEP was designated to coordinate the United Nations Plan of Action to Combat Desertification. With regard to deforestation and habitat loss, agreement on a set of nonbinding principles for forest conservation was reached in 1992. UNEP also initiated a series of in-depth country-by-country studies of biodiversity that led in 1992 to the Convention on Biological Diversity.

Results and Successes

The success of UNEP-instigated treaties, conventions, and protocols has resulted from the agency's effective use of scientific and expert advice to inform decision makers about complex environmental problems. For instance, the Global Biodiversity Assessment of 1995, which led to the Convention on Biodiversity, involved roughly 1,500 scientists. UNEP helped develop ways to produce, synthesize, and legitimize the expert knowledge of those scientists and then to provide reliable and accessible scientific advice on environmental policy options. In 1988 the World Meteorological Organization and UNEP set up the Intergovernmental Panel on Climate Change (IPCC). Since that time the 2,500 scientists associated with IPCC have produced a series of reports that have been highly influential in the debate about climate change. UNEP is not an environmental protection agency as such but more of a scientific advisory institution.

Historical Development

Twenty years after the Stockholm conference UNEP continued to explore the relationship of the environment and development at the 1992 United Nations Conference on Environment and Development (Earth Summit) in Rio de Janeiro, Brazil. One hundred seventy countries came together in Rio and adopted by consensus a common global strategy for environmental protection called Agenda 21. Among other things, Agenda 21 laid the groundwork for the 1997 Kyoto Protocol of the Framework Convention on Climate Change. Some participants felt that the recommendations of the Earth Summit favored development over environmental protection. Examples include state sovereignty over resources (and environmental and development policies), the promotion of global free trade and open markets, and a "polluter pays" approach in which market instruments and not strict regulatory mechanisms are used to curb environmental degradation.

It was also at the Earth Summit that the Precautionary Principle received a global hearing. The delegates agreed in Principle 15 of the Rio declaration on environment and development that "where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." The Precautionary Principle became a cornerstone for the 2000 Cartagena Protocol on Biosafety of the Convention on Biodiversity and has been used in additional forums to argue against genetically modified agricultural products and other forms of biotechnology. The European Union calls the Precautionary Principle a "principle of common sense" and uses it in judging food safety; San Francisco was the first American city to adopt the principle for its purchases and building projects.

In 2002 at the United Nations World Summit on Sustainable Development in Johannesburg, South Africa, development again seemed to occupy center stage. UNEP's executive director, Klaus Toepfer, diplomatically called the summit "satisfactory," but many delegates were angered by efforts, most notably those of the United States, to derail timetables and targets for environmental policies such as the use of renewable energy. Nevertheless, UNEP continues to be the best hope for international cooperation and global governance on life-threatening issues that know no boundaries.

MARILYN BERLIN SNELL

SEE ALSO *Biodiversity; Deforestation and Desertification; Ecology; Environmental Ethics; Environmentalism; Environmental Justice; Environmental Regulatory Agencies; Global Climate Change; Nongovernmental Organizations; Pollution; Rain Forest; Waste; Water.*

BIBLIOGRAPHY

Atchia, Michael, and Shawna Tropp, eds. (1995). *Environmental Management: Issues and Solutions*. New York: Wiley.

Brown, Noel, and Pierre Quiblier, eds. (1994). *Ethics and Agenda 21: Moral Implications of a Global Consensus*. New York: United Nations Environment Programme.

Toldba, Mostafa K.; Osama A. El-Kholy; E. El-Hinnawi; et al, eds. (1992). *The World Environment 1972–1992: Two Decades of Challenge*. London: Chapman and Hall. 1992.

Worldwatch Institute, in cooperation with the United Nations Environment Programme. (2002). *Vital Signs 2002: The Trends That Are Shaping Our Future*. New York: Norton.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

SEE *Environmental Regulation.*

UNITED STATES FEDERAL AVIATION ADMINISTRATION

SEE *Aviation Regulatory Agencies.*

UNITED STATES FEDERAL COMMUNICATION COMMISSION

SEE *Communications Regulatory Agencies.*

UNITED STATES FOOD AND DRUG ADMINISTRATION

SEE *Food and Drug Agencies.*

UNITED STATES GEOLOGICAL SURVEY

SEE *National Geological Surveys.*

UNITED STATES NATIONAL ACADEMIES

SEE *National Academies.*

UNITED STATES NATIONAL SCIENCE FOUNDATION

SEE *National Science Foundation.*

UNITED STATES NUCLEAR REGULATORY COMMISSION

SEE *Nuclear Regulatory Commission.*

UNITED STATES OFFICE OF TECHNOLOGY ASSESSMENT

SEE *Office of Technology Assessment.*

URBANIZATION

Urbanization is a historical phenomenon closely linked to changes in technology and to some extent science that also influences and is influenced by ethical ideals. Both technology and science develop with more intensity in cities, in part promoted by urban models of human behavior, which in turn may be reinforced by notions of technological instrumentalism and scientific objectivity.

Urbanization, Ancient and Modern

The term *urbanization* refers to the increasing concentration of people in cities. The first cities appeared after the development of plant cultivation and animal domestication. Formerly nomadic tribes settled in fertile river valleys and became increasingly dependent on agriculture.

The ancient cities of Mesopotamia were established between about 4000 and 3000 B.C.E. The cities of ancient Egypt appeared around 3300 B.C.E. and were closely linked to the increasing power of the pharaohs, who were both secular and spiritual leaders who could use their power to create new cities. By about 2500 B.C.E. urban societies had developed in other parts of the world, such as the Indus River Valley in India and Pakistan and the Yellow River Valley of China. Subsequent urban developments of a classical form occurred in Athens, Rome, and other parts of the eastern Mediterranean. Despite urbanization in these ancient forms most people continued to live outside cities.

The modern city is linked closely to the development of industrialization, especially in Europe and North America. Before the Industrial Revolution cities were primarily centers for trade, political power, and religious authority. The rise of the machine in the late 1700s in both Europe and North America led to new city forms characterized by larger numbers of people living in areas with greater population density. As machines were developed and manufacturing increased, people began to migrate to cities from rural areas as laborers and consumers.

Technological change is not exclusive to the post–Industrial Revolution era. What distinguished that historical period was the unprecedented rapid increase in the number, kind, and effects of technological innovation and associated increases in urbanization. About 3 percent of the world population lived in urban areas in 1800, a number that rose to 13 percent in 1900 and more than 40 percent in 2000.

The Modern City

The rise of the modern city had significant economic, social, and cultural impacts. Urbanization changed many of the traditional institutions, values, and human experiences that characterized preindustrial cities. For example, while cities grew in importance in economic terms, they also became centers of poverty. Cities also brought together people of different cultures with different worldviews, traditions, and values. In addition, the concentration of people in urban areas created a host of ethical issues related to living together closely.

In 1905 the German social theorist Max Weber (1864–1920) observed that industrialization represented a fundamental process of social change that was embedded in the development of rationality and scientific knowledge. According to Weber, "demystification" challenged traditional religious ideas by providing an alternative basis of knowledge. Weber concluded that this brought about a notable decline in the acceptance of the spiritual explanations that are at the heart of religious beliefs and practices. As a result human activities that previously had been dominated by religious authority were controlled by an appeal to scientific and rational thinking.

In 1965 the Harvard professor of divinity Harvey Cox observed a close interconnectedness between the rise of urban civilization and the collapse of traditional religion. "Urbanization," Cox stated, "constitutes a massive change in the way men live together, and became possible in its contemporary form only with scientific and technological advances which sprang from the wreckage of traditional views" (Cox 1965, p. 1). Cox argued that that epochal change in worldviews resulted directly from the changing nature and character of cities. As cities became more cosmopolitan and as technology fostered greater interconnectedness through travel and communications, religion, Cox argued, lost its centrality in the hearts and minds of people. Nonreligious perspectives on the human condition replaced Christian religious norms and standards for conduct.

Urbanization in a Global Context

The patterns of economic, social, and cultural changes caused by rapid urbanization in the nineteenth and twentieth centuries are observable in modern cities. In general terms the world population is becoming predominantly urban. Industrialized or more developed countries were more than 75 percent urbanized in 2000, compared with 39 percent for less developed countries. To a certain extent economic gain and higher incomes are associated with urbanization. The expansion of production, communication, knowledge, and trade helped raise standards of living in the more developed countries.

In developing countries the urbanization experience has been vastly different: Industrialization accounts for a much lower proportion of the national economy, and these countries also have significantly lower income per capita. The concern in developing countries is the rate at which increases in the numbers of people living in urban areas are occurring. According to the United Nations Center for Human Settlements (2001), 40 percent of the population of developing countries was living in urban areas in 2001. By 2020 that number is expected to increase to 52 percent.

In 2001 three-quarters of global population growth occurred in urban areas in developing countries, posing significant problems associated with rapid growth in the parts of the world least capable of accommodating it. Most of the projected growth will occur in megacities:

cities with a population of ten million or more. These areas already face increasing difficulties in providing their inhabitants with adequate water, food, shelter, employment, sanitation, and basic services. Poverty has become increasingly urbanized as more people migrate from rural to urban areas. The United Nations Center for Human Settlements (2001) estimates that more than a billion people live in crowed slums in inner cities or in squatter settlements on the periphery of large urbanized areas. Not only does this result in strained local conditions, the rapid growth and concentration of poverty in urban areas in the developing world often leads to adverse consequences for national economies.

Although modern cities are part of a highly interdependent global network fostered by new information, communication, and transportation technologies, one significant characteristic of cities in the twenty-first century is the growth of disparities between the rich and the poor. The United Nations calls this the "divided city," and it is characteristic of urban areas in both developed and developing countries. Some researchers predict a new wave of rapid technological change in urban areas driven by information and communications technologies, which reinforce urban polarization and cause further erosion of traditional economic, social, and cultural activities. New technologies, they observe, reinforce and extend the reach of the economically and culturally powerful. Those who already have access to new technologies and most able to benefit from the potential of new technologies will use them to their advantage to assure their place as the principal beneficiaries of the "information revolution."

Another phenomenon closely linked to the modern city, especially in North America and parts of Europe, is suburbanization. Driven by advances in transportation and communication technologies, sprawl patterns of urbanization from central cities to suburbs began to emerge after 1945. By 1960, 60 million people in the United States were living in suburbs, compared with only 45 million in cities. Since 1980 suburban populations have grown ten times faster than have central-city populations.

In response to the problems associated with the rapid rise of modern urbanization and its attendant problems, urban planning emerged in the United States around the end of the nineteenth century. Although examples of planned cities date back several thousand years, urban planning developed from demands for social reform in both England and the United States. In the early twenty-first century urban planners are part of a distinct occupational skill group that applies a specified body of knowledge and techniques addressing land use, city functions, and a wide variety of other urban characteristics.

M. ANN HOWARD

SEE ALSO *Industrial Revolution; Modernization; Secularization.*

BIBLIOGRAPHY

Callahan, Daniel, ed. (1966). *The Secular City Debate*. New York: Macmillan. This collection of essays, critiques, and book reviews by a diverse group of authors was compiled in response to Harvard professor Harvey Cox's book *The Secular City*. The editor notes that the response to Cox's work was surprising, with more than 225,000 million copies sold in the first printing. An afterword by professor Cox is included.

Cox, Harvey. (1965). *The Secular City*, rev. edition. New York: Macmillan. Explores the theological significance of the modern city and includes an interpretation of the relationship between urbanization and modern secular society. Cox contrasts the modern city (technopolis) with traditional forms of human communities, particularly with regard to the influence of religion and religious institutions.

Ginsburg, Norton. (1966). "The City and Modernization." In *Modernization*, ed. Myron Weiner. New York: Basic Books.

Hetzler, Stanley A. (1969). *Technological Growth and Social Change*. London: Routledge & Kegan Paul. This collection of essays was originally prepared as lectures for *Forum*, an educational radio program sponsored by Voice of America. Twenty-five scholars explore how modernization, defined as technological development, occurs and how it can be accelerated. Ginsburg's essay reviews the history of cities and their historical functions. He describes the distinctly different characteristics of the modern city.

Lebebvre, Henri. (2003). *The Urban Revolution*, trans. Robert Bononno. Minneapolis: University of Minnesota Press. Henri Lefebre (1901–1991) was an influential French philosopher and sociologist. This work was originally published in 1970, but not translated into English until this edition. Highly theoretical, connecting urban research with social theory and philosophy, Lefebre's work marked a new view of "urbanism." Lefebre posited that "urban society" more aptly describes modern societies, rather than the term "postindustrial society," arguing that all forms of human settlements have been altered due to industrialization and urbanization. He noted that agricultural activity is inextricably linked to "industrialization." Even traditional forms of village life around the globe have been permanently transformed by industrial production and consumption.

Mumford, Lewis. (1961). *The City in History: Its Origins, Its Transformations, and Its Prospects*. New York: Harcourt Brace Jovanovich. An extensive exploration of the history of the city, beginning with Ancient Mesopotamia and Egypt, through the modern. In addition to an historical overview, Mumford critiques many of the historical urban forms. He is especially critical of the modern manifestation of urban communities and the negative influence of capitalism resulting in resource depletion. The annotated bibliography is extensive and very helpful to anyone interested in in-depth material.

Prud'Homme, Remy. (1989). "New Trends in Cities of the World." In *Cities in a Global Society*, ed. Richard V. Knight and Gary Gappert. Newbury Park, CA: Sage. Collection of essays that details the phenomenon of rapid global urbanization and the forces influencing the extraordinary changes in modern human settlements. Prud'Homme observes that the cities will have increasingly distinct "global" as opposed to "national" roles to play as economic forces become more global.

United Nations Center for Human Settlements. (2001). *Cities in a Globalizing World*. London: Earthscan. Compilation of work by more than eighty international researchers. The report reviews the status of the world's cities and summarizes global trends that will impact the cities of the future. Especially notable is the observation regarding the increased isolation of the urban poor in both developed and developing countries.

UTILITARIANISM

SEE *Consequentialism*.

UTOPIA AND DYSTOPIA

Part of being human is the ability to dream of a better (or worse) life, either in this world or the next. Some dreams have led to the study of nature and humans, from the deep mysteries of the atom and the gene, to the even deeper challenges of individual and collective sanities—all with an understanding that how one acts can be as important as why, especially when studies of nature (science) and how to transform nature (technology) confer ever greater powers and responsibilities on human beings. Some of humanity's best thinkers and artists have, for 2,500 years, created moral compasses by distilling human wisdom (and folly) into imaginative works called utopias and dystopias (sometimes called anti-utopias). These compasses are neither timeless nor universal; instead, their poles are constantly aligned and realigned by the forces of history, economics, politics, and aesthetics. Messages from these explorers of science, technology, and ethics have long had the potential to both frighten and enlighten. Indeed, they have been doing so at least since the hero escaped from that allegorical cave of shadows in Plato's classic utopia, *The Republic* (360 B.C.E.)—a parable clearly revisited and updated in the film *The Matrix* (1999).

Utopia Defined: Thomas More's Pun and the Myth of Utopianism

The word *utopia* originated in December 1516, when Thomas More published a book with that one word, capitalized, as its title. More wrote his text in Latin. Its complete, twenty-seven word title—*De optimo reipublicae statu deque nova insula utopia libellus vere aureus, nec minus salutaris quam festivus, clarissimi disertissimique viri Thomae Mori inclutae civitatis Londinensis civis et Vicecomitis*—features not only a latinizing of his own name and city but also a brand-new word coined as a trilingual pun. In Latin and English, utopia minimally disguises its truncated roots in two made-up, latinized homophones from the Greek words for a *good place* (*eu-topos*) and for *no place* (*ou-topos*). Hence, "Utopia: the good place which is no place" (Sargisson, p. 1). Since 1516 More's readers and translators alike have wrestled with the many puns and ambiguities of this multivoiced dialogue that is, in Vita Fortunati's words, "a bewildering mixture of reality and fiction" (Fortunati and Trousson 2000, p. 153).

The full title of More's book, in its first English translation by Ralph Robinson in 1551, was *On the best State of a Commonwealth and on the new Island of Utopia A Truly Golden Handbook, No Less Beneficial than Entertaining by the Most Distinguished and Eloquent Author Thomas More Citizen and Undersheriff of the Famous City of London*. This language—especially *best* and *Handbook*, *Commonwealth* and *Beneficial*—evokes the common understanding of *utopia* and *Utopia* as a blueprint for a perfect society. Such an initial reading makes it easy to dismiss utopian arguments as just unrealistic. Since the late twentieth century, scholars such as Ruth Levitas, Tom Moylan, Lyman Tower Sargent, Lucy Sargisson, and W. Warren Wagar have challenged this colloquial, negative view of utopian texts, thoughts, and theories.

The recorded usages of utopia expose a long history of undervaluing the impulse for social dreaming, for collectively desiring a better way of being. Denotations for utopia show a sustained effort to disempower minority reports from the critics of the dominant ideologies that have sustained (mostly premodern) heads of state and (mostly modern) captains of capital. A distinction between *imaginary* and *imaginative* is helpful here. After first asserting, "Utopian thought is imaginative," Northrop Frye observes that "The word *imaginative* refers to hypothetical constructions, like those of literature or mathematics. The word *imaginary* refers to something that does not exist" (Frye 1957, p. 193). More's island is a new *no place* that people can hold in their hands and in their minds; it is imaginative, not imaginary.

Another, less nuanced point is raised by the adjective *perfect* being applied to this system depicted by More. There is a figure—it is tempting to call him a character—in More's *Utopia* called "More," who spends much of his time listening to the exploits of Raphael Hythloday, a sailor and scholar who has been to Utopia. As Hythloday (an imagined figure whose name means *peddler of nonsense*) tells his tale, "More," the character, expresses several reservations. For "More"—and, one could surmise, for More, the man,—many of the Utopians' laws and customs "were really absurd" (More 1995, p. 110). Then, when Hythloday has finished, "More" says, "Meanwhile I can hardly agree with everything he has said (though he is a man of unquestionable learning and enormous experience of human affairs), yet I freely confess that in the Utopian commonwealth there are many features that in our own societies I would like rather than expect to see" (More 1995, p. 110–111). *Utopia* depicts, not a perfect social, legal, and political system, but instead a complex debate, enriched by humor, between More's earned political realism of low expectations and his cautious optimism of higher desires for society.

Utopian Studies: Modern Scholarship Challenges Utopian Stereotypes

The debilitating myth of utopianism as unrealistic perfectionism comes, in part, from concentrating on the content and form of utopias—on what is held and what is doing the holding—rather than on the function of utopia. Some important work has been done with the content and form approaches, most significantly the magisterial tome by Frank and Fritzie Manuel, *Utopian Thought in the Western World* (1979). But as Ruth Levitas notes, "to focus on the function of utopia is already to move away from colloquial usage, which says nothing about what utopia is for, but implies that it is useless" (Levitas 1990, p. 5).

Turning attention to how utopias function, scholars, led by Lyman Tower Sargent (1988), have challenged the dominant commonplace understanding of utopia by reexamining the history of utopian expressions, locating many newly-discovered and rediscovered resources. Other scholars, following the example of Ernst Bloch (1970), have expanded utopia by finding it "immanent in popular culture, in the fashion industry, dance, film, adventure stories, art, architecture, music, and even medical science" (Sargisson, p. 12). Even a Parisian graffito from May 1968—"Be realistic. Demand the impossible"—becomes fodder for utopian analysis, with its second command serving as the apt title for Tom Moylan's 1986 study of science fictional treatments of the critical utopian impulse by Joanna Russ, Ursula K. Le Guin, Marge Piercy, and Samuel R. Delany.

This new wave of utopian studies operates not as a small, monolithic cabal but rather as a growing international community. For example, Fortunati and Raymond Troussan's 700-page *Dictionary of Literary Utopias* (2000) has ninety-nine contributors from more than a dozen countries. This key reference work offers a thorough comparative and interdisciplinary perspective on literary utopias and dystopias, yet even it cannot claim anything approaching complete coverage of utopian and dystopian thought. For a sweeping overview, historian and novelist W. Warren Wagar, contends, "At least two great rivers of utopian dreaming flow through the history of ideas, corresponding to the two great families of world-views, the naturalist and the idealist, which have contended with one another for thousands of years in every philosophical arena in the world" (Wagar 1991, p. 56). Furthermore "Since the seventeenth century, most blueprints for good societies have emanated from the naturalist family, as represented by the classic texts of Bacon, Condorcet, Comte, Cabet, Marx, Bellamy, Wells, and Skinner. But not all. Many utopian visions are grounded in such members of the idealist family of world-views as Platonism, mysticism, orthodox religious piety, and modern and postmodern irrationalism" (Wagar 1991, p. 56). Key writers, for Wagar, in this second tradition include William Morris, George Bernard Shaw, Herman Hesse, Aldous Huxley, Teilhard de Chardin, C. S, Lewis, William Burroughs, and Doris Lessing. In their idealist works, "utopia is not a bustling city registering worldly progress but a community of spirit earning grace" (Wagar 1991, p. 56).

Naturalistic Utopias: Bacon and Science

For present purposes, the name at the head of Wagar's naturalist tradition should be highlighted, Francis Bacon. His *New Atlantis* (1627) brings the politically responsible use of science and technology to the forefront of utopianism by way of its House of Salomon, a grand research institution that, historically speaking, serves as the prototype for modern laboratory science. Writing in 1665, Joseph Glanville affirms, "Salomon's House in the *New Atlantis* was a prophetic scheme of the Royal Society" (Fortunati and Trousson, p. 448). Before detailing its personnel, equipment, and methods, an Elder of the House of Salomon first explains its underlying goals: "The end of our foundation is the knowledge of causes, and the secret motions of things; and the enlarging of the bounds of human empire, to the effecting of all things possible" (Bacon 1627, p. 240).

Their division of labor anticipates such ventures as the Massachusetts Institute of Technology (MIT), the Manhattan Project, and Bell Laboratories. One subgroup of Elders functions, in Bacon's words, as *interpreters of Nature,* whose role foreshadows the modern scientific method itself. These protoscientists "raise the former discoveries by experiments into greater observations, axioms, and aphorisms" (Bacon 1627, p. 240). That is to say, two hundred years before the word *scientist* was coined, Bacon divided practitioners into the experimenters and the theorists. Moreover, his *New Atlantis* initiates the major model of modern utopias, ones that imagine liberating humanity through enhanced production and consumption, including Louis-Sebastien Mercier's *The Year 2440* (1770), Etienne Cabet's *Voyage en Icarie* (1840), and, after *Uncle Tom's Cabin* (1852) by Harriet Beecher Stowe, the most popular nineteen-century American novel, Edward Bellamy's *Looking Backward* (1888).

Idealist Utopias: Morris and Community

Idealist utopias are quieter than their naturalistic cousins. A sense of community is earned in them not by way of technology but through the avenues of spirit in Hermann Hesse's *The Glass Bead Game* (1949). In the naturalistic utopias (and in their dark avatars, the naturalistic dystopias), communication is enhanced (or thwarted) through the agency of faster and better telephones, telegraphs, and computers, among others, while in the idealist utopias (and their avatars) communication honors its root in *communing,* in the fullest sense of a people sharing life. (Tom Moylan [2000] provides an analysis of key examples of these science fictional utopias and dystopias from the 1980s and 1990s.) Idealist utopias are often explicit responses to naturalistic texts, as in Morris's *News from Nowhere* (1890) as a pastoral reply to Bellamy's *Looking Backward* (1888) and its shiny vision of an industrial army circa 2000. On rare occasions, a naturalist dystopia and its paired idealist utopia are written by the same author— for example, Aldous Huxley's *Brave New World* (1932) and *Island* (1962). Taken together, these major utopian streams engage in a complex critique of science and technology, especially in the twenty-first century science fiction short story, novel, and (to a lesser degree) film.

Charting Wilde's Map of the World and Beyond

In "The Soul of Man Under Socialism" (1891), Oscar Wilde poeticizes the positive utopian impulse, saying, "A map of the world that does not include Utopia is not worth even glancing at, for it leaves out the one country at which Humanity is always landing. And when Humanity lands there, it looks out, and seeing a better country, sets sail. Progress is the realization of Utopias." (Wilde 1891, p. 34). Yet while many anticipated and welcomed the rise of modern industry, science, and technology, a minority questioned their impact, wondering not about the feasibility but the wisdom of utopian schemes. Utopias and dystopia are asymmetrical concepts, akin to health and disease, whereby one person's hopeful dream is another's dyspeptic nightmare. One key example is behaviorist B. F. Skinner's *Walden Two* (1948), written as a positive, naturalistic utopia, yet often read as a dystopia—and one Henry David Thoreau would not have warmed to.

Overall, the miscoupling of science (natural and psychological) and power (political and economic) found its most compelling expressions in the great twentieth-century dystopias, especially Yevgeny Zamyatin's *We* (1920), Huxley's *Brave New World* (1932), and George Orwell's *1984* (1949). *We* is especially germane because of its moral calculus. That is, in Zamyatin's hyper-rational world, ethical values are literally, not metaphorically, based on mathematical calculations. Even more disturbing is Huxley's prophetic extrapolation of modern consumerism. He invented the perfect narcotics—soma and the *feelies*—for the dystopian year of our Ford, 632; in the twenty-first century, both can be found at the local mall. Lastly, *1984*'s impact on the understanding of power and politics, language and truth, and banality and desire are difficult to underestimate. After all, not every writer has his name become a ubiquitous adjective—Orwellian.

ROBERT SHELTON

SEE ALSO *Bacon, Francis; Brave New World; Critical Social Theory; Huxley, Aldous; More, Thomas; Morris, William; Posthumanism; Science Fiction; Science, Technology, and Literature; Wells, H. G; Zamyatin, Yevgeny Ivanovich.*

BIBLIOGRAPHY

Bacon, Francis. (1627). *New Atlantis. Famous Utopias of the Renaissance,* ed. Frederic R. White. Putney, VT: Hendricks House, 1981. Utopian and early modern scientific visions powerfully merged.

Bloch, Ernst. (1970). *Philosophy of the Future.* New York: Herder & Herder. A modern European philosopher reinvigorates utopian thinking.

Fortunati, Vita, and Raymond Trousson, eds. (2000). *Dictionary of Literary Utopias.* Paris: Champion. Insights and commentary by a hundred leading scholars of literary utopias and dystopias.

Frye, Northrop. (1957). *Anatomy of Criticism: Four Essays.* Princeton, NJ: Princeton University Press. A seminal text in modern literary theory.

Levitas, Ruth. (1990). *The Concept of Utopia*. Syracuse, NY: Syracuse University Press. Utopia examined by way of its form, function, and content.

Manuel, Frank E., and Fritzie P. Manuel. (1979). *Utopian Thought in the Western World*. Cambridge, MA: Harvard University Press. A sweeping overview of the main thinkers in utopian fiction and non-fiction.

More, Thomas. (1516). *Utopia*, eds. George M. Logan, and Robert M. Adams. New York: Cambridge University Press, 1995. The work that gave humanity the word *utopia*.

Moylan, Tom. (1986). *Demand the Impossible: Science Fiction and the Utopian Imagination*. New York: Methuen. Utopian and dystopian themes in contemporary science fiction.

Moylan, Tom. (2000). *Scraps of the Untainted Sky: Science Fiction, Utopia, Dystopia*. Boulder, CO: Westview Press. Still more recent science fiction seen through utopian and dystopian lenses.

Sargent, Lyman Tower. (1988). *British and American Utopian Literature, 1516–1985: An Annotated, Chronological Bibliography*. London: Garland Publishing. The major bibliography of utopian literature, annotated with insight and wit.

Sargisson, Lucy. (1996). *Contemporary Feminist Utopianism*. New York: Routledge. Feminist reexamination of utopian thought, literature, and criticism.

Wagar, W. Warren. (1991). "J. G. Ballard and the Transvaluation of Utopia." *Science-Fiction Studies* 18: 53–70. Wagar is an important utopian scholar, novelist, and teacher.

Wilde, Oscar (1891). "The Soul of Man Under Socialism." In *Selected Essays and Poems*, ed. Owen Dudley Edwards. London: Penguin, 1954. Wilde was indeed more than an amusing playwright.

V

VACCINES AND VACCINATION

Nowhere is the effort to use science and technology for human benefit clearer than in the development of vaccines against serious infectious diseases. Although vaccinations seldom have unintended consequences they can, on occasion, pose complex ethical issues.

Historical Developments

One of the key figures in Western vaccine history is the English physician Edward Jenner, who developed an effective prophylactic against smallpox in 1796. The protective material that Jenner used came originally from a cow infected with cowpox. When infected cows were milked, Jenner noted, as others had before him, that the milkmaids who did the milking developed pustules or sores on their hands that disappeared in time and did not harm the girls. These girls, it was further observed, did not get smallpox, which is a disease that left unsightly pockmarks on the face and skin where the pustular sores had been, and in about 30 percent of the cases was lethal. On May 14, 1796, Jenner took liquid from the developing sores of the hand of a milkmaid named Sarah Nelms and injected it into the skin of eight-year-old James Phipps. After about six weeks, when the sore had resolved and disappeared, Jenner injected Phipps's skin with virulent human smallpox. Phipps did not get the generalized disease and was protected against the widespread eruption of sores. After many such experiments, Jenner called the material he injected to achieve protection against virulent human smallpox, a vaccine deriving the term from the Latin *vacca* (cow).

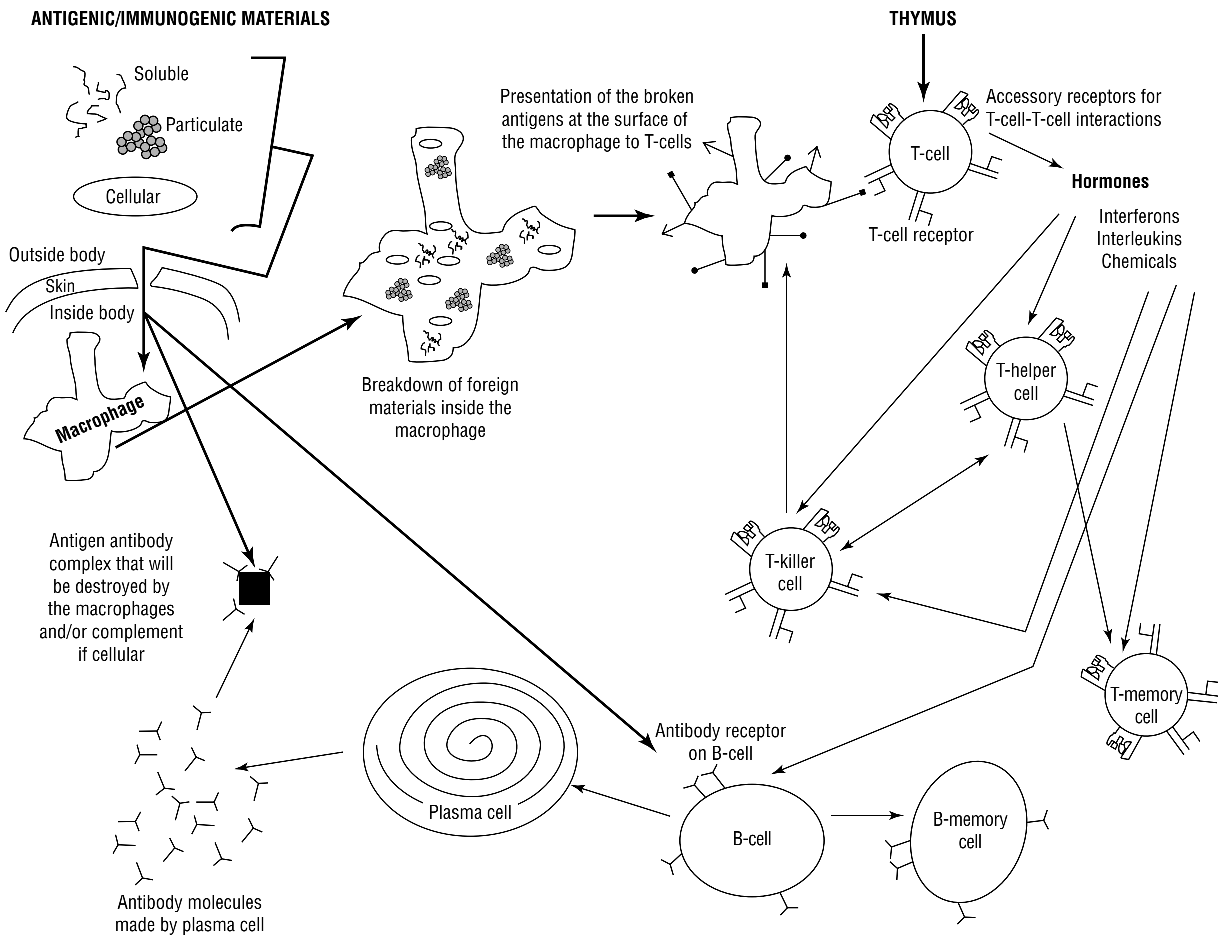
In the decades following Jenner's discovery many other vaccinators took up the procedure, and gradually the number of smallpox outbreaks started to decrease noticeably. By the time Louis Pasteur was developing his vaccines (for fowl cholera, rabies, and anthrax) in the late nineteenth century, smallpox was so much on the wane that Jenner's contribution to human well-being was much lauded in all the countries that had adopted his methods.

The continued use of the vaccine, made for mass distribution by collecting the pustular material from the skin of deliberately infected calves, led eventually to a campaign spearheaded by Donald Henderson, working with the World Health Organization (WHO), to completely eradicate human smallpox from planet Earth. In this they were successful, as attested by a declaration of the chief WHO scientists on December 9, 1979. This was the first time that a serious and socially debilitating human infectious disease had been entirely eradicated, and is one of the highest achievements of humankind. A second disease targeted for elimination through the use of vaccines is polio. By 2004, the disease notification returns showed that there were but several tens of cases in fewer than five countries per annum. It is held that elimination will have occurred when there will have been zero notified cases worldwide for at least two years, and this is confidently expected to occur before 2010.

The consequence of these pioneering results in vaccine use has been that many infectious diseases afflicting humans throughout history are now so much in the past that people have forgotten how dangerous, damaging, and deadly they can be. Human diseases that are in this category include diphtheria, tetanus, pertussis or whooping cough, polio, measles, mumps, rubella, rabies, hepa-

FIGURE 1

Simplified Overview of the Immune System



SOURCE: Courtesy of Ray Spier.

titis A and B, *Haemophilus influenzae* b, and yellow fever. A similar list for veterinary diseases includes foot-and-mouth disease, Newcastle disease, Marek's disease, anthrax, and canine distemper.

Vaccine Science

Vaccines that are intended to prevent infectious diseases are normally made from the organisms or close relatives of the organisms that cause the disease. In the former case, before the organism is used as a vaccine, it is killed or inactivated by a variety of techniques that include heating, treating with inactivating agents such as formaldehyde or acetyl-ethylene-imine, exposing to ultraviolet light or gamma radiation, and using denaturing agents such as urea and/or proteolytic enzymes. A further option when using an inactive vaccine is to use a part or subunit of the pathogenic agent. Here the bacterium or virus is disrupted and one or several of its component parts are used in the vaccine to which is added an adjuvant. This latter material is a nonspecific stimulator of the immune system that greatly potentiates the killed organism or its components as used in the vaccine.

When a live organism is used for a vaccine it is chosen for its relatedness to the disease-causing organism plus its *in*ability to cause disease, normally as a result of its attenuated or weakened nature. Both types of vaccines benefit from stabilizers and preservatives, but while the killed vaccines are more likely to survive at room temperature the live vaccines must be either held in refrigerated conditions or freeze-dried, in which state they will withstand limited exposure to more elevated temperatures.

The actual materials of the killed or live organisms that are active in the achievement of the vaccination effect are either the proteins or complex carbohydrates that exist on the outer skins or envelopes of the pathogenic microorganisms. While most carbohydrates are generally inert, they can be made into powerful and active agents when they are covalently joined to proteins. For the proteins themselves, scientists can identify immunogenic sites that are either dependent on a linear string of not less that six amino acids or a region of a protein molecule wherein an amino acid from one part of the linear chain comes into proximity with other amino acids to make up an immunogenically active area or site; these are called conformational immunogens. Normally two or three amino acids would be involved in such a conformational determinant. Lipids and nucleic acids are not normally involved in the immunogenicity of pathogenic organisms except in that they participate in creating an environment in which proteins and carbohydrates take up their active three-dimensional configurations.

These immunogenic materials can be found on all types of viruses and bacteria, and some protozoa. Whole animal cells that express proteins or glycoproteins (proteins to which carbohydrate groups are attached) at the exterior surface have also been used as vaccines, such as the anticancer vaccine for chickens that utilizes infection by the herpes virus that causes Marek's disease in poultry. There have been experiments demonstrating the feasibility of this approach to vaccinate against some human cancers, but more testing needs to be done.

Vaccines work by stimulating the human or animal immune system to produce glycoprotein antibodies and specialized cells that seek out and kill body cells that contain infecting organisms or materials they do not recognize as belonging to the normal body. In this way they are able to recognize cancer cells because such cells make unique molecules that are exposed at the surface of the cancerous cell and label that cell as one of the abnormal cells of the body that may be killed by the killer T cells of the immune system. Many such cancerous cells are made in the lifetime of a human and are dealt with in this way, thus protecting the human from the uncontrolled and killing effects of a rapidly expanding cancer. While much is known about these reactions, scientists are yet uncertain about many of the details that relate the invading or foreign microorganism to the response it evokes and the consequences of that response. Some of the complexity of the immune system may be gleaned from the overview diagram of Figure 1.

When a microorganism penetrates the skin barrier and survives the antimicrobial agents in the skin and tissues, it is ingested into a macrophage-dendritic cell. These cells (of which there are more than twenty tissue-specific types) engulf foreign particles and then break them down to smaller molecules that are released to become expressed on the outer surface of the cell. From this exposed site they attract another kind of cell of the immune system known as the T cell. This cell, found in the white cells of the blood, is formed when an undifferentiated white cell passes through the thymus gland.

There are many different and specialized T cells. T cells sport receptors on their surfaces that interact with specialized molecules on the surface of the macrophage cells, which proffer the broken-down piece of the invading organism to the T-cell receptor system. When this interaction occurs, the T cell excretes a number of locally acting hormones (parachrines) that cause other cells of the immune system, such as the antibody-producing B cells, to reproduce and differentiate to plasma cells. These cells excrete antibody molecules that bind to the foreign invading organism or foreign molecule, forming an antibody-antigen complex. Several such antibody molecules with differing binding specificities may bind to a single invading organism or complex molecule. The consequence of these attachments is that the foreign molecule or organism is marked for destruction by either the other specialized killer T cells or scavenger macrophages. Other T cells retain a "memory" of the immunogenic components of the foreign organisms, so that when the body is invaded at a later date (which may be many years later) the body is primed to respond in a more rapid and vigorous way to the invader. There are two main processes involved here. Each has its own cells, cell receptors, and parachrine hormones; each has its specialized cells with their own unique growth and differentiation responses. The resulting complexities have, so far, prevented the design of a new vaccine based solely on knowledge of how a vaccine works.

Notwithstanding these complexities, many new diseases are being targeted for control or elimination by vaccination. Among these, many new types of vaccine are being tested for acquired immunodeficiency syndrome (AIDS), caused by the human immunodeficiency virus (HIV), as well as novel vaccines that may protect children against malaria infection. Diarrhea and pneumonia are other killer diseases affecting young children and neonates (resulting in 2 million deaths per year). These bacterial diseases are preventable by vaccination, but the means for the inexpensive and safe delivery of

Incredulous people grouped around Dr. Edward Jenner as he administers the first vaccine, 1796. *(The Library of Congress.)*

the vaccine materials is still under investigation. Vaccines for herpes simplex, papilloma virus cancers of the uterus, and staphylococcal infections are under development, as are the new techniques of DNA vaccines and powerful adjuvants such as CpG (multiples of the dinucleotide cytosine-guanine).

Ethical Issues

Vaccines are generally given to people and neonatal infants in good health. As with any medical treatment, it is possible that, as a side effect, serious illness or disease may result from the administration of a vaccine. This raises ethical questions: How much harm should be incurred to achieve a benefit that is expressed as an increase in the well-being of a population or society? How much individual suffering justifies a particular social gain? Because the suffering has been inflicted by an individual vaccinator, this might be thought less acceptable than the natural suffering that would otherwise afflict an unvaccinated population. One or two seriously diseased children may be the result of a vaccination campaign that has prevented several hundred deaths and thousands of diseased and disabled people. This ethical issue can be approached on the basis of a calculus of suffering. The chance that any one individual will experience harm, pain, or loss (with no advance knowledge of who will be so affected) has to be set against the thousands of people who would almost certainly suffer if they were not vaccinated. This utilitarian calculus tends to hold sway in most parts of the world, but there will be individuals in advanced as well as developing societies with dissenting views.

Those of a fundamentalist persuasion might argue that preventing people from becoming diseased is preventing God from exacting a punishment by causing a disease on those that have turned to idols or otherwise misbehaved by disobeying God's commandments. Another similar statement might be that by taking action to prevent disease, humans are acting unnaturally. Counterarguments to these statements is that one of God's commandments is "Therefore choose life" (*Deut* 30:19), so vaccines are acceptable in that they preeminently save lives. The argument about unnaturalness turns on the definition of the natural or that which obeys the laws of thermodynamics. Vaccines are in the latter category and should, thereby, be both natural and acceptable.

In the early days of the smallpox vaccination campaigns, and before Jenner, the argument from the pulpit was that as there was a small chance that the vaccinee would catch smallpox from the vaccination (then called variolation), thus creating a way that an individual could commit suicide (albeit inefficiently), which was forbidden by both religious and secular authorities. Clearly the intent of the vaccinee is normally to avoid death so the commitment of a crime that involves an evil mind or intent is not applicable in this area.

A case can be made that by vaccinating all the young children of the developing world against neonatal infections there will be increases in population numbers that will eventually lead to starvation and further suffering. But as developing populations advance and more of the female population receive some education, birthrates decline—a situation aided by the increased probability that newly born children will survive the hurdles of the infectious diseases of childhood.

Some vaccines are expensive; for example, a three-dose course of vaccination for hepatitis B when it first became available was about $1,000. The U.S. Food and Drug Administration, or a comparable agency in another country, must license the marketing and widespread use of a vaccine. To obtain this license, a company may spend anywhere from $300 million to $800 million testing the vaccine's safety and efficacy and ensuring consistency of production, and this cost must be recouped within the remaining lifetime of whatever patent was taken out when the mere possibility of a vaccine was recognized. The poor or the people of the developing world clearly cannot afford expensive new vaccines. In a decade or so, however, the price of most new vaccines come down to affordable levels, and agencies such as WHO, charitable foundations such as the Bill and Melinda Gates Foundation, and local governments find the funds to buy vaccines purchased at special low prices. For people in the developing world these vaccines are generally free at the point of use.

It clearly costs less to test a vaccine in a developing country where the prevalence of the disease is at a higher level, and so the challenge level (the level of the virus in the population that can constitute a cause of disease infection against which the vaccine generates a protective response) is higher; fewer people therefore have to be enrolled in the efficacy tests. But it is clear that from a safety point of view, the people in the test are exposed to the risks of harmful side effects. Why should people in the developing world accept the risks of harm from a vaccine that is intended to decrease the risk of disease in the advanced or developed world? To obviate this disproportion, arrangements are often made so that those who have participated in the trial and others in their society may obtain preferential supplies of vaccine. But this is not always the case.

Finally, some argue that vaccines both promote more risky sexual behavior and obviate the need for the development of self-control by the use of a technical fix—the vaccine. This latter argument is parried by the contention that without the vaccine the disease situation in the society would be considerably worse and that a person's self-control is a matter for their personal determination and conscience. That a vaccinated person would behave in a way that would increase the chances of becoming infected is a real issue. If, however, the herd effect is to apply, then the increase in risky behavior will come to naught as the herd is so well protected that, no matter the risky behavior, the chances of getting the disease are drastically reduced.

In an era of heightened threats of terrorist attacks, it is important to realize that one such threat is the deliberate release of pathogenic microorganisms. To prevent such an event becoming a disaster it would be important to have available the necessary vaccines to limit the spread of contagious disease. This in turn could lead to further developments of pathogens that are not affected by the vaccines. An escalatory process is thus engendered. Determining how much of a society's resources will be devoted to these contingencies will require much skill in deliberation and adaptation to current conditions and future potential developments. Nevertheless, the relative importance of alternative personal and social expenditures will need to be continually reevaluated.

Notwithstanding the ethical issues, vaccines remain one of the most effective and powerful tools for controlling, reducing, or eliminating debilitating diseases. They also point the way ahead for the development of medicine in that more effort should be expended on the development of methods for the prevention of disease rather than the cure of diseases that could have been prevented.

Elementary-school student receiving a vaccine. *(© Bob Krist/Corbis.)*

R. E. SPIER

SEE ALSO *Antibiotics; Bioethics; HIV/AIDS.*

BIBLIOGRAPHY

Baxby, Derrick. (1981). *Jenner's Smallpox Vaccine.* London: Heinemann Educational.

Bazin, Hervé. (2000). *The Eradication of Smallpox,* trans. Andrew and Glenise Morgan. San Diego: Academic Press.

Coico, Richard; Geoffrey Sunshine; and Eliezer Benjamini. (2000). *Immunology: A Short Course*, 5th edition. Hoboken, NJ: Wiley-Liss. Useful and clear introduction.

De Kruif, Paul. (1927). *Microbe Hunters.* London: Jonathan Cape. An exciting review of the early work on vaccines written by an enthusiastic journalist.

Gregoriadis, Gregory; Anthony C. Allison; and George Poste, eds. (1989). *Immunological Adjuvants and Vaccines.* New York: Plenum Press. Includes most current developments.

Lederberg, Joshua, ed. (1999). *Biological Weapons: Limiting the Threat.* Cambridge, MA: MIT Press. A useful overview.

Plotkin, Stanley A., and Walter A. Orenstein, eds. (2003). *Vaccines,* 4th edition. Philadelphia: Saunders. Covers mainly human vaccines.

Radostits, O. M.; D. C. Blood; and C. C. Gay. (1994). *Veterinary Medicine,* 8th edition. London: Baillière Tindall. Covers animal diseases, treatments, and vaccines.

Vallery-Radot, René. (1927). *The Life of Pasteur,* trans. R. L. Devonshire. Garden City, NY: Doubleday.

VALUES AND VALUING

The concept of value is more complex than it might initially appear. Values can range across personal preferences as indicated by pleasures, desires, wants, and needs to more objective goods such as health, efficiency, progress, truth, beauty, and more. Values can also be negative as well as positive, and in the former case they are commonly termed "disvalues," with examples being pain or illness. Values in all these senses both influence and are influenced by science and technology.

However, what precisely makes each of these diverse phenomena into values is more difficult to indicate. The concept of value, its manifestation in values, and the process of valuing (and evaluation) have been subject to diverse economic, social scientific, and philosophical analyses, each of which introduces numerous distinctions of relevance to any description and assessment of values in and resulting from science, engineering, and technology. Because of such difficulties, the present review attempts no more than some general introductions to three areas of discussion and includes a briefly annotated bibliography to mostly philosophical references.

Economic Perspectives

The term *value* is derived from the Latin *valere,* to be worthy or strong, the root as well of *valiant, valor,* and *valid.* It can be used as a noun ("Science is one of the primary *values* in modern culture") or verb ("We *value* modern technology"), or turned into a modifier ("Engineering is a *valuable* activity"). The term first emerged during the rise of the modern period to refer to the monetary worth of some commodity. Eighteenth-century economists conceptualized value as dependent on humans, and as such value was subtly opposed to premodern notions of goodness as a transcendental manifestation (along with truth and beauty) of being as such.

In the labor theory of value, commonly referenced to the English philosopher John Locke (1632–1704), value is created by humans when they technologically transform nature. In classical economics the market price of a commodity was thought to reflect the objective value contributed to it by human labor. But critics of this view argued in favor of price reflecting almost wholly the values that consumers attribute to products in a competitive marketplace. Exchange value replaced use value as the primary form of value. In economic science the basic concern has thus become to analyze interactions between human values and market behavior.

Social Scientific Perspectives

A different analysis of values developed in the social sciences, where the concern was more with how values are rooted in or related to the self and how they constitute society or influence political behavior. One mid-twentieth century effort to promote the scientific study of social values was advanced by the pragmatist philosopher Charles Morris (1901–1979). Extending earlier work, Morris (1956) distinguished between operative, conceived, and object values; did an empirical, cross-cultural analysis of value preferences among college students in Canada, China, India, Japan, Norway, and the United States who completed a "ways to live" inventory; and then speculated about the social, psychological, and biological determinants of values. The results of this psychometric research, which revealed both stability in structures among thirteen different ways of life and differences between national samples, were not especially profound, but they nevertheless promoted the idea that values are amenable to empirical investigation. This was in opposition to any assumption that the fact/value distinction would exclude values from scientific examination.

On a more personal level, one of the most widely referenced psychological analyses of value is that of Abraham H. Maslow (1908–1970). According to Maslow (1971) human beings try to satisfy needs or pursue values in the following order of priority: physiological needs (air, water, food), safety (security, stability), needs of belongingness and love, esteem needs, and self-actualization. The need for self-actualization was further associated by Maslow with the pursuit of what he called B(eing)-values such as truth, goodness, and beauty.

An observation by Langdon Winner bears on the implications for science and technology of many psychological (and even some economic) approaches to values. Once values are subjectivized, "[r]aising the question of value is no longer so much an occasion to think about the qualities of things or conditions outside us [as it is] an opportunity to look within, to perform an inventory of emotions" (Winner 1986, p. 158). Persons no longer purchase objects because the objects themselves have value as they are likely to purchase objects to realize their own values.

In sociology and anthropology values are described not so much in individual or personal terms as dimensions of culture. Shared values create collective identity and solidarity in culture and society. Socialization is a process of inculcating values from one group or generation to another. Sociologists of science analyze what particular values are shared within communities of technical professionals and how the inculcation and reinforcement of such values takes place. Values are both expressive and functional more than cognitive.

It should also be noted that within modern societies as a whole, one of the features that defines them as modern is the shared value placed on science and technology. Some critics of technological society in turn argue that this shared commitment to and/or acceptance of science and technology may undermine other socializing values such as religion. Questions thus arise about the absolute value of scientific knowledge—and about the possibility of technologies configured by alternative values.

Philosophical Perspectives

In philosophy the examination of values is closely linked to ethics. The philosophical examination of values and valuing as distinct from ethics came of age in the mid-twentieth century in different ways in the pragmatic, analytic, and phenomenological traditions.

PRAGMATIC TRADITION. In the pragmatic tradition, work by John Dewey (1859–1952), Ralph Barton Perry (1876–1957), Stephen C. Pepper (1891–1972), and C. I. Lewis (1883–1964) has been central. For Perry, value is defined as "any object of any interest" (1926, p. 115), so that to say that X is valuable means that Y takes an interest in X. Pepper sees Perry's definition as too narrow and argues more generally that values are constituted by "all selections by a selective system that are relevant to human decisions" (1958, pp. 690–691).

Dewey and Lewis continued the pragmatic empiricism of Perry and Pepper by arguing the foundational character of the human creative act of valuing. For Dewey, values are *ends-in-view,* that is, always provisional and able to become means to another end-in-view. Going beyond sheer animal impulses or appetites that produce effects, human interest, desire, "having ends-in-view, and hence involving valuations, is the characteristic that marks off human from nonhuman behavior." Moreover, when science is put to "distinctively human use" its knowledge about the nonhuman world is utilized to assess such ends-in-view in terms both of whether they are likely to be achievable by the proposed means or capable of becoming means themselves for further provisional ends. "In this integration not only is science itself *a* value (since it is the expression and the fulfillment of a special human desire and interest) but it is the supreme means of the valid determination of all valuations in all aspect of human and social life" (1939, p. 66).

Like Dewey, Lewis sees evaluations as forms of empirical knowledge related to courses of human action. Values have empirical content, although this content bears solely on personal preferences and courses of action, which makes values subject to democratic choice and scientific assessment. The general study of values, which can involve more than ethical values, is for pragmatists more properly termed theory of value or axiology than ethics.

ANALYTIC TRADITION. In the analytic tradition, the early leaders were Charles L. Stevenson (1908–1979), A. J. Ayer (1910–1989), and R. M. Hare (1919–2002). According to Ayer, the philosophical analysis of values is better described as *metaethics* than as ethics, because its goal is more the clarification of the meaning of terms than normative argumentation. Adopting a positivist interpretation of science as the paradigm of knowledge, Ayer and Stevenson argued that ethical and value statements were simply noncognitive expressions of likes and dislikes. Hare subsequently merged metaethical analysis with ordinary language philosophy to undertake a critical examination of the "language of morals." Linguistically, value statements were argued to entail a universalization of likes and dislikes.

Another even more abstract metaethical approach to values can be found in the work of G. H. von Wright (1916–2003), a student of Ludwig Wittgenstein. Von Wright (1963) subjects a particular value, goodness, to extended conceptual analysis. For von Wright it is not so much the value of goodness that is a creative projection of human action as a human commitment to a specific value that establishes that value as a norm. Von Wright and others such as Sven Ove Hansson (2001) have further sought to develop a formalized logic of values and norms reasoning.

PHENOMENOLOGICAL TRADITION. In the phenomenological tradition the defining work was that of Max Scheler (1874–1928). Whereas pragmatism focused on the process of valuing and analytic philosophy on the meaning and logic of value propositions, Scheler sought a conceptual elucidation and critical assessment of the substantive value feelings people experience. Scheler undertook his phenomenological descriptions of experienced values in opposition to Kantian formalism and universalism—a formalism echoed in metaethical formalism. For Scheler, prerational or intuitive preferences are at the basis of substantive ethics. These feelings can be grouped into five basic types: sensible values, pragmatic values, life values, intellectual values, and spiritual values. For Scheler (and most subsequent phenomenologists) technology is constituted by pragmatic values and science by intellectual ones.

Implications

The philosophical study of values yields a number of distinctions used in reflecting on relations between science, technology, and values. Such distinctions include those between instrumental and final values (means and ends), between extrinsic and intrinsic values, and subjective and objective values. Although related, these distinctions are subtly different. For instance, instrumental or use values may be extrinsic or designed into technological artifacts so as to become intrinsic values that have subjective and objective dimensions.

In relation more specifically to science and technology there are three interrelated issues with regard to values: What sort of property is involved with having a value or being valuable? (That is, are values primarily aspects of things or of knowers and users?) Is this property subjective or objective? (That is, to what extent is value subject to scientific study?) How might this property be designed into products, processes, or systems? (That is, can values be part of engineering design and technological invention?)

By and large values are taken in economics and in philosophy to be second-order properties that arise in interactions among human beings (markets) or depend on human beings (their interests). Values are thus not determined by science though they are certainly manifested in science, and science can study values in at least three ways: inventorying what values people express, analyzing structural relations among values, and criticizing specific values as likely or not to be able to be realized given the way the world is. The engineering design of products, processes, or systems is always undertaken with some values in view both with regard to process and project termination. That is, questions are increasingly asked about whether certain values such as user-friendliness, gender equity, or democratic participation can be designed into technologies. But the degree to which such a question can be answered in any systematic manner remains problematic.

The problematic character of the values–science relation is another continuing issue. One of the most persistently defended distinctions in science and technology is that between facts and values. Although widely criticized—because it is not clear whether the distinction is itself a fact or a value or both—one of the most persistent difficulties is to figure out how best to relate the two once distinguished. Even those who want to defend the difference also want to argue that values should have some bearing on what kind of science gets done and how it is done, and on which kind of technology gets created and how it should be used.

One general effort to address such questions is Loren R. Graham's *Between Science and Values* (1981), in which the author distinguishes between restrictionist and expansionist relationships. In the restrictionist view, science and values are strongly separated, and science is argued to be autonomous with no univocal influence on values. According to Graham, this is a view that is more defensible in physics than in biology, especially when the biology involves research on human beings. In the expansionist view, science is argued to have either direct or indirect implications for values and vice versa. This is the view that Graham thinks is most reasonable, but also one that he admits is both difficult to determine the boundaries for and dangerous. Indeed, as his historical case studies in physics and biology across the twentieth century reveal, almost any effort to deal with the science–values relation has weaknesses as well as strengths. Values and valuing are as much a challenge to science as science is to values.

In conclusion, it is worth observing that discussions of science, technology, and values in the 2000s have become less central than in the 1950s or 1960s. Were Jacob Bronowski's widely read *Science and Human Values* (1956) to have been published in the 1990s it would more likely have been titled something like "Science and Ethics."

CARL MITCHAM

SEE ALSO *Axiology; Critical Social Theory; Ethical Pluralism; Existentialism; Neutrality in Science and Technology.*

BIBLIOGRAPHY

Bronowski, Jacob. (1956). *Science and Human Values*. New York: Julian Messner.

Dewey, John. (1939). *Theory of Valuation*. Chicago: University of Chicago Press. An introduction to a pragmatic theory of values or axiology.

Graham, Loren R. (1981). *Between Science and Values*. New York: Columbia University Press. A historical examination of the interaction of science and values in the twentieth century using cases from physics and biology.

Grice, Paul. (1991). *The Conception of Value*. Oxford: Clarendon Press. A theory of value drawing on both Aristotle and Immanuel Kant.

Hansson, Sven Ove. (2001). *The Structure of Values and Norms*. Cambridge, UK: Cambridge University Press. Presents a formal system for the representation of values and norms.

Jonas, Hans. (2000). *The Genesis of Values*, trans. Gregory Moore. Chicago: University of Chicago Press. Originally published 1997. A historicophilosophical analysis of the work of Friedrich Nietzsche, William James, Émile Durkheim, Georg Simmel, Max Scheler, John Dewey, and Charles Taylor arguing that "values arise in experiences of self-formation and self-transcendence" (p. 1).

Lewis, Clarence Irving. (1946). *An Analysis of Knowledge and Valuation*. La Salle, IL: Open Court. Argues a naturalist theory of evaluations as a form of empirical knowledge.

Maslow, Abraham H. (1971). *The Farther Reaches of Human Nature*. New York: Viking. A humanistic psychologist's argument for a hierarchy of needs-values.

Morris, Charles. (1956). *Varieties of Human Value*. Chicago: University of Chicago Press. An early psychometric study of different value preferences.

Pepper, Stephen C. (1958). *The Sources of Value*. Berkeley: University of California Press. One of the most systematic and expansive pragmatic theory of values.

Perry, Ralph Barton. (1926). *General Theory of Value: Its Meaning and Basic Principles Construed in Terms of Interest*. New York: Longmans, Green. Reprint, Cambridge, MA: Harvard University Press, 1950. Defines value as simply the object of an interest.

Perry, Ralph Barton. (1954). *Realms of Value: A Critique of Human Civilization*. Cambridge, MA: Harvard University Press. Extends the 1926 interest theory of value into a critical assessment of interests in society, ethics, politics, law, economics, science, art, and more.

Scheler, Max. (1973). *Formalism in Ethics and Non-formal Ethics of Values: A New Attempt toward the Foundation of an Ethical Personalism*, trans. Manfred S. Frings and Roger L. Funk. Evanston, IL: Northwestern University Press. Originally published 1913–1916. Distinguishes five basic feeling values: physical, useful, vital, mental, and religious.

von Wright, Georg Henrik. (1963). *The Varieties of Goodness*. London: Routledge and Kegan Paul. A conceptual analysis of goodness as a type of value.

Winner, Langdon. (1986). *The Whale and the Reactor: A Search for Limits in an Age of High Technology*. Chicago: University of Chicago Press. A collection of influential essays.

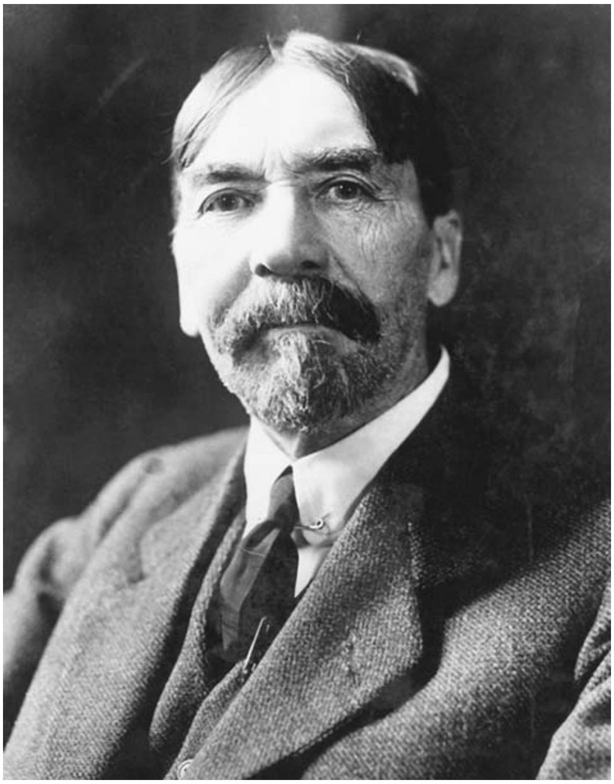
VEBLEN, THORSTEIN

Economist, sociologist, and a founder of institutional economics, Thorstein Bunde Veblen (1857–1929) was born in Manitowoc County, Wisconsin, on July 30. He studied under the economist John Bates Clark at Carleton College in Minnesota, then at Johns Hopkins University before earning his doctorate in philosophy at Yale University in 1884. After a career of teaching at the University of Chicago, Stanford University, the University of Missouri, and the New School for Social Research, he died near Menlo Park, California, on August 3.

Veblen was an iconoclast. During the early twentieth century he was the foremost critic of the business establishment and its effects on culture and society. He alienated other academics by challenging their acquiescence to business interests. He was a prolific writer whose most famous work earned both popular success and intense academic scrutiny.

As one of the first institutional economists, Veblen's writings were often diametrically opposed to classical or neoclassical economics. For Veblen neoclassical economics relies on static notions of individually determined self-interests. In contrast, institutional economics maintains that social institutions, arising from individual economic behavior, influence that behavior in return. This approach views the economy as an evolving system and places a strong emphasis on dynamics, changing structures (including technologies, institutions, and ethics), and shocks to the system arising from technological innovation.

His most famous work, *The Theory of the Leisure Class: An Economic Study of Institutions* (1899), was a scathing sociocultural commentary. Veblen provides both a dynamic theory of class movement and a theory of consumption. He paints a picture of the business class as evolving from an earlier stage of "savagery," in which people peacefully went about their daily lives without any notion of private property and with relatively little material wealth. Culture then evolved from this primitive state to one of "barbarianism" characterized by private ownership and a leisure class that did not have to



Thorstein Veblen, 1857–1929. The American political economist, sociologist, and social critic wrote about the evolutionary development and mounting internal tensions of modern Western society. *(© Corbis-Bettmann.)*

work, but instead derived its wealth from the exploitation of other human beings through technology. Members of the leisure class gained their status through control and knowledge of technology. Veblen maintained that the leisure class would remain in power and receive the economic benefits of being in power as long as they could appropriate technological skills, tools, and labor. This appropriation depends mainly on private property and the profits derived from ownership of economic resources. This ability to remain in power and to maintain a dominant class position depends in turn on creation of institutions through business and government to protect the property rights of the leisure class at the expense of everyone else.

Veblen argued that the concentration of technology and power would often lead to the accumulation of wealth in the hands of a small leisure class at the expense of those at the other end of the economic spectrum. In the absence of institutions, effective property rights, and cultural norms the majority of the population would have access to neither capital nor the means to secure it. This has proven to be the case in many developing countries, where the absence of well-defined and enforceable property rights makes capitalism prone to inequitable outcomes.

Veblen's theory of consumption, especially the idea of consuming something beyond basic necessities, was unique. Conspicuous consumption provides the basis for twentieth-century consumerism in which consumption of goods and services serves not only as a tool to meet basic needs but also as a symbol of status.

Veblen recognized both the importance of science and technology in the creation of wealth and tensions between scientific technology and commercial enterprise. In *The Theory of Business Enterprise* (1904) and again in *The Engineers and the Price System* (1921) he analyzed the tensions between technological efforts to create good products and commercial interests in making money. Because of his praise of the "instinct of workmanship" (in his 1914 book published under that title) in ways that would eventually be echoed by Samuel C. Florman's *The Existential Pleasures of Engineering* (1976), Veblen's analysis inspired the technocracy movement and its effort to place engineers in positions of political power.

Veblen was one of the great thinkers of the twentieth century. Whether it was jealousy of his publishing success or because of his aloof nature, Veblen was shunned by his colleagues during most of his career. Ironically, near the end of his life, the American Economic Association offered him one of the highest honors in the field, the presidency of the association. He declined as he was unconcerned with either fame or recognition by his peers. Instead Veblen focused his efforts on writing and cofounding the New School for Social Research in New York. The posthumous rediscovery of Veblen's ideas has lead to renewed interest in both institutional and evolutionary economics and a new appreciation for and interpretation of Veblen's ideas. His legacy in the creation of social and economic theory continues to grow in importance.

WILLARD DELAVAN

SEE ALSO *Engineering Ethics; Management.*

BIBLIOGRAPHY

Dorfman, Joseph. (1934). *Thorstein Veblen and His America.* New York: Viking Press. One of the best biographies of Veblen, comprehensive and well written.

Florman, Samuel C. (1976). *The Existential Pleasures of Engineering.* New York: St. Martin's Press.

Jorgensen, Elizabeth Watkins, and Henry Irvin Jorgensen. (1999). *Thorstein Veblen: Victorian Firebrand.* Armonk, NY: M.E. Sharpe. A wonderful biography replete with personal letters and interpretations of the letters.

Mouhammed, Adil H. (2003). *An Introduction to Thorstein Veblen's Economic Theory*. Lewiston, NY: Edward Mellen Press. Comprehensive guide to Veblen's economics and his place relative to other great thinkers of the twentieth century.

Veblen, Thorstein. (1899). *The Theory of the Leisure Class: An Economic Study in the Evolution of Institutions*. New York: Macmillan. His most cited and popular work; a critique of society and business practices.

Veblen, Thorstein. (1904). *The Theory of Business Enterprise*. New York: Scribners. A thoroughly convoluted attempt to define the modern corporation and explain why as an institution it is failing society

Veblen, Thorstein. (1914). *The Instinct of Workmanship, and the State of Industrial Arts*. New York: Macmillan. Veblen himself said this was his only important book. A synthesis of most of his important arguments.

Veblen, Thorstein. (1921). *The Engineers and the Price System*. New York: B. W. Huebsch. A collection of essays attacking the control of industry by investment bankers and outlining the role of engineers and the common worker in changing the inefficiencies of the existing power structure.

VEGETARIANISM

Vegetarianism is a traditional ethical stance and practice that has been influenced around the turn of the twenty-first century by science and technology. Strictly speaking, vegetarianism is a way of life in which one abstains from eating meat including fowl and fish. The *vegan* (pronounced "veegan") diet excludes all animal products, including eggs and milk. *Lacto-vegetarians* include milk products in their diet, and *lacto-ovo-vegetarians*, both milk and eggs. In the techno-scientific culture, a vegetarian diet may also be conscientious in other ways, such as by taking into account agricultural and food production methods, transportation distances, and the fairness of trade.

History of Vegetarianism

The history of vegetarianism began around the same time in the Mediterranean area and India. In Greece, Pythagoras (circa 569–475 B.C.E.) and his group were the first known to profess vegetarianism programmatically. Later the philosophers Epicurus, Plutarch, and some Neoplatonists recommended a diet without meat.

In India, the newly born Jain and Buddhist religions initiated the practice of vegetarianism in the fifth century B.C.E. Soon their idea of nonviolence (*ahimsa*) spread to Hindu thought and practice. In Buddhism and Hinduism, vegetarianism is still an important religious practice.

The religious reasons for vegetarianism vary from sparing animals from suffering to maintaining one's spiritual purity. In Christianity and Islam, vegetarianism has not been a mainstream practice although some, especially mystical, sects have practiced it. Monasticism in both East and West has often promoted vegetarianism.

In European and North American culture, vegetarianism witnessed a revival beginning in the seventeenth and eighteenth centuries and especially during the nineteenth century in part as a protest against some aspects of the scientific and industrial revolutions. Well-known vegetarians include Leonardo da Vinci (1452–1519), Mary Wollstonecraft Shelley (1797–1851), Richard Wagner (1813–1883), Henry David Thoreau (1817–1862), Leo Tolstoy (1828–1910), George Bernard Shaw (1856–1950), Mohandas Gandhi (1869–1948), and Albert Einstein (1879–1955).

Contemporary Issues

In contemporary culture, individuals have various reasons for pursuing vegetarianism. Although religious and spiritual arguments continue to be made, scientific research has also provided new justifications for vegetarianism. First, there is clear evidence that, contrary to early modern scientific theories that animals were like machines, animals in fact feel pain, anxiety, and other forms of stress. Thus it appears that breeding and killing animals for food causes them suffering. Moreover, some nutritional research indicates that a vegetarian diet is healthier than a carnivorous one. Finally, meat is ecologically more expensive to produce for food than vegetables: On average, the input ratio of units of proteins and energy fed to livestock to produce one unit of meat is ten to one.

Technologically enhanced food production has raised other concerns. For instance, it is highly questionable whether animals live in sufficiently humane conditions on contemporary farms. Indeed, the movement to promote the humane treatment of animals in the 1970s was extended from pets to other animals, and has had an influence on contemporary vegetarianism, as well as on the treatment of laboratory animals. Additionally, pesticides, hormones, and antibiotics involved in raising livestock have caused uneasiness. Similarly, the huge transport distances and the questions of global justice have encouraged people to think about what they eat, since food often is produced in Third World countries for wealthier nations.

The most common rejoinders to such vegetarian arguments are as follows: The ills of meat production do not directly imply any moral obligation for vegetarianism; meat has been a traditional part of human diet for thousands of years, hence it is not clear whether a vegetarian diet really suits everyone; and it is possible to arrange farms so that animals do not suffer unnecessarily. Moreover, often vegetarians have been accused of fanaticism and moralism; one common view is that they are just unbalanced people. In fact, it has also been noted that Adolf Hitler was a vegetarian.

The question of animal rights may also be related to vegetarianism. Just as *racism* involves one race oppressing another, it can be argued that *speciesism* involves one species oppressing another. Those who argue for the existence of animal rights commonly use their view to support vegetarianism. However, acceptance of the idea of animal rights immediately raises problems of the depth and extension of these nonhuman rights. Do animals have more than rights to life? Do all living creatures, including bacteria, have such rights? Usually only moral agents have rights, and duties as well; how does this apply to animals?

TOPI HEIKKERÖ

SEE ALSO *Animal Welfare; Food Science and Technology; Nutrition and Science; Organic Foods.*

BIBLIOGRAPHY

Dombrowski, Daniel. (1984). *The Philosophy of Vegetarianism.* Boston: University of Massachusetts Press. Provides a historical perspective into the philosophical ideas behind vegetarianism.

Singer, Peter. (1990 [1975]). *Animal Liberation,* 2nd edition. New York: Random House. A contemporary classic on the animal rights (first edition was published in 1975). Has had an important role in both vegetarian and animal liberation movement.

Spencer, Colin. (2002). *Vegetarianism: A History,* 2nd edition. New York: Four Walls Eight Windows. A historical account of vegetarianism, both from practical and theoretical points of view.

VEGETATIVE STATE

SEE *Persistent Vegetative State.*

VEREINS DEUTSCHER INGENIEURE

SEE *Professional Engineering Organizations.*

VERNE, JULES

The French novelist and playwright Jules Verne (1828–1905) was born in Nantes on February 8 and died in Amiens on March 24. He is best known for a series of novels published under the inclusive title *Voyages extraordinaires* (Extraordinary journeys). Some of these works have been interpreted, especially in English-speaking countries, as early science fiction, or used to stimulate discussion of ethical and political issues related to developments in science and technology—views that are at best only partial appreciations of his achievement.

Verne earned his *licence en droit* (master's degree in law) in Paris in 1850. After twelve years producing plays, opéras comiques, operettas, and short stories, he became famous in 1863 for his first published novel, *Five Weeks in a Balloon.* Verne subsequently published some fifty-three novels, among the best-known titles being *Journey to the Center of the Earth* (1864), *From the Earth to the Moon* (1865), *Twenty Thousand Leagues under the Seas* (1870), *Mysterious Island* (1870), *Around the World in Eighty Days* (1872), and *Michael Strogoff* (1876). After Verne's death, Hetzel, continuing the *Voyages extraordinaires* collection, published several novels, still under the name of Jules Verne, but all modified by his son Michel Verne, who added new chapters and new characters; Michel Verne even wrote a complete novel, *L'Agence Thompson and Co.* (The Thompson Agency and Company), which was edited under his father's name.

The objective of Verne's novels was primarily to teach geography, history, and the sciences to the French family. To make such dry disciplines attractive, Verne created initiatory stories happening in different geographies, such as: a judicial error and the innocence of the supposed culprit demonstrated through a cryptogram during the descent of the river Amazon in *The Jangada* (1881; also known as *The Giant Raft*); the cryptogram opens the novel, but cannot be solved during the whole story, because the key was considered as lost (after the discovery of the key, Jules Verne ends the novel with the readable message hidden in the cryptogram at the opening of the story); a *jeu de l'oie* (goose game, kind of snakes and ladders), allowing the reader to discover the United States in

The Will of an Eccentric (1899); or even a search for the missing link of human evolution in the African jungle in *The Aerial Village* (1902; also known as *The Village in the Treetops*). Writing for the French middle-class family did not prevent Verne from putting into his novels his views about colonialism, politics, and the society of his time. Antimilitarist and against the death penalty, Verne also denounced the misdeeds of slavery. He condemned British Victorian imperialism in such novels as *The Kip Brothers* (1902). During his lifetime he became known as a writer for children and was considered a scientific prophet. These two erroneous opinions continue to persist in the early twenty-first century. In reality, Verne was a writer of his time, using a style in which wordplay and hidden meanings were abundant; his work nevertheless heralded the structure of the modern novel.

Well into the twentieth century, Verne's works were so badly translated in the Anglo-Saxon countries that his readers could appreciate only his rare "futuristic" views, supported by a few extraordinary machines used to support the novelistic intrigue. Since the early 1960s, however, new translations by Walter James Miller, Edward Baxter, and William Butcher have allowed English-language readers to appreciate Verne as a true writer—a precursor of surrealism and other literary movements of the twentieth century such as the Collège de Pataphysique. (Pataphysics, an absurdist concept coined by the French writer Alfred Jarry, is the idea of a philosophy or science dedicated to studying what lies beyond the realm of metaphysics. It is a parody of the theory and methods of modern science and is often expressed in nonsensical language. A practitioner of pataphysics is a pataphysician.) Many scholarly studies in Europe and the United States show the modernity in Verne's novels, where irony and cold humor are always present.

Verne's many plays, usually written in collaboration with other authors, such as Charles Wallut and Adolphe d'Ennery, and most of his vaudeville works, operettas, and so on have grown old and would fail to have appeal in the early twenty-first century. *Journey through the Impossible* (1882), however, is a modern masterpiece, written at the juncture of the optimistic and pessimistic periods of Verne's life. This three-act play, cowritten with d'Ennery and inspired by *The Tales of Hoffmann,* a grand opera by Jacques Offenbach (1819–1880), is one of the main peaks in Verne's output. For the first and only time, the heroes do the impossible, when in the novels they did only what was extraordinary: The heroes from Verne's novels, including Nemo, Ox, and Ardan, meet onstage and go to the center of the earth in the first act, to the bottom of the Sea in the second, and to the far planet Altor in the third. The principal hero is the son of Captain Hatteras, who was the first discoverer of the North Pole. During the three acts, his fiancée Eva shares his adventures and difficulties—an unusual fact in the *Voyages extraordinaires*—and he hesitates between love and knowledge, the same way Hoffmann hesitates between love and art.

Jules Verne, 1828–1905. The French novelist was the first authentic exponent of modern science fiction. The best of his work is characterized by intelligent predictions of technical achievements actually within man's grasp at the time Verne wrote.

Verne's work has provided scenarios for more than four hundred films and television programs, not only in Hollywood but also in countries as far away as China. In many instances they have continued to provide a popular introduction to the wonders of science and technology, propagating the image of Jules Verne as science fiction author. Jules Verne wrote his novels during the time when steel and steam engines became popular, when electrical power was used more and more, and when the Eiffel Tower was built, and he uses all these new technologies in his novels to be an integral part of the adventures he was telling his readers.

There are two ways in reading Jules Verne: the first level is the initiatory story with an adventure and sometimes more or less unusual and fantastic machines. Because of the bad English translations, it was the only way English-speaking readers could enjoy Jules Verne. The second level is appreciating the use of technology and science as narrative tools, enjoying the imaginary solutions of problems and desperate situations of an adventure happening in a world where war, confrontations and intolerance exist.

JEAN-MICHEL MARGOT

SEE ALSO *Science Fiction; Science, Technology, and Literature.*

BIBLIOGRAPHY

Evans, Arthur B. (1988). *Jules Verne Rediscovered.* New York: Greenwood Press.

Taves, Brian, and Stephen Michaluk Jr. (1996). *The Jules Verne Encyclopedia.* Lanham, MD: Scarecrow Press.

Verne, Jules. (2002 [1898]). *The Mighty Orinoco,* trans. Stanford L. Luce, ed. Arthur B. Evans, introduction and notes by Walter James Miller. Middletown, CT: Wesleyan University Press. Originally published 1898. This novel is one of the most modern novels; the subject of the story is transgender, the transformation of a man into a women.

Verne, Jules. (2003). *Journey through the Impossible,* trans. Edward Baxter, introduction and notes by Jean-Michel Margot. Amherst, NY: Prometheus Books.

VIDEO GAMES

Video games may be defined as games involving electronic technology in which real-time interactive game events are depicted graphically on a screen through pixel-based imaging. Elements one would expect to find in a *game* are *conflict* (against opponents or circumstances), *rules* (determining what can or cannot be done and when), use of some *player ability* (skill, strategy, or luck), and some kind of *valued outcome* (winning vs. losing, highest scores, or fastest times, among others). All are usually present in video games in some manner, albeit to varying degrees. In video games, the scoring of points, adherence to the rules, and display of the game's visuals are all monitored by a computer, which also can control the opposing characters within a game, becoming a participant as well as referee. Most arcade video games, home computer games, and home video games using a television would qualify as video games.

The development of the video game was shaped by film, television, and computer technology, and its influences include pinball, arcade games, science fiction, sports, and table-top games. Video games appeared during a time in which interactive art, minimalism and abstraction, and electronic music were developing, and these provided an important part of the cultural context in which the video game evolved.

Modes of Exhibition

Video games have appeared in a number of different modes of exhibition, including mainframe games, coin-operated arcade video games, home video game systems, hand-held portable games and game systems, and home computer games.

The games created on the giant mainframe computers were limited to the large mainframe computers found only in laboratories and research centers. These games were experiments and were neither sold commercially nor generally available.

Coin-operated arcade games come in several forms: stand-alone consoles; cocktail consoles; and sit-inside or ride-on games. A stand-alone console, the most common, is a tall boxlike cabinet that houses the video screen and the control panel for the game. The game controls can include joysticks, track-balls, paddles (round, rotating knobs), buttons, and guns with triggers. Occasionally there are controls for more than one player, although single-player games are the most common.

The *cocktail* console is designed like a small table, with the screen facing upward through a glass tabletop. Often the game is designed for two players, with a set of controls on each end of the table and the screen between them. This type of console is popular in bars or restaurants where patrons can sit and play a video game, while setting their drinks on the tabletop (hence the name cocktail).

Sit-inside or ride-on consoles hold or contain the player's body during play. They may even involve physical movement, usually to simulate the driving or flying of a vehicle in the game, typically with a first-person perspective. In driving and racing games, foot pedals and stick shifts are sometimes included. Other games involve bicycle pedaling, skis, skateboards, and simulated horses.

Home video game systems typically use a television or computer monitor for their graphic displays, although some systems come with their own screens. Home game systems that display their graphics on a television can be console-based, cartridge-based, or use laserdiscs, CD-

Two youngsters play video games at an arcade. *(AP/Wide World Photos.)*

ROMs, or DVD-ROMs (home computer games also appeared on cartridges, floppy disks, diskettes, and audio tape). Console-based systems have their games hard-wired into the console itself, while cartridge-based game systems have their games hardwired into cartridges or cards that are plugged into the game console, allowing new games to be sold separately. CD-ROMs and DVD-ROMs are used for most contemporary game systems, because they can contain far more data than traditional cartridges.

Hand-held portable games and game systems that run on batteries can be carried along with the player. They are usually small enough to fit in the palm of one's hand, and typically have small LCD screens with buttons and controls around the screen. Some of these systems are cartridge-based as well.

Networked games involve multiple participants connected via the Internet to a video game world on a server, where they interact with the world and with each other's characters. Some of these games have hundreds or thousands of players and run twenty-four hours per day, with players logging on and off whenever they want. Players in these on-line worlds meet, converse, and form alliances and friendships without ever meeting face-to-face. Because real people control the player-characters, the social interaction is real, albeit in a more limited bandwidth than in-person interaction.

Ethics

Like film and television, video games have been criticized for having excessive violence, explicit sex, occasional racism, stereotypical characters, and an overall lack of edifying content. As graphics develop toward photo-realism, games grow more concrete in their visual representations and more like the images produced in other media, including those through which the player receives real world information (for example, television) and interacts socially (for example, the Internet). Combined with a simulated world in which players can act, video games can subtly influence players' behavior, beliefs, and outlook in real-life.

Most narrative media embody world-views through the ways in which characters' actions are linked to consequences, while video games link consequences to the player's own actions. Instead of merely watching and identifying with a character, the video game player is an active participant in the action seen on-screen. Whereas watching martial films does not help one develop physical skills, a video game *can* sharpen the player's hand-eye coordination skills and reflex responses, and stimulate aggression. The speed at which game action occurs often requires players to develop reflex responses at the expense of contemplation, sometimes resulting in a kind of repetitive stimulus-response training in which reaction speed is crucial. These responses can vary, from abstract figure manipulation, strategic thinking, and problem solving, to the hair-trigger automatic killing in fast-action games. While games can be designed to develop a variety of skills, shooting and killing are unfortunately among the most common.

On a larger scale, ethical worldviews can also be affected as successful game play often encourages or requires players to think in certain ways, and game narratives may link actions to outcomes and consequences that reinforce certain types of behavior. Thus it is a question of how the medium is used, how games are designed, and what values those designs embody. On-line role-playing games, for example, differ greatly from other forms of video games in that they are played by vast numbers of people in *persistent* (twenty-four-hour-per-day) game worlds, and games are ongoing and cannot be restarted. Some players invest a great deal of time and money in such games, building up their characters' powers and possessions, so there is often more at stake during game play, and ethics takes on greater importance as consequences within the game begin to extend into the real world.

While most people can clearly distinguish between video games and real life, ideas learned through the games can spill over to other behaviors in either positive or negative ways. Clearly there is a difference between real-world morality and that of the on-line game world. *Killing* another player's character may be considered an act of aggression, however the behavior falls within the established rules of play, and players whose characters are killed often come back with new characters. Yet the metaphor of killing remains, as does the fact that many people consider pretend killing to be fun. Likewise the goal-oriented nature of video games focuses more on what a player does and achieves rather than on what a player becomes. Additionally the malleability and repeatability of most video game experiences can lead to both experimentation and desensitization through repetition, because nothing is final or irreversible when a game can be restarted or when a player has multiple *lives*.

Other potential effects involve the player's default assumptions and ways of analyzing the world. For example, in most games everything is structured around the player and is present to produce an experience for the player. Other characters are there to either help or hinder the player-character, and often they speak in direct address to the player-character. Game objects exist for the player to use, take, or consume. The overall effect can be to promote a self-centered, utilitarian point of view in which players consider everything in the game world according to how it will affect or be of use to them.

At the same time, video games can have a positive influence, enhancing problem-solving skills, powers of observation, and patience. Completing an adventure game's objective, for example, usually requires goal-oriented behavior and often single-minded pursuit. Even when laden with puzzles and ambiguity, most adventure game problems and goals are clear-cut and simple relative to the problems and goals encountered in real life. The video game may remove the player momentarily from the complex problems of real life and offer solvable, simplified conflicts and goals that can be solved in a few hours (or days) and for which solutions already exist. In either case, these effects may be subtle, but repeated exposure to situations in which one is required to think a certain way can have gradual, long-term effects. Some values may find affirmation outside the games, such as overcompetitiveness and the accruing of personal wealth and goods.

In order to regulate games and hold game makers accountable, professional codes, such as that of the Association of Computing Machines (ACM) have been created. Additionally, the Entertainment Software Ratings Board (ESRB) provides a series of ratings (Early Childhood (EC), age 3 and up; Everyone (E), age 6 and up; Teen (T), age 13 and up; Mature (M), age 17 and up; and Adults Only (AO), age 18 and up), although these ratings are not always enforced in stores, where games might be sold to underage players.

While it is true that many games in the early twenty-first century are graphically violent and sexually explicit, it should be remembered that some of the best-selling games of all time (*The Sims, Myst,* and *Pac-Man,* for example) have been nonviolent, indicating that it is good game design, not sex or violence, that sells.

MARK J. P. WOLF

SEE ALSO *Computer Ethics; Entertainment; Science, Technology, and Literature; Special Effects; Violence.*

BIBLIOGRAPHY

DeMaria, Rusel, and Johnny Lee Wilson. (2002). *High Score!: The Illustrated History of Electronic Games*. New York: McGraw-Hill Osborne Media. An illustrated history covering the games, the hardware, and the people behind the industry.

Kent, Steven L. (2001). *The Ultimate History of Video Games: The Story Behind the Craze that Touched Our Lives and Changed the World*. Roseville, CA: Prima Publishing. A journalistic account of the history of video games compiled from dozens of interviews conducted by the author.

Wolf, Mark J. P., ed. (2001). *The Medium of the Video Game*. Austin: University of Texas Press. The first scholarly book devoted to examining the video game as an artistic medium.

Wolf, Mark J. P., and Bernard Perron, eds. (2003). *The Video Game Theory Reader*. New York: Routledge Press. A collection of scholarly essays examining the video game from a multitude of perspectives.

VIOLENCE

One of the multiple battlefields of environmental determinists versus biological determinists relates to the causes of violence. The former see violence as a primarily culturally rooted phenomenon, whereas the latter see it as being biologically determined This controversy, however, may be due to a failure to distinguish between aggressiveness and violence.

Aggressiveness and Violence

Aggressiveness is an instinct and therefore is a product of bioevolution. However, nature has not selected for the trait of aggressiveness alone but together with a set of inhibiting factors that are activated in certain circumstances, for instance, when two individuals who belong to the same group fight with each other and the life of one of them is threatened. As Irenäus Eibl-Eibesfeldt (1984) argues, a widely obeyed commandment in nature is "thou shalt not kill thy neighbor." Not even animals with as bad a reputation as wolves are an exception to this law.

In humans aggressiveness is linked primarily to the brainstem and the so-called limbic system or emotional brain (Sanmartín 2002). This part of the brain contains the structures that appear to be responsible for the responses (autonomous, somatic, hormonal, and neurotransmitter) that make up aggressive behavior. These automatic responses are triggered unconsciously by certain stimuli and coordinated by the amygdala, a structure in the inner region of the temporal lobe of both brain hemispheres.

The amygdala sets off the chain of effects that constitute the acting out of aggressive behavior in response to a stimulus. It also is responsible for stopping those effects when it receives inhibiting stimuli such as the emotional expression of fear shown by victims.

If humans were only the product of bioevolution, their aggressiveness would be regulated by the amygdala exclusively. However, humans are much more than a product of biological evolution. Indeed, the amygdala is connected to certain brain regions that are considered the seat of consciousness and that experienced extraordinary growth approximately 1.5 million years ago (Damasio 1994). These regions are in the frontal part of the brain cortex, the so-called prefrontal cortex. Their functions appear to be linked closely to the abilities that traditionally have been considered humankind's noblest: imagination, thought, and feeling. Ideas, thoughts, and feelings make up the framework that analyzes emotions and decides whether to reinforce or extinguish them. If, for instance, one of the emotions that constitute aggressiveness is reinforced, aggressiveness may go out of control and its natural inhibitors may be rendered inoperative. Soldiers and terrorists usually undergo a process of cognitive restructuring in which they learn to view their victims not as persons, but as things or symbols. Once victims are not seen as persons, it is impossible to empathize with them; consequently, their facial expressions have no inhibitory capacity.

Strictly speaking, violence is what occurs when the interaction between the expression and the inhibition of aggressiveness is disrupted in a way that hypertrophies aggressiveness and adds the intention to cause damage knowingly, as in the case of soldiers and terrorists. This disruption is influenced by ideas, thoughts, and feelings acquired over the course of a lifetime. Of equal importance are some of the products of the mind and in particular certain technical products. All of them are cultural elements. Violence therefore can be said to be primarily the result of the effects exerted by certain cultural elements on natural aggressiveness, hypertrophying it and conveying intentionality. The adverb *primarily* is used here because in certain cases (around 20 percent) the alteration of natural aggressiveness is caused by biological pathologies.

Technological Change as a Source of Violence

In most cases violence is born out of culture. Culture in turn is shaped by technology, as Ortega y Gasset (1939) argued, because humans are *a nativitate* (from birth) technical animals. Human beings change and survive because of bioevolution. However, humans do not worry as much about surviving as they do about the quality of life, always striving to achieve higher standards of well-being. This goal is achieved, but at the cost of creating a sort of supranature that consists of instruments or tools, machines, various forms of social organization, and instruments that apparently free humans of all the elements in nature that make them needy beings: cold, food, and the like.

Human beings also have directed technology toward themselves. On the one hand, they have constructed external prostheses that have modified their natural appearance. On the other hand, technology has penetrated so deeply into humans that they can in principle alter even their genetic information and therefore reconstruct themselves by following preestablished patterns and desires.

These technical interventions have had some negative effects, such as the conversion of innate aggressiveness into violence. Technology (not entirely by itself, of course) has upset the balance between natural aggressiveness and its natural mechanisms of control.

In addition, this technical supranature regularly experiences strong convulsions. At these times there take place the great technological changes that seem to drive historical transformations with increasingly greater speed. The mechanical clock, the fifteenth-century arts of navigation, railways, airplanes and spaceships, nuclear weapons, computers, the Internet, gene technology, and cloning are all technical inventions that have shaken traditions and compelled humans to adapt quickly to new situations. Human beings appear to be forced to adapt themselves to the changes in their technical supranature, not the other way round; this process often is described as social progress.

The consequent demand for adaptation generates a certain amount of stress that is becoming increasingly difficult to control. Uncontrolled stress usually degenerates into violence. In this sense, then, technology in general may become a source of violence (Sanmartín 2000).

Television and Violence

Two technologies are especially linked to violence: the mass media (especially visual media) and weapons.

In the early twenty-first century, not even the industry denies that exposure to violent images in television, video games, or the Internet has effects on the audience and, particularly, on children and adolescents. What is under discussion, however, is the type and degree of these effects. Albert Bandura (1977) stressed the idea that children learn violent behavior not only by imitating the real violence that is present in their environments, but also by emulating the violence (fictitious or not) broadcast on television. This correlation was confirmed by a longitudinal study started in 1960 by Leonard Eron, Monroe Lefkowitz, Leopold Walder, and L. Rowell Huesmann (Huesmann and Eron 1986) that used a sample of 800 eight-year-old children. Jeffrey Johnson (2002) published another longitudinal study showing that seeing violence on television at age fourteen correlated significantly with later aggression (assault and battery, violent or armed robbery). According to Johnson and associates (2002), if exposure to television was one hour per day at age fourteen, 5.7 percent of the individuals at a mean age of sixteen or twenty-two exhibited violent behaviors, and if exposure was increased to three or more hours per day, violent behavior went up to 25.3 percent. Craig Anderson and Brad Bushman (2002), in a related meta-analysis of longitudinal studies, cross-sectional studies, field experiments, and laboratory experiments carried out to that date concerning the possible influence of violence on television, demonstrated that all studies supported the existence of a significant correlation between exposure to violence on television and violent behavior.

Other studies have provided more clues to this problem. Foremost among them that of Jo Groebel (1999), which showed that the relationship between real violence and screen violence is interactive: Violent people use audiovisual media to reinforce their beliefs and attitudes, becoming even more violent. This study dealt with a large sample: 5,000 twelve-year-old children from twenty-three different developed and developing countries with social environments containing high or low rates of real violence. One interesting discovery was that 88 percent of the children had seen the move *The Terminator* (1984). An even more interesting discovery was that in high-violence environments half the children wanted to be like the Terminator, whereas in low-violence environments the number was only 37 percent. In other words, the influence of screen violence on real violence depends on the amount of real violence surrounding a child.

Before blaming television for violence in society, especially among children and adolescents, one must consider carefully the social environments of those children. When children live in homes in which they suffer or witness abuse, where there is alcohol or drug abuse, where parents and children do not get along, where the homes have cramped or unhealthy living conditions, without the support of other family members or friends, the result may be an environment in which the spark of television violence has little difficulty causing a fire by adding to preexistent violent attitudes and behaviors.

In the early twenty-first century, this environment often also contains videogames, either on game consoles or computer. Many authors, such as Degaetano and Grossman (1999) and Anderson (2004), state that the effects of violent images on video games are even worse than other kinds of images, for several reasons. Firstly, as opposed to films and television programs, in violent video games the player is forced to identify with the main character (the aggressor). Secondly, violent video games require active participation, and active participation promotes learning. Thirdly, video-game violence is directly rewarded. Finally, the level of violence in video games is far superior to that in films or on television.

Computers, and in particular the Internet, are connected to violence, especially violent crime, in different ways. Rather than generating new forms of crime, the Internet has revolutionized some traditional forms of crime by accelerating their transnationalization. If there is one thing that has rapidly globalized, it is the criminal activities of mafias and extremist organizations. Sexual exploitation—and pornography, in particular (Von Feilitzen and Carlsson, 2000)—drugs trafficking, the smuggling of chemical, nuclear and radioactive material, and especially the money-laundering business, have benefited from the globalizing effect of the World-Wide Web. In fact, every year more than 600 billion dollars (slightly more than 2% of global gross domestic product) are laundered world-wide, practically cost-free.

Weapons and Violence

One particular type of technology is especially linked to violence: weapons. From a naturalistic point of view, bioevolution has poorly equipped the human animal for causing severe damage and especially for killing other humans. Human beings do not have fangs, sharp claws, or pointed horns. In order to kill they have to use their feet or fists with great force and skill or put their hands on a victim's neck for several minutes. In such cases, killing takes place at close quarters and a victim's aggression-inhibiting signals are quite effective.

These inhibitors are bypassed, however, when weapons are used. From knives and swords to guns and bombs, weapons have evolved to increase the distance between users and victims, until the victims have disappeared from direct view. This is not a coincidence. Once distance has blurred facial expressions, postures, and other aggression inhibitors, victims cease to be seen as persons and become things. One cannot empathize with a thing, stop one's destructive actions, or even feel sorry afterward. In this way one of the beings most ill-equipped by nature for killing has become, by virtue of technology, one of the most effective killers.

JOSÉ SANMARTÍN

SEE ALSO *Aggression; Entertainment; Just War; Military Ethics; Movies; Television; Video Games.*

BIBLIOGRAPHY

Anderson, Craig A. (2004). "An Update of the Effects of Violent Video Games." *Journal of Adolescence* 27, 122-133.

Anderson, Craig A., and Brad J. Bushman. (2002). "The Effects of Media Violence on Society." *Science* 295: 2377–2379.

Bandura, Albert. (1977). *Social Learning Theory*. Englewood Cliffs, NJ: Prentice-Hall.

Damasio, Antonio R. (1994). *Descartes' Error: Emotion, Reason and the Human Brain*. New York: Putnam.

Degaetano, Gloria, and Dave Grossman. (1999). *Stop Teaching Our Kids to Kill: A Call to Action against TV, Movie and Video Game Violence*. New York: Crown.

Eibl-Eibesfeldt, Irenäus. (1984). *Krieg und Frieden* [War and peace]. Munich: R. Piper & Co. Verlag.

Groebel, Jo. (1999). "Media Access and Media Use among 12 Year Olds in the World." In *Children and Media: Image, Education, Participation*, ed. Cecilia von Feilitzen and Ulla Carlsson. Göteborg: The UNESCO International Clearing House on Children and Violence on The Screen.

Huesmann, L. Rowell, and Eron, Leonard D. (1986). *Television and the Aggressive Child: A Cross-National Comparison*. Hillsdale, NJ: Erlbaum.

Johnson, Jeffrey G.; Cohen, Patricia; Smailes, Elizabeth M.; et al. (2002). "Television Viewing and Aggressive Behaviour during Adolescence and Adulthood." *Science* 295: 2468–2471.

Ortega y Gasset, José. (1939). *Meditación de la técnica*. English Version: "Thoughts On Technology," in *Philosophy and Technology: Readings in the Philosophical Problems of Technology*, ed. Carl Mitcham and Robert Mackey. New York: The Free Press, 1972.

Sanmartín, José. (2000). *La violencia y sus claves* [The clues to violence]. Barcelona: Ariel.

Sanmartín, José. (2002). *La mente de los violentos* [The violent mind]. Barcelona, Ariel.

Von Feilitzen, C., and Carlsson, U. (2000). *Children in the New Media Landscape: Games, Pornography, Perceptions*.

Göteborg: The Unesco International Clearing House on Children and Violence on the Screen.

VIRTUAL REALITY

Virtual reality (VR) technology emerged in the 1980s, with the development and marketing of systems consisting of a *head mounted display* (HMD) and *datasuit* or *dataglove* attached to a computer. These technologies simulated three-dimensional (3-D) environments displayed in surround stereoscopic vision on the head-mounted display. The user could navigate and interact with simulated environments through the datasuit and dataglove, items that tracked the positions and motions of body parts and allowed the computer to modify its output depending on the recorded positions. Other types of VR that arose subsequently included *projection virtual reality*, in which users who wear special glasses interact with three-dimensional virtual models that are projected in a room and can be perceived from different angles, and *desktop virtual reality*, in which users stereoscopically view a virtual environment represented on a computer screen (using special stereo glasses) and interact with it using datagloves, or, more commonly, a mouse.

VR is used to simulate real environments, such as existing buildings or city areas, or to visualize imaginary ones, for instance spaceships or battlegrounds. VR is a technique with great possibilities for training, visualization, and entertainment. Applications are found in computer-aided design, construction, computer gaming, education, military exercises, aviation training (flight simulators), surgical training, therapy, and art.

Meanings of Virtual Reality

As Howard Rheingold (1991) notes, VR merges overlapping interests from the military for more realistic but risk-free training, of the science fiction imagination, and of entertainment industry efforts to intensify the vividness of various media. Although the term "virtual reality" most often refers to systems of the type just described, it is also used in a wider sense, to denote not fully realized virtuality, as in lesser forms of three-dimensional computer-simulated environments that are engaged from a first-person perspective. The most common example is first-person 3-D computer games. Such games are varieties of desktop virtual reality minus the stereo glasses. Wider still, VR sometimes denotes any interactive computer-generated environment, including those represented through two-dimensional graphics or through texts or symbols. In fact, the term *virtual* may be attached to any kind of object, event, or environment that is not realized physically but electronically, as in virtual money, virtual casinos, or virtual doctors (medical doctors that can be consulted over the Internet). In such cases, *virtual* may mean no more than "computer-simulated," or "on the Internet," or "in cyberspace," as opposed to "in physical space." This broad use of the term points to the fact that for many people, the term "virtual reality" and "virtual" are interpreted metaphysically as denoting a new, fictional kind of reality.

Mostly, however, the term *virtual reality* is used more narrowly, to refer to 3-D computer-simulated environments incorporating a first-person perspective that includes some degree of immersion, meaning that users feel that they are situated in an environment. Immersion can be enhanced through such means as realistic graphics and sounds, surround and stereo vision, surround sound, position tracking, and force and tactile feedback.

A distinction can be made between single-user and multi-user or networked VR. In single-user VR, there is only one user, whereas in networked VR, there are multiple users who share a virtual environment and appear to each others as *avatars*, which are graphical representations of the characters played by users in VR. A special type of VR is *augmented reality*, in which aspects of simulated virtual worlds are blended with the real world that is experienced through normal vision or a video link, usually through transparent glasses on which computer graphics or data are overlaid. Related to VR are *telepresence* and *teleoperator systems*, systems that extend a person's sensing and manipulation capability to a remote location by displaying images and transmitting sounds from a real environment that can (optionally) be acted on from a distance through remote handling systems such as robotic arms.

Ethical issues in virtual reality

VR has been the subject of speculation and critique in both academic circles and mass media. Popular culture portrays futures in which immersive VR is routinely used in society, as in science fiction movies such as *The Matrix* (1999), *Lawnmower Man* (1992), *Existenz* (1999), and the Star Trek series (with the Holodeck), and in novels such as William Gibson's Neuromancer (1984) and Neal Stephenson's Snow Crash (1992). VR is portrayed both positively, as a medium that offers endless possibilities for learning, entertainment, social interaction, and self-experimentation; and negatively, as a medium that causes users to flee from or deny everyday reality, that is used by evil minds to manipulate and gain control over others, and that dissolves any distinction between reality and fiction.

In the academic literature, authors have mainly tried to come to grips with the questions of how VR will transform people's conception of reality and how it will transform social life. As for the former question, authors tend to agree that VR will change the concept of reality and cause the distinction between reality and fiction to blur. However, some authors, such as Michael Heim (1993) and Sherry Turkle (1995), have argued that a distinction between physical and virtual reality will always exist because people are biological human beings that are born and die in the physical world and retain their roots there, whereas others, such as Philip Zhai (1998) have argued that such biological background facts are irrelevant and that VR can offer us a limitless world as rich and detailed as physical reality and can even replace the physical world as one's primary habitat.

As for social and ethical aspects of VR, most discussion has focused on the question of how the blurring of reality and fiction in VR may affect its users, on how reality is (mis)represented in VR, and on what forms of immoral behavior may occur in virtual environments. These issues will now be discussed in turn.

VR AND THE REAL WORLD. Some authors who hold that the extensive use of VR applications induces a blurring of the boundary between the real and the imaginary worry about negative social consequences. They worry that the idealized, vacuous and consequenceless worlds of VR come to serve as a model by which people comprehend the real (that is, physical) world, and conversely, that the attention and care that people attach to real-world people, animals, and things is also attached, inappropriately, to virtual things and personae. Another worry is that people may come to prefer the freedom and limitlessness of virtual reality and cyberspace over the limitations of physical existence and invest most of their time and energy in their virtual life, to the neglect of the real people and affairs in their physical lives. Proponents of VR argue instead that most people will be able to maintain a good sense of reality and will strike a healthy balance between their virtual life (which is, in part, also real life) and their physical life.

REPRESENTATION IN VR. VR environments that are intended to simulate actual realities may misrepresent these realities, according to expected standards of accuracy. This may cause their users to make false decisions or act wrongly, with potentially serious consequences, especially in areas in which life-or-death decisions are made, such as medicine and military combat. When VR is used for education and training, therefore, high standards of accuracy and realism should be expected, and developers have a responsibility to adhere to such standards. VR simulations may also contain biased representations that are not necessarily false, but that contain prejudices about people or situations. For example, a surgery training program may only practice surgery on young white males, a VR game may represent women and minorities in stereotypical ways, or a combat simulation program may only simulate combat situations in which civilians are absent. Like other media, VR may also break taboos by depicting morally objectionable situations, including violent, blasphemous, defamatory, and pornographic situations.

A man demonstrates a virtual reality device by lifting a virtual rock on a simulated Martian surface, wearing a video helmet and virtual reality gloves. *(© Roger Ressmeyer/Corbis.)*

BEHAVIOR IN SINGLE-USER VR. Most moral issues regarding representation in VR are not unique to it, and also apply to other types of simulations and pictorial representations. What is unique about VR, however, is the possibility to interact with environments that look real but are not. Because virtual environments are not real, any consequences of one's actions in VR, specifically in single-user VR, are not real-life consequences. It is therefore possible to perform actions in VR that would be cruel and immoral in the real world because they do harm, but can be performed without retribution in VR because no real harm is done. But is it morally defensible for people to act out graphic and detailed scenarios of mass murder, torture, and rape in VR, even when done in private? Are there forms of behavior that should not be encouraged or allowed even in VR, either because of their intrinsically offensive nature, or because such simulations desensitize individuals and may facilitate immoral behavior in the real world? Or is it the case that the possibility to act out fantasies in VR keeps some people, such as sex offenders or people prone to violence, from acting out this behavior in the real world, so that VR may actually prevent crime?

The interactivity made possible by VR developers also raises moral questions. VR applications may invite or discourage, require or prohibit, reward or punish behaviors. They may cheer users who go on killing sprees, or may instead voice moral outrage. Developers may be held to have a moral responsibility to reflect on the way in which they deal with immoral behavior by users, and whether and how they signal approval or disapproval of such behavior, or remain neutral.

INTERACTIONS IN MULTI-USER VR. In multi-user VR, users may engage in immoral or illegal behaviors such as theft, vandalism, murder, sexual assault, and adultery. What is confusing is that some of these behaviors may be real while others are imaginary. A user may harm or kill another user's avatar, but cannot harm or kill another user. Yet a user may also cause real harm to another user, by deeply insulting that user, stealing an identity, or wreaking havoc in a virtual apartment. Such actions are thought of as real and may even lead to criminal prosecution. Sometimes, however, it is not so clear what actions mean. Does genuine sexual assault occur when one user fondles another user's avatar against his or her will? What if such behavior is performed by a programmed avatar (a *bot*) that has been programmed to do so by its owner? Very different moral intuitions may exist about these and many other actions in multi-user VR, and more broadly in cyberspace.

Another issue that plays in multi-user VR and cyberspace is identity. As has been argued extensively in academic studies, VR avatars and role-playing in cyberspace enable people to experiment with identities and to experience otherness more vividly than ever before. A man can learn what it is like to be a woman, a white person can have the experience of a black person, and so forth. Negatively, such role-playing can be used to deceive others about one's true identity. But as psychologist Sherry Turkle (1995) has argued, such experiences may help users expand and develop their own identities and may deepen a distinctly human form of self-awareness.

PHILIP BREY

SEE ALSO *Cyberspace; Information Ethics.*

BIBLIOGRAPHY

Brey, Philip. (1999). "The Ethics of Representation and Action in Virtual Reality." *Ethics and Information Technology* 1: 5–14. Considers ethical issues of representation and single-user behavior in VR.

Ford, Paul. (2001). "A Further Analysis of the Ethics of Representation in Virtual Reality: Multi-User Environments." *Ethics and Information Technology* 3: 113–121. A follow-up to Brey's essay, this essay considers ethical issue or representation and behavior in multi-user VR.

Heim, Michael. (1993). *The Metaphysics of Virtual Reality*. New York: Oxford University Press. A series of essays on the history and future of contemporary people's computerized lives, including reflections on the nature and appeal of cyberspace and virtual reality.

Rheingold, Howard (1991). *Virtual Reality*. New York: Summit. An early but still significant study of VR, its history, and its promises for the future.

Turkle, Sherry (1995). *Life on the Screen: Identity in the Age of the Internet*. New York: Simon and Schuster. An important psychological study of how the Internet and its virtual environments are impacting identity formation and our way of thinking about reality, relationships, politics, and sex.

Zhai, Philip (1998). *Get Real: A Philosophical Adventure in Virtual Reality*. Lanham, MD: Roman & Littlefield. Extensive study of VR, virtuality, and its meaning for humanity. Zhai argues that the whole empirical world can and should be created in virtual reality.

VIRTUE ETHICS

The prominence of rules, consequences, rights, and duties is a relatively recent phenomenon in moral thought. For Plato, Aristotle, Laozi (or Lao-tzu), Confucius, the Buddha, and Jesus, the primary focus of the good life was on cultivating virtues and battling vices. Yet among these diverse traditions moral character and its significance for personal and social good have been subject to considerable debate—which continues in the early twenty-first century by drawing on the thought and research in sociology, anthropology, film studies, folklore, religion, biology, neurophysiology, pedagogy, medicine, and other disciplines. Both ancient reflection and contemporary scientific inquiries seek to identify the principle virtues and vices and how they develop or weaken. Adversaries debate whether the virtues (and vices) are intertwined, whether they exist independently, or whether there is a chief virtue (or vice). Such inquiries easily lead to more general questions of human flourishing and distinctiveness, so that ultimately at issue are basic questions concerning the nature of human happiness and the good society.

From the perspective of virtue ethics, science and technology are arguably enduring components of the good life. Aristotle (384–322 B.C.E.), for instance, describes virtue as a kind of human excellence or striving for perfection. (The Greek word for virtue is *arête*, which encompasses both moral capability and specific talents. A musician, for example, might give a *virtuoso* performance.) In this sense both *episteme* (knowledge or science) and *techne* (craft, art, skill, know-how) are forerunners to the modern notion of technology and involve human *arête*. Controversies about the responsibility of scientists and engineers evoke this twofold sense of virtue, insofar as they address the special types of knowledge they pursue as well as their moral positions regarding the results and applications.

Scientific discoveries and technological products also pose challenges to understanding and embodying a virtuous life. Studies of animal and human behavior raise questions about possible similarities between animals and humans in promoting cooperation or fostering competition. In place of proposals for political utopias and personal desires for posthumanist transformations, can advanced technosciences be limited or guided by the values found in folk wisdom, venerable sages, or sacred texts? Or do many technical inventions thwart the search for a virtuous life by zealously promoting and catering to ordinary vices? Instead of assisting with the cultivation of temperance, justice, courage, love, or charity, do they perhaps tempt humans with vanity, sloth, anger, lust, and greed?

Background

A virtue-based ethics is agent centered, presumes a telos or purpose for human life, and encompasses both personal and public goods. In light of ecological problems growing out of the human use of technology, critics have charged virtue ethics with being anthropocentric. It neglects or devalues the welfare of animals, natural entities, and the environment. Defenders of virtue ethics respond that a fundamental virtue such as humility promotes recognition of human limits and asks humans to view themselves as simply parts of a larger cosmic whole. Moreover, the concept of virtue as a perfection applies to nonhuman as well as human entities. While the idea of a telos or purpose in nature is problematic for science and technology, the topic remains a source for lively discussion among philosophers of biology who study possible adaptations to ethical theory. Indeed, even in the philosophy of technology, analyses of the role of functions is a research issue of potential relevance to virtue ethics.

As such issues indicate, despite the tendency to portray virtue ethics as a settled tradition of strong consensus and enduring narratives, there have always been lively debates about the scope of a virtuous life, the relative strengths or weaknesses of specific virtues and vices, and the best vision of human happiness. For example, three classic representatives of virtue ethics emphasize contrary views on pride. Aristotle considered it a principal virtue. One should attain a proper sense of self—one's accomplishments and contributions. A proud individual is not driven by vanity or boasting, for these lead to excesses of indulgence that would be unworthy of a free and rational person. The proud individual is courageous—the most fundamental virtue, for without courage one can hardly embody other cardinal virtues such as justice or prudence. A model is the citizen whose democratic participation is free of destructive vices such as envy or rancor.

Augustine of Hippo (354–430) and Thomas Aquinas (1225–1274), though, were among many Christians and religious thinkers who believed pride to be indicative of an exaggerated sense of self, involving vanity or, worse, the temptation to view oneself in godlike or superhuman terms. Pride was the queen of vices, for it spawned the decline toward deadlier ones, such as envy, anger, and lust. Such vices corrupt one's moral character and undermine efforts to become a just person. This distortion of self brings about neither happiness nor salvation, only ruin or damnation.

Buddhism and Daoism, meanwhile, taught that true virtue seeks the no-self or personal transcendence. This involves overcoming the drive for individuality in which satisfying the desires and needs of one's physical self is primary. Intellectual nitpicking may derail this goal. But reflection on the nature of this goal remains essential, and can generate parables and paradoxes that are potential guides to enlightenment (see Saeng 1991, Chuang Tzu 1996). Enlightenment is realized not when one becomes a dutiful citizen or achieves self-esteem, but is moved by compassion for another. This is an experience of insight and joy.

Disciples and pedagogues have continually debated the nature and prominence of the virtues. The Western tradition that featured the seven cardinal virtues—courage, justice, temperance, and prudence among pagans, and love, hope, and charity as the Christian additions—is hardly carved in stone. Seven has been a magical number, but other virtues have also been considered essential to the good life. Aristotle, for instance, devotes more attention to friendship than any other single virtue, and friendship may be considered the basis of scientific and technical communities.

At the same time the underpinnings of virtue have been extensively debated. For example, pagans focus on the meanings and demands of individual courage or the extent of its relation to political justice, whereas monotheists anchored a moral life not in self and society, but primarily in God. The contentiousness of these disputes and their failures to successfully promote virtue eventually led to a radical challenge of virtue ethics that nevertheless did not eliminate its relevance. Rather, according to the historian of modern moral philosophy J. B. Schneewind (1998), these disputes relegated the virtues and vices to secondary status. Displacing them as the primary focus of ethics were duties, happiness or pleasure, autonomy rather than character, and the right rules or laws for gauging ethical conduct.

After more than 200 years of rationalism and emotivism in moral theory, toward the end of the twentieth century virtue ethics underwent a revival. Dissatisfied with the inability of prominent moral theories to address human well-being, resolve concerns about justice in an increasingly technological world, and inform or guide individuals toward the good, philosophers began reassessment of the centrality of virtue. A key contributor to this was Alasdair MacIntyre, author of *After Virtue* (1981) and *Whose Justice? Which Rationality?* (1988). Invoking the wisdom of Aristotle and Thomas Aquinas, along with the lessons of contemporary social and political thought, MacIntyre espoused an enriched view of the integral and narrative self that challenged rival notions of the self as little more than a utility maximizer or logical servant to duty.

MacIntyre's learned eloquence and sharp critique of his own intellectual and moral times spawned a veritable industry. Responses ranged from best-selling children's books on the virtues to theoretical and scientific inquiries into the nature of moral character, whether or how it can be taught, and the relation of individuals to others: other humans, other species and life-forms, even deities. Some scientists have contended that, contrary to MacIntyre's emphasis on human identity as flourishing in cultural and historical storytelling, human morality should more sensibly emulate animals. Monkeys and chimpanzees, birds and elephants, according to zoologists, illuminate more accessible and realistic moral guidance than the (less realistic) heroes and saints who permeate human literature.

Such disputes—interweaving disciplines, incorporating historical and cultural contexts, responding to calls for justice or courage and to temptations of anger or lust—underscore the lasting appeal of virtue ethics. Unable to resolve all the philosophical questions put to it in journals and seminars, nor ready to dictate every moral situation (which theories can?), virtue ethics highlights controversies as vigorously as any other moral theory. Nowhere is this more clearly illustrated than in relation to science and technology.

Sloth, Leisure, Efficiency

Medieval Christians learned the seven deadly sins through the mnemonic device of an acronym—*s-a-l-i-g-i-a*. Each letter represented a deadly sin in order from the queen of vices (*superbia* being pride) to the deadliest (*acedia* or sloth). In between are situated *avaritia* (greed or covetousness), *luxuria* (lust), *invidia* (envy), *gula* (gluttony), and *ira* (anger). Warnings against sloth—from the Benedictine rule concerning the dangers of idleness to popular jokes about couch potatoes—represent it as the death of the soul as well as the spirited body. Sloth is more than laziness or lethargy; it constitutes a lack of purpose, an indifference to others and the goings-on of the world. In his *Pensees* (c. 1660), Blaise Pascal frequently remarked how people fill their time with diversions, such as games, chatter, and sensual delights. These prevent contemplation of more defining matters that include the meaning of one's death or a believer's relation to God.

By contrast, leisure is upheld as a sign of independence and accomplishment. What Pascal denigrates as diversions can be praised as just desserts. In leisure individuals explore their potential, be it in time of play, hobby, volunteer work, or even, as G. K. Chesterton (1874–1936) wryly noted, "the time to do nothing at all." To this end inventions promise to lessen arduous chores while opening more opportunities for whatever one desires. Household gadgets save on cleaning and organizing; robotics and assembly lines spare the sweat and blood of labor; sophisticated weaponry produce greater damage with risk to fewer personnel. Leisure relies on the promises of efficiency. These promises, however, can be misleading insofar as they exchange one set of difficult expectations for another. For example, the historian Ruth Schwartz Cowan (1983) has demonstrated the deceptive attractions of household technologies. The washing machine cuts down the once-a-week ardor of washing by hand and wringers, but introduces the everyday demand for a clean set of clothes, hence making laundry a daily chore. The invention of the four-burner stove with oven shifts family expectations from variations of a pot of stew to a five-course meal, hence the popularity of the cookbook. The overall result is that technologies tend to reduce the physical pressure of housework while increasing the solitariness and frequency of household tasks. The promise of more leisure, concludes Cowan, is often illusory.

From a virtue ethics perspective, however, there remain additional concerns with leisure. While *scholar* derives from the Latin word for leisure—implying both an individual and cultural good—leisure nevertheless poses considerable danger. As studied by Sissela Bok in *Mayhem* (1998), many leisure technologies involve decadent forms of play. Video games, television shows, and movies featuring callous and malicious regard for human (and animal) life have gradual effects on participants and audiences that can be just as pernicious as the tortures of ancient spectacles. This danger prevents individuals from seeking or realizing their potential as genuine human beings.

From the perspective of what might be called a technological virtue—if not technological duty—of efficiency, which emphasizes cost–benefit analysis, convenience, speed, and reliability, these gradual and pernicious effects are difficult to assess. A consequentialist or utilitarian option might consider measurable and substantive results enjoyable in the near future or negative influences on other virtues. Indeed, there are kinds of leisure that mask opportunities for sloth. This is not free time as envisioned by those who endorse human flourishing, but an appeal to vanity that plants the seeds for a slow death of one's humanity and moral character. Worse, humans become less focused on other virtues, such as justice, care, or loyalty.

Pride, Vanity, Control

As noted, Aristotle and his adherents view pride as a positive value, whereas Christian philosophers see it as vicious. Though numerous moral traditions and religions challenge pride, often what they have in mind is hubris or vanity. Hubris involves a kind of arrogance, boasting, or overweening confidence. Vanity involves an undue or unrealistic sense of one's self. Hubris is portrayed in one who fails because of unwarranted sense of self-worth. Vanity is depicted in one who wants to look younger, richer, more powerful, or more knowledgeable than one really is. Boasting, begrudging, and being envious are some of the cravings of vanity. These cravings are often driven by a technological fix, the unshaken belief that a device will always arise—such as diet pills, cosmetic surgery, or transplants—that helps to overcome the effects of aging or unwanted anatomical features. The vain person thus hopes others see a version of oneself that one does not quite believe. That is why medieval moralists pictured the vainglorious person staring into the mirror.

Pride is ambiguously presented in the human trait that desires control. Humans are increasingly adept at withstanding or overcoming natural forces. Protecting themselves from the whims of weather, rechanneling water sources so they can dwell in deserts, or regulating their own predatory or procreative tendencies, they find in science and technology the powers to explain and control the forces of nature. Humans also attempt to extend this control to human domains that were previously resolved in terms of freedom, wisdom, upbringing, or environment. For example, by reclassifying a vivacious or imaginative child as one with attention deficit disorder or disciplinary problems, the child shifts from a subject in need of a certain kind of pedagogy to a candidate for Ritalin.

Determining when technological control should yield to a moral approach is a perennial concern for virtue ethics, particularly for those who support Aristotle's notion that part of a virtuous life is striving for the means between the extremes. With increasing capabilities brought by a variety of technologies, humans still need to strike a balance between turning nature into a managed artifact and resigning themselves to all the challenges and threats nature presents.

The desire for control can nevertheless be another form of vanity. That the world, nature, or other people act without any regard for one's wishes or well-being—indeed, that they seem oblivious to one's very existence—insults a person's own (inflated) sense of self-worth. Symptomatic of this inflation is the ubiquity of cell phones. Owners insist they carry them for possible emergencies. But this claim is betrayed by its omnipresent use. Is the desire to be always and immediately accessible to anyone a symptom of vanity, justified pride, or unending control?

Honesty, Loyalty, Responsibility

Honesty is often described as an intellectual and a moral virtue. The ability to understand things clearly, to know one's own motives and aspirations, and to comprehend circumstances and other humans involves intellectual abilities that precede and accompany moral deliberations and actions. Yet the temptation to deceive others and manipulate the truth also makes honesty a moral issue.

This temptation is especially pronounced in professional ethics. Given their expertise, authority, and the confidence ordinary humans have in them, scientific and technical professionals have a distinctive responsibility to understand and articulate the possible effects of their research. The details of this responsibility can be overshadowed by conflicting loyalties. According to the American philosopher Josiah Royce (1855–1916), loyalty is a virtue essential to the good life. Though its etymology comes from law (*lex* in Latin), Royce views loyalty more in terms of love, purpose, and commitment. Individuals find meaning in their lives when anchored by the object of their loyalty; moreover, this attitude generates respect for the loyalties that give others a purpose.

In professional circles, however, loyalties are not always unified. Among researchers and engineers, for example, there can be obligations to one's employer, the sponsor of a research grant, colleagues and the principles of the discipline, families, and of course the general public. A notable exemplar is the scientist Joseph Rotblat (b. 1908). He was a contributor to the Manhattan Project, in which the United States developed the atomic bomb during World War II. After the defeat of Germany, Rotblat concluded that the project was no longer justified by the danger of Nazi bomb development and left the project. His is a difficult example to follow. Often researchers and even college professors can elucidate the lofty principles that they are supposed to adopt, but when millions of dollars from a grant are at stake, their loyalty to truth can be compromised by loyalty to the research momentum. Some moralists believe the virtues of integrity, self-respect, and honesty can overcome conflicts of loyalty and corruptible compromises. In complex enterprises, however, the notion of personal responsibility can be overshadowed by demands of the workplace or a competitive climate in which one sticks to the proverbial rules and goals of the game rather than challenging the legitimacy of the rules and goals. In such a context, the virtue of responsibility may be torn between courageous criticism and loyal adherence to the team, group, or community.

Justice, Greed, Progress

According to Plato and Aristotle, justice is a virtue that involves harmony or analogy between perfections in citizens and in the state. Modern political philosophy has been skeptical of this view and questioned whether the virtues of individual and society need to reflect one another. In his famous *The Fable of the Bees* (1705) Bernard Mandeville contended that a society can flourish in spite of—and often because of—the vices of its citizens. With appropriate constraints—such as a competitive market or constitutionally separated powers—the natural impulses and selfish appetites of the populace can be harnessed to yield social benefits. As Mandeville poetically noted: "Thus every part was full of vice / Yet the whole mass a paradise." This attitude persists insofar as economists claim that even though gas-guzzling sport-utility vehicles (SUVs) fuel vanity and greed, the Internet indulges lust, and fast food sates gluttony, economic growth and the general welfare are assured.

Virtue ethics theorists nevertheless question such an assessment. For instance, John Casey (1990) argues that justice is first and foremost a disposition within individuals, and defends the traditional view of the truly just person as one who leads a balanced life, recognizing the claims and goods of others. From this perspective, economic greed threatens justice. Though often associated with tycoons, royalty, and celebrities, greed is a temptation in nearly everyone. This is why, A. F. Robertson (2001) writes, stories and concerns about greed cross all ages, and are manifest in everything from children's tales such as "Puss in Boots" to intergenerational squabbles over property and controversies about professionals who appear more devoted to income and prestige than family or service to society. Daniel Callahan (1987) has further argued that with the advances of medical technology, the question needs to be raised whether humans have become greedy for life, attempting to live in excess of a natural life cycle, when they can no longer function or contribute, and at the expense of the well-being of younger generations.

From a virtue perspective, it is essential to ask whether greater affluence spawns generations of more just individuals (and more just societies) or creates more possibilities for vices to thrive (and injustice to grow). How often have parents and grandparents not lamented that increases in the number and glamour of toys among children are not easily correlated with any increases in willingness to share? To what extent does the example of the United States, whose abundance is historically unprecedented, but whose level of government-sponsored foreign aid is not particularly impressive, bear on assessments of political justice? According to Leo Marx (1987), in eighteenth-century America, philosophers such as Benjamin Franklin and Thomas Jefferson saw both personal and social justice as essential measures for assessing national progress. In the nineteenth century, however, the meaning of progress shifted from rights, equality, and personal freedom to material gain and industrial growth, a change that continued across the twentieth century and into the twenty-first.

Scholars such as Dinesh D'Souza contend that many critics miss the central issue on the debates over the meaning or evidence of progress. Instead of seeing wealth as a potential obstacle for the establishment or expansion of justice, D'Souza sees wealth as the key to increasing global well-being. While he acknowledges that enormous increases in scientific knowledge, technological power, and material prosperity characteristic of the 1980s and beyond have carved new gaps between the world's rich and the poor, he points out that in absolute terms the poor and the rich today live much more comfortable lives than did the poor and the rich 500 years ago. Whereas in 1500 only the most wealthy had indoor plumbing and well-heated homes, today even the traditional poor—such as students, seasonally employed, or those too feeble to work—possess cars, reside in secure surroundings, and rely on pricey media such as the Internet, cable TV, and cell phones. Interpreting Thomas Jefferson as a defender of class hierarchies based on a natural aristocracy of individual merits D'Souza believes capitalism has been a gift rather than curse to human life. The desire and search for wealth tames the destructive potential of greed and envy. Guided by a virtue of prosperity, capitalism embodies the prudence to use science and technology that, according to D'Souza, "... has in practice done more to raise the standard of living of the poor than all the government and church programs in history" (D'Souza 2000, p. 240).

This systematic effort towards greater wealth can also be the basis for an essential social virtue—namely, trust. Trust involves a common and cooperative regard for norms or mutual self-interest. In the view of social scientist Francis Fukuyama, this regard is most effective in communities where social capital and ethical values are most prominent. These communities are not, however, rooted in traditional units such as the family. They are instead found in associations that transcend kinship, such as businesses and companies. The benefits of these associations are most notably seen in three advanced technological and capitalist societies: the United States, Germany, and Japan. Here, according to Fukuyama, one understands the basis of other social virtues and their relation to a life of prosperity.

The estimated benefits of capitalism's virtues are not readily supported by research. Contrary to those who assume a millionaire's summer palace that perilously rests on the ledge of a shore cliff is the spark to global justice, demographers and ecologists find that prosperity's recipients are segmented rather than universal. That is, pockets of great wealth often have negligible or negative influences on the range of human (and non-human) suffering, starvation, or disease. Moreover, excesses of fortune foster a sense of obliviousness to the conditions of others. Such obliviousness—a potential vice insofar as it is interpreted as willful ignorance—turns a blind eye to human threats to the climate. It overlooks human causes of continual increases of pollution, thus jeopardizing the traditional lifestyles of native peoples. It downplays the continued emphasis on consumption of natural resources that generate droughts and scarcities among the world's poorer populations. Obliviousness becomes vicious when it pooh-poohs scientific claims that drastic changes in weather patterns brought on by human pollutants—in the year 2000 each American produced 4.5 pounds of garbage per day—endanger the lives of animals and fish throughout the planet (See, for example, De Souza, Williams, and Meyerson 2003, Post and Forchhammer 2004).

Character, Self, Other

Proponents of virtue ethics emphasize the development of moral character. This development assumes that there is an integral person, a core to an individual that is definitive. Moral pedagogy is directed to this core. The lessons about courage, loyalty, justice, or compassion found in traditional narratives, folktales, sacred texts, honest dialogue, or exemplars help form one's true or genuine identity. These sources reside in other humans, those who spin the narratives, relay the tales and texts, or are admired exemplars. Despite Voltaire's quip that character is so inborn humans could no more change it than wolves could lose their instincts, proponents of virtue ethics generally argue that moral character can be developed, taught, changed, and practiced.

This assumption has three challenges. The first is biological. Paul M. Churchland (1998), for one, proposes that human virtues can be more thoroughly understood from a neurophysiological perspective. Pedagogy and environment obviously have some influence, but they play a secondary role to identifying and treating malfunctioning synapses or chemical imbalances that might prevent the moral agent from successfully cooperating in the well-being of the group. Zoologist and ethnologist Frans de Waal (1996) contends humans have much to learn from animals who exhibit uncanny methods for establishing justice, tolerance, and compassion, and resolving conflicts, without resorting to massacres and war.

Second is a scientific and creative challenge. This challenge stems from the ambiguous human disposition of curiosity. Humans want to know, a desire that seems unquenchable. Curiosity is a likely culprit behind the original sin of Adam and Eve. The French philosopher Jean-Paul Sartre (1905–1980) describes the attempt to know another as a form of capture. At the same time, inventions give humans radical new ways for seeing, hearing, and learning about the world and the universe. Anyone with a stereo can hear Beethoven indefinitely more times than residents of nineteenth-century Europe. The depths of the oceans and dark abysses of the universe are as impossible for human curiosity to resist as exploring their own genetic material or the chemical charges that drive their urge to mate. And under the rubric of transhumanism, researchers are exploring how such fields as genetics and nanotechnology can reinvent the human forms of intelligence, emotion, physiology, and communication. This curiosity does not have to lead to identification of a true self; it can introduce possibilities for creating new selves. With the advent of cyberspace, according to Allucquère Rosanne Stone (1995), humans have found evermore ways of experimenting and playing with a variety of identities. The face-to-face encounter is not the ideal, just one of many options. It has its own limitations, from which cybercommunities can be valued as liberating rather than alienating.

Third is a philosophical and pedagogical challenge. The idea of a core self is neither self-evident nor coherent. For example, Alphonso Lingis (2004) describes an array of virtuous deeds—of illiterate mothers, gallant youths, mute guerillas, compassionate prisoners, free-spirited nomads—that cannot be attributed to an integral or holistic self. The realization of a virtuous capacity seldom springs from proper habits, one's internal biology, or the narratives of ancestors or cybercommunities. Instead, humans learn about courage, justice, or love as imperatives from contact with others—in their physical or embodied presence. Science and technology should expand rather than displace the possibilities for face-to-face encounters. Such possibilities suspend the insistence on control and self-respect by emphasizing respect for and openness to others, regardless of whether or not they are neighbors, friends, strangers, or aliens. This respect is not grounded in or preceded by understanding or knowledge of shared values. Instead, writes Lingis, it involves courage rather than caution to trust another insofar as trust dissipates one's own projects and identities. "Trust is a force that can arise and hold on to someone whose motivations are as unknown as those of death. . . . There is an exhilaration in trusting that builds on itself" (Lingis 2004, p. 12).

Such challenges recognize an ambiguity in the human relation to science and technology. Whether this ambiguity demonstrates progress or regress in ethical life is subject to debate. From a virtue-ethics angle, this debate must include the relative strengths of the virtues and vices, their personal and social significance, whether or how they can be taught, and to what extent science and technology primarily guide humans to realization of their true selves or invite them to devise or create other ways of being.

ALEXANDER E. HOOKE

SEE ALSO *Aristotle and Aristotelianism; Augustine; Buddhist Perspectives; Christian Perspectives; Confucian Perspectives; Jewish Perspectives; Islamic Perspectives; Pascal, Blaise; Plato; Shintō Perspectives; Thomas Aquinas; Thomism.*

BIBLIOGRAPHY

Berrigan, Daniel. (1989). "In the Evening We Will Be Judged by Love." In *Sorrow Built a Bridge: Friendship and AIDS*. Baltimore: Fortkamp Publishing. Memoirs by priest and political activist, who recalls with sorrow and wit his experiences in accompanying those who are dying from fatal diseases.

Bok, Sissela. (1998). *Mayhem: Violence as Public Entertainment*. Reading, MA: Addison-Wesley. Lucid and balanced presentation on potential social and moral hazards emerging from a culture entertained by everyday violence, particularly in the form of news, television dramas, and video games.

Callahan, Daniel. (1987). *Setting Limits*. New York: Simon and Schuster. Thoughtful account of how traditional morality and ongoing changes in medical technology have produced a tragic dilemma for contemporary life.

Casey, John. (1990). *Pagan Virtue: An Essay on Ethics*. Oxford: Clarendon Press. A thorough account of the principal virtues—particularly courage, temperance, justice, and prudence—that preceded Christian moral thought.

Chuang Tzu. (1996). "The Sign of Virtue Complete." In *Chuang Tzu: Basic Writings*, ed. and trans. Burton Watson. New York: Columbia University Press.

Churchland, Paul M. (1998). "Toward a Cognitive Neurobiology of the Moral Virtues." *Topoi* 17(2): 83–96.

Cowan, Ruth Schwartz. (1983). *More Work for Mother: The Ironies of Household Technology from the Open Hearth to the Microwave*. New York: Basic. Fascinating survey of promises and pitfalls encountered among household gadgets and utilities.

Crisp, Roger, and Michael Slote, eds. (1997). *Virtue Ethics*. Oxford: Oxford University Press.

Darling-Smith, Barbara, ed. (1993). *Can Virtue Be Taught?* Notre Dame, IN: University of Notre Dame Press. Scholars discuss the extent to which virtue ethics and specific ethics can be central feature of education.

Darling-Smith, Barbara, ed. (2002). *Courage*. Notre Dame, IN: University of Notre Dame Press.

De Souza, Roger-Mark; Williams, John; and Meyerson, Frederick. (2003). "Critical Links: Population, Health, and the Environment." *Population Bulletin* 58(3): 3–43.

D'Souza, Dinesh. (2000). *The Virtue of Prosperity: Finding Values in an Age of Techno-Affluence*. New York: Free Press. Articulate explanation and defense of the rise of capitalism and its positives influences on moral progress and human welfare.

Etzioni, Amitai, ed. (1995). *New Communitarian Thinking: Persons, Virtues, Institutions, and Communities*. Charlottesville: University Press of Virginia. Collection of essays by academic writers, with central focus on defending and reviving the sense of a traditional community as the basis for citizens leading a virtuous life.

Flanagan, Kieran, and Peter C. Jupp, eds. (2001). *Virtue Ethics and Sociology: Issues of Modernity and Religion*. New York: St. Martin's Press.

Fukuyama, Francis. (1995). *Trust: The Social Virtues and the Creation of Prosperity*. New York: The Free Press. Historical and sociological account of differentiations between high-trust and low trust societies, with contemporary industrial and capitalist countries triumphing over kinship and clan-driven countries in terms of generating greater trust and prosperity.

Gordon, Mary. (1993). "Anger." In *Deadly Sins*, ed. Thomas Pynchon et al. New York: Morrow.

Grayling, A. C. (2002). *Meditations for the Humanist: Ethics for a Secular Age*. Oxford: Oxford University Press.

Hooke, Alexander E., ed. (1999). *Virtuous Persons, Vicious Deeds*. Mountain View, CA: Mayfield Publishing. Presents a wide range of virtues and vices as discussed by philosophers and nonphilosophers, and historical and contemporary writers.

Horowitz, Maryanne Cline. (1998). *Seeds of Virtue and Knowledge*. Princeton, NJ: Princeton University Press. Historical account of two enduring themes in moral upbringing: one, virtues are like seeds, and need to be planted in young children early and nourished constantly; two, virtues and vices are in a battle over the human soul, and virtues must be ever vigilant in defeating the vices.

Hursthouse, Rosalind. (1999). *On Virtue Ethics*. Oxford: Oxford University Press. Systematic reflection on the nature of virtue ethics and discussion of relation of specific virtues to the good life.

Jordan-Smith, Paul. (1985). "Seven (and More) Deadly Sins." *Parabola* 10(4): 34–45.

Kupfer, Joseph. (1999). *Visions of Virtue in Popular Film*. Boulder, CO: Westview Press. Highlights a variety of films that depict virtues in plots and main characters.

Lingis, Alphonso. (2004). *Trust*. Minneapolis: University of Minnesota Press. Elaborate descriptions of various encounters involving humans having the courage and trust to rely on one another regardless of a common language or culture.

Lomborg, Bjørn. (2001). *The Skeptical Environmentalist: Measuring the Real State of the World*. Cambridge, UK: Cambridge University Press.

MacIntrye, Alasdair. (1981). *After Virtue*. Notre Dame, IN: University of Notre Dame Press. 2nd edition, 1984.

MacIntrye, Alasdair. (1988). *Whose Justice? Which Rationality?* Notre Dame, IN: University of Notre Dame Press.

Martin, Mark W., and Roland Schinzinger. (2005). *Ethics in Engineering*, 4th edition. Boston: McGraw-Hill.

Marx, Leo. (1987). "Does Improved Technology Mean Progress?" *Technology Review* 90(1): 33–41, 71.

Meilaender, Gilbert C. (1984). "It Killed the Cat: The Vice of Curiosity." In *The Theory and Practice of Virtue*. Notre Dame, IN: University of Notre Dame Press.

Post, Eric; and Forchhammer, Mads. (2004). "Spatial Synchrony of Local Populations Has Increased in Association with the Recent Northern Hemisphere Climate Trend." *Proceedings of the National Academy of the Sciences* 101(25): 9286.

Richards, Norvin. (1992). *Humility*. Philadelphia: Temple University Press. Extended analysis of a virtue that at first seems quaint, but here proposed to be central to living a good life.

Robertson, A. F. (2001). *Greed: Gut Feelings, Growth, and History*. Cambridge, UK: Polity Press. Anthropological study of historical and contemporary attitudes and practices that indulge and battle the temptations of greed.

Royce, Josiah. (1924). *Loyalty*. New York: Macmillan.

Saeng, Chandra N. (1991). "Insight-Virtue-Morality." In *Buddhist Ethics and Modern Society*, ed. Charles Wei-Hsun Fu and Sandra A. Wawrytko. Westport, CT: Greenwood Press.

Schneewind, J. B. (1998). *The Invention of Autonomy*. Cambridge, UK: Cambridge University Press. Scholarly investigation of the disputations of early modern moral philosophers, and how Immanuel Kant's idea of autonomy attempts to resolve the philosophical difficulties of formulating a secular and rational ethic.

Schwartz, Nancy L. (2004). "'Dreaded and Dared': Courage as a Virtue." *Polity* 36(3): 341–366.

Segal, Lore. (1996). "My Grandfather's Walking Stick; or, The Pink Lie." *Social Research* 63(3): 931–941.

Shaw, Bill. (1997). "A Virtue Ethics Approach to Aldo Leopold's Land Ethic." *Environmental Ethics* 19(1): 53–67.

Stone, Allucquère Rosanne. (1995). *The War of Desire and Technology at the Close of the Mechanical Age*. Cambridge, MA: MIT Press.

Taylor, Gabriele. (1996). "Deadly Vices?" In *How Should One Live?* ed. Roger Crisp. Oxford: Clarendon Press. Concentrated analysis of the meaning of a deadly vice, and whether specific virtues can confront or overcome the vices.

Waal, Frans de. (1996). *Good Natured: The Origins of Right and Wrong in Humans and Other Animals*. Cambridge, MA: Harvard University Press.

VON NEUMANN, JOHN

One of the most brilliant mathematicians of the twentieth century, John von Neumann (1903–1957) was born in Budapest, Hungary on December 28. He died February 8 in Washington, DC, having created the mathematical foundation for quantum mechanics, one of three competing theories of the physics of the universe, a theory of mathematical economics, the process for creating an implosion atomic bomb, and the theory of automation.

Von Neumann studied at the University of Budapest, the University of Berlin, and the prestigious Technische Hochschule in Zurich. While in Zurich, he worked with two outstanding mathematicians, Hermann (1885–1955) Weyl and George Polya (1887–1985). In 1926, von Neumann was awarded a Ph.D. in mathematics from the University of Budapest and a diploma in chemical engineering from the Zurich University.

Von Neumann lectured at the University of Berlin (1926–1929) and the University of Hamburg (1929–1930). During this later period he also held a Rockefeller fellowship that enabled him to do postdoctoral study with one of the mathematical giants of the time, David Hilbert (1862–1943), at the University at Göttingen. By 1927, von Neumann was acknowledged worldwide as a young mathematical genius, and in 1929, Oswald Veblen (1880–1960) invited him to Princeton University to lecture on quantum theory. In 1930 he became a visiting lecturer at Princeton and in 1931 was appointed a professor. In 1933, the Institute for Advanced Study was formed, and he became one of the first six full time members of the School of Mathematics. Von Neumann held this position for the remainder of his life.

Von Neumann published 130 articles and books during his career, evenly split between pure and applied mathematics, as well as twenty articles and books that made significant contributions to physics.

His 1932 book *Mathematische Grundlagen der Quantenmechanik* created a firm mathematical foundation for quantum mechanics. Quantum theory assumes that energy is not absorbed or radiated continuously, but rather discontinuously and only in multiples of definite invisible units called quanta. Quantum mechanics is a physical theory that describes the motion of objects using the principles of quantum theory. In this work, he also introduced a new form of algebra that he named *rings of operators*. In his monograph *Algebras of Operators in Hilbert Space*, von Neumann extended this algebra to group representation as well as to quantum mechanics. This part of mathematics is now called von Neumann algebras.

John von Neumann, 1903–1957. The Hungarian-born American mathematician was the originator of the theory of games and an important contributor to computer technology. (*© UPI/Corbis Bettmann.*)

Von Neumann's 1937 paper "A Model of General Economic Equilibrium" has been repeatedly cited as the greatest paper in mathematical economics ever written. The paper provided a theory of capitol and economic growth based upon a mathematical foundation.

Von Neumann created the entire field of game theory. His 1944 book (written with Oskar Morgenstern), *Theory of Games and Economic Behavior*, not only completed the theory but also introduced several other sets of axioms in other fields of economics.

During the Second World War, von Neumann worked with the scientists and administrators at Los

Alamos on the development of the atomic bomb. His two principal contributions to the Los Alamos project were the introduction of mathematical decision making and refinement of the implosion or plutonium bomb. He did not originate the idea of an implosion, but he did develop the correct density of explosives required to achieve the correct implosion.

Von Neumann's development of MANIC—an acronym for Mathematical Analyzer, Numerical Integrator, and Computer—enabled the United States to produce and test the world's first hydrogen bomb in 1952. Von Neumann spent much of his later life working in automata theory, a field that attempts to understand multiple automation applications working together to form a process or perform a task. He was also an early advocate of stored programs within a computer. His computer architecture is common to all personal computers and has come to be known as von Neumann architecture.

HENRY H. WALBESSER

SEE ALSO *Decision Theory; Turing, Alan; Wiener, Norbert.*

BIBLIOGRAPHY

Aspray, William. (1990). *John von Neumann and the Origins of Modern Computing*. Cambridge, MA: MIT Press. Describes the contributions of von Neumann to the development of von Neumann computer architecture.

Heims, Steve J. (1980). *John von Neumann and Norbert Wiener: From Mathematics to the Technologies of Life and Death*. Cambridge, MA: MIT Press. A dual biography, this is a work that traces the academic contributions of von Neumann and Norbert Wiener to the numerous areas of study each influenced as well as their relationship to one another.

Macrae, Norman. (1992). *John von Neumann*. New York: Pantheon. A general bibliography of the life, person, and contributions of the man.

von Neumann, John. (1937). "A Model of General Economic Equilibrium." In *Ergebnisse eines mathematischen Kolloquiums* [Reports of a mathematical colloquium], ed K. Menger. Notre Dame, IN: University Press of Notre Dame. Foretells what is to become the theory of games.

von Neumann, John, and Oskar Morgenstern. (1944). *Theory of Games and Economic Behavior*. Princeton, NJ: Princeton University Press. Offers a theory to explain certain classes of economic behavior.

von Neumann, John. (1958). *The Computer and the Brain*. New Haven, CT: Yale University Press. A work that stimulated the development of artificial intelligence as a field of study in computer science.

von Neumann, John. (1966). *Theory of Self-Reproducing Automata*. Urbana: University of Illinois Press. Published posthumously. A theory that explains the underlying structures needed to create automated systems capable of reproducing themselves.

VON WRIGHT, GEORG HENRIK

• • •

Philosopher and inventor of deontic logic, Georg Henrik von Wright (1916–2003), who was born in Helsinki, Finland, on June 14, was also a cultural critic of techno-scientific progress. In philosophy, von Wright is best known as Ludwig Wittgenstein's successor in the chair of philosophy at Cambridge (1948–1951), and for participating in the publishing of Wittgenstein's papers posthumously. Von Wright was also a major contributor to the rebirth of modal logic in 1950s. Among his most important academic works are *Norm and Action* (1963), *Varieties of Goodness* (1963), and *Explanation and Understanding* (1971). The last had a distinctive role in efforts to bridge the gap between the Anglo-American and continental European traditions in philosophy.

Apart from his work within academic philosophy, von Wright was an important public intellectual in Finland and Scandinavia. Throughout his career he wrote philosophical essays in which he dealt extensively with the questions of the effects of science and technology on human life. He presented his cultural analysis in *Vetenskapet och förnuftet. Ett försök till orienteering* (Science and reason: An attempt at orientation), published in 1986.

Von Wright's cultural philosophy focuses on the critical situation of modern Western civilization, seen as threatening the whole globe. Many of the most serious problems of the modern world can be understood as direct consequences of techno-scientific advance. Von Wright wrote about the ecological crisis, the existence of weapons of mass destruction capable of devastating all human life, the ethical vacuum that has followed secularization and collapse of traditional value systems, and the expansion of instrumental reason in all areas of human life.

Von Wright sought the origins of these problems in the history of ideas. He located the roots of modern science and technology in the objectification of nature, the inclination toward mechanistic and deterministic causal explanations, and reductionism. The manipulative ethos of modern natural science is explicit in the writings of the pioneering philosophers of science, such as Francis Bacon (1561–1626) and René Descartes (1596–1650). It is clear that this conceptual framework has produced impressive results. However, von Wright asserted that the cost has been high.

Furthermore, von Wright noted how science is becoming an ever more important force for production. This development is problematic for science itself. The crucial question concerns what will happen to truth as the goal of science, if science becomes dependent on demands for profit, and if new discoveries are kept secret for commercial and military purposes. Von Wright also doubted the ability of modern science to provide a culturally understandable and meaningful worldview.

Although von Wright arrived at his conclusions independently, his analysis of techno-scientific progress has predecessors. Cultural critics such as Oswald Spengler, Lewis Mumford, Jacques Ellul, and the thinkers of Frankfurt School developed similar themes. Von Wright's achievement is the sobriety and transparency of his analysis. His background in analytical philosophy makes his argument especially interesting, because this tradition has usually been very optimistic concerning modern natural science.

TOPI HEIKKERÖ

F**SEE ALSO** *Scandinavian and Nordic Perspectives; Wittgenstein, Ludwig.*

BIBLIOGRAPHY

Schilpp, Paul Arthur, and Lewis Edwin Hahn, eds. (1989). *The Library of Living Philosophers,* Vol. 19: *The Philosophy of Georg Henrik von Wright*. La Salle, IL: Open Court.

von Wright, Georg Henrik. (1963). *The Varieties of Goodness*. London: Routledge & Kegan Paul.

von Wright, Georg Henrik. (1986). *Vetenskapen och förnuftet. Ett försök till orienteering* [Science and reason: An attempt at orientation]. Borgå, Sweden: Söderström.

von Wright, Georg Henrik. (1993). *The Tree of Knowledge and Other Essays*. Leiden: Brill.

W

WASTE

Advanced industrial societies produce enormous quantities of waste. People know it when they see it, yet waste does not admit of any strictly physical definition. Moreover what is at one point waste can at another point easily be resource. Examples include archaeological digs in archaic trash dumps, artistic creations of *objets trouvés* co-generation plants, and recycling centers.

However waste is defined and measured, it is safe to say that never before have humans produced and thrown away as much as they do in the early twenty-first century. Mass production through industrialization, extensive packaging (to facilitate both shipping and sales), and rapid obsolescence (whether planned or as an accidental effect of technological progress) in a free market economy, driving the compulsion to make things and consume them, have formed a world in which artifacts are produced, consumed, and discarded to an historically unprecedented extent.

Indeed there is a tendency for the lifetime of *durable* products to be shortened to that of *consumables,* and for non-renewable natural resource stocks to be consumed in the same way as renewable production flows, which some critics ascribe to the inability of *free market forces* to distinguish between them. Given the size of the phenomenon and its potential damaging effects on public health, the environment, and future generations, waste is one of the fundamental problems facing the techno-scientific and consumer society.

Regulations

The rapid growth, diversification, and toxicity of waste production have been accompanied, though not matched, by legislation, the development of regulatory institutions, and new methods of treatment and control. Waste has become a priority of environmental risk politics for national and international authorities (for example, the European Union [EU], U.S. Environmental Protection Agency [EPA], Organization for Economic Co-Operation and Development [OECD], World Health Organization [WHO], United Nations Environment Programme [UNEP], and so on), and one of the crucial concerns of social and ecological movements (such as Greenpeace).

The roots of this politicization go back to the nineteenth century and the earliest public health reforms spearheaded by medical scientists and advocates of public hygiene (Melosi 1981). This process is related to growing feelings of repugnance and the formalizing of new rules of conduct, discipline and self-control. Waste, which was increasing as the population of urban areas grew, was synonymous with chaos, disorder, and contagion, and had to be put out of sight. The concept of *matter out of place,* used by Mary Douglas (1966) in an anthropological study of dirt and pollution, offers a vision of waste as something that intrudes on ordered arrangements where everything has its rightful place.

Another impulse for the politicization of waste came in the 1970s with the emergence of ecological movements and environmental ethics. Rachel Carson's pioneering book, *Silent Spring* (1962), was a decisive influence in these developments. In it she denounced the harmful effects on human and animal health of the massive application of DDT and other chemical pesticides in agriculture. Consciousness of ecological frailty and feelings of ambiguity in relation to the unexpected consequences of technological advances were later reinforced by environmental accidents in the fields of technology and energy (for example, Times Beach and Love Canal in the United States, and the Seveso dioxin-contaminated waste drums in Europe).

Waste Policy

Waste policy is formed as part of a wider strategy, either to decrease pollution and protect the environment, or to bring about technological and industrial change and innovation. In each of these aims, there is remarkable ambivalence regarding the technological implications.

On the one hand, technology itself is responsible for much waste production and global pollution. Each technical development, despite its many benefits, has brought an increase in the amounts and types of waste. After the non-degradable waste produced by the steel and iron industries of the early industrial era, plastic, chemical, and pharmaceutical products have given rise to even more waste products that are more toxic and difficult to treat, control, and dispose of. On the other hand, technology is also absolutely necessary for waste prevention and the disposal of pollutants. All the principles of current international waste management strategy—minimization, recycling, reuse, and improving final disposal and monitoring—depend, in general, on techno-scientific solutions. For example, the ability to recycle is built into some products at the design stage; and some technological innovations are created specifically to improve the treatment or recovery of waste.

So-called ecological or green strategies are made difficult by the many sources of waste—domestic, commercial, industrial, medical, agricultural, construction, and so on—and its physical and chemical nature, comprising (among other materials) metals, plastics, glass, paper, and vegetable matter, often in complex and hard-to-separate combinations as in batteries, cartons, and cars. When waste cannot be recycled or reused, it is usually burnt ("incinerated") at high temperatures or dumped into landfill sites. However each of these methods may cause air, water, and soil pollution, and may have harmful effects on human, plant, and animal health.

Hazardous and Radioactive Waste

Hazardous waste, and especially radioactive waste, requires extra care in its treatment and disposal. Because of their potential harmful effects—and the political, social, and ethical questions they raise—hazardous and radioactive wastes are generally the most studied. Most international policies and treaties deal with waste of these types, whose environmental problems are global in scope and indifferent to national, generational, or class boundaries. Yet despite similarities, entirely separate legislation governs the two types, and they have different regulatory institutions and interest groups.

The contents of hazardous wastes may cause serious damage to human health and/or the environment, when improperly treated, stored, transported or disposed of. There are differing definitions and systems of classification in different countries and even between states and regions of the same country. It is symptomatic that there is little agreement on the definition of *hazardous*, on who is responsible for this definition, and on what substances are considered as hazardous waste.

According to Brian Wynne (1987), a sociologist who has addressed environmental issues and in particular the problem of waste, the lack of consensus between countries over hazardous waste is the main difficulty for international regulation. Furthermore this type of waste is usually taken to be not dispersed and diluted in the environment, but *packaged* for further treatment before eventual destruction, containment, and/or dispersal, and is thus more liable to have concentrated and harmful effects. In their life cycles these wastes not only change in physical and chemical terms, but also pass through the control of various human agents. A complex *behavioral-technical system* therefore underpins hazardous waste, bringing together natural processes and human interaction in an unpredictable and imprecise way. This happens all over an industrial network, whose entire infrastructure—for collection, transport, storage, treatment, and disposal of waste—requires extensive regulation.

In general this type of waste is identified in three ways: (a) by reason of certain properties, detected by test procedures such as flammability (may cause or prolong fire), corrosiveness (may destroy live tissue that comes into contact with it), toxicity (inhaling, swallowing or penetration through the skin may involve serious risk or even death), etc.; (b) by the presence of toxic chemical elements or abnormal concentrations of these, also detectable by tests; and (c) by listings of specific categories of waste identified as being hazardous and for which no tests are necessary. Radioactive waste contains substances which emit ionizing radiation. Proper management and safe and environmentally sustainable storage are vital but complex tasks. Nuclear waste, depending on the source, its levels of radioactivity, longevity and hazard, may be classified in two broad categories: "high-level" (from the reprocessing of spent nuclear fuel) and "low-level" (generally in the form of radioactively contaminated industrial or research waste). Other categories are transuranic radioactive waste and uranium mill tailings. One may identify two key problems with this classification: first, "low-level" waste contains some elements that are more radioactive than some of those contained in "high-level" waste; second, the public tends to perceive all radioactive waste as being "high-level."

Regardless of whether the risks are great or small, citizens typically fear toxic products and their carcinogenic effects in general, and nuclear radiation in particular. Despite accusations of irrational "chemophobia," the concerns of ordinary people are based on the impact of accidents such as those at Three Mile Island, Chernobyl, and Bhopal. In addition to these accidents, and compounding the potential threat of chemical products, each year several hundred synthetic chemical products are brought to market without being subjected to any prior tests. This underlies the phenomenon of "bioaccumulation," whereby all substances that are resistant to degradation, whether tested or not, gradually build up in successive stages of the food chain.

Ethical Issues

The regulation of waste raises four key ethical and political issues. The first derives from the need for integrated waste management involving a range of actors on different levels. In addition to international responsibility—which is necessary, for example, to control exports of waste and to avoid illegal dumping in the oceans—the following are also key elements:

(a) the model of economic development, for example one in which recycling and waste reduction activities are encouraged, leading to the idea of sustainable development;

(b) scientific research that can salvage traditional technologies that are less harmful to the environment, invent alternative technologies, and develop products with an ecologically friendly design;

(c) attitudes and incentives in business, where new designs and technologies can be used to minimize the environmental impact of a product;

(d) the civic consciousness of citizens, who may demand environmentally friendlier ("greener") products, less packaging, and access to reliable information through, for example, labeling (such as the "eco-label" – a flower logo in Europe).

A second issue concerns the ethical dilemmas raised by the risks associated with waste technologies. Given the rational impossibility of a *zero-risk* society, the debate about the threshold of acceptable risk and how it ought to be distributed generally swings between utilitarian and egalitarian ethical perspectives. Problems arise because no standard threshold provides all citizens with equal protection from harm. Moreover that threshold, which is an average annual probability of fatality linked to some hazard, may not protect the basic rights of all individuals with their specific characteristics and needs.

For Kristin Shrader-Frechette (1991), a leading investigator of the ethical dilemmas associated with nuclear waste, it is essential to obtain the free and informed consent of those who are exposed or put at risk. Those who impose societal risks on others should compensate them in order to obtain their consent. Informed and freely-given consent and compensation are guidelines which are appropriate for avoiding popular hostility. This arises frequently in discussions on where to site waste treatment facilities, reflecting syndromes known as NIMBY (*not-in-my-backyard*), NIABY (*not-in-anybody's-backyard*), or LULU (*locally-undesirable-land-use*).

A third issue is the link to the methodology used in technological assessment and analysis of environmental impact. A socially acceptable study of these problems cannot be reduced to simple cost-benefit analysis based on calculations of mathematical probabilities while ignoring moral values such as equality, equity, social justice, and common well-being.

Apart from examining the magnitude, risks, and benefits, any assessment should also weigh the moral acceptability of technology, because the issues involved cannot be reduced to factual terms. To fail to recognize this is to commit a version of the *naturalistic fallacy* (Moore 1903) by deducing and justifying ethical conclusions from technical considerations (Shrader-Frechette 1980). This error is even more serious when found in studies used to support policy decisions relating to matters of public interest.

A final ethical consideration is that a significant number of waste-related activities, from collection to recycling, are very profitable. Indeed wastes are a vital part of the capitalist economy: consumerism and an active throwaway mentality encourage constant production and fuel ever-expanding human needs.

However the fact that an entirely new industry has developed, on a for-profit basis, to deal with the waste problem, gives rise to a conflict between public and private interests. The involvement of private groups in matters of public interest may create conflict, even though a strong public sector can encounter problems with excessive bureaucracy and consequent distortions. To avoid exacerbating such conflicts, citizens are often given access to full information on each case and/or committees of experts are appointed to give scientific opinions on the regulation of waste management.

Modern society strives for a balance between economic development and environmental protection, finding a threshold that reconciles the inevitable production of waste with a commitment to ecological sustainability. The depletion of natural resources that may not be renewable, and the (often related) by-production of hazardous waste, is an increasingly important focus of long-running debates regarding conflict between state regulation and market forces, between individual action and collective consequences, and between the practical and the ethical impact of new or newly mass-consumed technologies.

HELENA MATEUS JERÓNIMO

SEE ALSO *Carson, Rachel; Consumerism; Ecology; Environmental Ethics; Environmental Impact Assessment; Environmental Regulatory Agencies; Hazards; Nuclear Waste; Pollution; Risk; Sustainability and Sustainable Development; United Nations Environmental Program.*

BIBLIOGRAPHY

Carson, Rachel. (1962). *Silent Spring*. Boston: Houghton Mifflin.

Douglas, Mary. (1966). *Purity and Danger*. London: Routledge & K. Paul.

Dowling, Michael, and Joanne Linnerooth. (1987). "The Listing and Classifying of Hazardous Waste." In *Risk Management and Hazardous Waste: Implementation and the Dialectics of Credibility*, ed. Brian Wynne. Berlin and New York: Springer-Verlag.

Melosi, Martin V. (1981). *Garbage in the Cities: Refuse, Reform, and the Environment, 1880–1980*. College Station: Texas A & M University Press.

Moore, George Edward. (1903). *Principia Ethica*. Cambridge, UK: Cambridge University Press.

Shrader-Frechette, Kristin. (1980). *Nuclear Power and the Public Policy: The Social and Ethical Problems of Fission Technology*. Boston: D. Reidel Publishing Company.

Shrader-Frechette, Kristin S. (1991). *Risk and Rationality: Philosophical Foundations for Populist Reforms*. Berkeley: University of California Press.

Strasser, Susan. (1999). *Waste and Want: A Social History of Trash*. New York: Metropolitan Books.

Wynne, Brian, ed. (1987). *Risk Management and Hazardous Waste: Implementation and the Dialectics of Credibility*. Berlin and New York: Springer-Verlag.

WATER

Water is the liquid of life and is crucial to every type of organism, from simple bacteria to megafauna, as well as to many of the physical processes that shape the planet, as in the weathering of mountains and valleys. For life in all forms, water is more important than even oxygen, because there exist anaerobic bacteria that can live without air but no anhydroxic bacteria that can exist without water. When astrobiologists seek to determine the possibility of life on other planets, their first question concerns the presence of water. Throughout human history, however, water has had as much a symbolic as biological significance, and human beings have adapted to environments both abundant and scarce in water, through different technological, ethical, and political engagements. Water is so rich in metaphor that it cannot be reduced to merely H_2O, nor to a fluid circulated in pipes, metered, and then distributed by authorities. The duality of meaning that water embodies includes the fact that it can be both deep and shallow, life-giving and destructive, a blessing and a curse, and something that cleans the surface and also purifies the inner soul.

Water in Science

As a chemical compound water is composed of one atom of oxygen and two of hydrogen. Because acids are characterized by hydrogen ions (H^+) and bases by hydroxide ions (OH^-); water (H_2O) may be described as neither acidic nor basic, rather equally both:

$$H_2O \rightarrow H^+ + OH^-$$

The structure of water is:

$$H : \ddot{\underset{\cdot\cdot}{O}} : H$$

Oxygen is attached to two hydrogen atoms with two covalent bonds leaving two nonbonding pairs of electrons. Hydrogen bonding is particularly important in biochemical systems, because biochemical molecules contain many oxygen and nitrogen atoms that participate in hydrogen bonding. Hydrogen bonds between water molecules are responsible for the interesting physical properties of water that made it the solvent of life. Together with the extended temperature range between its solid (ice) and gaseous (steam) states, that makes liquid water able to serve as the foundation for those extremely complex carbon formations that constitute living organisms.

When present at a depth of at least two meters (six feet), pure water is a pale blue, odorless, tasteless, and transparent liquid. Other observed colors are due to various impurities, nonliving and living. It is mostly "blue water" that flows in rivers and into lakes and aquifers. "Green water" refers to the precipitation that is directly used by nonirrigated agriculture, pasture, and forests, and to evapotranspiration.

In its liquid and solid forms, water covers 71 percent of the surface area of the globe. Humanity's anthropocentric worldview explains why this mostly "blue" planet was (mis)labeled Earth. Of all the water on the planet, only 3 percent is freshwater, a figure that includes glacial ice and other hard-to-reach water sources. Of this, only 0.003 percent of the surface and subsurface water is usable by humans.

Hydrology is the science of the properties, distribution, and circulation of surface and subsurface water. In hydrologic terms, water that collects in rivers, lakes, or reservoirs is called surface water. That which seeps into the shallow or deeper layers of Earth is called aquifer. The gaseous, solid, or liquid phases of water affect both the element's chemistry such as its bonding and its physics such as its density. Water is an excellent solvent, and hence it has many constituents that are dissolved or suspended in it. These facilitate chemical interactions, which aid complex metabolisms. This explains why water is critical for all life-forms.

Pure water can be obtained through painstakingly and costly mechanical processes. Water is then the most benign of all chemical compounds known to humans. Water that contains dissolved carbonates such as calcium and magnesium is known as hard water. People notice this because it suppresses the formation of lather with soap, and when boiled, it leaves a "lime scale" that is seen in cookware. Soft water is free of such carbonates.

Water circulates from the ocean and surface of Earth to the atmosphere and then gravitates back in various forms including snow, rain, and fog. Human activities affect this hydrological cycle, most prominently through the building of physical barriers such as dams and through modifications of watersheds. Most water resources are renewable except for fossil (or connate) water that is laid down in sedimentary rocks and sealed off by overlying beds. Nevertheless, human contamination of groundwater stock, and alterations of watersheds (or, in British parlance, "drainage basins") through, for example, deforestation or paving over hydrologically critical areas can reduce aquifer recharge, alter flow characteristics, and, in severe cases, deplete a formerly renewable resource.

Many large watersheds lack time series data, and scientists in riparian states (those who study watersheds) often use different methodologies for collecting their data, which makes data sharing among water basin states ineffective and integrated management of the river system difficult.

Technologies of Water

Natural water is managed through a system of wells, dams, artificial reservoirs, conveyance systems, and human-made ponds. Humans withdraw untreated water from surface sources and pump it from aquifers. The water is treated and then pumped into carefully laid-out distribution systems such as water mains, which are connected to underground networks and sometimes to (elevated) storage facilities.

The geographical setting of the source of water, water treatment, its distribution, return flow collection, and return flow treatment—each requires a unique technological approach in order that people can access and use the resource. Economic considerations and regulations regarding human health and environmental protection also affect the choice of technology.

Easy-to-tap water sources were the first to be developed. Growing water needs require new and innovative technologies because water is increasingly extracted from deeper wells and piped in from further and further locations; furthermore, in a growing number of countries that have exhausted their supplies, freshwater is obtained by removing the salts and other contaminants from sea water (desalination). Growing water scarcity is inducing the development of water-efficient technologies. Given that agriculture is by far the largest consumer of water, drip irrigation techniques offer huge water savings, especially when compared to sprinkler irrigation or the traditional, but low-cost, flood irrigation.

Historically, the water wheel, a wheel with paddles or buckets attached to the outside, was first used to lift water from a river onto irrigation channels. Eventually, a water-powered wheel was developed and used in the Middle Ages for extracting power from a flow of water. Its applications included milling flour and machining and pounding linen for use in paper. Similarly, the steam engine contributed to Europe's economic development especially during the Industrial Revolution. This engine coverts the potential energy of the pressure in steam to mechanical work.

Water systems have been targets in warfare, and the threat of terrorism is requiring new technologies and strategies to protect water supply systems, especially in large metropolitan centers, and in countries where in which the majority of the population depends on a few desalination plants. Efforts are afoot to develop remote but real-time water-quality monitoring systems that not only encompass the traditional water-quality parameters but also can detect currently unmonitored biological agents that could threaten freshwater supplies, such as bacteria, viruses, and protozoa.

Ethics of Water

Water is central to the health of the ecosystem, central to the beliefs and customs of many religious communities, and vital to the maintenance of the economic well-being of modern and traditional lifestyles. Allocating water across competing users must thus be tempered by extensive stakeholder participation and weighed against any adverse social or ecological impacts that a solely economic approach may cause.

The increasing demand for freshwater is related to population growth, trends toward more protein-based diets, and overall improvements in the quality of life. Countries typically tap their lowest cost and most reliable sources of water first. As these sources become fully utilized, the development of new sources carries with it heavier financial costs and environmental consequences.

The equitable allocation and sustainable use of water require good governance that is rooted in policies that are scientifically, culturally, and economically sound; in institutional structures that are community friendly and invite public participation; and in decision makers who are competent and fair, and have the support of the political forces. It also requires employing modern technologies that have been adopted in many Western countries but are beyond the reach of poorer ones.

In 2002 the United Nations Committee on Economic, Social and Cultural Rights declared water a human right. It stated that the human right to water entitles everyone to sufficient, safe, acceptable, physically accessible, and affordable water for personal and domestic uses. An adequate amount of safe water is necessary to prevent death from dehydration, reduce the risk of water-related disease, and provide for consumption, cooking, and personal and domestic hygienic requirements. The signatories to the International Covenant on Economic, Social and Cultural Rights are required to progressively ensure access to clean water, equitably and without favoritism.

Politics of Water

Negotiating water-sharing agreements on for international rivers tends to be complex. Allocation agreements among competing users often involve a combination of geoclimatic factors as well as legal, historical, technological, demographic, political, and ethical considerations. In the case of international rivers, upstream states are generally seen as having leverage in influencing the allocation process simply because they control the “water tap.”

Water allocation arguments include the largely discredited view that a country has an absolute sovereignty over resources that originate inside its political boundaries. Prior appropriation agreements state that the earliest users of water have rights to it. This convention is widely used in the American Southwest and by a few other countries, such as Iraq in connection with its share of the waters of the Tigris and Euphrates rivers. Before a balanced allocation formula can be reached, several factors need to be carefully considered and fairly weighted for every riparian country. These factors include a country’s contribution to the total flow of the river, current and projected population size, area of arable land, and the extent to which the health of the national economy is dependent on water. A sustainable and ethical management strategy must also consider and protect the needs of aquatic life, upstream habitats (especially forests), wetlands, and floodplains, as well as the water needs of future generations. International agreements make the integrated (and sustainable) management of river systems easier.

Acute and protracted water scarcity is likely to be a source of violent conflict especially in countries where the agricultural sector is a vital contributor to national economic health. This danger has helped place water scarcity high on the world’s political agenda. Globally, the overwhelming majority of water is consumed by the agricultural sector. There has been a gradual and continuing shift away from supply management to demand management of water, whereby people are asked to make the most out of their existing resources. Communities try to maximize their crop yields per unit of water (more “crop per drop”) and their financial returns by planting suitable, lucrative crops. Similarly, a few arid and semiarid countries are gradually shifting away from water thirsty crops such as citrus to ones that are more suited to their own climatic and physical environments such as wheat, lentils, and chickpeas.

Immense amounts of water are wasted through leakage from antiquated urban supply networks and unsustainable irrigation strategies. Existing technologies such as the efficient, water-saving drip irrigation technique and microsprinklers have been around for decades but used on only around 1 percent of all irrigated lands. Even relatively small improvements in efficiency through the transfer of appropriate irrigation technologies and the implementation of various policy incentives and/or disincentives will result in substantial water savings.

One proposed strategy would involve governments gradually charging farmers the real and full cost of water. Progressively higher charges per unit of water consumed would induce most users to think before they turn on the water. Water quality can be protected by raising people's awareness about the adverse effects of pollution, making it prohibitively expensive to pollute, and by building sanitation infrastructures and wastewater treatment plants. This will minimize pollution levels and provide the public with recycled water to be used in nonhuman ways that do not directly affect food production, such as car washes and irrigation of lawns.

When national sources are exhausted, countries seek alternatives such as importing water, usually from nearby countries. Globalization and the opening of international markets are likely to encourage large-scale trading of freshwater across international borders. This is a controversial because of the likely environmental impacts and the political implications that a dependency on imported water may create.

Desalination, however, is an increasingly promising water-augmentation method. This process entails removing soluble salts from water to make it suitable for various human uses. Technological advances have been steadily decreasing its unit price, which is inducing more countries and facilities to use it. A growing number of countries have been increasingly adopting desalination technologies to augment their national or area-specific freshwater supplies.

HUSSEIN A. AMERY

SEE ALSO *Acid Mine Drainage; Air; Dams; Deforestation and Desertification; Earth; Environmental Ethics; Fire.*

BIBLIOGRAPHY

Al-Jamal, M. S.; S. Ball; and T. W. Sammis. (2001). "Comparison of Sprinkler, Trickle, and Furrow Irrigation Efficiencies for Onion Production." *Agricultural Water Management* 46(3): 253–266.

Amery, Hussein A., and Karen B. Wiley. (2003). "Resolution of International Water Conflicts: From the U.S. Southwest to the Euphrates River Basin States." *International Journal of Global Environmental Issues* 3(2): 226–239.

Amery, Hussein A., and Aaron T. Wolf, eds. (2000). *Water in the Middle East: A Geography of Peace*. Austin: University of Texas Press.

Birkett, James D. (1984). "A Brief Illustrated History of Desalination: From the Bible to 1940." *Desalination* 50: 17–52.

Faruqui, Naser I.; Asit K. Biswas; and Murad J. Bino, eds. (2001). *Water Management in Islam*. Ottawa: International Development and Research Centre; Tokyo: United Nations University Press. A unique anthology that outlines the potential role culture and religion could play in the protection and efficient management of water resources.

Gleick, Peter H. (2004). *The World's Water, 2004–2005*. Washington, DC: Island Press. A biannual report that contains impressive current data on various aspects of water resources from around the globe, and a few state of the art articles.

Illich, Ivan. (1985). *H2O and the Waters of Forgetfulness*. Dallas: Dallas Institute of Humanities and Culture.

Olivera, Marcela, and Jorge Viaña. (2003). "Winning the Water War." *Human Rights Dialogue* 2(9). Also available from http://www.cceia.org/viewMedia.php/prmID/951

Postel, Sandra. (1999). *Pillar of Sand: Can the Irrigation Miracle Last?* New York: Norton. The book examines the role irrigation played in the rise and fall of ancient civilizations. It draws on this to examine how the current growing reliance on irrigation, the mounting water scarcity, salinization of soils, and the rising tensions between riparian states affects countries and could impact them in the twenty-first century.

Stumm, Werner, and James J. Morgan. (1996). *Aquatic Chemistry*, 3rd edition. New York: Wiley.

Swan, C. H. (1978). "Middle East: Canals and Irrigation Problems." *Quarterly Journal of Engineering Geology* 11(1): 75–78.

United Nations. World Water Assessment Programme. (2003). *Water for People, Water for Life*. New York: UNESCO Publishing.

U.S. National Research Council, Committee on Sustainable Water Supplies for the Middle East; Israel Academy of Sciences and Humanities; Palestine Academy for Science and Technology; and Royal Scientific Society, Jordan. (1999). *Water for the Future: The West Bank and Gaza Strip, Israel, and Jordan*. Washington, DC: National Academy Press. Examines the need to enhance and protect sustainable water supplies in the West Bank and Gaza Strip, Israel and Jordan. It proposes criteria needed for developing sustainable water resources while maintaining environmental support systems. The collaborative study brought scientists and engineers from the U.S. National Academy of Research and from other countries in the region, and it marked unprecedented cooperation among Israel, Jordan and the Palestinian organizations.

World Commission on Dams. (2000). *Dams and Development: A New Framework for Decision-Making*. London: Earthscan.

James Watson, b. 1928. The American biologist was a discoverer of the double-helical structure of the deoxyribonucleic acid molecule. *(The Library of Congress.)*

WATSON, JAMES

Co-discoverer of the molecular structure of DNA, James Watson (b. 1928) was born in Chicago on April 6, and became a controversial figure in debates about the social and ethical implications of genetic research. Watson received his Ph.D. in zoology from Indiana University in 1950. His partnership with Maurice Wilkins and Francis Crick led to the 1953 discovery of the complementary double-helix configuration of the DNA molecule, for which the three researchers shared the 1962 Nobel Prize in physiology and medicine. In 1968 Watson was named director and in 1994 president of Cold Spring Harbor Laboratory, which he shaped into a leading center of research on the genetic basis of cancer. In 1988 Watson was appointed Associate Director for Human Genome Research at the National Institutes of Health (NIH), where he initiated the Ethical, Legal, and Social Implications (ELSI) program as part of the Human Genome Project (HGP).

Although Watson continued his research, including important work on the function of messenger RNA (mRNA), his career shifted toward administration and the promotion of science (McElheny 2003). In these capacities, he confronted some of the political and ethical dilemmas born of his co-discovery of "the key to life." The subsequent revolution in genetics raised questions about the proper use of this new knowledge. Indeed, Watson on occasion made controversial and sometimes-contradictory statements on several of these issues, including recombinant DNA (rDNA) research, reproductive rights, and germline genetic therapy (see Watson 2000).

During congressional testimony in 1971, Watson expressed strong concerns about genetic engineering and reproductive technologies, and in the mid-1970s he played a role in establishing a moratorium on certain kinds of rDNA research. However, he later came to regret this position and even called critics of the research "a bizarre collection of kooks, sad incompetents, and down-right shits" (Beckwith 2003, p. 357). Watson defended a cornucopian attitude about the promises of genetic technologies to solve societal problems and dismissed public fears as irrational, Luddite paranoia.

In this regard, two of his strongest convictions about the use of genetic technologies were his libertarian ideology and a desire to engineer the human genome. First, he argued that society should not impose rules on individuals concerning their use of genetic knowledge. People should be allowed to make those decisions in private, especially women who are faced with difficult reproductive choices. Second, he maintained that germline gene therapy, despite its similarity to morally reproachable governmental eugenics programs, deserves serious consideration as a personal option because of the potential for human betterment. In other words, "If we could make better human beings by knowing how to add genes, why shouldn't we?" (Wheeler 2003). For Watson, the genome is a cruel limitation on the vast possibilities that scientists could create by manipulating human DNA.

Watson's most lasting legacy in the realm of the politics of science is his creation of the ELSI in the HGP carried out by the National Center for Human Genome Research Institute (NCHGI). In an "unprecedented experiment in American science policy," Watson unilaterally set aside 3 to 5 percent of the HGP budget to support ELSI studies of new advances in genetics with the goals of identifying and defining major issues and developing initial policy options (Juengst 1996).

It is difficult to decipher Watson's intentions in creating the ELSI program. He was quoted as saying, "I wanted a group that would talk and talk and never get anything done" (Andrews 1999, p. 206). Yet he also claimed, "Doing the Genome Project in the real world means thinking about [social impacts] from the start, so that science and society can pull together to optimize the benefits of this new knowledge for human welfare and opportunity" (Watson and Juengst 1992, p. xvi).

Most likely, Watson viewed the ELSI program as a form of enlightened scientific self-interest. It could create a social environment conducive to genetics research by aiding in the development of policies that prevent people from being harmed by the use of genetic information and technologies. In Watson's view, genetics research produces inherently valuable knowledge. As Juengst explains, "The question that the ELSI program addresses is the virtuous genome scientist's professional ethical question: 'What should I know in order to conduct my (otherwise valuable) work in a socially responsible way?'" (1996, p. 68). The societal buffer that the program creates may explain why Watson referred to the creation of the ELSI program as one of his top accomplishments. Although Watson created it on a whim, the ELSI program has had a lasting impact on the practice of science as similar programs are becoming common aspects of scientific research.

ADAM BRIGGLE

SEE ALSO *Genetic Research and Technology; Human Genome Organization.*

BIBLIOGRAPHY

Andrews, Lori B. (1999). *The Clone Age: Adventures in the New World of Reproductive Technology*. New York: Henry Holt. Memoir touches on several of the most pressing issues in reproductive technology.

Beckwith, Jon. (2003). "Double Take on the Double Helix." *American Scientist* 91: 354–358. Review of *DNA: The Secret of Life* and *Watson and DNA: Making a Scientific Revolution*.

Juengst, Eric T. (1996). "Self-Critical Federal Science? The Ethics Experiment Within the U.S. Human Genome Project." *Social Philosophy and Policy* 13(2): 63–96. Comprehensive analysis of the ELSI program; surveys various critiques of the program and makes a case that its strength as a policy mechanism lies in its decentralized "un-commission" design.

McElheny, Victor K. (2003). *Watson and DNA: Making a Scientific Revolution*. Cambridge, MA: Perseus. Authoritative biography of Watson, covering his scientific accomplishments, his impact on the scientific community, and his political and ethical views about the use of genetics in society.

Watson, James D., and Eric T. Juengst. (1992). "Doing Science in the Real World: The Role of Ethics, Law, and the Social Sciences in the Human Genome Project." In *Gene Mapping: Using Law and Ethics as Guides*, ed. George Annas and Sherman Elias. New York: Oxford University Press. The editors introduce the book by surveying the questions raised by new knowledge in the field of genetics and articulates the role of the ELSI program in the HGP.

Watson, James D. (2000). "Genome Ethics." *New Perspectives Quarterly* 17(4): 48–50. Outlines Watson's views on the ethics of genome research and demonstrates his strong materialist account of human origins and the implications of this philosophy for decisions regarding reproduction and the use of genetic technologies.

Wheeler, Timothy. (2003). "Miracle Molecule, 50 Years On." *Baltimore Sun* February 4, p. 8A. Surveys the implications of the discovery of DNA and Watson's life since then.

INTERNET RESOURCE

Watson, James D. (2000). "Genome Ethics." *New Perspectives Quarterly* 17(4): 48–50. Available from http://www.digitalnpq.org.

WEAPONS OF MASS DESTRUCTION

The phrase *weapons of mass destruction* (WMDs) was first used in the *London Times* in 1937 to describe Germany's blanket-bombing—using conventional weapons—of the city of Guernica, Spain (Mallon 2003). During the Cold War, the Soviet Union adapted the phrase to describe, collectively, nuclear, biological, and chemical (NBC) weapons (Norris and Fowler 1997). The U.S. Department of Defense defines WMDs as "weapons that are capable of a high order of destruction and/or being used in such a manner as to destroy large numbers of people," including high explosives, nuclear, chemical, biological, and radiological weapons. WMDs, however, often refer primarily to nuclear weapons.

History

Historical accounts of WMDs include the use of toxic smoke during the Peloponnesian War and during the Sung Dynasty in China (Hersh 1968); the Tartars catapulted plague-infected corpses into walled cities. Use of a *scorched earth policy* (Langford 2004) was also a common battle tactic in which retreating armies would destroy crops, burn villages, and poison wells and water supplies.

Large-scale production and deployment of nonnuclear WMDs was not possible until the beginning of the twentieth century (Hersh 1968), at which time scientists developed a more comprehensive understanding of how various chemicals functioned and of the manufacturing technologies necessary to synthesize large quantities of toxins. Advances in science thus led to the proliferation and stockpiling of numerous chemical agents such as mustard gas, phosgene, and chlorine. Chemical-weapons use during World War I resulted in the death of at least 90,000 people with more than 1.3 million additional casualties (Hersh 1968). Germany was the first nation to use poison gas during the war, but Great Britain, France, and the United States also used chemical weapons.

During World War II Germany and Japan conducted numerous chemical and biological weapon experiments on civilian and prisoner populations, yet such weapons were not used during combat. The United States was the first nation to use nuclear weapons when it bombed Hiroshima and Nagasaki in 1945. Many historians suggest that the incendiary bombing of Tokyo and Dresden by the United States during World War II, which killed thousands of civilians, also constituted use of WMDs. Use of chemical and biological weapons by several nations continued in the latter half of the twentieth century. One example is the defoliant Agent Orange that was used extensively by the United States in Vietnam to destroy vegetation. Iraq illegally used poison gas against the Iraqi Kurds killing tens of thousands of civilians. Although an exact accounting is impossible, the Federation of American Scientists indicates that dozens of nations possess, are developing, or are capable of developing WMDs.

The September 11, 2001, terror attacks that caused mass destruction and loss of life, however, were not perpetrated with NBC weapons, leading some experts to push for a more expansive definition of WMDs. Everett Langford describes WMDs as "those things which kill people in more horrible ways than bullets or trauma, or which cause effects other than simply damaging or destroying buildings and objects, with an element of fear or panic included" (Langford 2004, p. 1). Using this definition, WMDs would also include the airplanes used in the 2001 terror attacks; fungi used to destroy specific crops; defoliants; large scale incendiary devices; pathogens that kill agricultural animals; and other nonlethal agents. Sohail Hashmi and Steven Lee, however, argue that WMDs are different from conventional weapons because, "when used in war, [they are] inherently indiscriminate, meaning that their use ... would almost certainly result in the deaths of many civilians" (Hashmi and Lee 2004, p 10).

Ethics

For several reasons WMDs, especially NBC weapons, fall into different moral and ethical categories than conventional weapons. Over millennia, humans developed ethical guidelines and rules for *just war*. But Michael Walzer argues that nuclear weapons "are the first of mankind's technological innovations that are simply not encompassable within the familiar moral world" (Hashmi and Lee 2004, p 5).

Unlike more conventional arms, WMDs do not stay in the location in which they were deployed; detonation of NBC weapons invariably produce plumes of radiation and toxins that can travel hundreds of miles, well beyond the boundaries of the battlefield. The plume could kill innocent civilians within the country and in neighboring countries not involved in the conflict. Use of WMDs could also render large tracts of land uninhabitable, not only affecting the short term ability of a nation to feed itself after hostilities cease, but also that of future generations.

With conventional weapons, large numbers of people are needed to deploy enough bombs in order to cause widespread damage, so that there is at least some level of checks and balances in the decision process. WMDs, by contrast, may require just a handful of people whose actions can cause large-scale devastation, and thus WMDs are inherently less democratic than conventional weapons. The strongest ethical argument against using WMDs is quite simply that their use could destroy the world, killing billions of innocent people in *mutually assured destruction* (Hashmi and Lee 2004).

Politics

The world community made several attempts to control WMDs after World War I. The most important treaties are the Geneva Protocol (1925), which prohibits the use of both biological and poison gas methods in warfare; the Nuclear Non-Proliferation Treaty (1968), which prohibits states from acquiring nuclear weapons if they had not already detonated a nuclear weapon by January 1, 1967; the Biological and Toxin Weapons Convention (1972), which prohibits the development, stockpiling, and acquisition of biological weapons; and the Chemical Weapons Convention (1993), which prohibits the use, development, and stockpiling of chemical weapons.

Proliferation of WMDs during the twentieth century was characterized by the activities of large nation-states that possessed the financial resources, infrastructure, and intellectual capital necessary to research, test, and produce such weapons. Rapid technological advances in biological and chemical science coupled with readily accessible how-to information via the Internet and the collapse of the Soviet Union have markedly increased the risk of proliferation of WMDs. Individuals and small groups now have the capability of producing WMDs such as ricin, anthrax, and radioactive *dirty bombs*, without state support.

Through even more rapid technological advances in the years to come, the world may see a future with even more dangerous WMDs capable of being produced and deployed by just a few talented individuals, using genetic engineering, nanotechnology, and robotics (Joy 2000). Unlike the *old WMDs* of the twentieth century that required significant state support to produce, and thus could be controlled to some degree through international treaties, *new WMDs* pose entirely new problems of control, not to mention ethical and moral considerations that have yet to be fully addressed by the scientific community.

A first attempt in this direction is the "Statement on Scientific Publication and Security" produced by a group of scientific journal editors, scientists, and government officials at a National Academy of Science (NAS) meeting in January 2003. In the statement the authors acknowledge that some scientific information "presents enough risk of use by terrorists that it should not be published" (Journal Editors and Authors Group 2003, p. 1149). Rather than establishing strict guidelines for censorship, however, the authors leave such decisions up to the journal editors, who must weigh the possible security threats against the scientific merit and potential societal benefits of publishing the article. There are many more questions to ask, and actions to take, however, if society is to adequately address the threat of WMDs in the twenty-first century.

ELIZABETH C. MCNIE

SEE ALSO *Atomic Bomb; Baruch Plan; Biological Weapons; Chemical Weapons; Limited Nuclear Test Ban Treaty; Just War; Military Ethics; Nuclear Ethics.*

BIBLIOGRAPHY

Hashmi, Sohail H., and Steven P. Lee, eds. (2004). *Ethics and Weapons of Mass Destruction: Religious and Secular Perspectives*. Cambridge, UK: Cambridge University Press. An excellent resource with views on the ethics of WMDs from numerous religious and other and perspectives.

Hersh, Seymour. (1968). *Chemical and Biological Warfare: American's Hidden Arsenal*. Indianapolis, IN: Bobbs-Merrill Company.

Journal Editors and Authors Group. (2003). "Statement on Scientific Publication and Security." *Science* 299(5610): 1149.

Joy, Bill. (2000). "Why the Future Doesn't Need Us." *Wired* 8(4): 238–262. Also available from http://www.wired.com/wired/archive/8.04/joy.html.

Langford, R. Everett. (2004). *Introduction to Weapons of Mass Destruction: Radiological, Chemical and Biological*. Hoboken, NJ: John Wiley. A thorough review of all technical, health-related and medical issues concerning WMDs in the early twenty-first century.

Norris, John, and Will Fowler. (1997). *NBC: Nuclear, Biological and Chemical Warfare on the Modern Battlefield*. Cambridge, UK: Cambridge University Press.

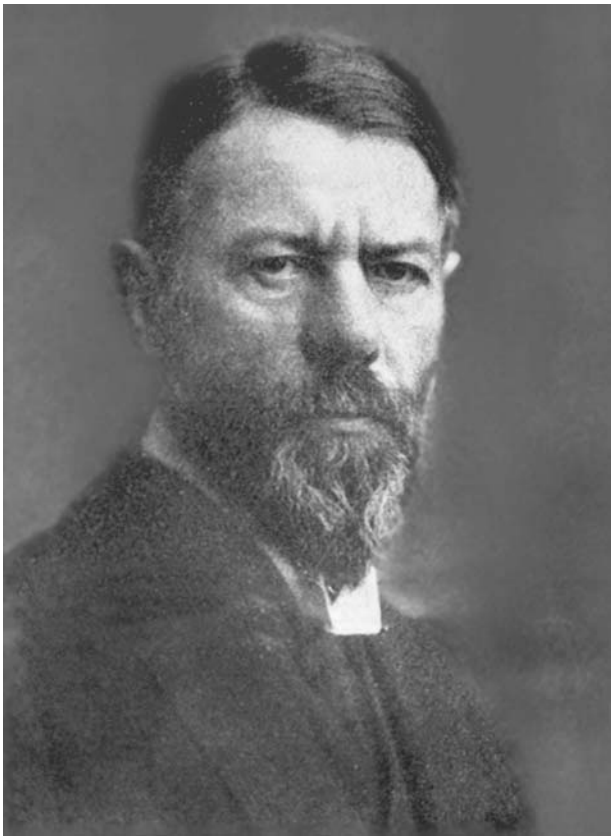
INTERNET RESOURCES

Federation of American Scientists. "States Possessing, Pursuing or Capable of Acquiring Weapons of Mass Destruction." Available from www.fas.org/irp/threat/wmd_state.htm.

Mallon, Will. "WMD: Where Did the Phrase Come From?" History News Network. Available from http://hnn.us/articles/1522.html.

WEBER, MAX

Max Weber (1864–1920) was arguably the most important social and political theorist of the twentieth century, as well as the unwilling father of modern sociology (a role he unknowingly shared with Èmile Durkheim). The eldest of six children (with a brother Alfred, who also became a famous sociologist and cultural analyst), Max Weber was born in Erfurt, Prussia, on April 21, grew up in a suburb of Berlin, and spent his entire adult life in German university towns. He pursued law, economics, and philosophy at Heidelberg, Strassburg, Berlin, and Göttingen (1882–1886), served in the army reserve for two years during college, returned home, and studied law in Berlin, graduating in 1889. He won academic appointments in Berlin and Freiburg, but was forced to retire from teaching after suffering a nervous breakdown that immobilized him between 1897 and 1903—an almost pure example of what Sigmund Freud at precisely the same time had labeled the *Oedipus complex*. Finally recovered enough to take an extended, transformative trip to the United States in 1904, and freed of teaching duties by an inheritance, Weber spent the next sixteen years producing an unrivalled body of sociocultural, economic, and sociological analyses that



Max Weber, 1864–1920. The German social scientist was a founder of modern sociological thought. His historical and comparative studies of the great civilizations are a landmark in the history of sociology. *(The Library of Congress.)*

is second to none in the history of modern social science. He died unexpectedly on June 14 at the age of 56, a victim of the global influenza pandemic. Weber had married his cousin, Marianne Schnitger, in 1893, and it was her tireless work between 1920 and 1924 as editor of his many posthumous books that fixed Weber's rightful place in the social science pantheon, because during his life he had published only a small percentage of what he wrote.

Weber's common fame rests on his *Protestant Ethic and the Spirit of Capitalism* (1904–1905), originally published as two articles in a scholarly journal. Here he demonstrated why northern European Protestant behavior was more conducive to the formation of early capitalism than were southern European Catholic beliefs and practices, a hypothesis that has given rise to thousands of commentaries and critiques. But he also contributed fundamental works to the sociology of law (which he virtually invented), the sociology of music (also a first), the sociology of the economy, the philosophy of social science method, the comparative sociology of religion (also his creation), social stratification, the sociology of bureaucracy, and of power and *charisma* (his term), and so on. His major work is *Economy and Society* (1922), a massive study assembled by his wife (herself an important feminist public intellectual), and translated into English for the first time in 1968. Weber's importance grows with time, and he is the only classic social theorist for whom in the early twenty-first century an entire scholarly journal is named. A recent bibliography of works in English concerning Weber numbers more than 4,900 items, and as Karl Marx and Freud become increasingly less tenable as the major analysts of the modern world, Weber's ideas become ever more pertinent and revealing.

Weber's thoughts about science and ethics are neatly summarized in two of the most famous lectures ever given by a social scientist, "Science as a Vocation" (November 1917) and "Politics as a Vocation" (January 1919). Both were delivered at the University of Munich before large audiences of returning veterans and other students (among them, Rainer Maria Rilke) in a highly politicized atmosphere, with Weber expected to take a strongly nationalistic stance similar to many of his colleagues. Instead he spoke in contrarian terms by insisting that science requires objectivity and *value-freedom* from its practitioners, who must be motivated by a selfless *Beruf* (vocational calling) dedicated solely to the discovery of truth, and never by mundane self-aggrandizement or political values. He warned against the *cult of personality* and the seductive weakness for *selling a worldview* that interferes with proper scientific work. Weber drew on Friedrich Nietzsche, Leo Tolstoy, the Sermon on the Mount, Charles-Pierre Baudelaire, Immanuel Kant, and his young friend, Georg Lukács (1885–1971) in making a strong case for scientific research as a single-minded search for the unprettified truth, and nothing else.

In the companion lecture, "Politics as a Vocation," Weber continued in this vein, introducing one of his most famous distinctions, between *an ethic of ultimate ends* and *an ethic of responsibility*. The former defines the bailiwick of scientists, while the latter belongs to politicians and other activists, whose *raison d'être* is the strategic furthering of an ideological program. Weber warned that when these two ethics are joined within a single person, they inevitably lead to the degeneration of both roles, and to cultural calamity. As Weber explained in one of his most famous and controversial paragraphs:

> We must be clear about the fact that all ethically oriented conduct may be guided by one of two fundamentally differing and irreconcilably opposed maxims: conduct an be oriented to an "ethic of ultimate ends" or to an "ethic of responsibility." This is not to say that an ethic of ultimate ends is

> identical with irresponsibility, or that an ethic of responsibility is identical with unprincipled opportunism. Naturally nobody says that. However, there is an abysmal contract between conduct that follows the maxim of an ethic of ultimate ends—that, is in religious terms, "the Christian does rightly and leaves the results with the Lord"—and conduct that follows the maxim of an ethic of responsibility, in which case one has to give an account of the foreseeable results of one's action ("Politics as a Vocation" in *From Max Weber,* p. 120).

Within a very few years, the scientists and ethicists of Nazi Germany experienced the dire consequences of ignoring the thrust of Weber's speeches—which accounts in part for the Nazi government's interest in discrediting the memory of Weber after his death. Interestingly Weber is one of few German intellectuals of the twentieth century whose reputation was never threatened by world memory of the Third Reich.

ALAN SICA

SEE ALSO *Axiology; Durkheim, Émile; Ethical Pluralism; Marx, Karl; Secularization; Sociological Ethics; Spenser, Herbert.*

BIBLIOGRAPHY

Eliaeson, Sven. (2002). *Max Weber's Methodologies.* Cambridge, UK: Polity Press.

Käsler, Dirk. (1988). *Max Weber: An Introduction to His Life and Work,* trans. Philippa Hurd. Oxford: Polity Press; Chicago: University of Chicago Press.

Sica, Alan. (2004). *Max Weber: A Comprehensive Bibliography.* New Brunswick, NJ: Transaction Publishers.

Weber, Max. (1930). *The Protestant Ethic and the Spirit of Capitalism,* trans. Talcott Parsons. London: Allen and Unwin; New York: Charles Scribner's Sons.

Weber, Max. (1946). "Science as a Vocation"; "Politics as a Vocation." In *From Max Weber,* trans. and eds. Hans Gerth and C. Wright Mills. New York: Oxford University Press.

Weber, Max. (1968). *Economy and Society: An Outline of Interpretive Sociology,* 3 vols., ed. Guenther Roth and Claus Wittich. New York: Bedminster Press. Reissued, University of California Press, 1978, in 2 volumes.

WEIL, SIMONE

French philosopher, mystic, and social critic Simone Weil (1909–1943) was born in Paris on February 3 and died in Ashford, Kent, in England on August 24. Though raised in a prosperous bourgeois family and classically educated at the Ecole Normale Supérieure, Weil sympathized from an early age with the plight of the poor, the oppressed, and the afflicted.

Simone Weil, 1909–1943. The French thinker, political activist, and religious mystic was known for the intensity of her commitments and the breadth and depth of her analysis of numerous aspects of modern civilization. *(AP/Wide World Photos.)*

Before the age of twenty Weil identified herself as an anarcho-syndicalist. She was attracted to the philosophy of Marx but refused to join the communist party. Her earliest sustained social analysis, "Reflections Concerning the Causes of Liberty and Social Oppression," provided a critique of Marxism that Albert Camus (1913–1960) judged the most profound of the twentieth century. This critique focused on what Weil thought was the inadequacy of Marx's optimistic view that technological progress would lead inevitably to the liberation of the proletariat. For her, technological development gave humanity more control over nature only at the expense of greater dependency on what she called the *collectivity*. The collectivity includes the bureaucratic structure of the state (political and legal authority, including the government and the police) as well as the private corporations that produce the goods and services of the economy.

Weil argued that labor is not in itself the cause of oppression. For her, genuine human freedom meant freedom from the illusions that, in industrial society, take the form of ideologies and myths, of which the idea of progress is the preeminent example. In order to be free of the tyranny of illusion, human beings must come to know themselves as limited beings. Their finitude is revealed through methodical, thoughtful engagement with necessity; in other words, through work. Work is therefore a good that is not to be eliminated but ought to be the spiritual center of civilization. Weil argued that the problem with modern technology is that methods (mechanical or bureaucratic) are built into machines or organizations, thereby eliminating the need for thinking. A method, once developed, can be applied indefinitely, without ever being understood by the person who applies it. Generally, there is method in the motions of work, but none in the minds of the workers who tend automatic machines. They are reduced to slavery; they have lost their freedom.

This analysis formed the basis of Weil's critique of the industrial system that, in her view, dedicated itself to the maximization of the productivity of the worker rather than the maximization of freedom in the work process. In her two years of factory work (1934–1935), she saw that workers usually cannot understand the techniques they apply and this fact undermined their thinking relationship to reality. Due to the division and coordination of labor which in turn is a function of the techniques of production, there is a virtually complete divorce between thought and action. The manual laborers on a production line are not free, are dehumanized and reduced to slaves, not because they perform physically laborious tasks but because their tasks are so structured as to exclude the possibility of thought. Mental workers, those who make up the essential bureaucratic structure by which the activity of the workers is brought into coordinated relation, may be as enslaved as the manual laborers themselves because their thinking is ordinarily divorced from any direct action or work, and does not involve a dialogue with those whose lives they order. They too have lost touch with necessity.

Weil's critique of modern industry led her to analyze modern science as itself having become a thoughtless collective enterprise that relies on specialization for its advancement. No single mind can grasp even a subdiscipline of physics or chemistry. Researchers take over not only the results but the methods developed by their predecessors without understanding them or their relation to the whole. Weil concluded that the scientist can be crushed by science in much the same way that the workers are crushed by their work.

Toward the end of her life when her most profound religious thinking and social analysis was done, Weil contrasted modern (or, as she called it, classical) science, developed after Galileo and Newton between the sixteenth and the nineteenth centuries, with ancient Greek science. She concluded that modern science had emancipated the study of nature, first understood on the analogy of work (that is, in terms of energy), from the idea of the good, and then from the idea of necessity. In the 1940s, Weil predicted that the incomparable technical achievements of science would become divorced from any ordering principle and destroy human scale, as complexity was piled on complexity and society became uprooted.

Weil died prematurely in England at the age of 34. The significance of her posthumously published writings on religion as well the social and political crises of her times are only beginning to be appreciated for their depth and originality.

LAWRENCE E. SCHMIDT

SEE ALSO *Freedom; Humanization and Dehumanization; Marxism.*

BIBLIOGRAPHY

McLellan, David. (1990). *Utopian Pessimist*. New York: Poseidon Press. A biography by the renowned scholar of Marxism that emphasizes her links to the labor movement in France between the wars.

Pétrement, Simone. (1976). *Simone Weil: A Life*. New York: Pantheon Books. A carefully documented biography by a dear personal friend and renowned scholar of ancient Gnosticism.

Weil, Simone. (1968). "Classical Science and After." In her *On Science, Necessity and the Love of God*. Oxford, UK: Oxford University Press. Written in Marseille in 1941, this essay takes up the critique of classical (modern) science adumbrated in "Reflections Concerning the Causes of Liberty and Social Oppression."

Weil, Simone. (1971). *The Need for Roots*. New York: Harper Colophon. Written at the end of 1942 for De Gaulle who was leading the Free French in London, this report outlines Weil's proposal for the reconstruction of France after Hitler's defeat.

Weil, Simone. (2001). "Reflections Concerning the Causes of Liberty and Social Oppression." In her *Oppression and Liberty*. Translated by Arthur Wills and John Petrie. New York: Routledge. Written in 1933–1934 before her year of factory work, this lengthy essay outlines Weil's reasons for

rejecting the liberal and Marxist optimism about the liberating potential of technological progress.

WELLS, H. G.

Herbert George Wells (1866–1946) was born in Bromley, Kent, United Kingdom, on September 21, to servants turned shopkeepers. After a poor education in local private schools he was apprenticed to the drapery trade at age fourteen. After a spell as a pharmacist's assistant Wells became a student-teacher in Midhurst, where he won a scholarship to study for a degree under the biologist Thomas Henry Huxley (1825–1895) at the Normal School of Science in South Kensington. After initially failing to earn a degree, he became a schoolteacher and completed his bachelor of science degree in zoology at the University of London in 1890. He died in London on August 13.

Although eventually Wells became world famous as the author of *The Time Machine* (1895), *The Invisible Man* (1897), *The War of the Worlds* (1898), and other novels, his first two books were science textbooks published in 1893. Throughout the 1890s Wells was a regular contributor to scientific periodicals and wrote popular science articles for the mainstream press. Even after becoming famous as a writer of fiction, Wells maintained an interest in science as a Fellow of the Zoological Society after 1890 and joined the Sociological Society (on its foundation in 1904). He debated eugenics with the scientist Francis Galton (1822–1991) and others and published scientific works such as *Anticipations of the Reaction of Mechanical and Scientific Progress upon Human Life and Thought* (1901), *The Science of Life* (1930), and *Science and the World-Mind* (1942).

Wells's contribution to science, technology, and ethics was considerable. He recognized from his university days that although human progress was not inevitable, science would play a key role in human achievement. From Huxley he adopted the notion of ethical evolution: humankind's responsibility to influence the biological destiny of humans and other species positively. That notion ultimately led Wells to promote, at the micro level, a welfare state based on negative eugenics and state provision of a "basic minimum" and, at the macro level, a cosmopolitan world state based on education, cooperation, and socialist planning.

Eugenics was an important subject for Wells during much of his career. He first considered it in *Anticipations* (1901) before analyzing it more closely in works such as *Mankind in the Making* (1903), *A Modern Utopia* (1905), *Men Like Gods* (1923), *The Science of Life* (1930), and *The Work, Wealth and Happiness of Mankind* (1931) and finally rejecting it outright in *The Rights of Man* (1940) and *'42 to '44* (1944). During the Edwardian period Wells believed that negative eugenics could be a viable means of preventing the procreation of "the people of the abyss": the incurably diseased, habitual criminals or drunkards, and those unable to adapt to the rapidly changing modern world. Gradually he tempered his position, seeing welfare provision, education, and medical science as more important factors for improving the quality of successive generations. With the rise of Nazi eugenics after 1933, Wells distanced himself from general eugenic theory, declaring that any form of compulsory or state eugenics would be a fundamental breach of human rights in *The Rights of Man* (1940).

H. G. Wells, 1866–1946. The English author began his career as a novelist with a popular sequence of science fiction that remains the most familiar part of his work. He later wrote realistic novels and novels of ideas.

According to Wells, human progress rests on technological advancement, and he predicted that in the twentieth century humanity would either destroy itself or create material abundance and cosmopolitan unity. His 1935 film *Things to Come* is a marvel of invention, with ultramodern architecture, highly skilled workers, scientific population control, space flight, moving footpaths, and more. However, the society it portrayed was brought about only by generations of warfare, and in this lies the tension that existed between Wells's vision of a technological future and the means to achieve it.

Although Wells preached disarmament and world peace throughout his life, his futuristic utopian societies founded on the power of science consistently had to go through devastating wars to be achieved. Humankind had to learn a severe lesson before it would apply the gifts of science to its destiny. Thus, in *The War in the Air* (1909), powered flight leads to aerial combat; in *The World Set Free* (1914), harnessing the atom leads to nuclear war; and in *The Shape of Things to Come* (1933), material progress leads to global conflict and an "air dictatorship." All these stories end with global human fellowship and peace, but they are achieved at a high price.

Wells's legacy in terms of science, technology, and ethics lies in his imaginative application of science to invention, his hopefulness about what science may produce for humanity, but also his warnings about what the abuse of science may mean for the human race. In his nonfiction writings Wells was ambiguous throughout his life, never able to offer a peaceful route to the achievement of his predicted scientific utopias. Although Wells was never certain in his hope or despair for the future, his ultimate mood on the subject is aptly characterized in the title of his final work, published a few months before the dropping of atomic bombs on Japan, *Mind at the End of Its Tether* (1945).

JOHN S. PARTINGTON

SEE ALSO *Eugenics; Progress; Science Fiction; Science, Technology, and Literature; Utopia and Dystopia.*

BIBLIOGRAPHY

Haynes, Roslynn D. (1980). *H.G. Wells: Discoverer of the Future: The Influence of Science on His Thought.* New York: New York University Press. A detailed study of Wells's application of scientific concepts in his literary art; an alternative reading to Reed (see below).

Partington, John S. (2003). *Building Cosmopolis: The Political Thought of H.G. Wells.* Aldershot, UK: Ashgate. A comprehensive analysis of Wells's political thought, considering the influence of Huxleyan notions on Wells's worldview, and detailing Wells's support and later rejection of eugenics.

Reed, John R. (1982). *The Natural History of H.G. Wells.* Athens: Ohio University Press. An alternative study of the influence of science on Wells's literary work; an alternative reading to Haynes (see above).

Smith, David C. (1984). *H.G. Wells: Desperately Mortal: A Biography*. New Haven, CT: Yale University Press. The outstanding biography of Wells.

Wagar, W. Warren. (1961). *H.G. Wells and the World State.* New Haven, CT: Yale University Press. The first thorough study of Wells's world-state ideas.

Wells, H.G. (1984). *Experiment in Autobiography: Discoveries and Conclusions of a Very Ordinary Brain (Since 1866).* London: Faber and Faber. Wells's outstanding autobiography, first published in 1934.

WHISTLEBLOWING

The origin of the term *whistleblowing* is uncertain. It may refer to English policemen blowing whistles to alert others to an illegal act or to sports referees stopping a game due to a rule infraction. The term began to be used in a way relevant to science, technology, and ethics in the 1960s and became part of the common vocabulary as a result of Ralph Nader's investigative activities during the 1970s. *The American Heritage Dictionary* defines a whistleblower as "one who reveals wrongdoing within an organization to the public or to those in positions of authority," but a more detailed analysis of the term is appropriate.

Analysis of the Concept

Based on the above definition, it is possible to distinguish between internal and external whistleblowing. Internal whistleblowing occurs when the hierarchical chain of command within an organization is violated, so that one's immediate superiors are bypassed, perhaps because they have refused to act or are themselves involved in the wrongdoing. The whistleblowing is internal, however, because it stays within the organization. External whistleblowing refers to going outside the organization, possibly to a regulatory agency, the press, or directly to the public. The philosophical literature often restricts the use of the term to external whistleblowing, but the media typically use it in both senses.

A further distinction may be made between open and anonymous whistleblowing. The former means that the identity of the whistleblower is known, while such identity remains unknown in the latter. Anonymous whistleblowing is generally considered to be less effective, because it is more easily ignored and because no follow-up with the whistleblower is possible. Organizations have also shown themselves willing to devote significant resources to discover the identity of anonymous whistleblowers, a task made easier by the limited number of individuals who typically have access to the information being revealed. At the same time, whistleblowers often want to hide their identities because of possible reprisals from their organizations or colleagues.

The idea of *wrongdoing* also requires clarification. Generally not every wrongdoing is considered to be a legitimate subject for whistleblowing. The wrongdoing must entail serious harm, whether physical, psychological, or financial. Depending on the particular philosophical perspective, the notion of harm might be extended to situations where human beings are only indirectly affected, such as through damage to the environment. Serious harm is considered to be the appropriate criterion in that whistleblowing itself is an act which that tends to harm the parties involved and thus requires a balancing of outcomes.

Finally, although omitted in the popular definition, whistleblowers need to be insiders, that is, either currently or formerly associated with the organization on which they are blowing the whistle. Outsiders might be considered spies, investigative reporters, or moles, but not whistleblowers. Whistleblowing must involve a conflict of loyalties, between the duty of loyalty to an organization and duties to the public or to a principle. For an infiltrator, no such duty of loyalty to the organization exists. It should be noted, however, that whistleblowers often do not perceive themselves as being disloyal, especially in instances of internal whistleblowing, but believe they are working for the long-term organizational good.

Ethical Perspectives

From the perspective of ethics, whistleblowers are faced with deciding whether breaking the bond of loyalty is justified in a particular circumstance. The philosopher Richard DeGeorge proposed the classic criteria for justifying whistleblowing; most other criteria are a reaction to his formulation. DeGeorge argues that external whistleblowing is morally permissible if three conditions are met: (a) substantial harm will be done to persons; (b) the immediate superior is made aware of the problem; and (c) the chain of command of the organization is exhausted. DeGeorge contends that whistleblowing is morally obligatory if two additional conditions are met: (d) enough documented evidence is available to the whistleblower to convince an impartial individual; and (e) the whistleblower has a justified belief that the wrongdoing will be corrected as a result of going public.

A number of critiques have been leveled against DeGeorge's criteria, including questions about the extent to which a future rather than a past harm must be involved, immediacy of the harm, lack of consideration for the fate of the whistleblower, and importance of the motives governing the action. Fundamentally these debates reflect the divergence between consequentialist and deontological approaches to the issue. Consequentialist thinkers emphasize the costs to the institution and to the whistleblower and the detrimental results of mistaken or malicious whistleblowing, while deontological thinkers tend not to distinguish as significantly between degrees of harm and are more concerned with justice being done.

For engineering, in particular, the issue of whistleblowing has been a major focus of ethical discussions because of the potential impact of engineering activities on public safety. Most codes of engineering ethics follow the lead of the Accreditation Board for Engineering and Technology (ABET) by emphasizing that "engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties." Preventing physical harm to people is seen as a special professional responsibility of engineers based on their technical expertise. Many codes even obligate engineers to blow the whistle by requiring notification of *the proper authority* when public safety is endangered.

Whistleblowing in science generally has a different justification. Most often it is related to the research process and falsification of data, although research can also directly harm the human subjects involved or the public at large through the introduction of products based on falsified data. The difference in emphasis between science and engineering whistleblowing can be traced to the fundamental emphasis given to truth and accuracy in science, as opposed to the need to protect the public from harmful technologies in engineering.

Due to the serious consequences associated with whistleblowing, most analyses stress that it should be an avenue of last resort. Many discussions have emphasized ways that organizations can avoid whistleblowing, including creating an internal ethics office, fostering open door practices, having clear organizational policies, or appointing an ombudsperson. One reason to highlight such alternatives is that the whistleblower often becomes the target of subsequent investigations, directing attention away from the misconduct that was revealed.

In fact, the consequences for whistleblowers are so universally negative, including shunning by colleagues and organizational reprisals, that whistleblowing is legitimately an act of moral heroism. Commentators such as Kenneth Alpern argue that engineers, given their special responsibility for the public safety, should be required to be moral heroes. Others, such as Mike Martin, believe that whistleblowing is a supererogatory act whose obligatory nature must be evaluated on a case-by-case basis, taking into account both professional duty and personal considerations. Whether certain individuals should be singled out and required to suffer grave consequences for the common good will continues to be a matter of debate.

HEINZ C. LUEGENBIEHL

SEE ALSO *Engineering Ethics.*

BIBLIOGRAPHY

Alpern, Kenneth D. (1983). "Moral Responsibility for Engineers." *Business and Professional Ethics Journal* 2(2): 39–47. Argues that engineers have a higher duty than others to blow the whistle.

Davis, Michael. (1996). "Some Paradoxes of Whistleblowing." *Business and Professional Ethics Journal* 15(1): 3–19. Critiques DeGeorge's analysis of whistleblowing and substitutes a complicity theory.

DeGeorge, Richard T. (1999). *Business Ethics,* 5th edition. Upper Saddle River, NJ: Prentice Hall. Provides the most commonly cited treatment of whistleblowing. Also distinguishes between responsibilities of business people and professionals.

Johnson, Roberta Ann. (2003). *Whistleblowing: When it Works—and Why.* Boulder, CO: Lynne Rienner. Emphasizes the legal dimensions of whistleblowing.

Lubalin, James S., and Jennifer L. Matheson. (1999). "The Fallout: What Happens to Whistleblowers and Those Accused But Exonerated of Scientific Misconduct?" *Science and Engineering Ethics* 5(2): 229–250. An empirical study of consequences associated with whistleblowing in science.

Martin, Mike W. (1992). "Whistleblowing: Professionalism, Personal Life, and Shared Responsibility for Safety in Engineering," *Business and Professional Ethics Journal* 11(2): 21–37. Argues against DeGeorge that deciding whether whistleblowing is obligatory should be contextually determined based on an all-things-considered judgment.

Martin, Mike W., and Roland Schinzinger. (1996). *Ethics in Engineering,* 3rd edition. New York: McGraw-Hill. The most widely used text on engineering ethics. It extends DeGeorge's analysis of whistleblowing.

Whitbeck, Caroline. (1998). *Ethics in Engineering Practice and Research.* New York: Cambridge University Press. Focuses on ethical issues in scientific research.

INTERNET RESOURCE

National Society of Professional Engineers. "NSPE Code of Ethics for Engineers," rev. January 2003. Available at http://www.nspe.org/ethics/eh1-codepage.asp.

WIENER, NORBERT

Born in Columbia, Missouri, on November 26, Norbert Wiener (1894–1964) gained prominence as a world-famous mathematician who founded the interdisciplinary field of *cybernetics,* questioned its social implications, and encouraged scientists and engineers to consider the social consequences of their work. He died in Stockholm, Sweden, on March 18.

A child prodigy, Wiener earned a B.S. from Tufts University at the age of fourteen and a Ph.D. from Harvard at eighteen. As a professor of mathematics at the Massachusetts Institute of Technology (MIT), he made his mark in the areas of statistical theory, harmonic analysis, and prediction and filtering. While doing research on an antiaircraft system during Word War II, Wiener developed the key idea behind cybernetics: Humans and machines could both be studied using the principles of control and communication engineering. Both were information-processing entities that interacted with the environment through feedback mechanisms to pursue goals.

The atomic bombings of Japan in August 1945 brought the issue of social responsibility to the fore for Wiener. He wrote a resignation letter to the president of MIT that fall, stating that he intended to leave science because scientists had become the armorers of the military and had no control over their research. Although Wiener may have never sent the letter, he stopped doing military work. He became well-known for this stance in 1947 when the press reported his refusal to attend a military-sponsored symposium on computers and to share his war-time research with a company developing guided missiles. Wiener reasoned that "the bombing of Hiroshima and Nagasaki, has made it clear that to provide scientific information is not a necessarily innocent act, and may entail the gravest consequences" (Wiener 1947, p. 46).

Wiener expressed his views on the ethical and social aspects of science and technology in *Cybernetics* (1948), *The Human Use of Human Beings* (1950), and *God and Golem, Inc.* (1964). All three books warn about the potentially dangerous social consequences of the very field he had founded. Wiener claimed that cybernetics had "unbounded possibilities for good and evil" (Wiener 1948, p. 37). Electronic prostheses would benefit humans, and automated factories, the basis of a *second industrial revolution,* could eliminate inhuman forms of labor. If, however, humans "follow our traditional worship of progress and the fifth freedom—the freedom to exploit—it is practically certain that we shall face a decade more of ruin and despair" in implementing this technology (Wiener, 1950, p. 189). He also criticized game theory and military science for viewing the world as a struggle between good and evil.

Wiener considered whether to stop working on cybernetics because of its dangers. But it belonged "to the age, and the most any of us can do by suppression is to put the development of the subject into the hands of the most irresponsible and most venal of our engineers," namely, those doing military work. He recommended educating the public about the social implications of his field and confining research to areas, "such as physiology and psychology, most remote from war and exploitation" (Wiener, 1948, p. 38–39). Near the end of his life, Wiener said scientists and engineers should stop being amoral *gadget worshipers* (Wiener 1964) and imagine the consequences of their work well into the future. In regard to growing concerns about the dehumanizing effects of computerization, he recommended a cybernetic division of labor: Humans should perform functions best suited to them, computers those best suited to computers.

Cybernetics has led a life of its own outside of Wiener's control. In the late 1940s, philosophers in the Soviet Union criticized Wiener for attacking dialectical materialism, then did an about-face in the 1950s and adopted cybernetics wholeheartedly. In Western Europe and North America, in the 1960s, cybernetics lost prestige among scientists who questioned its rigor and universal claims. Beginning in the 1980s, some humanists praised Wiener's antimilitarism, while others criticized cybernetics for creating a philosophy of nature and a computer-based material culture that turns humans into *cyborgs* (cybernetic organisms). At the same time, historian and philosopher Donna Haraway co-opted Wiener's cybernetic vision to create an ironic cyborg epistemology with which to critique the global corporate-military-university complex and the technosciences that sustain it.

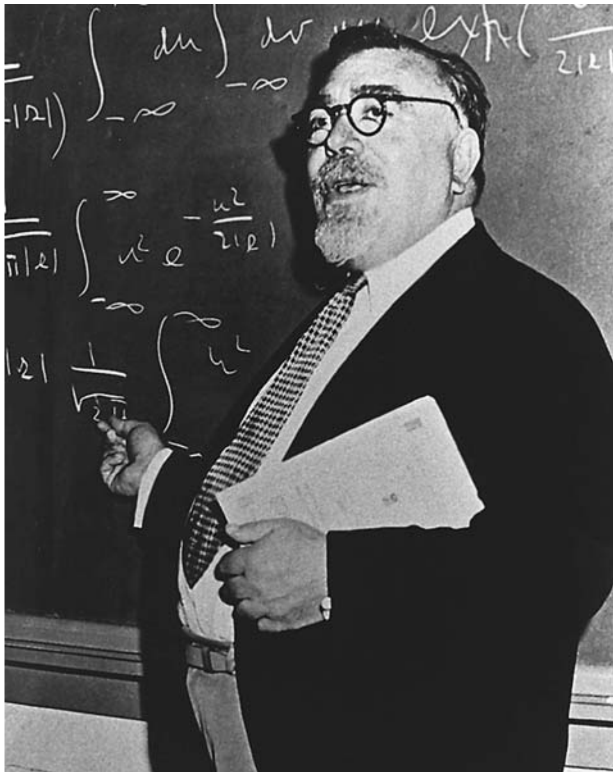
RONALD KLINE

SEE ALSO *Automation; Cybernetics; von Neumann, John.*

BIBLIOGRAPHY

Galison, Peter. (1994). "The Ontology of the Enemy: Norbert Wiener and the Cybernetic Vision." *Critical Inquiry* 21(Autumn): 228–266.

Heims, Steve J. (1980). *John von Neumann and Norbert Wiener: From Mathematics to the Technologies of Life and Death.* Cambridge, MA: MIT Press.



Norbert Wiener, 1894–1964. The American mathematician studied computing and control devices. Out of these studies he created the science of cybernetics. *(The Library of Congress.)*

Wiener, Norbert. (1947). "A Scientist Rebels." *Atlantic Monthly* 179(1): 46. Reprinted in *Bulletin of the Atomic Scientist*, February 1947, 31.

Wiener, Norbert. (1950). *On the Human Use of Human Beings: Cybernetics and Society.* Boston: Houghton Mifflin.

Wiener, Norbert. (1961). *Cybernetics: Or Control and Communication in the Animal and the Machine,* 2nd edition. New York: MIT Press.

Wiener, Norbert. (1964). *God and Golem, Inc.: A Comment on Certain Points Where Cybernetics Impinges on Religion.* Cambridge, MA: MIT Press.

WILDERNESS

Few currents in literature, the arts, and religion run deeper than the cultural fascination with wildness, and its locational concomitant, wilderness—places where primordial reality dominates and the artificialities of humans, including their sciences and technologies, are not apparent. Marks of the depth of the idea are its universality and flexibility. Appeals to wilderness can be found in cultures as diverse as China and North America. In its many intellectual guises and emotional overlays it has proven adaptable and meaningful across great historical divides. Although here the emphasis will be on its Euro-American manifestations, it is important to recognize that wilderness is not an idea exclusive to that culture.

Euro-American Context

In the Euro-American context the idea of wilderness is associated with the view that humans by nature separate themselves from nature, which then provides the backdrop for most considerations of ethics. Yet throughout western history, ethical principles have been formulated to apply only on the human side of the human-wildness divide. This separation of humans from wildness is especially important normatively, because it shapes the context in which new technologies are evaluated, including technologies that radically alter nature and irreversibly destroy wildness in the process of *development* and *progress*. Against the backdrop of wilderness, science has sometimes been judged both tame and distorting. Appeals to wilderness are often the basis for criticizing technologies, especially technologies that radically alter nature or irreversibly destroy wildness in the process of *development* and *progress*.

Max Oelschlaeger (1991) hypothesizes that Mediterranean cultures, especially at the eastern end where agriculture was taking hold, began developing in their mythology a separation of human culture from nature as early as 10,000 B.C.E. in the Yahwist tradition. In later Hebrew history, sojourns in the wilderness became symbols for the spiritual purification of prophets; at the same time, wild lands were treated as wastelands awaiting transformation into *productive* farmland. Oelschlager attributes this ambivalence to residual tensions between settled agriculturalists and nomadic, *wilder* tribes of herders and gatherers. These two themes—wildness and civilization through cultivation—are entwined throughout the Judeo-Christian tradition. Christ's sojourn in the wilderness, in keeping with the Hebrew tradition of seeking purification by retreating from society into wilderness, is portrayed as a time of spiritual strengthening in preparation for a future ministry.

The idea of wilderness as an obstacle to the human will, which grew out of the earlier tendency of agriculturalists to distinguish their works—the domain of their physical control—from wild nature lying beyond civilization, took on a renewed meaning with the discovery of the New World. In this context, the fascination with wilderness was expressed as a struggle between the Enlightenment view of human perfectibility through science and technology, and romanticism as expressed in the French philosopher Jean-Jacques Rousseau's idea of the *noble savage*. According to this view, pre-civilized humans, not yet corrupted by the affectations of society, have a purity not found in contemporary society. This fascination with wildness was inspired by the discovery of *primitive* cultures, and reinforced the romantic critique of the overly rational and mechanical world of the Enlightenment.

Once imported into the New World, the wilderness versus civilization theme took on new vitality as colonists came in direct contact with wilderness and with *wild* tribes they saw as *savages*. Jonathan Edwards—despite his reputation as a brimstone orator—preached benevolence toward the whole of God's nature (Miller 1967, p. 283). More concretely, the battle between civilization and wilderness was fought again each day at the advancing edge of colonial development of lands formerly inhabited by Native American tribes. In a classic analysis of U.S. history, Frederick Jackson Turner (1920) emphasized the importance of the frontier in the identity of the United States, predicting that a huge transformation in consciousness would ensue as the frontier closed. Turner saw the existence of an open frontier, and the idea of *manifest destiny* associated with it, as definitive of the American experience. Accordingly the closing of the frontier was thought to usher in a new era in American life.

Two Views of Wilderness

It is useful to separate two aspects of the wilderness idea as it has developed in American thought. First there was the indicated experience of wildness as a countervailing force resisting the daily transformation of wild lands into farmland and cities in the path of westward expansion. This process of *civilizing* lands that had before been the habitat of nomadic tribes of hunters and gatherers represents a replay of the growth of agricultural societies across the Middle East and Europe in the original expansion of agriculture in the Old World. In this conflict, wilderness was cast as one pole in a dialectic between human culture and wild nature.

The reality of these day-to-day struggles to transform wilderness into productive land may be contrasted with a second, emergent idea of wilderness, an idea—one might say an idealization—of wildness and wilderness that has evolved within academic and intellectual circles, especially in North America and in Australia. The works of Perry Miller (1967), Leo Marx (1967), Roderick Nash (1982) and the philosophers Mark Sagoff (1974) and Max Oelschlager have all articulated and emphasized the importance of the idea of wilderness in the American identity and self-perception. These authors, whose careers correspond to a growing academic interest in environmental studies all brought new dimensions to a vital strain in American intellectual life, as exemplified, for example, in the writings of Ernest Hemingway, Wallace Stegner, Annie Dillard, and many others. These authors reprise a longstanding theme—as exemplified in the Leatherstocking Tales of James Fenimore Cooper and his hero, Natty Bumppo, of associating life at the edge of wilderness as symbolic of freedom, self-reliance, and character.

The emphasis in the United States on the idea of wilderness led to a re-shaping of the related concept, "nature," which came to mean "primordial nature," whereas in Europe—where most land had been altered by humans long ago—people enjoyed the "countryside," with farms, homes, and businesses distributed across the landscape, as "natural." The assimilation of the idea of nature to that of primordial nature, and referring only to lands where humans have no presence, has contributed to the polarization of thought about nature in the United States. Whereas Europeans enjoy mixed landscapes, Americans distinguish wilderness from "the working landscape," and there are bitter disagreements about what activities are appropriate in wilderness areas. Advocates of wilderness thus try to eliminate activities, such as motorized recreation, from wilderness areas, considering such uses inappropriate and damaging to the primordial quality of wilderness.

The complex, often conflicting theme of nature versus culture has been important in environmental thought and action. Henry David Thoreau, the transcendentalist, said "in Wildness is the preservation of the World" (Thoreau 1998 [1862], p. 37), and his ideas are echoed in the work of John Muir (founding president of the Sierra Club) and many other wilderness advocates. Muir's reverence for forests and wild nature clashed with the ideas of Gifford Pinchot, the first Forester of the National Forest Reserves, who argued that all resources should be developed to improve the material lot of humans. So reverence—and passion—for wildness exists in sharp contrast to another, opposing theme: the need to control and civilize nature for human use. This tension in the environmental movement, it could be argued, reflects the broader ambivalence of Euro-American culture toward wildness and civilization.

Wilderness Policy

Muir's respect for wilderness also motivated Aldo Leopold, the philosophical forester who worked tirelessly to protect wild areas from development, from within and, later, outside the U.S. Forest Service. Leopold convinced the Forest Service to set aside the Gila Wilderness in 1922, and he co-founded the Wilderness Society—an activist group that advocates for wilderness protection—in 1935. Leopold advocated for preservation of the wilderness on several bases; he countered the utilitarians and materialists by noting that wilderness backpacking and hiking are uses, too, and that some land has more utility for back-country recreation than for development. He also argued that humans need wild, natural systems as *models* of healthy systems if they are ever to become intelligent managers of the modified systems that are their immediate habitats. Leopold, however, at his most passionate, argued for wildness and wilderness as a *cultural* necessity, and as a matter of *intellectual humility*. "The shallow-minded modern" must, he thought, learn to appreciate wilderness as a symbol of our "untamable past," and "giving definition and meaning to the human enterprise" (Leopold 1949, p. 200–201, 96).

In 1964 the U.S. Congress passed the Wilderness Act, which gave wilderness areas considerable protections. This act, which provides for the designation and protection of wilderness areas, defined wilderness "in contrast with those areas where man and his own works dominate the landscape, is hereby recognized as an area where the earth and its community of life are untrammeled by man, where man is a visitor who does not remain." Far from resolving the conflict between wilderness advocates and advocates of economic development, however, the passage of the act has resulted in a series of political struggles regarding which, and how much, U.S. government land would be designated as wilderness, and what kinds of activities would be allowed on designated land.

A New Wilderness Debate

In the 1990s, a new wilderness debate broke out, as philosophers, historians and scientists all called into question the truth and efficacy of the wilderness *myth*. An early salvo in this new war came from the philosopher J. Baird Callicott, who criticized the entrenched idea/myth of wilderness because it supports an inaccurate view of humans as separate from nature; and because the myth has colonialist overtones, treating members of the cultures who lived there as less than human, whereas these peoples *managed* the land, albeit less intensively than the European colonists. Callicott also thinks the myth confuses policy by emphasizing exclusion of all humans from wilderness. If the emphasis were shifted to protecting *wildness*, protection would only forbid the intrusion of modern, industrial uses, Callicott argues, and one might encourage people to live with nature in unobtrusive ways in order to cohabit with wildlife.

Subsequently this debate was rekindled in two contexts. First the historian William Cronon, who had implicitly raised some of Callicott's issues in his 1983 book, *Changes in the Land,* published a book in which he and his co-authors emphasized that the idealized, mythical idea of wilderness is very much an American construction, a culturally relative idea that should be recognized as very particular to the United States, and prone to hide rather than illuminate the reality of European settlement and colonial land transformations (Cronon 1995).

The wilderness debate also shaped a subsequent debate in conservation biology, as conservation biologists suggested that, whatever the original rationale for wilderness, the wilderness areas in the early twenty-first century are indispensable reserves to protect biological diversity. This idea has since been criticized by Callicott, who argues against the assumption that wilderness areas must be depopulated in order to protect wild species, arguing that conservation biologists requiring wilderness simply perpetuates the old dichotomy between humans and nature. Further the philosopher of biology, Sahotra Sarkar, has argued persuasively that the goals of biodiversity protection and wilderness preservation often conflict; this debate shows signs of continuing well into the twenty-first century. (Sarkar 1999).

The idea of wilderness has been, and remains, both seminal and controversial in ongoing discussions of the American character. Further this idea provides an attitudinal backdrop for explorations in environmental ethics and environmental thought, and also for debates about environmental policy. Given this central role in European and North American—especially U.S.—thought and action, it is not surprising that the idea deeply affects the ways humans understand—and evaluate—new and emerging technologies.

BRYAN G. NORTON

SEE ALSO *Earth; Environment; Environmental Ethics; Wildlife Management.*

BIBLIOGRAPHY

Callicott, J. Baird, and Michael P. Nelson. (1998). *The Great New Wilderness Debate*. Athens: The University of fGeorgia Press.

Cronon, William. (1983). *Changes in the Land: Indians, Colonists, and the Ecology of New England*. New York: Hill and Wang.

Cronon, William, ed. (1995). *Uncommon Ground: Toward Reinventing Nature*. New York: Norton.

Leopold, Aldo. (1949). *A Sand County Almanac and Sketches Here and There*. New York: Oxford University Press.

Marx, Leo. (1967). *The Machine in the Garden: Technology and the Pastoral Ideal in America*. London: Oxford University Press.

Miller, Perry. (1967). *Nature's Nation*. Cambridge, MA: Harvard University Press.

Nash, Roderick. (1982). *Wilderness and the American Mind,* 3rd edition. New Haven, CT: Yale University Press. First edition was published in 1967.

Oelschlaeger, Max. (1991). *The Idea of Wilderness*. New Haven, CT: Yale University Press.

Sagoff, Mark. (1974). "On Preserving the Natural Environment." *Yale Law Journal* 81: 205–267.

Sarkar, Sahotra. (1999). "Wilderness Preservation and Biodiversity Conservation—Keeping Divergent Goals Distinct." *Bioscience* 49: 405–412.

Thoreau, Henry David. 1998 (1862). "Walking." In *The Great New Wilderness Debate,* ed. J. Baird Callicott and Michael P. Nelson. Athens: University of Georgia Press.

WILDLIFE MANAGEMENT

In some sense, wildlife management is not new. Wildlife was managed for subsistence hunting—by burning fields to create grass for ungulates, for example—by early humans and even perhaps by protohumans. *Game management*—management of animals for *sport* hunting, in particular—has been traced at least as far back as ancient Egyptian civilizations. Large game fields, managed for sport, were maintained for the recreation of Egyptian royalty. Hunting restrictions—which can be thought of as the precursors of modern wildlife management—can be traced back to early tribal customs and taboos. Typically game management involved few species—mostly for food and sport, but also for aesthetics in some cases—and was practiced over relatively small areas in a decentralized manner.

Since the twentieth century, due mainly to a confluence of developments in ecology and society, game management has been supplemented by more comprehensive wildlife management in most developed countries. Game management programs often dominate government wildlife management departments because of their political popularity and because they have, in hunting and fishing license fees, a strong source of revenue. Beginning in the 1920s with the pioneering work of Aldo Leopold, wildlife management took its place next to game programs. Eventually many governments reconceptualized game management as one specialization in the broader field of wildlife management, and in the early-twenty-first century most governments include agencies that accept some responsibility for maintaining healthy populations of almost all indigenous species.

Leopold and Evolution of Wildlife Management in the United States

Leopold, working with his more field-oriented friend, Herbert Stoddard, provided both the intellectual and practical leadership in shifting government agencies, at least in the United States, toward a more holistic approach toward wildlife management. As a consultant and researcher on game populations in the early 1930s, Leopold met and became friends with the British ecologist Charles Elton, an advocate of the empirical study of whole ecosystems. Elton and Leopold both recognized the implication of ecology: It is very difficult to manage single species in isolation without upsetting important ecological processes over time. This insight was driven home to Leopold by the abnormal fluctuations in deer populations in the southwestern United States, where he was director of operations, and sometimes game manager, over national forest holdings. Leopold had employed predator eradication as a means to create an artificially large herd of deer for hunting. During an especially bad winter, more than 60 percent of the deer died because they had eaten all available browse, causing a population crash, destroying vegetation, and encouraging soil erosion. In areas where top predators have been removed and there are no natural checks on wildlife population increases, there are often disagreements about the ethical treatment of animals, including conflict with private hunters and with government management agencies over policies involving culling of wildlife populations. Reducing populations of species whose natural predators have been eliminated is a great challenge. Agencies charged with controlling wildlife populations are sometimes strongly criticized by the public, which has become increasingly concerned with animal welfare and animal rights (Dizard 1999, Sharpe et al. 2001).

Leopold, years later in his classic book of essays *A Sand County Almanac and Sketches Here and There* (1949), included a brief but elegant mea culpa. He said he had mismanaged the land, creating starving deer and eroding hillsides, because he had not yet learned "to think like a mountain" (Leopold 1949, p. 130). Leopold treated his conversion as a revelation and also as a metaphor that must guide the future of wildlife management. Haunted by the "fierce green fire" that he saw in the eye of a dying she-wolf—a wolf shot by his group of forest rangers—Leopold realized, he said, that "there was something new to me in those eyes—something known only to her and the mountain" (Leopold 1949, p. 131). Leopold gradually rejected predator eradication programs and eventually advocated protection of wolves in wilderness areas. He devoted his remaining career to advocating and practicing holistic wildlife management, applying ecological principles to whole ecosystems. He was learning to think on the timescale significant to mountains—and was accepting moral responsibility for the long-term results of his short-term thinking about wolves and deer.

After leaving the U.S. Forest Service in 1928, Leopold became, first, a private consultant on game and sport hunting, and eventually the first professor of game management at the University of Wisconsin. He concluded that predators were an essential element in a healthy ecosystem, and shifted emphasis in his managerial theory and practice toward more holistic habitat management and away from management for single species (Leopold 1939, Flader 1994). By the late 1960s and early 1970s, some states had initiated *nongame wildlife programs*, and since then wildlife programs have flourished in response to strong public support and coexist, more or less easily, with game management programs. Demographic changes also had an impact as more of the population moved to the suburbs and the exurbs. These changes corresponded with an increase in leisure time and an increased demand for opportunities to interact with wildlife in nonconsumptive ways, for example during popular activities such as hiking, camping, and birdwatching. By appealing to this growing interest, governmental and nongovernmental agencies built a political constituency that supported parks, reserves, and wilderness. (Hays 1987).

Leopold, following Henry David Thoreau and John Muir—other *holists* who were very influential in conservation—thus shifted the focus of management from species to systems, and departed from his *resource management* approach. He moved toward a *biotic* view, which sets out to protect the integrity of ecological systems.

Leopold's evolution began with his belief that the goal of management is to maximize game availability; by the time he published his landmark book, *Game Management* in 1933, Leopold had also begun to emphasize the *quality* of game, arguing that quality is inversely related to artificiality. He advocated minimizing interference in the hunter/prey relationship to the greatest extent possible. Leopold believed sportsmanship was enhanced—and moral and aesthetic values supported—

when the sportsman interacts directly with wild game, without the interference of wildlife managers. Leopold realized, however, that growth and dispersion of human populations increases the need for more invasive management. Thus he saw game management as a negotiation between demand for quantity of game for increasing populations and the continuing threat to the quality of game and the hunting/fishing experience.

Leopold also argued that the same methods that he and others had applied to game management should be employed to maximize wildlife more generally, and closed the 1933 book by arguing that managers should apply similar methods to all wildlife. He stated that the goal of wildlife management was "to retain for the average citizen the opportunity to see, admire and enjoy, and to challenge to understand, the varied forms of birds and mammals indigenous to his state" (Leopold 1933, p. 403). Leopold advocated use of agricultural tools to produce more wildlife, claiming that the goals of the profession were not just to keep all life forms in existence, but also to ensure "*that the greatest possible variety of them exist in each community*" (Leopold 1986, p. 403).

By 1939 Leopold had become less optimistic regarding the possibility of managing for particular species, recognizing that ecological relationships are so complex that manipulation of systems to maximize some species will always have unforeseen consequences; species are so intertwined that only habitats can be protected. Leopold advocated protection of whole habitats and argued that society should value whole communities of plants and animals, and stop trying to value and favor some species inordinately. Leopold continued, until his death in 1949, to advocate holistic management, and registered many successes in protecting natural areas. He recognized, however, that truly holistic management remained mostly a dream. His influence, nevertheless, continues, as many wildlife managers follow Leopold's principles and emulate his method of integrating ecological science and management.

Issues in the Twenty-first Century

Since Leopold's time, and especially since the 1980s, concern with wildlife management has been supplemented with attempts to save *biological diversity*, which is a very broad and complex concept that includes wildlife. In the United States, biodiversity policy has been shaped by the Endangered Species Act of 1973, which restricts activities that threaten species of concern, and also mandates species and habitat restoration for species that are listed because of risk of extinction or extirpation from regional habitats. Although the act is politically controversial, protection of species remains a high priority for large majorities of the public. The act has also been criticized for retaining a bias toward *single-species management*, and there have been many efforts to reshape wildlife management to protect ecosystems and habitats. In this broader effort, endangered species protection is an important element, and the act, with its emphasis on single species management, nevertheless protects many species and their habitats through its designation and protection of critical habitats for listed species, which are of course shared with other plants and animals.

One important ethical controversy arises over the treatment of wild animals in captivity. While zoos have since late in the twentieth century shifted their message from purely recreational enjoyment of animals toward a conservation emphasis, animal rights organizations attack zoos as *animal prisons*, and question the holding of wild animals in captivity as a way to supplement or shore up sagging wild populations. Critics of invasive management of specimen animals ask: What gives humans—who have already disrupted animal communities all over the world—the right to capture and hold animals for conservation breeding purposes? (Norton et al. 1995)

Since 1970, as wildlife management and biodiversity protection policies have become more scientific by incorporating ecology and many other physical and social sciences into the management process, several important consensuses regarding both goals and methods have emerged. One important consensus is that large parks and preserves are necessary, but usually not sufficient, to protect all varieties of wildlife, because even large parks often lose significant numbers of mammal species (Newmark 1995). Accordingly there is increasing interest in managing *the matrix* of private lands that embeds reserves. This may involve creating buffer zones of lighter use around reserves, and creation of protected riparian corridors to connect various reserves and populations of animals (Harris 1984).

Gap analysis has emerged as the state of the art method for protecting biological diversity. According to this technique, ecosystem and habitat conservation programs are judged by comparing biodiversity priorities with existing and proposed reserves. By identifying *gaps*—important ecological communities that have no protection—conservation efforts can be concentrated on saving all community types and, in the process, the species of wildlife that depend upon them (Church et al. 1996, Scott and Csuti 1996). The goal of international conservation is to protect representative samples of all the biological communities in the world (McNeely 1989). Efforts are underway to restore some whole ecological systems and to reintroduce predators in some areas, such as the Greater Yellowstone Ecosystem in the western United States. Restoration of wildlife populations and protection of their habitat is praised not only for its ecological benefits, but also as a means to involve communities in local conservation projects, thereby building community leadership and making citizens more aware of environmental values.

The future of wildlife management—and of wildlife itself— in the early twenty-first century is uncertain. As cities expand into countryside, it becomes more difficult to maintain populations of many species, especially large predators. Scientific experts fear that species such as wolves, mountain lions, and bears will become increasingly hard to protect. As areas not dominated by human uses shrink, wildlife will have to be managed more invasively to protect the diverse biological heritage each generation has inherited. Such management, however, undermines the wildness of wildlife and affects, as Leopold stressed, the quality of the human experience of wild creatures.

Learning to protect truly wild populations will be a challenge for the future. Rapidly accelerating rates of extinction demonstrate that humans have not learned these protection methods yet. As the pressures of expanding populations and cities continue though the twenty-first century, much wildlife will be lost as ubiquitous species that easily cohabit with humans take over the remaining, fragmented habitats. Only a concerted effort to understand and to act decisively can avoid a drastic simplification of the biological context in which humans evolved. Such an effort would involve unprecedented cooperation among scientists, governments, private land-owners, and wildlife management agencies, and could only achieve success if techniques are developed to manage whole regions to maintain adequate reserves and other protections to form a complex matrix of human and natural communities.

BRYAN G. NORTON

SEE ALSO *Environment; Environmental Ethics; Management; Wilderness.*

BIBLIOGRAPHY

Church, Richard L.; David M. Stoms; and Frank W. Davis. (1996). "Reserve Selection as a Maximal Covering Location Problem." *Biological Conservation* 76: 105–112. A review of scientific approaches to reserve design.

Dizard, Jan. E. (1999). *Going Wild: Hunting, Animal Rights, and the Contested Meaning of Nature*. Amherst: University of Massachusetts Press. A thoughtful discussion of the problems of managing wild populations in close proximity to human communities.

Elton, Charles. (1927). *Animal Ecology*. New York, NY: Macmillan. Elton led the way toward a more systems-approach to studying animal species.

Elton, Charles. (1958). *The Ecology of Invasions of Plants and Animals*. New York, NY: John Wiley. The classic ecological treatment of migrations of plants and animals.

Flader, Susan L. (1994) *Thinking Like a Mountain: Aldo Leopold and the Evolution of an Ecological Attitude toward Deer, Wolves and Forests*. Madison: University of Wisconsin Press. Originally published in 1974. A detailed study of Leopold's changing views on wolf management.

Harris, Larry. (1984). *The Fragmented Forest*. Chicago: University of Chicago Press. An analysis of the causes and remedies of habitat fragmentation.

Hays, Samuel. (1987). *Beauty, Health, and Permanence: Environmental Politics in the United States, 1955–1985*. Cambridge, UK: Cambridge University Press. A historical look at evolving goals of environmental management.

Leopold, Aldo. (1939). "A Biotic View of Land." *Journal of Forestry* 37: 113–116. A brief essay that marked a key milestone in Leopold's evolution toward holistic management.

Leopold, Aldo. (1949). *A Sand County Almanac and Sketches Here and There*. Oxford: Oxford University Press. Leopold's much-read and much-loved reminiscences of a life in conservation science.

Leopold, Aldo. (1986). *Game Management*. Madison: University of Wisconsin Press. Leopold's classic (1933) "textbook" of management science.

McNeely, Jeffrey A. (1989). "Protected Areas and Human Ecology: How National Parks Can Contribute to Sustaining Societies of the Twenty-first Century." In *Conservation for the Twenty-First Century*, ed. David Western and Mary Pearl. New York: Oxford University Press.

Newmark, William D. (1995). "Extinction of Animal Populations in Western North American National Parks." *Conservation Biology* 9: 512–527. An important scientific paper often cited to show the limitations of reserves in the protection of all species.

Norton, Bryan G.; Michael Hutchins; Elizabeth Stevens; and Terry Maple, eds. (1995). *Ethics on the Ark: Zoos, Animal Welfare, and Wildlife Conservation*. Washington, DC: Smithsonian Institution Press. An anthology of differing viewpoints on zoos and their role in conservation.

Scott, J. Michael, and Blair Csuti. (1996). "Gap Analysis for Biodiversity Survey and Maintenance." In *Biodiversity II: Understanding and Protecting Our Biological Resources*, ed. Marjorie L. Reaka-Kudla, Don E. Wilson, and Edward O. Wilson. Washington, DC: John Henry Press. A summary of the goals and techniques of gap analysis.

Sharpe, Virginia A.; Bryan Norton; and Strachan Donnelly. (2001). *Wolves and Human Communities: Biology, Politics, and Ethics*. Washington, DC: Island Press. An anthology of viewpoints on the possible re-introduction of wolves to upstate New York.

Thoreau, Henry David. (1960). *Walden*. New York: New American Library. Thoreau was a pioneer in seeing wildlife as a key to living a better life. *Walden* was first published in 1854.

Thoreau, Henry David. (1998). "Walking." In *The Great New Wilderness Debate*, ed. J. Baird Callicott and Michael P. Nelson. Athens: University of Georgia Press. Essay originally published in 1862.

WITTGENSTEIN, LUDWIG

Engineer, architect, and one of the most influential analytic and linguistic philosophers of the twentieth century, Ludwig Wittgenstein (1889–1951) was born in Vienna, Austria, on April 26 and died a few days after his sixty-second birthday in Cambridge, England, on April 29. Although seldom emphasized in works about the philosopher, Wittgenstein's life was deeply engaged with technology. He studied mechanical engineering in Berlin and aeronautical engineering in Manchester, England, securing the patent for a propeller in 1911. He also conducted combustion chamber research and his ideas were used for helicopter engines after World War II. Even after abandoning his engineering career, Wittgenstein's engineering education continued to exercise an influence on his philosophical work.

Ludwig Wittgenstein, 1889–1951. After making important contributions to logic and the foundations of mathematics, the Austrian philosopher Wittgenstein moved away from formalism to an investigation of the logic of informal language. *(Hulton Archive/ Getty Images.)*

Wittgenstein began his career as a philosopher in 1912 after reading Bertrand Russell and Alfred North Whitehead's *Principia Mathematica* (Volume I, 1910). The logical foundations of mathematics was one of the most important philosophical issues of the day, and between 1914 and 1918 Wittgenstein wrote one of his *Tractatus Logico Philosophicus*. Its spare hundred pages contain a philosophy of logic, of language and meaning, of science, an ontology, and by implication, ethics. Language is the basis for all thought, so that the first philosophical task must be to understand its relation to the world in order to clarify its meaning. Many philosophical problems rest on confusions about the meaning of language; when these confusions are revealed, the problems vanish. Only scientific problems are real and thus able to be truly solved.

Wittgenstein's work was a fundamental influence on the philosophical program of the logical empiricists of the Vienna Circle, including Otto Neurath (1882–1945), Moritz Schlick (1882–1936), and Rudolf Carnap (1891–1970). This program argued that metaphysics, ethics, and religious beliefs were *non-scientific* and therefore beyond serious philosophical enquiry. Ethical values themselves were sometimes presented as no more than expressions of personal or social emotions. This positivist interpretation of Wittgenstein's thought remained influential even into the 1980s. In the *Tractatus* itself, however, Wittgenstein maintained that although only scientific problems are real, what really matters for human beings are unsolvable questions about right and wrong, good and bad, the meaning of life and so on (Wittgenstein classified these as mystical questions). To be unable to give acceptable scientific answers to such questions did not imply their meaninglessness.

After his death the publication of Wittgenstein's *Philosophical Investigations* revealed a very different Wittgenstein than that associated with the *Tractatus*. To some extent, Wittgenstein turned away from a logical, scientific clarification of language, because diversity of language uses demonstrates the futility of the effort. Language does not function as a scientific mirror of the world but as a profound social phenomenon, as a practice among people. The meanings of words are found in their uses in different contexts, as they are used in *language games,* which belong to specific *ways of life* or *forms of life,* and mistakes arise when philosophers try to find essential meanings in words, because such meanings do not exist. Language is also a learned technique, and to some extent all techniques, even scientific ones, are similar: They all have a deeply social element. There is no *super-game* of philosophy or science that could subsume all other games.

Wittgenstein neither considered himself a scientist nor accepted the idea of technological progress, and he departed clearly from the standard interpretations of scientific development as articulated first by the logical empiricists and then in revised form by Karl Popper (1902–1994) and his followers. In scattered remarks, such as those found in *Culture and Value* (1980), Wittgenstein expressed distrust of modern science and technology and considered them, along with industrialization, as the main causes of war. "Man has to awaken to wonder—and so perhaps do peoples. Science is a way of sending him to sleep again," he once wrote (*Culture and Value,* p. 5e). In his view, science not only fails to deal with the most significant issues but also tends to homogenize the world. The scientific age is associated with a decline in culture, and attempts to popularize science are, according to Wittgenstein, largely mistakes.

Influenced by Viennese cultural and artistic critics such as Karl Kraus (1874–1936), Wittgenstein was sensitive to the negative effects of modern science and technology. Skeptical of progress, he wrote, "It isn't absurd, e.g., to believe that the age of science and technology is the beginning of the end for humanity; that the idea of great progress is a delusion" (*Culture and Value,* p. 56e). The experience of both World Wars and the disappearance of a whole way of life help explain Wittgenstein's critical distrust of scientific and technological development alone as inherently beneficial. In response to the use of the atomic bomb, he actually considered the possibility that modern technology might destroy the whole human race. His pessimism was similar to that of many other intellectuals, including his mentor Bertrand Russell (1872–1970). However, Wittgenstein did not pursue these concerns in any rigorous way.

Many of Wittgenstein's ideas are key features in subsequent criticisms of science and technology. The political theorist Langdon Winner (1986) uses the *form of life* concept to explain how technology becomes a part of one's humanity, as a kind of second nature. As a consequence, technological artifacts often acquire a political character. From an epistemic point of view, sociologist David Bloor (1983) also draws on Wittgenstein to develop a critical assessment of the social nature of scientific knowledge. The so-called "strong program" of the Edinburgh school in the sociology of scientific knowledge uses Wittgenstein's ideas as a basis for their research. Wittgenstein's influence is pervasive and his thinking leaks out into many different fields, including discussions of values in science and technology. For instance, John Searle used Wittgensteinian techniques to attack claims for artificial intelligence (1986). Wittgenstein's main contribution to science and technology criticism consists of a heightened sensitivity to "bewitchment" (Wittgenstein's term) in technological discourse.

ANDONI ALONSO

SEE ALSO *Logical Empiricism; Progress; Skepticism; von Wright, Georg Henrik.*

BIBLIOGRAPHY

Alonso Puelles, Andoni. (2002). *El arte de lo indecible (Wittgenstein y las vanguardias).* Cáceres, Spain: Universidad de Extremadura. An examination of mutual influences between Wittgenstein and art.

Bloor, David. (1983). *Wittgenstein: A Social Theory of Knowledge.* New York: Columbia University Press.

Glock, Hans-Johann. (1996). *A Wittgenstein Dictionary.* Oxford: Blackwell. The most useful general reference to the many aspects of Wittgenstein's thought and the controversies it has generated.

Kenney, Anthony. (1988). *Wittgenstein.* Harmondsworth, UK: Penguin. The best English introduction to Wittgenstein's philosophy as a whole.

Monk, Ray. (1990). *Ludwig Wittgenstein: The Duty of Genius.* New York: Penguin. The best general biography.

Searle, John R. (1986). *Minds, Brains and Science.* Cambridge, MA: Harvard University Press.

Winner, Langdon. (1986). *The Whale and the Reactor: A Search for Limits in an Age of High Technology.* Chicago: University of Chicago Press.

Wittgenstein, Ludwig. (1922). *Tractatus Logico-Philosophicus,* trans. C.K. Ogden and F.P. Ramsey. London: Routledge.

Wittgenstein, Ludwig. (1953). *Philosophical Investigations,* ed. G.E.M. Anscombe and R. Rhees. Oxford: Blackwell.

Wittgenstein, Ludwig. (1961). *Tractatus Logico-Philosophicus,* trans. D.F. Pears and B.F. McGuinness. London: Routledge.

Wittgenstein, Ludwig. (1980). *Culture and Value,* ed. G.H. von Wright in collaboration with H. Nyman; trans. Peter Winch. Oxford: Blackwell.

Wittgenstein, Ludwig. (1993). *Philosophical Occasions: 1912–1951,* ed. James C. Klagge and Alfred Nordmann.

Indianapolis, IN: Hackett. An extensive collection of shorter texts, including "A Lecture on Ethics."

WORK

Work done by human beings is purposive action guided by intelligence; work that is repetitive or arduous is often called labor. Both purpose and intelligence may originate in persons other than those actually doing the work. Associated with the basic definition are many related usages including effort expended (also called toil); the result of that effort (a work of art); and one's job or employment, workplace, trade, occupation, or profession. In all these senses work is subject to technological modification, scientific and literary study, and ethical reflection.

Historical Background

In early civilized societies, the kind of work people did depended on their class: The elite had slaves do whatever they considered demeaning, notably if it involved unrewarded physical exertion. Certain religious attitudes perpetuated this devaluation. Some Buddhist and Christian monks, for instance, have associated physical inactivity with the highest spiritual states.

By contrast, in medieval Europe, a combination of prayer and work (*ora et labora*) came to be viewed as a more fully human expression of spirituality. Government despoliation of monasteries during the reformation reduced the feasibility of a life devoted primarily to prayer. But comparable lifestyles are still possible. These aside, the Industrial Revolution tied most workers' survivability to remunerative employment.

Throughout recorded history societies have adopted various attitudes and expectations regarding work. Knowledge of this history lends perspective to contemporary attitudes and expectations. Over time, though, vast technological changes have been made in the production, marketing, and distribution of goods and services, so that past arrangements may not pertain to contemporaneous circumstances. The young Karl Marx (1818–1883) thought history pointed toward an egalitarian society in which every worker would freely choose which activities to engage in. Hannah Arendt (1958) preferred instead a socially stratified society, as in ancient Athens, where a knowledgeable few engage in (political) action, while others work (produce something) or labor (exert themselves physically).

History aside, work-related matters are now routinely viewed in economic terms. In particular, all types of paid activity are identified as labor (skilled and unskilled), and labor costs are largely determined by supply and demand. The supply of labor is, in turn, increasingly a function of globalization; and labor is sought mostly for tasks that technology has not mastered. In this context, work is conceptualized as remunerative employment and is commodified.

Indeed, in the early twenty-first century most people associate work with earning a living and, for the career-oriented, enhancing social status. Frequently, though, personal career aspirations exceed what is attainable under the prevailing economic system—whence arise a number of ethical issues.

These ethical issues include the following: Is the character of work determined solely by the market? Who is obliged to work? Under what circumstances? Should remuneration provide a decent living for the worker (a living wage) and for the worker's family (a family wage)? Which if any institution(s) should provide and/or assure employment, humane working conditions, meaningful and satisfying work? Are those unable to find employment entitled to subsistence? The social effects of scientific and technological change increase the salience of these issues.

Established Ways to Think about Work

Practical approaches to such questions involve both ethical determinations and public policies. These, in turn, draw on research findings in such disciplines as history, economics, sociology, psychology, and jurisprudence, most of which have tended to reinforce socially favored attitudes toward work.

Work is now commonly treated as something bought and sold—typically, a service or product. Employers decide which services or products to offer or generate in a given locale and employ workers accordingly. Workers' remuneration is a function of their productivity in their economic environment. This productivity, in turn, is measured by subtracting overhead—that is, the expenses incurred by conducting a business on-site—from revenue received for services or products. Because a large part of overhead is labor costs, management strives to keep these to a competitive minimum, and may therefore resort to workforce downsizing, technological displacement, and/or workplace relocation. From these practices arise many ethical issues directed to fostering cross-cultural fairness in every aspect of the employment relationship, but especially those having to do with hiring, retention, remuneration, and working conditions. Also important, especially to employees, is finding in work both personal fulfillment and conformity with a socially promoted work ethic (Gini 2000).

A work ethic involves making work a key measure of personal success (Rose 1985, Beder 2000). Industrial-era capitalists fostered a work ethic to maintain a sufficient supply of willing workers. But workplace rationalization and globalization (see below) have rendered the work ethic an unreliable incentive. Some theorists nonetheless still call for meaningful work (Schwartz 1982, Byrne 1990) and a right to work. The latter expression sometimes signifies individualist opposition to unionization (Dickman 1987) and sometimes, gainful employment as such (Harvey 2004, Skopcol 1990). In either sense it is stymied by cost-cutting strategies that replace higher- with lower-paid workers and human beings with machines.

Since the Great Depression in the 1930s governments have assumed some responsibility for this problem by funding systems of unemployment compensation (UC): twenty-two countries had done so by 1949, and sixty-eight countries by 2004. Some scholars argue that any structurally unemployed person is entitled to subsistence income. But governments increasingly require a claimant for UC (as distinguished from generic welfare support) to have been employed and/or be actively seeking employment. Thus in the 1990s even Nordic countries, long noted for their generous UC programs, made these programs less accessible and their benefits less supportive.

Many factors enter into the amount of compensation a person receives for work done. These include the level of development and/or indebtedness of the economy within which one works, one's social and political affiliations, and one's gender, race, national origin, and so on. For example, work done by women is sometimes labeled differently from men's work to justify paying women less (Wright et al. 1987; Mohanty 2003). A society may also set ethical limits on the time a worker may devote to play (Byrne 1990). This pro-work mindset (manifested even in the career-oriented way parents view their children's preschool activities) seeks to maintain an abundance of available labor, now on a global scale.

Large corporations increasingly dominate worldwide employment without assuming responsibility for the negative consequences of their decisions regarding workforce size or location. Even in the face of automation (Byrne 1990) and globalization (Goudzwaard 1979), though, less socially disruptive strategies are possible. These are supported by calls for decent working conditions and a living wage (for example, the United Nations' Universal Declaration of Human Rights, arts. 23 and 24; John Paul II, 1981). Such declarations, though, forestall few if any downsizing decisions. Moreover, the unemployed are often stigmatized and considered personally responsible for their situation even as governments dismantle programs that would mitigate the effects of unemployment (Beder 2000). These conflicting attitudes about work show that the ways in which work has been viewed are no longer adequate to the challenges now emerging.

Finding New Ways to Think about Work

The premodern fusion of work and life associated with primitives and studied by cultural anthropologists is now rare. The modern fusion of work and compensation is coming undone as the availability of jobs depends less on individual skills or dedication than on strategic workplace and/or workforce selections that contribute to profit maximization. In short, the industrial-age problem of worker displacement engendered by rationalization of process is now being compounded by globalization. So earlier analyses of work-related problems need to be reviewed through new lenses if a humane approach to work is to be restored.

Already in the eighteenth century some theorists began speculating about the future of work in view of the inroads of mechanization. Building on earlier utopian visions, some social planners proposed founding communes that would use technologies selectively (Manuel and Manuel 1979). But classical economists, including Adam Smith (1723–1790) and David Ricardo (1772–1823), believed that an unfettered market would achieve "full employment equilibrium." As explained by the French economist Jean-Baptiste Say (1767–1832), for example, supply creates its own demand and this engenders full employment. This "law of markets," or Say's law, predicts that as laborsaving devices replace workers more products become available at prices more consumers can afford, thereby creating a need for additional workers. On this theory, unemployment is not structural (inevitable given system priorities) because a machine-challenged workforce will accept lower wages, which in turn diminishes the need for more expensive machinery (Gini 2000). The mature Marx predicted instead that capitalists' continued recourse to laborsaving devices would engender a great mass of marginalized and potentially insubordinate poor. Proving this prediction incorrect has been a priority for theorists and politicians ever since.

In the nineteenth and early twentieth centuries laborers were assumed to have minimal intelligence, which Taylorization and Fordism sought to exploit. But such workplace strategies destroy job satisfaction, lowering productivity. So during much of the twentieth century social scientists were recruited to improve workplace *human relations* and *quality of work life,* in large part to forestall unionization. In this vein, industrialist Henry Ford once raised his workers' wages above then-current rates so his employees could afford to buy his automobiles. Still others, from John Stuart Mill (1806–1873) to Franklin D. Roosevelt, worried about what the British economist John Maynard Keynes (1883–1946) called *technological unemployment* (Gini 2000, Goudzwaard 1979). Contemporary defenders of Say's law do not share these concerns. Their *trickle-down economics,* however, do not address the emerging phenomenon of companies "churning" a literally global workforce to cut costs. So this survey of work-related issues must, finally, take note of recent attempts to evaluate these new approaches to workforce dynamics.

The problem, in brief, is how to accommodate the tendency (a) of employers to pursue the least costly means of production and (b) of employees to seek the most advantageous compensation. In the age of discovery made possible by the development of reliable ships, employers combined on-site production with slave labor. In the industrial era, employers welcomed wage laborers to their fixed-site factories. Now in the age of computers and electronic telecommunications it is possible to locate supplies, employees, equipment, product, and vendors in whatever mix most favors a given business. Enslavement is now a violation of human rights under international law. It still occurs, however, and in other ways as well. Transnational corporations exploit Third World workers and will continue doing so until prohibited under international law (Moran 2002). They will do so because they gain monetary, trade, tax, and other advantages by locating facilities and employees so as to minimize total labor costs and maximize return on capital. Adding these strategies to automation, capitalist management strives to control workers, as did communist managers (Shaiken 1985). Control of the work process now depends, however, not just on routinizing a task but on where and by whom that task is most profitably carried out.

Most workers need to use tools, including highly complex machines that sometimes replace workers. Thus the availability of employment depends in part on what technology and operators are available. With this in mind, contemporary experts, like their forebears, debate whether introducing new technologies expands or contracts job opportunities (Aronowitz and DiFazio 1994, Bix 2000). In fact, it does both, either by requiring additional workers, as did the assembly line, or by rendering skills previously in demand obsolete, as has containerization and automated manufacturing processes, or both eliminating some jobs and creating others, as has the computer. The U.S. Department of Defense's funding of science and engineering since World War II has severely skewed educational and hiring priorities in many technical fields (Standler 2004). And computer-based network technology generally reduces complex layers of jobs to comparatively few, thereby rendering many employees superfluous. Some laid-off workers can be retrained for new jobs (hence the U.S. Workforce Investment Act of 1998). These jobs, however, are often temporary and/or part-time with no employer-provided benefits. In this context employers no longer stress company loyalty but promise their employees heightened skills for placement elsewhere. But those seeking reemployment may be deemed *overqualified,* in part because they are in a labor pool that includes many others, some no less skilled, in or from countries where compensation is substantially lower. Partly because of this migration of work unemployment is much lower in many developing countries, especially in the Asia-Pacific region, than in some developed countries, especially in Europe. This situation remains subject, however, to profit-maximizing strategies, which are ever under review. So however work is distributed around the world, it will enhance a globalized buyer's market that primarily benefits corporate executives and investors.

This noted, economic growth does tend to lower unemployment, albeit not precisely in accord with Okun's law (a 1% increase in the rate of economic growth lowers the unemployment rate by 0.3%). Lower unemployment, though, is not inconsistent with job obsolescence. Individuals with advanced degrees, especially in technical and business-related fields, do have better marketability than do those less or less appropriately educated. And it is true that in developed countries, especially in Europe, new jobs are being created mainly in the service sector. This sector, though, is itself being transformed by the same network technology that has reduced the number of jobs in manufacturing.

Workers' Rights in a Global Workplace

The global marketplace raises pressing ethical issues regarding workers' rights. But workers' rights are difficult to enforce in many countries. So business ethicists recommend codes of ethics that can be applied cross-culturally. These have tended to favor management, but public awareness of corporate executives' malfeasance and disproportionate compensation has generated support for tighter external regulation of business practices. The decades-old debate about corporate responsibility now takes into account stakeholder theories, which extend property rights to groups other than shareholders and management, such as plant-location cities, suppliers, and customers. But such theorizing is difficult to apply to structurally consolidated professional services, such as in health care, or to transnational combinations in industries such as finance, telecommunications, and retail groceries. Government and corporate leaders extol the resulting increases in productivity, even as they blame the unemployed for not having jobs (Beder 2000). Such politically motivated problem skimming, however, does not address people's growing sense that the globalized marketplace is limiting their employment opportunities.

Global employment strategies that are advantageous to an employer disadvantage some potential employees more than others. Protective tariffs may be imposed to safeguard jobs tied to goods not produced at competitive costs. But the availability of substantially cheaper labor in or from developing countries disfavors retention of higher-paid employees in developed countries. Thus by the year 2015 the U.S. electronics industry will have transferred some three million jobs to India, and possibly as many as that to China. Comparable moves are planned in Europe, even in non-English-speaking countries. Meanwhile, China now produces four times as many apples as the United States so that only growers in the state of Washington can still compete without tariff protections. And if U.S. tariffs on orange juice are abolished under a proposed free trade agreement, Brazil's product will capture the U.S. market and Florida orange growers will no longer hire Mexican migrant workers. Changes of this magnitude in job markets cannot be neutralized by extolling the rewards of adhering to a work ethic. A better response might be to somehow apply Marx's maxim: from each according to ability, to each according to need. This ideal, however, is not easily introduced into the corporation-dominated global economy.

Economists who study the effects of globalization disagree about their ultimate ramifications. Some retain the optimism of Say's law by arguing that the global economy as a whole improves whenever something is produced where it can be done efficiently and at a substantially lower cost than elsewhere. This thesis, which economists explain in terms of *comparative advantage*, needs to be modified to take into account both international monetary exchange rates and the losses incurred by displaced workers. Moreover, if the comparative advantage in question depends on exploiting workers (for example, in sweatshops) or engaging in illegal activities (such as laundering money), it is subject to additional ethical objections. To address such distortions of global fairness both the International Labour Organization and its parent body the United Nations (UN) have identified certain core labor standards with which all employers should comply. Subscribed to by many UN member nations, these standards favor workers' right to organize and condemn forced or compulsory labor, child labor, and discrimination in employment or occupation. Much debated is whether the inclusion of these core labor standards in trade agreements would mostly benefit Third World workers or First World corporations (Basu et al. 2003).

Work in the Future

In short, the ethical problems associated with a globalized and technologically challenged workforce involve not only economic but social and political considerations as well, especially because their solution requires moving beyond the modern tendency to base people's income eligibility almost exclusively on their work. This is rarely considered in the United States, where job responsibilities (such as being "on call 24/7") are blurring the line between work and leisure. Meanwhile in the United Kingdom programs are being developed precisely to achieve better "worklife balance." In some places, such as Alaska and Saudi Arabia, resource-based wealth has been distributed to all citizens, even those not participating directly in the generation of that wealth. Expanding such arrangements and devising others not dependent on the market is desirable (Offe and Heinze 1992) but unlikely so long as such traditional capitalist values as property rights and the work ethic remain dominant. For the foreseeable future, then, few besides the independently wealthy will be able to live decent lives without engaging in wage work. Where, then will this work be found?

This question is often answered by extending historical precedents into the future, namely, by viewing past transitions (from agricultural to industrial to service and to information sectors) as an evolutionary indication of another major employment sector to come. This may be so, but present data fail to reveal this new source of work in the world.

In the United States alone, some three-fourths of all workers deal with—create, collect, or use—information. The complexity of their involvement, and thus of their compensation over a lifetime, is partly a function of their education. But only 25 percent of the U.S. workforce have had four years of college, and only 5 percent have advanced degrees. The growth rate of researchers in the United States is a third less than the rate for all OECD countries. A fourth of the scientists in the United States are foreign-born, as are a third of doctorate-level scientists and engineers. Moreover, the United States has in recent years been attracting fewer foreign students to its technical programs. Indeed, it has been lowering annual ceilings for high-skilled (H-1b) visas even as the Japanese have greatly increased theirs. Meanwhile, more than 10 percent of all U.S. workers, mostly women, do not have regular full-time jobs. Given such indications of the present situation, what is needed is surely neither utopian nor anti-utopian scenarios but all the social inventiveness Americans can muster.

EDMUND F. BYRNE

SEE ALSO *Affluence; Automation; Business Ethics; Capitalism; Class; Critical Social Theory; Efficiency; Entrepreneurism; Industrial Revolution; Globalism and Globalization; Levi, Primo; Management: Models; Marx, Karl; Money; Poverty.*

BIBLIOGRAPHY

Arendt, Hannah. (1958). *The Human Condition*. Chicago: University of Chicago Press. Argues that the political sphere should address intellectual concerns, not the life-maintenance concerns of laborers.

Aronowitz, Stanley, and William DiFazio. (1994). *The Jobless Future: Sci-Tech and the Dogma of Work*. Minneapolis: University of Minnesota Press. Affirms that as technology diminishes job opportunities society must replace free market mythology with more egalitarian policies.

Basu, Kaushik, Henrik Horn, Lisa Román, and Judith Shapiro, et al., eds. (2003). *International Labor Standards: History, Theory, and Policy Options*. Oxford: Blackwell. Examines the history and economic implications of the controversial call for international labor standards.

Beder, Sharon. (2000). *Selling the Work Ethic*. Carlton North, Victoria, Australia: Scribe. Discusses the idea that the capitalist-fostered work ethic is both factually unfounded and detrimental to human well-being.

Bix, Sue. (2000). *Inventing Ourselves Out of Jobs? America's Debate over Technological Unemployment*. Baltimore and London: Johns Hopkins University Press. Diverse interested parties over three generations support technological advances, disagree about responsibility for structural unemployment.

Byrne, Edmund F. (1990). *Work, Inc.: A Philosophical Inquiry*. Philadelphia: Temple University Press. Asserts that defense of workers' rights requires community constraints on corporate hegemony.

Dickman, Howard. (1987). *Industrial Democracy in America*. La Salle, IL: Open Court. Claims organized labor is an unjustifiable hindrance to *laissez-faire* capitalism.

Gini, Al. (2000). *My Job, My Self: Work and the Creation of the Modern Individual*. New York: Routledge. Maintains that work is essential to maintenance of a human being's sense of self-worth.

Goudzwaard, Bob. (1979). *Capitalism and Progress: A Diagnosis of Western Society*, trans. Josina Van Nuis Zylstra. Grand Rapids, MI: Eerdmans. Argues that supportive economic theories notwithstanding, people's faith in progress is in crisis.

John Paul II, Pope. (1981). *On Human Work: Encyclical "Laborem Exercens."* Washington, DC: United States Catholic Conference. Has value primarily as manifestation of the worker's intrinsic dignity and vocation.

Manuel, Frank E., and Fritzie P. Manuel. (1979). *Utopian Thought in the Western World*. Cambridge, MA: Harvard University Press, Belknap Press. A comprehensive survey of utopian writings in the Western intellectual tradition.

Mohanty, Chandra Talpade. (2003). *Feminism Without Borders: Decolonizing Theory, Practicing Solidarity*. Chapel Hill, NC: Duke University Press. Describes how diverse local cultures regarding gender are used to exploit women workers.

Moran, Theodore H. (2002). *Beyond Sweatshops: Foreign Direct Investment and Globalization in Developing Countries*. Washington, DC: Brookings Institution Press. Advocates more equitable distribution of foreign investment in developing countries.

Offe, Claus, and Rolf G. Heinze. (1992). *Beyond Employment: Time, Work, and the Informal Economy*, trans. Alan Braley. Philadelphia: Temple University Press. Examines the emergence of an informal economy that replaces waged labor with non-monetary exchanges of services.

Rose, Michael. (1985). *Re-working the Work Ethic*. London: Batsford. Examines changes in workplace values and responsiveness to rewards and controls.

Schwartz, Adina. (1982). "Meaningful Work." *Ethics* 92(4): 634–646. Argues that a more democratic division of labor is better suited to enhancing individual autonomy.

Shaiken, Harley. (1985). *Work Transformed: Automation and Labor in the Computer Age*. New York: Holt, Rinehart, and Winston. Affirms that workers should have more input into the planning, programming and control of computerized automation.

Skocpol, Theda. (1990). "Brother, Can You Spare a Job? Work and Welfare in the "United States." In *The Nature of Work: Sociological Perspectives*, ed. Kai Erikson and Steven Peter Vallas. New Haven, CT: Yale University Press. Presents the idea that employment assurance, as recommended by New Deal planners, needs to be reconsidered now that the era of selective welfare is over.

Wright, Barbara Drygulski, et al., eds. (1987). *Women, Work, and Technology: Transformations*. Ann Arbor: University of Michigan Press. Feminist responses to gender-biased accounts of women's involvement in workplace technologies.

INTERNET RESOURCES

Harvey, Philip (2004). The Right to Work and Basic Income Guarantees: Competitive or Complementary Goals? Available at http://www.etes.ucl.ac.be/BIEN/Files/Papers/2004Harvey.pdf. Assesses alternative ways proposed to redress the failure of economies to assure a decent standard of living.

Standler, Ronald B. (2004). "Funding of Basic Research in Physical Science in the USA." Available at http://www.rbs0.com/funding.pdf. Argues that science in the United States is too dependent on military funding priorities.

WORLD BANK

The World Bank (Bank) or International Bank for Reconstruction and Development was created at a meeting of the forty-four World War II allied nations in Bretton Woods, New Hampshire, in 1944. Because of its promotion of economic development, the Bank is also an international institution involved to some extent with issues relevant to science, technology, and ethics.

Historical Emergence

At its inception, the Bank's mission was to make long term capital loans to countries harmed by World War II and, more generally, to undeveloped countries worldwide. Sister organizations founded at the same time, with overlapping missions, include the International Monetary Fund (IMF), the International Development Association, the International Finance Corporation, and the Multilateral Investment Guarantee Agency. Through an agreement signed in November 1948, the Bank acts as a specialized UN agency.

Surprisingly the Bank was largely irrelevant to the process of rebuilding Europe after World War II; the majority of the huge financial commitment came through the United States' Marshall Plan. In the first twenty-five years after its creation, the World Bank made only a handful of loans to European states (albeit large ones), including loans for the reconstruction of the steel industry in France, Belgium, and Luxembourg (McLellan 2003). With money in hand collected from its subscribing members, the Bank nevertheless felt an intense *pressure to lend,* and fell back to a secondary mission, that of lending to economically underdeveloped countries.

The Bank's charter contained language militating in favor of project-based lending, and in the early years most of its loans were for the finance of specific projects such as the development of mines or dams (Skogly 2001). The Bank, which experienced a failure rate of as much as 70 percent of its loans in the poorest countries (McLellan 2003), soon noticed that local conditions did not support the success of these projects. Among the factors cited by the Bank for project failure in poor countries are ineffective government, corruption, and *lack of transparency* (World Bank 1994).

To respond to these problems, the Bank began a program of so-called structural adjustment loans or SALs, which represented a movement away from its original project-based lending. SALs involve money advanced for a variety of projects and efforts, and are explicitly conditioned on the implementation of structural and economic changes by the borrowing country, including decentralization, privatization, cost-cutting, and discontinuance of tariffs and supports for its own currency.

In 2002 the Bank made $11.5 billion in loans in support of ninety-eight projects in forty countries. It currently has a total of about 1,800 projects in almost every developing country (McLellan 2003).

Evaluation

The main charge leveled against the Bank is that its ideological approach to lending actually creates the poverty it is intended to combat. Most critics focus on the SALs with their attendant mandatory conditions. Vikas Nath says that the Bank reduced many Third World nations to even greater poverty and dependence on Western aid. Countries often have to borrow from other sources to repay the Bank. Borrowing countries "gradually lost their ability to shape their own future. . . ." (McLellan 2003, p. 62). In the poorest countries, government employment arguably provides a social safety net when jobs in private industry are unavailable. Critics argue that, by forcing cuts in government employment, the Bank throws people into poverty, since the predicted growth in private employment does not materialize soon enough, or with salaries high enough, to pick up the slack.

For many years, the Bank rarely assessed the environmental or social impact of projects it funded. The Sardor Sarovar dam project in India, projected to displace 1 million people, was canceled because of local protests. The Bank admits that under its current portfolio of projects, some 26 million people have been evicted, lost land, or lost livelihoods. As a result, in the early-twenty-first century the Bank conducts environmental reviews of all projects, and lending for environmentally beneficial projects makes up 10 percent of its portfolio. (McLellan 2003).

Critics also question whether a for-profit institution can carry out a not-for-profit mission in the Third World. "The World Bank focuses on economic growth until it is distracted by other issues like hunger, women, health, the environment, etc. The World Bank tries to adapt itself to these considerations without giving up its basic goal" (Danaher 1994, p. ix).

Such critics contend that the SALs in particular lead to the repression of democratic rights in poor countries, without reducing poverty. "Structural adjustment is a policy to continue colonial trade and economic patterns developed during the colonial period.... [Third World countries] are more dependent on the ex-colonial countries than we ever were" (Danaher 2003, p. 4). Thirty out of forty-seven African governments have been in SALs for many years—yet by 1992, rather than being reduced, their external debt had more than doubled (to $290 billion) (Danaher 2003).

Shakrukh Rafi Kahn studied the impact of Bank lending in Pakistan over a twenty-year period. Though some initiatives, such as privatization of state-owned banks, were somewhat successful, he noted the greatly disproportionate impact of the Bank's SAL policies on the nation's poor: "They have been hurt many times over. Not only have they borne a disproportionate burden of the cuts in employment, cuts in subsidies and the rise in prices, but they also have started bearing more of the tax burden" (Kahn 1999, p. 120).

The Bank, in more guarded language, seems to be aware of the problems with its programs. In a publication on governance in developing countries, the Bank notes that the form of government (democratic or autocratic) is not one of its concerns. In reviewing its SALs around the world, the Bank concedes that things have not gone well in Africa: "Bank assistance to Africa is dominated by the collapse of public sector capacity in many countries, brought about by a combination of state over-extension, delayed adjustment to changed external economic circumstances, natural events, and poor governance" (World Bank 1994, p. 9). It recognizes that Western solutions to problems cannot always be transferred wholesale to countries with very different traditions. The Bank concludes "Performance in sub-Saharan Africa has been disappointing" (World Bank 1994, p. 11).

In a more overtly self-critical document, water expert George Keith Pitman (2002) argues that the Bank is poorly organized to implement its own water resources management strategy. Knowledge and leadership on water issues is seriously fragmented within the Bank's management structure, while budget cuts have eroded the knowledge function. Pitman also quotes certain nongovernmental organizations (NGOs) that believe "the pressure to lend ... has not been removed and continues to work against aspects of the water policy that recommend greater attention to smaller and cheaper alternatives" (Pitman 2002, p. 39).

The Poverty Action Lab, a Massachusetts Institute of Technology project, has begun randomized evaluations of the impact of Bank projects. Its researchers agree that success cannot be measured only by concrete achievements; assessments must include the impact of Bank projects on the lives of the poor (Dugger 2004). For example, hiring additional teachers for rural Indian schools did not improve test scores, but treating debilitating intestinal worms in Kenyan students raised attendance at a cost of only $3.50 per treated person per year.

Economists at the Poverty Action Lab say that the Bank's culture led to a certain complacency in the past, preventing the Bank from rigorously evaluating its own projects. The Bank is beginning to pay attention, organizing its own randomized studies.

Columbia professor Joseph Stiglitz believes that the Bank has been more successful than the international monetary fund in undertaking sweeping reforms of its own structure and approach: "the bank has always been less hierarchical than the IMF and more accepting of alternative views.... [by 1997] the bank had begun to seriously address the fundamental criticisms levied at it" (Stiglitz, p. 122).

Conclusion

The Bank is a well-funded, powerful Western institution with the mission of aiding developing countries. Many of its good intentions may be wasted due to its attempt to apply free market solutions in countries with very different traditions, or that are simply not ready for these approaches.

JONATHAN WALLACE

SEE ALSO *Development Ethics; Modernization; Money.*

BIBLIOGRAPHY

Danaher, Kevin, ed. (1994). *Fifty Years is Enough: The Case Against the World Bank and the I.M.F.* Boston: South End Press. A collection of essays from a left-wing and critical perspective.

Dugger, Celia. (2004). "Letter From Washington: World Bank Challenged: Are the Poor Really Helped?" *The New York Times*, July 28, p. A4.

Kahn, Shakrukh Rafi. (1999). *Do World Bank and I.M.F. Policies Work?* New York: St. Martin's Press. A study of the impact of twenty years of structural adjustment loans in Pakistan

McLellan, Elisabeth P., ed. (2003). *The World Bank: Overview and Current Issues*. New York: Nova Science Publishers. An overview of the Bank's history and impact on the third world

Pitman, George Keith. (2002). *Bridging Troubled Waters: Assessing The World Bank Water Resources Strategy*. Washington, DC: World Bank. A World Bank analyst argues that the Bank's strategy on water resources is flawed

Skogly, Sigrun. (2001). *Human Rights Obligations of the World Bank and the International Monetary Fund*. London: Cavendish Publishing. An analysis of the impact of the Bank under the International Law of Human Rights.

Stiglitz, Joseph. (2003). "Democratizing the International Monetary Fund and the World Bank: Governance and Accountability," in *Governance: An International Journal of Policy, Administration and Institutions*, 16 (1) 111–139. A defense of the World Bank as an institution responsive to its critics.

World Bank. (1994). *Governance: The World Bank's Experience*. Washington, DC: Author. The Bank's critique of the impact of its structural adjustment loans, placing some of the blame on local corruption and conditions.

WORLD COMMISSION ON THE ETHICS OF SCIENTIFIC KNOWLEDGE AND TECHNOLOGY

The World Commission on the Ethics of Scientific Knowledge and Technology (COMEST) mirrors at the international level numerous national commissions on science, technology, and ethics. In the early 1990s, the General Conference of the United Nations Educational, Scientific, and Cultural Organization (UNESCO) formally recognized that the changes wrought by science and technology raise questions that demand ethical reflection (Pompidou 2000). In 1997 it approved the creation of COMEST to institutionalize this growing awareness that ethical reflection must become an integral part of scientific research and its technological applications. COMEST and the Bioethics Programme at UNESCO comprise its Programme on the Ethics of Science and Technology, which is designed to further the mission of UNESCO to serve as the conscience of the United Nations.

In addition to advising UNESCO on its program concerning the ethics of scientific knowledge and technology, COMEST is mandated to: (a) be an intellectual forum for the exchange of ideas and experience; (b) identify the early signs of risk situations; (c) advise decision makers on such issues; and (d) promote dialogue between scientific communities, decision makers, and the general public. COMEST is composed of eighteen members and eleven ex-officio members diversified by expertise, nationality, and culture. The operating budget of COMEST for the 2002–2003 biennial was $3.8 million.

By mid-2004, COMEST had held three main sessions. The first was in Oslo in April 1999, which focused on analysis of the ethical aspects in the fields of energy and freshwater resources and the information society. The second, in Berlin in December 2001, was devoted to assessing the progress of COMEST and its influence. In addition, a youth forum on the ethics of science and technology was held and a statement about space policy developed. The third session was held in Rio de Janeiro in December 2003 with a significantly wider agenda incorporating the ethics of biotechnology and nanotechnology. In addition, the Rio de Janeiro Declaration on Ethics in Science and Technology, signed by representatives from Portugal and several countries in South America and Africa, committed the party nations to pursue ethical approaches to scientific and technological advance. The sessions were attended by policy makers, scientists, and representatives from various organizations and member nations.

Complementing these three sessions are various COMEST subcommissions and working groups. Four subcommissions have focused on the ethical aspects of freshwater resources, space policy, energy use, and the information society. These research topics were designed to follow up on the efforts of the World Conference on Science hosted by UNESCO and the International Council for Science (ICSU) held in Budapest in 1999. Working groups have addressed issues such as ethics education and ethics and responsibility in research training.

The principle outputs of the subcommissions and working groups have been a series of publications. Each report surveys an issue and highlights the ethical questions involved. The main focus is on recommendations to COMEST or other decision-making bodies regarding alternative courses of action. For example, the subcommission on the ethics of freshwater created the Research and Ethical Network Embracing Water (RENEW) to identify and endorse examples of best ethical practices of freshwater use. It also produced a report, "Some Examples of Best Ethical Practices in Water Use," that used five case studies to highlight fundamental ethical principles to guide water use policies. Other subcommissions have outlined considerations that could point the way toward more just and sustainable policies (for example Pompidou 2000, Kimmins 2001). The principle of precaution and the concepts of sustainable development and environmental responsibility underpin these recommendations.

COMEST has grown over its short history. Its budget increased 50 percent for the 2002–2003 sessions, and it has broadened its scope of topics. The global scale of COMEST provides its three main strengths. First the internationalization of ethical issues involving science and technology necessitate a global forum such as COMEST to foster communication and mediate conflicts. Its multicultural and interdisciplinary analyses have contributed to better identification of the ethical issues involved in areas such as freshwater, space, and energy. They have also detected early signs of possible risks to society and articulated guidelines for decision makers in the public and private sectors. Second its global reach allows COMEST to promote the development of ethical reflection on these issues in countries that do not have such institutions. Third the scope of COMEST allows it to formulate universal norms to guide the wise use of science and technology.

The global scale of COMEST is also a weakness because it can distance its analyses from the site-specific considerations necessary for formulating ethical policies. Invoking universal standards and ethical principles in concrete situations presents COMEST with its biggest challenge. Several subcommission reports recognize the need to tailor solutions to local conditions (Kimmins 2000). Yet this means that COMEST may be out of synch with its intended audiences and must strive to reconcile its global reach with local needs. Toward this end, COMEST must establish more objective assessments of its work in order to evaluate its efforts.

ADAM BRIGGLE

SEE ALSO *United Nations Educational, Scientific, and Cultural Organization.*

INTERNET RESOURCES

Brelet, Claudine. (2004). "Some Examples of Best Ethical Practice in Water Use." United Nations Educational, Scientific, and Cultural Organization. Available from http://portal.unesco.org/shs/en/ev.php-URL_ID=4382&URL_DO=DO_TOPIC&URL_SECTION=201.html. A 54 page report by the COMEST subcommission on the Ethics of Freshwater Use.

Kimmins, James P. (2001). "The Ethics of Energy: A Framework for Action." United Nations Educational, Scientific, and Cultural Organization. Available from http://unesdoc.unesco.org/images/0012/001235/123511eo.pdf. A 55 page report by the COMEST subcommission on the Ethics of Energy, covering the current situation of energy throughout the world and the ethical challenge of energy, with recommendations for future action.

Pompidou, Alain. (2000). "The Ethics of Space Policy." United Nations Educational, Scientific, and Cultural Organization. Available from http://portal.unesco.org/shs/en/ev.php-URL_ID=4382&URL_DO=DO_TOPIC&URL_SECTION=201.html. A 137 page report by the working group on the Ethics of Space Policy addressing ethical implications of space activities for different sociocultural contexts.

World Commission on the Ethics of Scientific Knowledge and Technology. United Nations Educational, Scientific, and Cultural Organization. Available from http://portal.unesco.org/shs/en/ev.php-URL_ID=1373&URL_DO=DO_TOPIC&URL_SECTION=201.html. Link to the COMEST page of the UNESCO web site.

WORLD HEALTH ORGANIZATION

The World Health Organization (WHO) is one of the sixteen United Nations (UN) specialized agencies, with a mission to promote world health. The organization's broad conception of health as including politicized issues such as poverty, apartheid, and environmental quality has aroused controversy over the years.

Organization and History

The WHO was conceived at the 1945 San Francisco conference at which the United Nations was formed. It came into being on April 7, 1948, after its constitution was ratified by twenty-six of the original sixty-one members. WHO is based in Geneva and has six regional offices: Africa, Europe, Southeast Asia, Americas, Eastern Mediterranean, and Western Pacific. Governance is provided by the World Health Assembly, with representatives from (as of 2005) 192 member states. The assembly selects an executive board, which in turn nominates a director general, who is elected by the assembly for a five-year term.

The original top WHO priorities in 1948 were malaria, maternal and child health, tuberculosis, venereal disease, nutrition, and environmental sanitation.

Subsidiary concerns included public health administration, parasitic and viral diseases, and mental health.

WHO is the successor to a series of international Sanitary Commissions, beginning in the nineteenth century, that concentrated on the containment of infectious diseases. Whereas the philosophy of those earlier organizations was to keep infectious diseases out of nations or regions, the philosophy of WHO was to eradicate those diseases wherever they were found, a "total change of perspective" from that of its predecessors (Beigbeder 1998, p. 13).

In the early twenty-first century WHO fields emergency teams of medical professionals who respond to the outbreak of new infectious diseases such as severe acute respiratory syndrome (SARS) and avian flu. WHO also helps member countries create or improve medical schools and services.

Concept of Health

The WHO definition of health is very broad. According to the organization's constitution, health is "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." WHO conceives of health as a fundamental human right and cornerstone of world peace.

In line with its broad definition of health, WHO has been a pioneer in environmental concerns. It was concerned as early as the 1950s about the effects of the eradication of insect species and the peaceful uses of nuclear power.

Although WHO has been most effective as a detail-oriented technical organization concentrating on medical and scientific problems such as smallpox eradication, its broad mandate has opened the door to numerous efforts to politicize it. From the beginning the WHO assembly has debated and voted on resolutions introduced by its members on political topics such as the effect on Palestinian physical and mental health of the Israeli occupation or on Nicaraguan health of U.S. sanctions. From the date Israel joined WHO the Eastern Mediterranean group always held its meetings in Arab capitals to which the Israeli delegates were not permitted to travel, effectively keeping Israel from playing a role in WHO regional activity. This situation was not resolved for more than thirty years, when Israel was invited to join the European region.

The U.S. ambassador William Scranton said in 1976 that "the absence of balance, the lack of perspective and the introduction by the World Health Organization of political issues irrelevant to the responsibilities of the World Health Organization do no credit to the United Nations" (Siddiqi 1995, p. 8).

Smallpox Eradication: A WHO Success

WHO played a lead role in one of the more dramatic medical victories of modern times: the worldwide elimination of smallpox. The organization announced its smallpox campaign in 1966 and was able to declare victory in 1979, at a cost of about $313 million. WHO acted as a clearinghouse for strategy, knowledge, and vaccine and coordinated a worldwide volunteer effort. To date smallpox is the only infectious disease that WHO or any other organization has succeeded in eradicating. Unlike malaria, one of the most visible failures of WHO, smallpox was an easier target because it is transmitted from human to human with no animal vectors, has a low rate of transmission and develops slowly, is easy to diagnose, and is easy to contain with small doses of vaccine.

Malaria: A WHO Failure

In 1955 WHO announced the ambitious goal of worldwide elimination of malaria; by 1960, sixty-five countries and territories had antimalarial programs. Those programs relied primarily on spraying the walls of houses with DDT. In 1966 WHO announced that 813 million people, 52 percent of the at-risk population, had been insulated from the disease. From 1959 to 1966 almost 11 percent of the organization's annual budget was devoted to the malaria campaign. However, things began to backslide soon afterward as malaria cases began to increase in some countries; for example, Pakistan, which had only 9,500 cases in 1968, had 10 million in 1974 (Siddiqi 1995).

By 1969 WHO recognized that the eradication program had failed. Many mosquitoes lived, bred, and bit their victims far away from the house walls that were being sprayed; some forms of shelter did not have walls; some species were becoming resistant to DDT or otherwise had changed their behavior; WHO had failed to account for population migratory patterns; and many countries did not have the infrastructure necessary to support the program. In 1969 WHO acknowledged that the eradication program did not "adequately take into account economic and social factors" in malaria-ridden countries (Siddiqi 1995, p. 163). Subsequently, WHO changed its focus from eradication to control of malaria. The disease continues to be the world's most lethal parasite-borne ailment and the second most important killer after tuberculosis in more than 190 countries inhabited by 40 percent of the world's population (Beigbeder 1998).

Despite its failure to conquer malaria, WHO has continued to attempt the worldwide eradication of infectious diseases. It vowed to eliminate polio by 2005. However, the September 11, 2001, attacks and the perceived intentions of al Qaeda to use any biological weapon available to attack the West led to renewed consideration of whether disease eradication will ever be possible (Roberts 2004).

Infant Formula: A Controversial Initiative

In December 1969 WHO began to focus on the decline in breast-feeding in Third World countries, which it believed might have been attributable to the aggressive promotion of formula substitutes. Many highly political nongovernmental organizations (NGOs) had seized on this issue as an important one, symbolic of the continuing fallout from colonialism and the exploitation of the Third World by multinational companies. In October 1979 WHO and the United Nations International Children's Emergency Fund (UNICEF) cosponsored a conference that was attended by NGOs and the formula industry. WHO, which had accepted a mandate to mediate between the opposing sides, adopted a working document that appeared to the companies to adopt many NGO grievances without citing supporting data. This led to collisions with "important commercial interests" (Beigbeder 1998, p. 76). The conference resulted in no compromises, and the NGO-industry dialogue was discontinued. WHO and UNICEF pressed on, in 1981 adopting nonbinding recommendations to member states relating to the marketing of substitutes for breast milk.

During the formula debate WHO was seen by critics as intervening in an ideological debate without citing firm scientific evidence for the proposition that babies were being harmed or killed by the use of formula instead of breast milk. WHO also was accused by the industry of disregarding social and even medical factors that contributed to the use of formula, such as its use by women with inadequate production of breast milk (Beigbeder 1998).

The Normative Role of WHO

WHO has three different modes of action under its constitution: It can adopt conventions, make regulations, or issue nonbinding recommendations. Whereas the first two actions bind its members to act, the third does not.

In practice most of the work done by WHO has been an exercise of its nonbinding recommendation power. The organization has been extremely reluctant to exercise its normative powers to make binding international law or rules. This is partly attributable to the initial reluctance of the United States to ratify the WHO charter, fearing that its actions would dictate the passage of domestic legislation: "Clearly, WHO's more influential member states have no intention to convert the Organization into a World Ministry of Health, no more than they wish to create a world government" (Beigbeder 1998, p. 15). WHO has proposed a single convention on tobacco that was never adopted. Even its nonbinding recommendations are a "starkly limited tool" (Koplow 2003, p. 143). Some commentators believe that WHO's reluctance to exercise its normative powers is a product of "organizational culture established by the conservative medical professional community that dominates the institution" (Taylor 1992, p. 303). David Koplow has noted that the WHO "has no power to enforce compliance, to mandate any particular resolution of a dispute, or to impose sanctions upon recalcitrant states" (Koplow 2003, p. 145).

Organizational Effectiveness

The organization's executive director Halfdan Mahler asked in 1987 whether WHO was to be "merely a congregation of romanticists talking big and acting small" (Beigbeder 1998, p. 191). His successor, Hiroshi Nahajima, appointed in 1988, said that "in the past, we have tended to be rigid and doctrinaire, when, in fact, the utmost flexibility is called for" (Beigbeder 1998, p. 28).

In a 1991 report the Danish government evaluated the effectiveness of WHO programs in Kenya, Nepal, Sudan, and Thailand and found "weak analytical capacity," a lack of prioritization, and failure to delegate authority (Beigbeder 1998, p. 191). Member nations often lack the resources to pay for the measures recommended by WHO or do not have the infrastructure or commitment necessary to implement them.

In the early years of the twenty-first century WHO, like other UN agencies, experienced a struggle for dominance between its First World and Third World members. While the United States continued to pay 25 percent of the organization's budget, the WHO executive board, only 42 percent of whose members came from Third World nations in 1950, by that time had an overwhelming majority of Third World representation (68 percent) (Siddiqi 1995). The United States and its allies frequently exercised behind-the-scenes influence on the outcome of WHO deliberations in a way that contradicted the apparently democratic and majoritarian structure of the organization. For example, the United States and Russia, the holders of the last publicly known smallpox stocks, were able to set WHO policy on the destruction of those stocks.

Evaluation

When it concentrates on technical cooperation, WHO sometimes has been extremely effective, as it was in eliminating smallpox from the world. However, like its sister UN agencies it has expended a large proportion of its resources and credibility in political and ideological disputes that have detracted from its technical mission.

JONATHAN WALLACE

SEE ALSO *Bioethics; Health and Disease.*

BIBLIOGRAPHY

Beigbeder, Yves. (1998). *The World Health Organization*. The Hague, Netherlands: Martinus Nijhoff.

Koplow, David A. (2003). *Smallpox: The Fight to Eradicate a Global Scourge*. Berkeley: University of California Press.

Roberts, Leslie. (2004). "Polio: The Final Assault." *Science* 303: 1960–1968.

Siddiqi, Javed. (1995). *World Health and World Politics: The World Health Organization and the United Nations System*. London: Hurst.

Taylor, Allyn Lise. (1992). "Making the WHO Work." *American Journal of Law and Medicine* XVIII(4): 101–346.

WORLD TRADE ORGANIZATION

The World Trade Organization (WTO) is the largest, most powerful international organization dealing with global rules of trade among nations. It was formed in 1995 following the so-called Uruguay Round of negotiations under the General Agreement on Tariffs and Trade (GATT), the previous multilateral trading system established in 1948. Whereas GATT was primarily concerned with trade in goods, the WTO covers trade in goods and services, banking and finance, intellectual property, dispute settlement, and trade policy reviews. The purpose of the WTO is to provide a negotiating forum for nations to form agreements to lower trade barriers to ensure that trade flows as freely, fairly, and predictably as possible. The WTO regulates trade by administering and negotiating trade agreements, resolving trade disputes, reviewing national trade policies, providing technical assistance and training programs in developing nations, and cooperating with other international organizations. All WTO trade agreements are the result of a consensus among representatives of member governments, ratified by the parliaments of the participating nations. These binding agreements guarantee nations their trade rights and responsibilities. For the 147 member nations, the WTO is the most influential institution of international commerce.

WTO Agreements and Organization

Under WTO agreements, countries should neither discriminate among their trading partners nor should they discriminate between foreign and domestic products and services. Every government should be given "most-favored-nation" status whereby any favor granted to one nation must be granted to every other nation, thus ensuring that all trade partners be treated equally. The WTO aims to make trade more free and more fair by lowering trade barriers such as customs duties (tariffs), eliminating import bans or quotas, and limiting the nontariff trade barriers that nations may implement and enforce, such as domestic laws regulating product standards and liability, environmental protections, use of tax revenues for public services, and other domestic laws regulating investment and trade. The WTO limits the nature of tariffs a nation may impose, as well as what kind of nontariff barriers to trade nations may implement and enforce. Through the WTO Dispute Settlement Process, nations can challenge each other's laws on behalf of their commercial interests if they believe barriers to trade exist. If member nations do not conform to WTO regulations they face possible economic sanctions.

Six main agreements comprise the WTO: the umbrella agreement establishing the WTO, the General Agreement on Tariffs and Trade, the General Agreement on Trade in Services (GATS), and the agreements on Trade-Related Aspects of Intellectual Property (TRIPS), Dispute Settlement, and Trade Policy Reviews. The highest authority is the Ministerial Conference, where delegates from member nations meet every two years to reach consensus on multilateral agreements. The second level of authority, responsible for decisions between Ministerial Conferences, has three branches: the Dispute Settlement Body, the Trade Policy Review Body, and the General Council. The General Council is divided into three more councils, each handling a different area of trade: the Goods Council, the Services Council, and the TRIPS Council. Numerous specialized committees and working groups work on the details of individual agreements, as well as issues relating to the environment, development, finance, and regional trade agreements. The WTO Secretariat is based in Geneva, Switzerland, headed by a director-general with limited authority. The Secretariat's main duties include providing legal and technical support to the various councils and ministerial conferences, conducting research, and performing public affairs activities.

Relation to Science and Technology

Many WTO agreements affect the science and technology laws and practices of member nations. One example is the Sanitary and Phytosanitary Measures Agreement (SPS), which sets food safety and animal and plant health standards, including quarantine, inspection, and testing requirements. The aim of the SPS agreement is to establish standards based on accepted science to allow countries to set reasonable health and safety regulations but only to the extent necessary to protect human, plant, or animal life or health. The SPS agreement prevents countries from using higher sanitary and phytosanitary measures in order to protect domestic producers. WTO members can challenge each other's food health and plant and animal safety regulations if they exceed mandated limits.

The Agreement on Technical Barriers to Trade (TBT) ensures that product standards, regulations, testing, and certification for all goods, including industrial and agricultural products, do not become obstacles to trade. The TBT agreement sets limits on the standards governments may enforce to achieve social, environmental, consumer, or public health objectives. The aim is to prevent technical regulations and industrial standards from being used for protectionism. The WTO recognizes the rights of nations to protect the environment and public welfare but not if standards give domestically produced goods an unfair advantage or so far exceed the standards of other nations that they become an obstacle to trade. The TBT agreement subjects national product standards and regulations to scrutiny under WTO Trade Policy Reviews and challenges in Dispute Settlement Court.

The Agreement on Trade-Related Aspects of Intellectual Property establishes the levels of protection governments have to give the intellectual property rights of other governments. The agreement covers copyright (including computer programs, music recordings, and film), trademarks (signs and slogans), geographical indications (place-names that indicate where a product is from and what it is, such as champagne or tequila), industrial designs (for large-scale technologies), patents (protecting products and processes lasting for twenty years), trade secrets (and other undisclosed information with commercial value), and integrated circuit layout designs. TRIPS extends intellectual property rights to include pharmaceuticals, plant varieties, human and plant cell lines, microorganisms, and genes. The agreement defines what counts as intellectual property, how governments should enforce rights, and how to settle disputes over rights between member nations.

Criticisms of the WTO

The WTO has been dogged by controversy from its inception. It continues to be on the defensive against criticism that its agreements privilege corporate interest goals over public interest goals. Critics maintain that the WTO illegitimately dictates the policies of sovereign nations, promotes free trade at any cost, and gives commercial interests priority over development, the environment, health, safety, and worker rights. They further claim that it eliminates both job security and food security, favors developed nations over underdeveloped nations, and fosters a dispute resolution process that is undemocratic and unaccountable. The WTO maintains that through lowering import tariffs and "harmonizing" the international rules of commerce trade should become more predictable, more competitive, and more beneficial for all nations, especially less-developed nations.

DAVID M. KAPLAN

SEE ALSO *Intellectual Property; Political Economy; Property.*

BIBLIOGRAPHY

Wallach, Lori, and Michelle Sforza. *Whose Trade Organization?: Corporate Globalization and the Erosion of Democracy: An Assessment of the World Trade Organization*. Washington, DC: Public Citizen, 1999.

World Trade Organization, ed. *The Legal Texts: The Results of the Uruguay Round of Multilateral Trade Negotiations*. Cambridge, UK, and New York: Cambridge University Press, 1999.

INTERNET RESOURCE

World Trade Organization Website. Available from http://www.wto.org.

WRIGHT, GEORG HENRIK VON

SEE *von Wright, Georg Henrik.*

Z

ZAMYATIN, YEVGENY IVANOVICH

Yevgeny Ivanovich Zamyatin (1884–1937), who was born in Lebedyan, Tamov district, Russia on February 1, is best known for having written *We* (1920), the archetypal anti-utopian novel. The son of a Russian Orthodox priest and a mother who had received a liberal education, he was a constant critic, siding with the Bolsheviks before the revolution and chiding the new government after their victory.

Zamyatin's critical posture was not limited to Russia. Although he was a naval architect by training, when he was in Great Britain (1916–1917) to supervise the building of Russian icebreakers, he published *The Islanders*, a satire of the English. Over the course of his career Zamyatin wrote about forty books, a few of which were quite influential in their time, but he is remembered primarily for one he could not publish. When the Soviets began to censor literature in 1922, the first manuscript banned was *We*, which then appeared in English in the United States (1924) and in Russian in Prague (1927). After 1929 Zamyatin could not publish at all at home. In 1931 at Zamyatin's request, Stalin allowed him to emigrate to Paris, where he lived, unsupported by the local Russian community, until his impoverished death on March 10.

We is the forty-record journal of D-503, an engineer supervising the building of *The Integral*, a spaceship intended to impose the philosophy of the totalitarian One State on other planets: "If they will not understand that we are bringing them a mathematically faultless happiness, our duty will be to force them to be happy" (p. 3). The fundamental contradiction between mechanism and individualism defines the novel. People are "Numbers": The higher the number, the higher the rank; there are vowels and even numbers for females, consonants and odd numbers for males. The "Lex Sexualis" states, "A Number may obtain a license to use any other Number as a sexual product" (p. 22)

Everyone lives according to a Table of Hours. All residences are made of glass. Curtains may be drawn only during Sexual Hours. Despite his role and self-conscious desire to be a good citizen, D-503 develops a soul. The first, unexamined symptom is his desire to express himself, to write the book that is before the reader. The second is a complex passion he feels for I-330, a bold woman revealed as a revolutionary who is trying to use D-503 to gain control of *The Integral* but also may have fallen in love with him.

The development of his soul subtly changes D-503's viewpoint: "As I crossed the avenue, I turned around. Here and there in the huge mass of glass penetrated by sunshine there were grayish-blue squares, opaque squares of lowered curtains, the squares of rhythmic, Taylorized happiness" (p. 41). The reference to Frederick Winslow Taylor (1856–1915), the inventor of time-motion studies and "industrial engineering," Zamyatin's high priest of dehumanizing technology, suggests why D-503 says, "Love = f(D), love is the function of death" (p. 127).

I-330 does seduce D-503, but an assistant prevents a takeover of the ship. I-330 is killed publicly, and D-503, like every other citizen of One State, undergoes a new procedure to remove the imagination, after which he concludes, with horrible happiness, "Reason must prevail" (p. 218).

Perhaps it must. In 1988, under glasnost, when the Soviet Union began to "rehabilitate" banned literature, *We* was on the very first list.

The fundamental contradiction between mechanism and individualism that Zamyatin explored has resonated ever since in discussions of science, technology, and ethics. As societies, by adopting modern science and technologies, have come to possess increasingly potent tools for individual action, those tools often have resulted in the conscious imposition or spontaneous emergence of machinelike social orders. For good and bad, after all, railroads make people run on time. This dilemma echoes through powerful and popular works ranging from Edgar Rice's play *The Adding Machine* (1923) to monitory novels such as Aldous Huxley's *Brave New World* (1932), Ayn Rand's *Anthem* (1938), George Orwell's *Nineteen Eighty-Four* (1948), and William Gibson's *Neuromancer* (1984) as well as potent sociological analyses such as Jacques Ellul's *The Technological Society* (1964) and touchstone movies such as *Blade Runner* (1982).

ERIC S. RABKIN

SEE ALSO *Science Fiction; Science, Technology, and Literature; Utopia and Dystopia.*

BIBLIOGRAPHY

Cooke, Brett. (2002). *Human Nature in Utopia: Zamyatin's* We. Evanston, IL: Northwestern University Press. A literary critical and sociobiological analysis of the meanings and place of *We*.

Richards, David John. (1962). *Zamyatin: A Soviet Heretic*. London: Bowes and Bowes.

Zamiatin, Eugene [Zamyatin, Yevgeny]. (1959 [1924]). *We*, trans. Gregory Zilboorg. New York: Dutton. (Original Russian Ms., 1920.)

Zamyatin, Evgeny [Yevgeny]. (1978 [1918]).*The Islanders*, trans. T. S. Berczynski. Ann Arbor, Michigan: Trilogy Publishers.

ZOOS

Evidence suggests that humans first domesticated animals beginning about 10,000 B.C.E., but collecting wild and exotic animals did not begin until about 3,000 B.C.E. During the next few millennia, gardens, animal collections, parks, and animal reserves grew in numbers and range. But it was not until the development of the nation-state in the sixteenth century that organized menageries, zoos, and aquaria emerged and proliferated (Kisling Jr. 2001). In the early twenty-first century visiting zoos is one of the most popular activities in many countries, yet keeping animals in zoos—particularly large mammals such as elephants and whales—raises important ethical questions that pit the interests of science and conservation against those of animal rights.

History

The first recorded examples of animal collections were found in the great civilizations of Mesopotamia, such as Assyria, Sumeria, and Babylon. Animal collections were the privilege of the wealthiest people, usually royalty, who could afford to capture or purchase, and maintain, exotic animals. Early collections often included falcons, deer, exotic birds, fish, gazelle, apes, monkeys, ostriches, lions, and elephants. Falcons and lions were often used in royal sport for hunting and fighting, and some parks and preserves were created for this very purpose (Kisling Jr. 2001). Animal collections, gardens and parks also existed in ancient Egypt, Asia, India, Greece, North and South America, and later in Europe, but continued to be a hobby enjoyed primarily by royalty.

In medieval Europe, animal collectors grew in number to include monasteries and municipalities, although collecting was still an expensive practice. As these collections grew in size during the Renaissance, particularly with the addition of exotic animals captured in the new world, they were referred to as menageries. With the onset of the industrial revolution, more people had extra spending money and leisure time in which to indulge in various interests, including the financial support of menageries. In the late-eighteenth and early-nineteenth centuries, private collections evolved into publicly supported menageries (Kisling Jr. 2001). The shift from menagerie to *zoological garden*, or simply zoo, also occurred in the early-nineteenth century. In 1825 the Zoological Society of London suggested creating a zoological garden in which living animals with "their nature, properties and habits may be studied" (Kisling Jr. 2001, p 37), indicating a shift to a more scientifically grounded purpose in collecting animals.

Human knowledge of animal husbandry has improved significantly since the mid-1800s. In early zoos it was not uncommon to see animals kept in small cages with dirt or concrete floors and in generally poor conditions. Twenty-first century zoos are more sensitive to the needs of the animals, and many animals are housed in naturalistic habitats that simulate the animal's original ecosystem. Zookeepers also recognize the importance of mentally stimulating larger mammals through various enrichment activities in order to keep them alert and healthy. Large animal parks in which animals roam freely have also become increasingly popular.

Ethical Issues

Proponents of keeping animals in zoos claim that there is much to be gained in terms of science, conservation, and even the long term welfare of the animals themselves. In some zoos, extensive research is undertaken in the fields of zoology, biology, animal behavior, and veterinary medicine, providing valuable information that is useful in a variety of milieus (Bostock 1993). Many endangered species are bred through intricately designed captive breeding programs, in accordance with species survival plans to ensure the genetic diversity, and thus survivability, of the species. The successful captive breeding program of the highly endangered California condor by the San Diego Zoo produced enough animals that many were released back into the wild. Some zoos have also evolved from simple purveyors of facts about individual animals into educators, describing the ecosystems, environmental concerns, and policy issues surrounding the animal, thus attempting to provide a more complete learning experience to the public. Indeed up until the recent proliferation of cable TV programs dedicated to animals, visiting the zoo was often the public's first exposure to, and education about, exotic animals and related conservation issues. Educating the public, many supporters believe, is crucial for raising awareness of critical conservation and preservation issues. Finally proponents point to the fact that many zoo animals live longer in captivity than their wild counterparts, suggesting that zoos are actually beneficial to the animals themselves (Bostock 1993).

Opponents of zoos contest the claims that the animals are well-treated. Despite significant improvements in zoo-keeping practices, many zoos around the world still display animals in small cages and in sterile environments. Even in the United States, many animals are not provided the minimum standards required by the American Zoo and Aquarium Association (AZA). According to the Humane Society of the United States, only about 10 percent of more than 2,000 animal exhibitors licensed by the U.S. Department of Agriculture (USDA) are approved by the AZA, which has high standards for animal care. Opponents also doubt the legitimacy of scientific research, suggesting that such research is in fact not that common, and that most is geared solely toward the management of captive animals and cannot be extrapolated to wild populations (Hancocks 2001). Questions also arise concerning conservation efforts in zoos. For example, is the purpose of conservation to preserve genes, individual animals, entire populations, or ecosystems? And which species should be selected for captive breeding programs? Still others argue that there is much to be done in terms of educating the public, in that zoos tend to perpetuate an overly simplistic, dominionistic, if not positivistic, view of the natural world. The result is that zoos tend to ignore smaller yet more populous animals in favor of charismatic megafauna that most visitors find more interesting (Hancocks 2001).

Philosopher Dale Jamieson, in his now famous, and controversial, essay, "Against Zoos," argues that even if there are some benefits to zoos, there is an overwhelming ethical reason for not having them, namely the rights inherent in each animal to live freely and to develop its own potential. Furthermore he contends that capturing wild animals for the hungry zoo market often leads to the death of many other animals, often the mothers or adult males who protect the young. While zoo supporter Stephen Bostock agrees that capturing wild animals is one of zoo keeping's weaknesses, even calling for a ban on the trading and capturing of wild animals, he disagrees with the notion that only wild animals can live freely. Freedom, he suggests, describes an environment in which most of the animals' needs are cared for, and well-managed zoos can do just that.

As a result of the continued professionalization of zoos and zoo keeping, several international associations have developed codes of ethics by which member zoos must abide. Ethical standards focus on everything from minimum standards of animal care, responsibility to the animals, species survival plans, commitment to biodiversity and conservation efforts, and professional conduct. Member zoos found in violation of ethical standards face sanctions or dismissal from the association. Many ethical discussions regarding zoos will likely continue, but some claim that debating whether or not zoos should exist at all is one that should end. David Hancocks explains that zoos are here to stay, and that human energy should focus on how to improve them, and to develop a new relationship with animals and nature (2001).

ELIZABETH C. MCNIE

SEE ALSO *Animal Rights; Animal Welfare; Bioethics; Colonialism and Postcolonialism; Modernization.*

BIBLIOGRAPHY

Bostock, Stephen St. C. (1993). *Zoos and Animal Rights: The Ethics of Keeping Animals*. London: Routledge. Bostock makes a strong argument in favor of zoos and of their scientific, environmental, and societal benefits.

Hancocks, David. (2001). *A Different Nature: The Paradoxical World of Zoos and Their Uncertain Future*. Berkeley: University of California Press. Hancocks makes convincing suggestions regarding the need to change the goals of zoos and the way zoos are managed.

Jamieson, Dale. (1985). "Against Zoos." In *In Defense of Animals*, ed. Peter Singer. Oxford: Basic Blackwell.

Kisling Jr., Vernon N. (2001). "Ancient Collections and Menageries." In *Zoo and Aquarium History: Ancient Animal Collections to Zoological Gardens*, ed. Vernon N. Kisling Jr. Boca Raton, FL: CRC Press. This edition provides an excellent history of zoos and aquaria around the world.

Norton, Bryan G.; Michael Hutchins; Elizabeth F. Stevens; and Terry L. Maple, eds. (1995). *Ethics on the Ark: Zoos, Animal Welfare, and Wildlife Conservation*. Washington, DC: Smithsonian Institution Press. This book, published in cooperation with the AZA, includes chapters by many of the important authors on all sides of the ethics of zoos, animals, and conservation and is an excellent resource. Part of the Zoo and Aquarium Biology and Conservation Series.

INTERNET RESOURCES

American Zoo and Aquarian Association. "AZA Code of Professional Ethics." Available from http://www.aza.org/AboutAZA/CodeEthics/.

European Association of Zoos and Aquaria. "Code of Ethics." Available from http://www.eaza.net/info/2ethics.html.

Human Society of the United States. "Zoos." Available at http://www.hsus.org/wildlife/issues_facing_wildlife/zoos/.

South East Asian Zoos Association. "SEAZA Code of Ethics." Available from http://www.seaza.org/CommitteeWelfare.html.

APPENDIX CONTENTS

The *Encyclopedia of Science, Technology, and Ethics* includes five appendices designed to provide supporting materials for individual articles and further resources for readers.

APPENDIX I

SELECTIVE, ANNOTATED, GENERAL BIBLIOGRAPHY ON SCIENCE, TECHNOLOGY, AND ETHICS

This selected bibliography emphasizes works in English and in print during the early 2000s that are also accessible to the generally educated reader. The goal is to provide an introduction to some of the most useful efforts to lay out arguments relevant to science, technology, and ethics. Arguments may focus on science and technology as a whole or on some specific aspect of the science, technology, and ethics interaction.

The bibliography is divided into six sections:

1. Reference Works
2. Monographs and Edited Volumes: General Implications
3. Monographs and Edited Volumes: Specialized Approaches
4. Textbooks
5. Twentieth and Twenty-First Century Ethics
6. Journals

Reference works are alphabetized by title, and include a few items of marginal value, if only to steer readers away from some materials that might otherwise attract attention. Monographs and edited volumes are divided into those of a general orientation and those focused more on specific sciences or technologies. Some specific approaches that nevertheless have broader implications as well as textbooks that transcend the genre are included in the section on general monographs. This section thus constitutes the core resources in the bibliography. Supplementing these core sections is another of selected works on ethics that indicate the background traditions of reflection brought to bear on science and technology from the early twentieth century.

Like reference works, journals are alphabetized by title. All other works are alphabetized by author or editor. Multiple works by the same author are arranged chronologically by date of publication.

1. Reference Works

Applied Ethics: Critical Concepts in Philosophy. Ruth Chadwick and Doris Schroeder, eds. 6 vols. London: Routledge, 2002. Vol. 1 deals with the nature and scope of applied ethics. Vols. 2 and 3 focus on ethical issues in medicine, technology, and the life sciences. Vol. 4 is dedicated to environmental issues. Vol. 5 is on business and economics. Vol. 6 is on politics. Collects and reprints a large number of influential articles from the last half of the twentieth century. Each volume includes an introduction summarizing the historical context and trends.

The Blackwell Guide to the Philosophy of Computing and Information. Luciano Floridi, ed. Malden, MA: Blackwell, 2004. Twenty-six articles. Most directly relevant are those on "Computer Ethics," "Computer-mediated Communication and Human-Computer Interaction," "Internet Culture," "The Philosophy of AI and Its Critique," "Virtual Reality," and "Philosophy of Information Technology."

A *Companion to Environmental Philosophy*. Dale Jamieson, ed. Oxford: Blackwell Publishers, 2003. Pp. xvi, 531. Collects a preface and thirty-six essays arranged in four parts: cultural traditions, contemporary environmental ethics, environmental philosophy and its neighbors (e.g., literature, aesthetics, history, ecology, politics, and law), and problems in environmental philosophy.

A Companion to Ethics. Peter Singer, ed. Cambridge, MA: Blackwell, 1991. Pp. xxii, 565. Forty-seven chapters highlighting origins of ethics, major traditions, the Western philosophical tradition, basic theories of obligation, applied ethics (poverty, environmentalism, euthanasia, abortion, sex, personal relationships, equality, animals, business, crime and punishment, politics, and war), arguments concerning the nature of ethics (realism, intuitionism, naturalism, etc.), and challenges (feminism, evolution, Marxism, etc.). Although neither "science" nor "technology" appear in either the table of contents or the index, this provides useful background material for discussions in science, technology, and ethics.

A Companion to Genethics. Justine Burley and John Harris, eds. Oxford: Blackwell, 2002. A comprehensive look at the philosophical, ethical, social and political dimensions of developments in human genetics.

The Concise Encyclopedia of the Ethics of New Technologies. Ruth Chadwick, ed. San Diego: Academic Press, 2001. A selective examination of several contemporary technologies and the ethical dilemmas they present along with examples of frameworks for their assessment like environmental impact statements and different ethical theories. Arranged as 37 articles each with an outline, glossary, defining statement, and bibliography. A repackaging of selected articles from the 4-vol. *Encyclopedia of Applied Ethics*.

Encyclopedia of Applied Ethics. Ruth Chadwick, ed. 4 vols. San Diego: Academic Press, 1998. A major synthetic and informative reference work. Two hundred eighty one articles (averaging 5000 to 10,000 words) covering theories, concepts, and ethics related to medicine, science, the environment, law, education, politics, business, the media, social services, and social interactions. Two relevant spin-off collections are *The Concise Encyclopedia of the Ethics of New Technologies* (2001) and *The Concise Encyclopedia of Ethics in Politics and the Media* (2001).

Encyclopedia of Bioethics. Warren Reich, ed. First edition, 4 vols. New York: Macmillan Reference, 1978. Second edition, 5 vols. New York: Macmillan Reference, 1995. Third edition, 5 vols., Stephen G. Post, ed. New York: Macmillan, 2004. A model of scholarship and influence.

Encyclopedia of Ethical, Legal, and Policy Issues in Biotechnology. Thomas H. Murray and Maxwell J. Mehlman, eds. 2 vols. New York: John Wiley, 2000.

Encyclopedia of Ethics in Science and Technology. Nigel Barber. New York: Facts on File, 2002. A one-person product. Slightly better than Newton's *Social Issues* volume below, but similar.

Encyclopedia of Twentieth-Century Technology. Colin A. Hempstead, ed. 2 vols. New York: Routledge. Approximately 400 articles by about 175 authors. The focus is on technical descriptions, but there are a few articles on "Technology and Ethics" and related topics.

The Facts on File Encyclopedia of Science, Technology, and Society. Rudi Volti, ed. 3 vols. New York: Facts on File, 1999. Approximately 900 well crafted articles by 95 contributors, the majority of whom are historians of science and technology. Although the preface describes the focus as society as much as science or technology, the work is better or technical than social dimensions. There are no articles, for instance, on ethics, which is not even an indexed term.

Handbook of Science and Technology Studies. Jasanoff, Sheila, Gerald E. Markle, James C. Petersen, and Trevor Pinch, eds. Thousand Oaks, CA: Sage, 2004.

Science, Technology, and Society: An Encyclopedia. Sal Restivo, ed. New York: Oxford University Press, 2005.

Social Issues in Science and Technology: An Encyclopedia. David E. Newton. Santa Barbara, CA: ABC-CLIO, 1999. Approximately 350 entries, mostly 500–1000 words each. A one-person product of relatively high quality. Paperback version titled *From Global Warming to Dolly the Sheep: An Encyclopedia of Social Issues in Science and Technology*.

2. Monographs and Edited Volumes: General

Alcon, Paul A. *Practical Ethics for a Technological World*. Upper Saddle River, NJ: Prentice Hall, 2001. Pp. xiv, 239. Aims to be a guide to ethical decision making in the technological world; works back and forth to explore ethics and technology and their mutual interactions. Naive and weakly spiritual in orientation.

Allen, Anita L. *The New Ethics: A Guided Tour of the Twenty-First Century Moral Landscape*. New York: Miramax Books, 2004. Pp. xxxviii, 322. Overviews the contemporary ethical landscape focusing on widespread unethical behavior (e.g., lying, cheating, and corruption), new moral challenges presented by science, technology, and medicine, and complacency and apathy. Discusses ways to improve ethical behavior at work and in education. Concludes with sections on choosing well (e.g., consumption, family, and dying) and justice in multi-cultural societies.

Barbour, Ian. *Ethics in an Age of Technology*. San Francisco: Harper, 1993. Pp. xix, 312. An extended analysis of divergent ethical views of technology focusing on the values of justice, participation, and development. Considers case studies in agriculture, energy, genetic engineering, and computers. Argues in defense of environmental sustainability, appropriate technologies, and personal responsibility for promoting progressive change through education, political action, and the pursuit of alternative visions of the good life.

Barbour, Ian. *Religion and Science: Historical and Contemporary Issues*. San Francisco: Harper, 1997. Pp. xv, 368. This is a revised and expanded edition of *Religion in an Age of Science* (1990). Gives a broad overview of historical interactions between religion and science, and develops a typology of four ways of interacting: conflict, independence, dialogue, and integration. Defends dialogue and integration in both method and substantive forms of knowledge.

Bird, Stephanie, J., and Raymond Spier, eds. "The Role of Scientific Societies in Promoting Research Integrity." Theme issue, *Science and Engineering Ethics*, vol. 9, no. 2, April 2003. Pp. 158. Fourteen papers on the role professional scientific societies in promoting and implementing guidelines for research ethics. Includes examples, recommendations for further work, and strategies for evaluating existing programs.

Borgmann, Albert. *Holding On to Reality: The Nature of Information at the Turn of the Millennium*. Chicago, IL: The University of Chicago Press, 1999. Pp. 274. Explores, philosophically and historically, the relationship between things and signs, or reality and information, especially the rise of information as reality. Articulates and advocates a theoretical and ethical balance of signs and things that holds onto reality by averting a slide into hyperreality.

Borgmann, Albert. *Technology and the Character of Contemporary Life: A Philosophical Inquiry*. Chicago: University of Chicago Press, 1984. Borgmann's most general argument for a distinction between technological devices and focal things, each of which influences the development of different patterns of human behavior.

Borgmann, Albert. *Crossing the Postmodern Divide*. Chicago: University of Chicago Press, 1992. Pp. 173. A lucid and concise description of deep contemporary cultural challenges that traces them back to foundational thinkers in modern Western philosophy (e.g., Descartes) and presents a way forward that avoids the dehumanizing extremes of "hyperreality."

Buchanan, Richard, and Margolin, Victor eds. *Discovering Design: Explorations in Design Studies*. Chicago: University of Chicago Press, 1995. Pp. xxvi, 254. Includes the article "Prometheus of the Everyday: The Ecology of the Artificial and the Designer's Responsibility" by Ezio Manzini.

Callahan, Daniel. *The Tyranny of Survival: And Other Pathologies of Civilized Life*. New York, NY: Macmillan, 1973. Pp. xv, 284. Reprinted, University Press of America, 1985. Argues for a more realistic and sustainable aspiration than the quest for endless technological progress and unbounded individual freedom. Uses population growth and genetic technologies to illuminate technological change and argue for limiting technological excess and cultural hubris.

Callahan, Daniel. *What Kind of Life: The Limits of Medical Progress*. New York: Simon and Schuster, 1990. Pp. 318. Takes a synoptic view and argues that deep premises about health, illness, and life are fundamentally flawed and lead to insatiable expectations for healthier, longer lives that cannot be satisfied and that drive under-performing and increasingly expensive health care systems. Offers a new way to think of health that could help devise a more reasonable and just health care system that balances worthy aspirations with necessary limits.

Callahan, Daniel. *Setting Limits: Medical Goals in an Aging Society*. Washington, D.C.: Georgetown University Press, 1995. Pp. 272. Explores the shadows of medical progress and the attendant new ways of thinking about health, life, and aging (e.g., old age is to be overcome with the use of science and technology). Addresses such questions as the proper ends of medicine, what the young owe the old, the allocation of resources to the elderly, and care of the elderly dying. Seeks to stimulate a discussion on the future of health care for the aged and proposes a different way of understanding this issue. Concludes with responses to critics.

Callahan, Daniel. *The Troubled Dream of Life: In Search of a Peaceful Death*. Washington, D.C.: Georgetown University Press, 2000. Pp. 255. Integrates legal and policy issues of death and dying with deep philosophical questions about the meaning of death and its relation to self. Argues that many problems in the care of the dying, both in public attitudes and medical progress stem from mistaken views of death. Seeks to foster a common view of death by treating foundational issues rather than specific law or policy questions.

Callahan, Daniel. *What Price Better Health? Hazards of the Research Imperative*. Berkeley: University of California Press, 2003. Pp. xii, 329. Centered on the concept of the research imperative in medicine, which is a complex topic that refers to the inherent momentum of research and the view that the importance of research could trump moral values. Argues it is primarily a cultural (as opposed to a property inherent in the research community) problem that fuels most of the "shadows" or hazards of medical research. Chapters consider several issues including research as a moral obligation, enhancement, risks and benefits, human subjects research, and a distinction between doing good and doing well.

Collins, Harry, and Trevor Pinch. *The Golem: What You Should Know about Science*. 2nd ed. New York: Cambridge University Press, 1998. Pp. xix, 192. Directed to a general audience. Argues that science is akin to a clumsy and dangerous yet potentially helpful creature. Presents the actual workings of science to show that the authorization of knowledge claims is a political, complex, and messy process of persuasion that produces many controversies. Includes a description of the "experimenter's regress." Collects an introduction, conclusion, and seven case studies on the production and negotiation of new scientific knowledge, including experiments on relativity, the chemical transfer of memory, and solar neutrinos.

Collins, Harry, and Trevor Pinch. *The Golem At Large: What You Should Know About Technology*. New York: Cambridge University Press. 1998. Pp. xi, 163. Continues the social constructivist argument applied to technology.

Committee on Science, Engineering, and Public Policy (US). Panel on Scientific Responsibility and the Conduct of Research. *Responsible Science: Ensuring the Integrity of the Research Process*. 2 vols. Washington D.C.: National Academy Press, 1992 and 1993. Pp. xxiii, 199 (each vol.). Authorized by the National Research Council (whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine). Reviews factors affecting the integrity of science and the research process in the US and institutional mechanisms for addressing allegations of misconduct. Recommends steps for reinforcing responsible research practices.

Ellul, Jacques. *The Technological Society*. Trans. John Wilkinson. New York: Knopf, 1964. Pp. xxxvi, 449, xiv. A classic examination of the social and moral consequences of the domination of "technique," or the totality of methods driven by the urge to absolute efficiency. Provides an historical overview and analyses of technique and the economy and state. Features a chapter titled "The Characterology of Technique," which argues that modern technique is fundamentally new due to its pervasiveness, connection to modern science, large scale, "automatism," and "self-augmentation."

Federman, Daniel, Kathi E. Hanna, and Laura Lyman Rodriguez, eds. *Responsible Research: A Systems Approach to Protecting Research Participants*. Washington, DC: National Academies Press, 2002. Pp. xix, 290. An Institute of Medicine report commissioned by the Secretary of the Department of Health that offers a comprehensive review of the present system for protecting human participants and suggestions for strengthening it. Recommends gathering data and taking a diversity of approaches to maximize the protection of individuals participating in research. Emphasizes a systematic approach and the importance of institutional cultures, training, improved informed consent, and improved research review procedures.

Feenberg, Andrew. *Critical Theory of Technology*. New York: Oxford University Press, 1991. Pp. xi, 235. Updates critical social theory for a high-tech world.

Feenberg, Andrew. *Alternative Modernity: The Technical Turn in Philosophy and Social Theory*. Berkeley: University of California Press, 1995. Pp. xi, 251.

Feenberg, Andrew. *Questioning Technology*. New York, NY: Routledge, 1999. Pp. xvii, 243. A philosophy of technology that critiques essentialism and shows the centrality of technological design to modern society and democratic politics. Proceeds in three parts: the politicizing of technology, democratic rationalization, and technology and modernity.

Feenberg, Andrew, and Alastair Hannay, eds. *Technology and the Politics of Knowledge*. Bloomington: Indiana University Press, 1995. Collects 16 articles by Steven Vogel, Robert B. Pippin, Langdon Winner, Albert Borgmann, Hubert L. Dreyfus, Terry Winograd, Tom Rockmore, Don Ihde, Yaron Ezrahi, Donna Haraway, Helen Longino, Marcel Hénaff, Pieter Tijmes, Paul Dumouchel, and Bruno Latour.

Florman, Samuel C. *The Existential Pleasures of Engineering*. 2nd ed. New York, NY: St. Martin's Press, 1994 (1st edition, 1976). Pp. xviii, 205. Inquires into the nature of the contemporary engineering experience. Views it as vital and alive, something to be celebrated as a response to deep human impulses, and as a source of sensual and spiritual reward.

Fox, Warwick, ed. *Ethics and the Built Environment*. London: Routledge, 2000. Pp. xv, 240. Seeks a critical mass of ideas to initiate a field of study to rectify envir-

onmental ethics traditional disregard of the built environment. Collects seventeen essays arranged into three sections: the green imperative, building with greater sensitivity to people and places, and toward a theory of ethics of the built environment.

Fukuyama, Francis. *Our Posthuman Future: Consequences of the Biotechnology Revolution*. New York: Farrar, Straus, and Giroux, 2002. Pp. xiii, 256. Examines the some techniques and ethical issues, develops an understanding of natural human rights, and concludes with comments on the regulation of biotechnology and recommended policies for the future. Creates a taxonomy of concerns and argues that the greatest reasons to worry about biotechnology are not utilitarian but that the human essence will somehow be lost. Argues for greater political control over the uses of science and technology.

Fuller, Steve. *The Governance of Science: Ideology and the Future of the Open Society*. Buckingham, PA: Open University Press, 2000. Pp. xii, 167. Rejects communitarian and liberal ideologies of science in favor of a republican approach centered on the right to be wrong. Argues that the scaling up of science threatens this ideal and focuses on the challenges of multiculturalism and capitalism for the university as a republic of science. Proposes a new social contract for science.

Goujon, P., and Bertrand Heriard Dubreuil, eds. *Technology and Ethics: A European Quest for Responsible Engineering*. Leuven, Belgium: Peeters, 2001. Pp. xx, 616. Collects 37 essays in three sections as part of the core materials project for the development of courses in professional ethics, in order to serve as a European engineering ethics handbook. The three main sections consider the ethics of industrial engineers, institutional responsibility, and the social and political policy implications. Includes contributions by humanists, social scientists, and engineers.

Guston, David H. *Between Politics and Science: Assuring the Integrity and Productivity of Research*. New York, NY: Cambridge University Press, 2000. Pp. xvii, 213. Examines the deterioration of the post-World War II assumption in U.S. science policy that integrity and productivity were the automatic products of unfettered scientific inquiry. Shows how "boundary organizations" have developed since the 1980s to rebuild and maintain trust between politics and science. Shows the attention to detail necessary for designing such institutions to be effective.

Habermas, Jürgen. *Technik und Wissenschaft als ''Ideologie.''* [Technology and Science as "Ideology"]. Frankfurt am Main: Suhrkamp, 1968. Pp. 169.

Habermas, Jürgen. *The Future of Human Nature*. Oxford: Polity Press, 2003. Pp. 127, viii. Asks if there are post-metaphysical answers to the question: what is the good life? Expands this question beyond personal ethics to the questions of a species ethic posed by genetic technologies where a novel kind of self transformation poses the dilemma that the "ethical understanding of language-using agents is at stake *in its entirety*." Concludes with a postscript and a reflection on faith and knowledge.

Harris, Charles E., Michael S. Pritchard, and Michael J. Rabins. *Engineering Ethics: Concepts and Cases*. 3rd ed. Belmont, CA: Wadsworth, 2005. Pp. xvii, 390. (1st ed., 1995). Analyzes the field of engineering ethics through ethical problem-solving strategies, generic topics of concern such as responsibility, honesty, and risk, and special topics such as professional societies, the environment, and international engineering contexts. Designed for classroom use, it includes case studies and an interactive CD-ROM.

Heidegger, Martin. *The Question Concerning Technology and Other Essays*. Trans. William Lovitt. New York: Harper and Row, 1977. Pp. xi, 182. A classic work in the philosophy of technology, argues that modern technology is more than merely instrumental means to ends, but rather it is a "challenging revealing" that hides Being and presents the world as a standing reserve of objects ready to hand. An ontological account of technology's fundamental impact on human experience.

Hickman, Larry A. *Philosophical Tools for Technological Culture: Putting Pragmatism to Work*. Bloomington: Indiana University Press, 2001. Pp. xi, 215. Argues that philosophy has a productive role to play as reformer and critic of technological culture between post-modern decontstructionism and the ancient practice of grand system building. Draws inspiration from John Dewey to develop a kind of philosophy called "productive pragmatism." Takes up several issues including education, expertise, art, community, and responsibility.

Hughes, Thomas P. *Human-Built World: How to Think About Technology and Culture*. Chicago: University of Chicago Press, 2004. Pp. xii, 223. An extended bibliographic essay on the history of technology and its various interpretations across time. Draws primarily from literature, art, and architecture to trace the transformation in meanings of technology from the second creation to machine to systems, controls, and information, to culture. Concludes with comments on creating an ecotechnology.

Ihde, Don. *Technology and Lifeworld: From Garden to Earth*. A phenomenological analysis of human-technology relations that suggests the emergence of a new kind of ethical relationship between humans and the world.

Institute of Medicine National Research Council. *Integrity in Scientific Research: Creating an Environment that Promotes Responsible Conduct*. Washington, DC: The National Academies Press, 2002. Pp. xiv, 202. A report issued by the Institute of Medicine Committee on Assessing Integrity in Research Environments that defines the desired outcomes in research integrity and the teaching of research ethics and provides a set of initiatives to enhance integrity in research. Also considers methods for assessing those initiatives.

Johnson, Deborah G., ed. *Ethical Issues in Engineering*. Englewood Cliffs, NJ: Prentice Hall, 1991. Pp. viii, 392. Collects 32 articles providing historical and social context of engineering ethics, analyses of professional codes, and discussions of responsibilities to society, company loyalty, and obligations to clients.

Johnson, Deborah G. *Computer Ethics*. 3rd ed. Upper Saddle River, NJ: Prentice-Hall, 2001. Pp. xvi, 240. (1st ed. 1985; 2nd ed. 1994). Articulates the field of computer ethics with a focus on the core issues of professional ethics, privacy, property, accountability, and social implications and values. Includes two chapters on ethics and the internet. Each chapter includes short case studies, analysis, study questions, and suggested readings.

Jonas, Hans. *The Imperative of Responsibility: In Search of an Ethics for the Technological Age*. Trans. Hans Jonas and David Herr. Chicago: University of Chicago Press, 1984. Pp. xii, 255. (Originally published as *Das Prinzip Verantwortung: Versuch einer Ethik fuer die technologische Zivilisation*. Frankfurt am Main: Insel Verlag, 1979; and *Macht oder Ohnmacht der Subjektivitaet? Das Leib-Seele-Problem im Vorfeld des Prinzips Verantwortung*. Frankfurt am Main: Insel Verlag, 1981.) Rethinks the foundations of ethics in light of modern technology by developing a metaphysical theory of responsibility that takes account of the extended time and space horizons affected by technological action. Also introduces a philosophy of nature to bridge the chasm between "is" and "ought" and develops a "heuristics of fear" to counter the dangers of utopianism. Jonas' goal is to develop an ethics of responsibility capable of saving humanity from the excesses of its own Promethean power.

Jonas, Hans. *Mortality and Morality: A Search for the Good after Auschwitz*. Ed. Lawrence Vogel. Evanston, IL: Northwestern University Press, 1996. Pp. xi, 218. Considered the consummation of Jonas' quest to critique nihilism and develop an ethic capable of limiting the powers of modern technology. Jonas grounds an imperative of responsibility in the phenomenon of life and speculates on theology and faith after the Holocaust. Includes an introduction by Lawrence Vogel that provides philosophical and historical context.

Kass, Leon. *Life, Liberty, and the Defense of Dignity: The Challenge for Bioethics*. San Francisco: Encounter, 2002. Pp. 313. Argues that there is more to biotechnology than saving life and avoiding death, namely, the preservation of human dignity and human nature. Claims that this is a peculiar challenge for modern liberal democracies where the dangers lie close to cherished principles, especially individual freedom, equality, and social progress. Traces the root of the dangers to modern scientific, especially biological, thought.

Keulartz, Jozef, Michiel Korthals, Maartje Schermer, and Tsjalling Swierstra, eds. *Pragmatist Ethics for a Technological Culture*. Norwell, MA: Kluwer Academic Publishers, 2002. Pp. xxvi, 264. Argues that pragmatism can serve as a solid way to cope with questions of technology and human values. Includes twenty chapters arranged into prologue, epilogue, and sections on technology and ethics, the status of pragmatism, pragmatism and practices, and discourse ethics and deliberative democracy.

Kitcher, Philip. *Science, Truth, and Democracy*. Oxford: Oxford University Press, 2001. Pp. xiii, 219. Argues that epistemic values do not stand apart from or above other values and practical interests. This requires a new ideal of science beyond the neat separation of science from society. This ideal is labeled "well-ordered" science, which is set in a democratic framework that takes the proper notion of scientific significance to be that which would emerge from ideal deliberation among ideal agents. Then considers problems posed by lapses from the ideal and responsibilities of those who work on projects that conflict with the ideal.

Latour, Bruno. *Science in Action: How to Follow Scientists and Engineers through Society*. Cambridge, MA: Harvard University Press, 1987. Pp. 274. A classic anthropological study of the actual workings of science (rather than theoretical accounts of those workings or deference to a "black box" account) to understand how hypotheses become accepted facts. Emphasizes the importance of interpersonal interactions and rhetoric in both the literature and laboratory for the making of

science. Furthered the social construction of science movement begun by Thomas Kuhn.

Latour, Bruno. *Politics of Nature: How to Bring the Sciences into Democracy*. Cambridge, MA: Harvard University Press, 2004. Pp. x, 307. Argues for an end to the dichotomy between nature and society and offers a new conceptual context for understanding political ecology and its promise to advance democracy that accounts for humans and non-humans as citizens. Claims that our conception of science is important both for our understanding of nature and politics.

Lightman, Alan, Daniel Sarewitz, and Christina Desser, eds. *Living with the Genie: Essays on Technology and the Quest for Human Mastery*. Washington, DC: Island Press, 2003. Pp. viii, 347. Examines the contrast between the rapid pace of technological change and the enduring core of humanness within the overarching argument that science and technology are the result of decisions and are thus fundamentally about voice and the allocation of power in democratic societies and the global economy. Collects a general introduction and sixteen essays that address topics at the interface of values, science, and technology such as artificial intelligence, HVAC systems, disability, death, happiness, and property rights.

Lowrance, William W. *Modern Science and Human Values*. New York, NY: Oxford University Press, 1985. Pp. xiv, 250. Examines how technical progress and expertise influence and are influenced by other parts of society. Argues that a more nuanced understanding of science, technology, and values is necessary for more effectively putting science and technology into the service of society. Themes include facts and values, expertise, decision-making, and science and technology in the polis.

McKibben, Bill. *Enough: Staying Human in an Engineered Age*. New York: Times Books, 2003. Pp. xiii, 271. Argues that aggressively pursuing certain new technologies (genetic engineering, robotics, and nanotechnology) will lead to a post-human era that impoverishes the meaning of being human. Explores how the technologies work and how to control them. Asks the central questions of whether people in the West lead sufficiently comfortable lives with sufficient technology now and whether controlling technologies is possible at all.

Melzer, Arthur M., Jerry Weinberger, and M. Richard Zinman, eds. *Technology in the Western Political Tradition*. Ithaca, NY: Cornell University Press, 1993. Pp. xv, 333. Presents a preface, introduction, and twelve essays that address the political character and implications of technology from classical antiquity through the nineteenth century and the meanings of technology for contemporary political life. An introduction by Leon Kass establishes "the problem of technology" as it provokes questions of human happiness at the same time that it undercuts the validity of answers to those questions. This leads to a need to rediscover the nontechnological conception of liberty and dignity in liberal democracies.

Mitcham, Carl, and Robert Mackey, eds. *Philosophy and Technology: Readings in the Philosophical Problems of Technology*. New York: Free Press, 1972. Paperback edition, 1983. Pp. xii, 403. A collection of 26 articles, some originally translated, that has remained in print for more than 30 years. The sections on "Ethical and Political Critiques," "Religious Critiques," and "Two Existentialist Critiques" are the most relevant.

National Academy of Engineering. *Emerging Technologies and Ethical Issues in Engineering*. Washington, D.C.: The National Academies Press, 2004. Pp. x, 155. Result of an NAE conference. Includes a keynote address by William A. Wulf and nine essays in three sections: emerging technologies, state of the art in engineering ethics, and ethics in engineering education.

National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. *Responsible Science: Ensuring the Integrity of the Research Process*. Vol 1. Washington, DC: National Academy Press, 1992. Pp. xxiii, 1999. Result of a panel discussion to review factors affecting the integrity of research and recommend steps for reinforcing responsible research practices. Also reviews institutional mechanisms for addressing allegations of misconduct and considers the advantages and disadvantages of formal guidelines for the conduct of research.

National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. *Responsible Science: Ensuring the Integrity of the Research Process*. Vol 2. Washington, DC: National Academy Press, 1993. Pp. xi, 275. See above for background. This volume includes background papers, samples of guidelines for the conduct of research, scientific research policies and practices, and policies and procedures for handling allegations of misconduct.

Postman, Neil. *Technopoly: The Surrender of Culture to Technology*. New York: Knopf, 1992. Pp. xii, 222. A broad-brush criticism of technological culture that updates arguments from the 1960s and 1970s.

President's Council on Bioethics. *Beyond Therapy: Biotechnology and the Pursuit of Happiness, A Report of the*

President's Council on Bioethics. New York: Regan Books, 2003. Pp. xiii, 328. A report by the U.S. bioethics commission with a foreword by its Chair, Leon Kass. Explores the ethical and social implications of using biotechnology for purposes of enhancement beyond therapy even as it problematizes this distinction. Includes chapters on "Better Children," "Superior Performance," "Ageless Bodies," "Happy Souls," and a conclusion.

Resnik, David B. *The Ethics of Science: An Introduction*. London: Routledge, 1998. Pp. x, 221. Develops a conceptual framework for understanding the ethics of scientific research and applies it to ethical questions in science. Seeks to clarify the nature of research ethics and the meaning of ethical behavior in science. Draws from several case studies and includes an appendix with 50 hypothetical case studies.

Sarewitz, Daniel. *Frontiers of Illusion: Science, Technology, and the Politics of Progress*. Philadelphia: Temple University Press, 1996. Pp. xi, 235. Deconstructs several "myths" instantiated in post-World War II U.S. science politics in order to gain clarity on the central questions of how science can best serve society, what science to pursue, and the relationship between scientific progress and human welfare. Concludes with a chapter titled "Toward a New Mythology," which includes policy recommendations for more explicitly integrating other values with epistemic pursuits in a democratic fashion.

Sassower, Raphael. *Technoscientific Angst: Ethics and Responsibility*. Minneapolis, MN: University of Minnesota Press, 1997. Pp. xv, 140. Relates the lessons of Auschwitz and Hiroshima to contemporary decision making about technoscience and the responsibility of intellectuals in a way that borrows from Hannah Arendt and Hans Jonas. Examines the anguish and angst felt by scientists but rarely exposed and the ambiguity concerning the responsibility of the technoscientific community in the face of mass destruction.

Sclove, Richard. *Democracy and Technology*. New York: Guilford Press, 1995. Pp. xiv, 338. Argues for democratic participation in technology, and proposes criteria for assessing engineering design in terms of the promotion of democracy.

Shrader-Frenchette, K. S. *Risk and Rationality: Philosophical Foundations for Populist Reforms*. Los Angeles: University of California Press, 1991. Pp. x, 312. Sketches a middle ground between the dominant sides of industrial charges of scientific illiteracy and populist charges of technological oppression. Proposes a new paradigm for making decisions about when the acceptance of public hazards is rational that includes more trust in the judgments of non-experts. Proceeds through a general introduction to a discussion of problematic risk-evaluation strategies to proposed reform for risk evaluation.

Shrader-Frenchette, Kristin. *Ethics of Scientific Research*. Lanham, MD: Rowman & Littlefield, 1994. Pp. x, 243. Arranged in ten chapters: introduction to and history of research ethics, professional codes, objectivity, promoting the public good, handling conflicts, uncertainty, case study in conservation research, gender and racial biases, social responsibility of engineers, and public health research. Last three chapters are authored by Helen Longino, Carl Mitcham, and Carl Cranor respectively.

Shrader-Frechette, Kristin. *Environmental Justice: Creating Equality, Reclaiming Democracy*. Oxford: Oxford Press, 2002. Pp. xiii, 269. Argues not only for protecting nature but also for public-interest advocacy in the name of the people who are victimized by environmental injustices. Diagnoses, analyzes, and seeks to resolve environmental injustices. Chapters elucidate concepts of justice (e.g., distributive, participatory, and procedural) and focus on case studies such as future generations and nuclear waste disposal, poor peoples and land use decisions, and risky occupational environments. Concludes with steps to take action.

Spier, Raymond. *Ethics, Tools, and the Engineer*. New York, NY: CRC Press, 2001. Pp. xiv, 306. Employs an evolutionary biology framework to discuss ethics and engineering. Discusses the meaning of ethics, describes engineers as toolmakers and users, considers the control and proper use of tools, and speculates on the cloning of humans. Also discusses the hazard and operability (HAZOP) process as a gatekeeping operation.

Spier, Raymond, ed. *Science and Technology Ethics*. New York, NY: Routledge, 2002. Pp. viii, 247. Reexamines contemporary ethics, asking whether sufficient ethical guidelines exist to minimize the disruptions of science and technology and maximize their benefits. Proposes new approaches to science and engineering practices. Eleven essays examine science and engineering broadly, developments in biology and information technology, the military industry, and environmental responsibilities.

Stokes, Donald E. *Pasteur's Quadrant: Basic Science and Technological Innovation*. Washington, DC: Brookings Institution Press, 1997. Pp. xiv, 180. Examines and reconceptualizes the division between basic and applied research that is at the core of post-World War II U.S. science policy. Analyzes the ways in which understand-

ing and use are often tightly intertwined in use-inspired basic research, presents this in a quadrant, and uses this to offer recommendations for a new contract between government and science.

Suzuki, David, and Peter Knudtson. *Genethics: The Clash between the New Genetics and Human Values*. Cambridge, MA: Harvard University Press, 1989. Proposes a set of genetic principles that emphasize individual rights and confidentiality with regard to genetic screening, caution in violating boundaries across species, and a ban on biological weapon development and the genetic manipulation of human germ cells.

Tenner, Edward. *Why Things Bite Back: Technology and the Revenge of Unintended Consequences*. New York: Alfred A. Knopf, 1996. Pp. xiii, 346. Explores the way in which technology, no matter how well designed, demands more human work despite promises to the contrary and introduces more chronic and insidious problems as the acute ones are never wholly resolved. These occurrences are explained as "revenge effects" that emerge from the interplay of technology, laws, customs, and habits. This stems largely from the inability to foresee future consequences of action.

Tiles, Mary, and Hans Oberdiek. *Living in a Technological Culture: Human Tools and Human Values*. London: Routledge, 1995. Pp. xi, 212. A philosophical reflection on technology, its many meanings, and its manifold relationships to culture. Examines conflicting visions of technology, facts and values, efficiency, science and the authority of experts, the transition from applied science to techno-science, and politics and responsibility.

Wenk, Edward, *Tradeoffs: Imperatives of Choice in a High-Tech World*. Baltimore, MD: Johns Hopkins University Press, 1989. Pp. xii, 238. Explores the neglect by economic and political institutions of the social impacts of new technologies and seeks to provide the "attentive public" with knowledge on how to direct and control technological applications. Argues that technology is more than hardware, but is an entire social system, that always entails side effects and tradeoffs that demand close attention to risk and uncertainties in a process of "looking before we leap." Explores public policy, private sector policies, their relationship, and the relationship of technology to science.

Whitbeck, Caroline. *Ethics in Engineering Practice and Research*. New York: Cambridge University Press, 1998. Pp. xx, 330. Uses a collection of case studies to address the professional and research responsibilities of engineers. Designed for classroom use, it includes a general introduction to ethical concepts and offers interactive activities with Case Western Reserve University's Online Ethics Center for Engineering and Science at http://onlineethics.org/.

Wiener, Norbert. *The Human Use of Human Beings: Cybernetics and Society*. Boston, Houghton Mifflin, 1950. Gives an account of the purpose of a human life and four principles of justice. Offers a method of applied ethics and discusses questions and topics in computer ethics. Republished by Da Capo Press in 1988.

Winner, Langdon. *The Whale and the Reactor: A Search for Limits in an Age of High Technology*. Chicago: University of Chicago Press, 1986. Outlines a political philosophy of technology as a form of political action. Technologies are not just means but "forms of life." Includes the influential essay "Do Artifacts Have Politics?" (pp. 19-39), to which the answer is yes. Other chapters discuss failed attempts to introduce technological fixes into political life as well as the weakness of environmentalism, technology assessment, and appeals to values.

3. Monographs and Edited Volumes: Specialized

Abram, David. *The Spell of the Sensuous: Perception and Language in a More-than-Human World*. New York: Pantheon Books, 1996. A personal and phenomenological account of human being as fundamentally dependent on contact and conviviality with what is not human. Calls for a renewal of human relationships with the sensuous world in which technologies are rooted in order to reassess the human and technological relationship with natural places. Aimed at both environmental activists and scholars.

Adas, Michael. *Machines as the Measure of Men: Science, Technology and Ideologies of Western Dominance*. London: Cornell University Press, 1989.

Aman, Kenneth, ed. *Ethical Principles for Development: Needs, Capacities or Rights*. *Proceedings of the IDEA/Montclair Conference*. Upper Montclair, NJ: Institute for Critical Thinking, 1991.

Angell, Marcia. *Science on Trial: The Clash of Medical Evidence and the Law in the Breast Implant Case*. New York: W. W. Norton and Company, 1996. Pp. 268. Critical analysis of law's treatment of science in the case of breast implants by medical researcher and former journal editor. Inquires into the distinctions in the way science, the law, and the public regard evidence and weigh risk. Organized in ten chapters with a preface and

afterword. Includes history, analysis of litigation and regulation, and the effects of corruption.

Arnhart, Larry. *Darwinian Natural Right: The Biological Ethics of Human Nature*. Albany: State University of New York Press, 1998. Defends a contemporary version of Aristotelian ethics using evolutionary biology.

Attfield, Judy. *Utility Reassessed: The Role of Ethics in the Practice of Design*. Manchester: Manchester University Press, 1999.

Barry, Robert L. and Gerard V. Bradley, eds. *Set No Limits: A Rebuttal to Daniel Callahan's Proposal to Limit Health Care for the Elderly*. Urbana: University of Illinois Press, 1991. Collects eight essays (including a preface and prologue) that criticize age-based rationing schemes for the allocation of health care resources. Argues that health care reforms are necessary but that it is not legally or morally justifiable to deprive people of life-sustaining care solely on the basis of their age. Considers moral and ethical, legal and jurisprudential, and public policy and economic aspects of age-based rationing.

Bavertz, Kurt, ed. *Sanctity of Life and Human Dignity*. Dordrecht: Kluwer, 1996. Pp. xix, 318. Engendered by a 1992 conference, compiles a general introduction and eighteen essays including an annotated bibliography and literature review. Sections include the concepts of human dignity, sanctity of life, and person, problems of critical care, and the role of the state.

Bayertz, Kurt. *GenEthics*. Cambridge, UK: Cambridge University Press, 1995. Clarifies the ethical dimensions generated by new human reproductive and genetic advancements. Most emphasis is on reproductive assisting technologies.

Beatley, Timothy. *Ethical Land Use*. Baltimore, MD: John Hopkins University Press, 1994.

Beauchamp, Tom, and Veatch, Robert eds. *Ethical Issues in Death and Dying*. 2nd ed. New York: Prentice Hall, 1996. Pp. xiv, 458. Gathers nine chapters of diverse resources pertaining to death and dying including essays, case studies, and government publications. Chapters are: definitions of death, truth-telling with dying patients, suicide, physician assisted suicide and euthanasia, forgoing treatment and causing death, decisions to forgo treatment involving once competent persons, decisions to forgo treatment involving never-competent patients, futile treatment and terminal care, and social reasons for limiting terminal care.

Bell, Robert. *Impure Science: Fraud, Compromise, and Political Influence in Scientific Research*. New York, NY: John Wiley & Sons, Inc., 1992. Pp. xvi, 301. Explores how the pursuit of money and prestige have compromised and corrupted scientific research in the U.S. Uses many case studies (e.g., Breuning and Baltimore) to substantiate and illuminate argument. Concludes with recommendations.

Belsey, Andrew, and Ruth Chadwick, eds. *Ethical Issues in Journalism and the Media*. London: Routledge, 1992. Pp. xiii, 179. Eleven original essays on topics such as ethics and politics, owners, editors, and journalists, terrorism and reporting restrictions, objectivity, honesty, privacy, codes of conduct, and freedom of speech.

Benso, Silvia. *The Face of Things: A Different Side of Ethics*. Albany: State University of New York Press, 2000. Pp. xxxviii, 258. Tries to bridge Emmanuel Levinas' emphasis on "love without things" and Martin Heidegger's "things without love" by arguing for an ethics of festive things. Amazingly fails to reference the work of Albert Borgmann.

Berry, Wendell. *The Unsettling of America: Culture and Agriculture*. San Francisco: Sierra Club Books, 1977. Pp. ix, 228. A criticism of modern industrial agriculture and its ecological and cultural consequences. A third edition was published by University of California Press, 1996.

Bertrand, Claude-Jean, ed. *An Arsenal for Democracy: Media Accountability Systems*. Cresskill, NJ: Hampton Press, 2003. Pp. xi, 420. Provides information on a wide range of ways in which to democratize the news media and make it accountable to the public, primarily through media accountability systems. Posits these systems as intermediaries between total loss of social responsibility and strict legal regulation. Arranged in twenty-nine chapters including principles and rules, press councils, research, ombudsmen, and media accountability systems in seven countries.

Bertrand, Claude-Jean. *Media Ethics and Accountability Systems*. New Brunswick, NJ: Transaction, 2000.

Brody, Baruch. *The Ethics of Biomedical Research*. New York: Oxford, 1998. Pp. xiii, 386. Covers both animal and human subjects research including chapters on genetic research, research involving vulnerable subjects, drug/device approval process, and a concluding chapter with philosophical reflections. Features four appendices on international, European transnational, U.S., and other countries' research ethics policies.

Brunner, Ronald D., Christine H. Colburn, Christina M. Cromley, Roberta A. Klein, and Elizabeth A. Olson. *Finding Common Ground: Governance and Natural Resources in the American West*. New Haven: Yale University Press, 2002. Pp. xiii, 303. Designed to help broad audiences understand the potential of community-based initiatives for resolving public policy disputes in the name of the common interest. Organized into a general introduction, four case studies, and a conclusion that seeks to draw out the lessons learned from community-based initiatives of policy making.

Buchanan, Allen, Dan Brock, Norman Daniels, and Daniel Wikler. *From Choice to Chance: Genetics and Justice*. New York: Cambridge, 2000.

Bud, Robert. *The Uses of Life: A History of Biotechnology*. Cambridge: Cambridge University Press, 1993. Pp. xvii, 299. Explores the long history of biotechnology, emphasizing the past 100 years, from ancient conceptions to nineteenth century zymotechnology to human genome research. Also tracks the disparate meanings of the term over time and cultures.

Callicott, J. Baird. *In Defense of the Land Ethic: Essays in Environmental Philosophy*. Albany: State University of New York Press, 1989. Pp. x, 325. Takes the econcentrist standpoint, drawing from sociobiology and ecology, that modern values of Western civilization must be overhauled. Organized into five sections: animal liberation and environmental ethics, a holistic environmental ethic, a non-anthropocentric value theory for environmental ethics, American Indian environmental ethics, and environmental education, natural aesthetics, and E.T. The second section develops and defends Aldo Leopold's land ethic.

Casebeer, William D. *Natural Ethical Facts: Evolution, Connectionism, and Moral Cognition*. Cambridge, MA: MIT Press, 2003. Argues for a strong form of scientific ethics, recapitulating a neo-Aristotelian virtue theory using resources from evolutionary biology and cognitive neuroscience.

Chadwick, Ruth, Darren Shickle, Henk ten Have, and Urban Wiesing, eds. *The Ethics of Genetic Screening*. London: Kluwer, 1999. Pp. xvi, 255. Collects twenty-one essays resulting from a three-year multinational and multidisciplinary project known as Euroscreen. Opens with an overview of genetic screening and the ethical principles available for addressing developments in the field with special reference to the Wilson and Jungner principles on screening. Other topics include nation-specific perspectives on ethical debates, regulatory systems, and history.

Chiles, James R. *Inviting Disaster: An Inside Look at Catastrophes and Why They Happen*. New York, NY: HarperBusiness, 2002. Pp. xxx, 338. Compiles twelve chapters and an introduction that use major disasters to highlight how "smart," increasingly complex systems fail as the pace and scope of change overwhelms human capabilities of response and control.

Chubin, Daryl E and Ellen W. Chu, eds. *Science Off the Pedestal: Social Perspectives on Science and Technology*. Belmont, CA: Wadsworth Publishing Co., 1989. Pp. x, 196. Designed for classroom use. Presents a primarily U.S.-centered account of science as cultural force, way of knowing, and institutionalized activity to supplement more traditional science teaching. Collects fourteen chapters and a postscript in three parts: science, technology, and other social institutions, world views and politics of knowledge, and science and technology as public resources.

Cohen, Avner, and Steven P. Lee, eds. *Nuclear Weapons and the Future of Humanity: The Fundamental Questions*. Totowa, NJ: Rowman and Allanheld, 1986. Pp. xii, 496. The single best collection of articles on this topic. Collects twenty-five essays and an afterward by John Holdren. Topics include reflections on the present threat, the oddity of nuclear thinking, just war and morality, and reformations of social and political realities toward a non-nuclear future. NUC Ethics

Cook, Robert Lynn. *Code of Silence: Ethics of Disasters*. Jefferson City, MO: Trojan Publishing, 2003.

Council of Biology Editors, Inc. *Ethics and Policy in Scientific Publication*. Bethesda, MD: Council of Biology Editors, Inc., 1990. Pp. xiii, 290. Presents the results of a survey of Council members about nineteen scenarios to identify and define ethical issues in publishing research results. Also presents twenty-nine papers from a conference. Issues include misconduct, peer review, conflicts of interest, informed consent, and much more.

Crocker, David A., and Linden, Toby, eds. *Ethics of Consumption: The Good Life, Justice, and Global Stewardship*. Lanham, MD: Rowman and Littlefield, 1998. Pp. xviii, 585. Contains "The Road Not Taken: Friendship, Consumerism and Happiness" by Robert E. Lane, pp. 218-248.

Cutcliffe, Stephen H. *Ideas, Machines, and Values: An Introduction to Science, Technology, and Society Studies*. Lanham, MD: Rowman and Littlefield, 2000. Pp. xii, 179. A broad overview of STS as a field of study including its historical emergence, relationships to the philosophy, sociology, and history of science and technology, and programs, institutions, and journals in the field. Includes a chapter on interdisciplinarity and the current state of STS and comments on future directions for the field.

Cutcliffe, Stephen H., and Carl Mitcham, eds. *Visions of STS: Counterpoints in Science, Technology, and*

Society. Albany: State University of New York Press, 2001. Pp. vi, 170. Collects a general introduction on the historical background and challenges of STS and ten essays arranged in three sections: general perspectives, applications, and critiques. Aims to clarify the complexities and debates within STS that emerge from its interdisciplinary nature by presenting ten views of where STS is or where it should be heading.

Danielson, Peter. *Artificial Morality: Virtuous Robots for Virtual Games*. New York, NY: Routledge, 1992. Pp. xiv, 240. Engages in controversies about the adequacy of rational choice theories and builds moral robots to explore the role of artificial intelligence in the development of a claim that morality is person-made and rational. Shows that moral agents are rational in the sense that they successfully solve some social problems that amoral agents cannot solve.

Davis, Michael. *Ethics and the University*. New York, NY: Routledge, 1999. Pp. xii, 267. Organized in three parts: a broad introduction to ethics in the academy, research ethics, and teaching ethics.

Davis, Michael. *Profession, Code and Ethics*. Burlington, VT: Ashgate Publishing Co., 2002. Pp. ix, 256. Addressed at scholars, teachers, and students. Presents a definition of profession and argues that codes of ethics are inherent to the nature of professionalism. Collects fourteen chapters arranged in four parts: lawyers, engineers and scientists, police, and teaching ethics.

Davis, Michael. *Thinking Like an Engineer: Studies in the Ethics of a Profession*. New York, NY: Oxford University Press, 1998. Pp. xii, 240. Inquires into the nature of engineering and the ethical principles that guide it. Provides historical background, comments on codes of ethics and whistleblowing, and thoughts on protecting engineering judgment. Then supplies empirical work to support the philosophical account of engineering

Deane-Drummond, Celia, Bronislaw Szerszynski, and Robin Grove-White, eds. *Reordering Nature: Theology, Society, and the New Genetics*. London: T and T Clark, 2003.

De Waal, Frans. *Good Natured: The Origins of Right and Wrong in Humans and Other Animals*. Cambridge, MA: Harvard University Press, 1996.

Dreyfus, Hubert L. *On the Internet*. New York, NY: Routledge, 2001. Pp. ix, 127. Critiques certain aspects of the promise of the internet to extend and improve human interaction, especially distance learning. Grounds his critique in the history of Western philosophy and certain long-standing conceptions such as mind-body dualism. Looks to existentialism and its focus on embodiment as an important resource for theories of education. Argues distance education can work, but care must be made to implement it correctly.

Escobar, Arturo. *Encountering Development: The Making and Unmaking of the Third World*. New Jersey: Princeton University Press, 1995. Pp. ix, 290. A discursive poststructuralist critique of economics as the foundational structure of modernity. Argues that development and the "Third World" are being unmade due to repeated failures to achieve goals and aspires to imagine alternatives for a post-development era.

Evan, William M., and Mark Manion. *Minding the Machines: Preventing Technological Disasters*. Upper Saddle River, NJ: Prentice Hall, 2002. Pp. xxiv, 485. Offers explanations for why technological disasters occur and preventive measures to cover all areas of risk. Topics examined include: history and theories of disasters, strategic responses, design and organizational failures, sociocultural failures, responsibilities of institutions and individuals, and participatory technology and the role of the citizen. Also comments on legal system and private corporations and provides some case studies.

Farber, Paul Lawrence. *The Temptations of Evolutionary Ethics*. Berkeley: University of California Press, 1994.

Foster, Kenneth R., and Peter W. Huber. *Judging Science: Scientific Knowledge and the Federal Courts*. Cambridge, MA: MIT Press, 1997. Pp. 333. An extended commentary on scientific validity and the law's rules of evidence aimed at non-expert audiences. Explains the significance of the *Daubert* criteria and addresses the central question of when evidence presented as scientific should be considered reliable enough to be presented to a jury. Concludes with an attempt to reconcile the law's needs for workable rules of evidence with the views of scientific validity and reliability held in scientific disciplines.

Fukuyama, Francis. *Trust: The Social Virtues and the Creation of Prosperity*. New York: Free Press, 1995. A comparative historical study of high-trust and low-trust societies and their business and economic consequences.

Goldberg, Steven. *Culture Clash: Law and Science in America*. New York: New York University Press, 1994. Pp. xi, 255. Argues that law and culture are at the roots of the slippage between the promise of U.S. science and the reality of commercial technology. Organized into ten chapters including the constitutional status of and statutory framework for basic research, science and religion in the law, legal restrictions on new technology, the human genome, nuclear fusion, and artificial intelligence.

Goldschmidt, Walter. *As You Sow: Three Studies in the Social Consequences of Agribusiness*. New York: Universe Books, 1978. Pp. liv, 505. Examines the consequences of corporate agriculture for rural communities in the United States. Features an extended general introduction on "Agriculture and the Social Order" that traces the rise of agribusiness.

Gough, Michael, ed. *Politicizing Science: The Alchemy of Policymaking.* Stanford, CA: Hoover University Press, 2003. Pp. xxi, 313. Shows the ways in which the connections between politics and science can thwart the achievement of social goals. Collects a preface, introduction, and eleven essays written by scientists about specific cases of excessive politicization.

Gould, Stephen J. *Rocks of Ages: Science and Religion in the Fullness of Life*. New York: Ballantine Books, 2002. Pp. viii, 241. Discusses the relationship between religion and science, arguing that the two are non-overlapping magisteria (NOMA) that can work peacefully together but only if there is no attempt to synthesize them somehow or bring one under the domain of the other. Argues that science deals with facts and theories about nature, whereas religion deals with human values and ultimate meaning.

Graham, Gordon. *The Internet: A Philosophical Inquiry*. New York, NY: Routledge, 1999. Pp. ix, 179. Assesses the implications of the internet for concepts of identity, moral anarchy, censorship, community, democracy, virtual reality, and imagination. Opens by negotiating the extremes of luddism and technophilia.

Greenberg, Daniel S. *Science, Money, and Politics: Political Triumph and Ethical Erosion*. Chicago: University of Chicago Press, 2001. Pp. x, 530. Examines and seeks to explain the prosperity and autonomy of science in the United States from the end of World War II to the turn of the century. Argues that the scientific "metropolis" has successfully lobbied for political resources, especially money and independence, but in so doing it has eroded its ethical integrity through these strategies of acquiring support and in the conduct of research. Takes a thematic approach through twenty-eight chapters that take up beliefs, social characteristics, goals, and revealing episodes.

Greenberg, Daniel S. *The Politics of Pure Science*, 2nd edition. New York: New American Library, 1999 (1st edition, 1967). Pp. xxvii, 311. Draws from personal experience writing for the journal Science on the politics of science and focuses on basic research. Explains how this politics works without sliding into either reverence or cynicism. Divided into three sections that treat the scientific community, the shaping of science politics during and after World War II, and some more recent examples of science politics. Concludes with notes about the new politics of science that demands more accountability from the scientific community.

Hamelink, Cees J. *The Ethics of Cyberspace*. Thousand Oaks, CA: Sage, 2000.

Hargrove, Eugene. *Foundations of Environmental Ethics*. Englewood Cliffs, NJ: Prentice Hall, 1989. Pp. x, 229. Organized into three sections. "Traditional Positions" explores Greek and modern philosophy. "The Environmental Position" outlines aesthetic, scientific, and wildlife protection attitudes and treats the perennial issues of value such as instrumental versus intrinsic. "Philosophical and Ethical Implications" presents an ontological argument for environmental ethics and discusses "therapeutic nihilism" in the context of environmental management.

Harries, Karsten. *The Ethical Function of Architecture*. Cambridge, MA: MIT Press, 1997. Pp. xiii, 403. Argues that architecture faces a deep philosophical problem bound up with questions of interpretation, the good life, and genuine dwelling as technology transforms human experience away from a focus on place and community. Claims that architecture should help define a sense of place in a disorienting world by articulating a common ethos. Includes 123 illustrations.

Hayles, M. Katherine. *How We Became Posthuman*. Chicago: University of Chicago Press, 1999. Pp. xiv, 350. Drawing from the history of cybernetics and information theories, argues that the emergence of distributed cognition and the disembodiment of infromation both furthers and overturns the liberal humanist subject. "Posthuman" is used in multiple, sometimes ironic ways, but all of which connot some form of union of humans with intelligent machines. Argues that human identity is more than information, but relies also on its instantiation and seeks to foster a future that embraces information technology "without being seduced by fantasies of unlimited power and disembodied immortality, that recognizes and celebrates finitude [and material embeddedness] as a condition of human being" (p. 5).

Hefner, Philip. *Technology and Human Becoming*. Minneapolis: Fortress Press, 2003. Proposes a Christian theory of co-creation in the use of science and technology.

Heller, Agnes. *Beyond Justice*. Oxford, U.K.: Basil Blackwell, 1987. Pp. vi, 346. Critiques theoretical assumptions underlying traditional and modern notions of justice, argues that all claims to justice are rooted in other values such as freedom and life, and claims that, although justice may be a precondition of the good life, the good life is something beyond justice. Contains analytic, historical, and normative chapters.

Hendler, Sue, ed. *Planning Ethics: A Reader in Planning Theory, Practice and Education*. New Brunswick, NJ: Center for Urban Policy Research, 1995. Pp. xx, 374. Reflects and furthers the expansion of professional ethics to more public and global concerns. Collects fifteen essays in three parts, each of which is set in the context of ethical theory: planning theory, planning practice, and planning education. Intended for planners and philosophers.

Herkert, Joseph R., ed. *Social, Ethical, and Policy Implications of Engineering*. New York: Institute of Electrical and Electronics Engineers (IEEE) Press, 2000. Pp. xi, 339. Collects 35 articles arranged in three categories: the societal context of technology and engineering, ethical responsibilities of engineers, and engineering ethics and public policy. Emphasis is placed on the policy aspects of contemporary ethical issues. Aimed at engineering educators, students, and practitioners. All articles are reprinted from the *IEEE Technology and Society Magazine*.

Hess, David. *Science Studies: An Advanced Introduction*. New York: New York University Press, 1997. Pp. vii, 197. Focuses on U.S. topics and highlights cross-disciplinary misunderstandings in the field. Collects six chapters including a chapter that discuss the philosophy of science, sociology of science, social studies of knowledge, critical and cultural studies of science and technology, and a conclusion that primarily treats policy issues.

Heyd, David. *Genethics: Moral Issues in the Creation of People*. Berkeley: University of California Press, 1992. Attempts to resolve many ethical paradoxes in intergenerational justice raised by advances in medicine, genetic engineering, and demographic forecasting.

Higgs, Eric. *Nature by Design: People, Natural Process, and Ecological Restoration*. Cambridge, MA: MIT Press, 2003. Pp. xv, 341. Introduces concept and cases of ecological restoration. Focuses on the concern that restoration acts as an apology for technological excess and demonstrates a hubristic urge to manipulate nature to mirror cultural values. Proposes "focal restoration" as a preferred way of ensuring participation and engagement in restoration projects and highlighting the importance of responsible and intentional "wild" design.

Higgs, Eric, Andrew Light, and David Strong, eds. *Technology and the Good Life?* Chicago: University of Chicago Press, 2000. A collection of essays on the work of Albert Borgmann.

Hilgartner, Stephen. *Science on Stage: Expert Advice as Public Drama*. Stanford, CA: Stanford University Press, 2000. Pp. xvi, 214. Uses two National Academy of Science reports to examine the production and use of science advice in an age conflicted by a vision of expertise as both value-laden and objective. Employs the theoretical trope of the theater to investigate how advisory bodies produce credibility and authority by managing information and appearances in complex ways. Investigates the "boundary work" and rhetorical and narrative techniques at the borders of science and society and uses the idea of "stage management" to differentiate "back stage" from "front stage" elements of science advice.

Homan, Roger. *The Ethics of Social Research*. New York: Longman, 1991.

Howard, Ted, and Jeremy Rifkin. *Who Should Play God?: The Artificial Creation of Life and What It Means for the Future of the Human Race*. New York: Delacorte Press, 1977. Pp. 272. Introduces genetic engineering and its history, links it to the ideology of eugenics supporters, describes its likely forms of application, and concludes with recommendations. Staunchly opposes genetic engineering and reductionism, arguing that the choice is between preserving humans and other species as they are or launching a mass program of biological reengineering. Argues that genetic engineering is inherently anti-democratic and elitist and requires active public participation to prevent dehumanization.

Jasanoff, Sheila. *The Fifth Branch: Science Advisors as Policymakers*. Harvard University Press, 1990. Pp. xiii, 302. Draws from social studies of science, especially constructivist work, to present a conceptual framework and differentiated vocabulary for the dilemmas faced by science advisory committees. Argues for procedural reforms in the role of science advisors in public policy making. Addresses the question of the limits of participatory decision-making in an age of growing technological complexity and expert knowledge.

Jasanoff, Sheila. *Science at the Bar: Law, Science, and Technology in America*. Cambridge, MA: Harvard University Press, 1995. Pp. xvii, 285. A classic overview of law-science relationship from social studies of science perspective. Argues that the courts actively influence the production of science and technology and serve as democratizing agents, but are often constrained in this role by positivistic assumptions. Analyzes scientific and legal modes of reasoning and concludes with a prescriptive look ahead.

Kass, Leon. *Toward a More Natural Science: Biology and Human Affairs*. New York: Free Press, 1985. Pp. xiv, 370. An Aristotelian account that argues that science can go too far if it is not appropriately regulated by the wisdom contained in our emotional reactions to certain technological advances.

Kavka, Gregory S. *Moral Paradoxes of Nuclear Deterrence*. New York: Cambridge University Press, 1987. Pp. xii, 243. A tightly argued exploration of the major quandaries that defends nuclear deterrence, if subjected to proper restrictions, as morally justified. Highlights conflicts and dilemmas both within and between utilitarian and deontological ethics.

Kellert, Stephen R. *The Value of Life: Biological Diversity in Human Society*. Washington, DC: Island Press, 1996. A taxonomy of views of nature.

Kevles, Daniel J. *In the Name of Eugenics: Genetics and the Use of Human Heredity*. Berkeley: University of California Press, 1985. Seminal work on history of eugenics and the eugenic implications of new reproductive technologies. Reprinted by Harvard University Press, 1995.

Kimbell, Richard. *Assessing Technology: International Trends in Curriculum and Assessment*. Philadelphia, PA: Open University Press, 1997. Pp. xiv, 249. Explores the issues of assessment that have emerged with the technology curriculum in the U.K., especially the problems of process-centered assessment that involve evaluating students' capabilities in the process of design and development. Provides international comparisons to the U.S., Germany, Taiwan, and Australia. Concludes with general reflections.

Koehn, Daryl. *The Ground of Professional Ethics*. New York, NY: Routledge, 1994. Pp. x, 224. Confronts and rebuts the challenge to the authority and ethics of professionals by arguing that it rests on a secure and morally legitimating ground because and to the extent that these professions are structured to merit the trust of clients.

LaFollette, Marcel C. *Stealing into Print: Fraud, Plagiarism, and Misconduct in Scientific Publishing*. Berkeley: University of California Press, 1992. Pp. viii, 293. Focuses on how scientific misconduct affects communication practices and policies in the journals that disseminate the results of scientific research.

Layton, Edwin T. Jr. *The Revolt of the Engineers: Social Responsibility and the American Engineering Profession*. 2nd ed. Baltimore: Johns Hopkins University Press, 1986. Pp. xxii, 286. (First published 1971.) Classic examination of the professionalization of engineering in the U.S. from 1900-1945. Analyzes the tensions between business interests and technical expertise, and describes failed attempts during the first half of the 20th century to promote unity and autonomy (the "revolt") around an ideology of engineers as professional leaders of advanced civilization. A new preface comments briefly on post-World War II developments.

Levine, Robert. *Ethics and the Regulation of Clinical Research*. 2nd ed. New Haven: Yale, 1988.

Light, Andrew and Eric Katz, eds. *Environmental Pragmatism*. London: Routledge Press, 1998. Pp. xvi, 352. Presents environmental pragmatism as a way to direct the fruits of (open-ended, pluralistic, and context specific) philosophical inquiry toward practical resolution of environmental problems. Collects seventeen essays and a general introduction.

Marcus, Stephen J., ed. *Neuroethics: Mapping the Field: Conference Proceedings, May 13-14, 2002, San Francisco, California*. New York: Dana Press, 2002. Pp. vii, 367. Result of a conference composed of scientists, ethicists, humanists, and others on the personal and social implications of human brain research. Organized into five sections: notions of self, social policy, ethics, public discourse, and mapping the future. Also includes two speeches, one by Arthur Caplan that argues the main issue is equity rather than worries about enhancement, and an introduction mapping the new emerging field of neuroethics.

Margolin, Victor. *The Politics of the Artificial: Essays on Design and Design Studies*. Chicago: University of Chicago Press, 2002. Pp. 273.

Mason, Richard, Florence Mason, and Mary Culnan. *Ethics of Information Management*. Thousand Oaks, CA: Sage Publications, 1995.

McDonough, William, and Michael Braungart. *Cradle to Cradle: Remaking the Way We Make Things*. New York: North Point Press, 2002. Pp. 193.

McGee, Glenn. *The Perfect Baby: A Pragmatic Approach to Genetics*. New York: Rowman and Littlefield, 1997. Denies the necessity of a "genethics," arguing that the wisdom we need can be found in the everyday experience of parents.

Mehlman, Maxwell J., and Jeffrey R. Botkin. *Access to the Genome: The Challenge to Equality*. Washington, DC: Georgetown University Press, 1998. Summarizes the Human Genome Project and discuss its practical

health applications and ethical and policy challenges such as bans, equal access, genetic handicapping, and genetic lotteries.

Mendelsohn, Everett, Merritt Roe Smith, and Peter Weingar, eds. *Science, Technology and the Military*, 2 vols. Boston: Kluwer, 1988. Pp. xxix, vii, 288; 274. Collects papers presented at 1987 conference with an introductory overview. Topics include war and the restructuring of physics, the military and technological development, industry, medicine, academy, and nuclear weapons and power.

Mepham, Ben., ed. *Food Ethics*. London: Routledge, 1996. Pp. xiv, 178. Collects ten essays and a select bibliography on such issues as food aid and trade, biotechnology, global hunger, consumer sovereignty, research ethics, and nutrition and health. Features an essay that presents an evaluative framework for ethical analysis of food biotechnologies.

Mirowski, Philip and Esther-Mirjam Sent, eds. *Science Bought and Sold: Essays in the Economics of Science*. Chicago: University of Chicago Press, 2002. Pp. ix, 573. Presents science as a deeply economic activity of investment and profit and shows the changing relations between science and economics. Collects a general introduction and nineteen original and reprinted essays arranged in six parts including science as a production process, science as a problem of information processing, contours of the globalized privatization regime, and the future of scientific credit.

Molotch, Harvey. *Where Stuff Comes From: How Toasters, Toilets, Cars, Computers and Many Other Things Come to Be As They Are*. New York: Routledge, 2003. Pp. 324.

Moulakis, Athanasios. *Beyond Utility: Liberal Education for a Technological Age*. Columbia: University of Missouri Press, 1994. Pp. viii, 171. Generated from experiences teaching a Humanities for Engineers course. Considers the larger purposes of liberal arts education and how they relate to the education of professionals. Addresses the controversy in education circles about tradeoffs between narrow, professional and broad, humanistic education.

National Academy of Engineering. *The Engineer of 2020: Visions of Engineering in the New Century*. Washington, D.C.: The National Academies Press, 2004. Pp. xv, 101. Result of a forward-looking conference about what engineering will and should be like in the future and to what extent engineers can shape that future. Includes an appendix with possible future scenarios.

Paradis, James, and George C. Williams, eds. *Evolution and Ethics*. Princeton, NJ: Princeton University Press, 1989. Contains the essay "A Sociobiological Expansion of Evolution and Ethics" by George Williams.

Pattyn, Bart, ed. *Media Ethics: Opening Social Dialogue*, Leuven, Belgium: Peeters, 2000. Contains the important article "An Intellectual History of Media Ethics" by Clifford Christians.

Pelletier, Louise, and Alberto Pérez-Gómez, eds. *Architecture, Ethics, and Technology*. Montreal: McGill-Queen's University Press, 1994.

Perrow, Charles. *Normal Accidents: Living with High-Risk Technologies*. New York: Basic Books, 1984. (Revised 1999, Princeton, NJ: Princeton University Press). Pp. x, 386. Traces six examples of modern industrial systems to argue that tight coupling and interactive complexity inevitably produce accidents, and that these are more important concerns than operator error or the failure of parts. Offers an assessment of these systems and recommendations for future action. Concludes with a discussion of high-risk decision making.

Peters, Ted. *Playing God?: Genetic Determinism and Human Freedom*. 2nd ed. New York: Routledge, 2003. Pp. xvii, 260. Rejects genetic determinism and argues that human nature is the product of genes, environment, and free will. Defends a Christian understanding of humans as future-oriented and cocreative as an ethic for guiding genetic research. Takes up questions of genetic manipulation beyond therapy, ethics and science in the "gay gene" controversy, and such issues as patenting genes, cloning, stem cell research, and germline intervention.

Postrel, Virginia. *The Future and Its Enemies: The Growing Conflict over Creativity, Enterprise, and Progress*. New York: Free Press, 1998. Pp. xviii, 265. A libertarian defense of technological innovation as basis for human freedom that portrays two alternative futures: one that is diverse, dynamic, decentralized and choice-driven and the other that is static, centralized, and controlled. Explores the clash between dynamism and stasis and defends the former over the latter. Has a companion website at www.dynamist.com.

Proctor, Robert N. *Value-Free Science? Purity and Power in Modern Knowledge*. Cambridge, MA: Harvard University Press, 1991. Pp. xi, 331. Traces the origin of value neutrality in the separation of theory and practice, the isolation of moral knowledge from natural philosophy, and the mechanical conception of the universe. Explores the exclusion of morals and politics in the

social sciences, especially in Germany, and reviews more recent critiques of value-neutral science.

Reiss, Michael J., and Roger Straughan. *Improving Nature? The Science and Ethics of Genetic Engineering.* New York: Cambridge University Press, 1996. Covers a broad range of ethical and theological concerns in genetic engineering of microorganisms, plants, animals, and humans.

Resnik, David B. *Owning the Genome: A Moral Analysis of DNA Patenting.* Albany: State University of New York Press, 2004. Pp. xiii, 235. Examines the main arguments for and against different types and scopes of DNA patenting from both consequentialist and deontological perspectives. Argues that consequentialist arguments pertain to most issues, whereas deontological arguments have a more limited application. Claims that DNA patenting offers society many important benefits and poses a few important threats. Articulates and defends the precautionary principle in some areas and concludes with policy recommendations.

Rifkin, Jeremy. *Who Should Play God?: The Artificial Creation of Life and What It Means for the Future of the Human Race.* New York: Delacorte Press, 1977.

Rip, Arie, Thomas J. Misa, and Johan Schot, eds. *Managing Technology in Society: The approach of Constructive Technology Assessment.* London, England: Pinter, 1995. Pp. xii, 361. Explores the concept of critical technology assessment and the need for it in the goal of maximizing benefits and minimizing harms of technologies, uses case studies to argue that changing entrenched technologies and institutions is difficult but possible, discusses conditions for learning about experiences to try in other contexts, and argues that such policies will be context specific.

Roco, Mihail C., and William S. Bainbridge, eds. *Societal Implications of Nanoscience and Nanotechnology.* Dordrecht, The Netherlands: Kluwer, 2001. Pp. vii, 370. Collects articles from various contributors organized into five introductory chapters on nanotechnology goals and societal interactions, social science approaches to assessment, and recommendations. Chapter six provides topical considerations including education, medicine, environment, space, and security.

Rolston III, Holmes. *Conserving Natural Value.* New York: Columbia University Press, 1993. Pp. 259. A philosophical argument that seeks to balance natural and cultural values and considers the anthropocentric and intrinsic theories of value.

Sachs, Wolfgang ed. *The Development Dictionary: A Guide to Knowledge as Power.* London: Zed Books, 1992. Pp. 306. Compiles a general introduction and nineteen essays that deconstruct key terms in the modern development discourse such as needs, progress, science, technology, development, state, and environment. Argues that it is time to abandon the dominant development paradigm or "cast of mind."

Sarewitz, Daniel, Roger A. Pielke, Jr., and Radford Byerly, Jr, eds. *Prediction: Science, Decision Making, and the Future of Nature.* Washington, DC: Island Press, 2000. Pp. xv, 405. Addresses the application of scientific predictions to environmental problems, noting promises and limits, and pointing out that predictions are at once technical, political and social. Argues that the relationship of predictions to policy making is rocky due to the complexity of systems that generate uncertainty (and uncertainty about uncertainty) and the widely held and problematic assumption that predictions can simplify the decision-making process. Includes a general introduction and eighteen essays collected in six parts: prediction as a problem, natural hazards, politics, policy, prediction in perspective, and a conclusion.

Schlossberger, Eugene. *The Ethical Engineer.* Philadelphia, PA: Temple University Press, 1993. Pp. xii, 284. Addressed both to practicing professionals and engineering students. Uses illustrating cases to supplement the text. Includes an introduction to engineering ethics and ethical decision making, comments ethical theories and the sources of ethical decisions, issues such as honesty, good faith, employee-employer relations, and consulting.

Schmitz, David, and Elizabeth Willott. *Environmental Ethics: What Really Matters, What Really Works.* Oxford: Oxford University Press, 2002. Pp. xxi, 566. Collects classic essays in environmental ethics in fifteen topical areas, each introduced with questions for reflection and discussion.

Schumacher, E. F. *Small Is Beautiful: Economics as if People Mattered.* New York: Harper Perennial, 1989. (Originally published 1973, Harper & Row; reprint 1999, Hartley & Marks.) Pp. xxiii, 324. A critique of neo-classical economics, its conception of human nature and desires, natural resources, and its tendencies to globalize systems of production and distribution on massive scales. Defends small-scale, decentralized economies and includes the influential essay "Buddhist Economics," which challenges the goal displacement of growth-oriented economies that use technology to alienate human meaning by focusing on conceptions of "right livelihood" and celebrating the humanizing and liberating quality of work when scaled down and rooted in a community.

Schweber, S. S. *In the Shadow of the Bomb: Bethe, Oppenheimer, and the Moral Responsibility of the Scientist.* Princeton, NJ: Princeton University Press, 2000. Pp. xviii, 260. Examines the different reactions of two physicists to the moral dilemmas posed by the development and use of atomic weapons and questions of the professional responsibilities and public roles of scientists and engineers. Details the different roles played by Oppenheimer and Bethe, their foundations, and their consequences.

Sen, Amartya. *Development as Freedom.* New York: Anchor Books, 1999.

Sieber, Joan E., ed. *The Ethics of Social Research: Surveys and Experiments.* 2 vols. New York: Springer-Verlag, 1982. Pp. xii, 249 and x, 187. Designed to assist social scientists in preparing for and resolving ethical issues. Arranged as ten chapters in the first volume and seven in the second in four total sections: respect for the individual, protection of privacy and confidentiality, ethnographic fieldwork and beneficial reciprocity, and the roles of social scientists in research regulation and media relations.

Silver, Lee. *Remaking Eden: Cloning and Beyond in a Brave New World.* New York: Avon, 1998. Pp. viii, 317. Takes stock of the current state of reproduction and genetics (reprogenetics) technology to survey likely future scenarios. Argues that Huxley's dystopian vision of a "brave new world" is mistaken because individuals, not governments, will control reprogenetic technologies and that a society that values individual freedom above all else has difficulty justifying restrictions on the use of technologies by individuals. Surveys the changing meanings of parenthood, childhood, and the meaning of human life, dismisses many oppositions to reprogentic technologies, and concludes that such new technologies are inevitable as guaranteed by the global market.

Sismondo, Sergio. *An Introduction to Science and Technology Studies.* Malden, MA: Blackwell, 2004. Pp. vii, 202. Provides a clear overview of the field for readers unfamiliar with it. Intended for undergraduate or graduate classroom use. Organized into sixteen chapters that address historical and conceptual topics such as the Kuhnian revolution following the prehistory of STS, actor-network theory, social construction of knowledge, rhetoric and discourse, and expertise and the public understanding of science.

Sonnert, Gerhard. *Ivory Bridges: Connecting Science and Society.* Cambridge, MA: The MIT Press, 2002. Pp. x, 227. Scrutinizes the links between science and society beginning with a Jeffersonian concept of science policy, followed by a consideration of voluntary public interest associations of scientists, and concluding with questions of autonomy and responsibility.

Steinbock, Bonnie, ed. *Ethical and Legal Issues in Human Reproduction.* Hampshire, U.K.: Ashgate, 2002.

Stock, Greg. *Redesigning Humans.* New York: Houghton Mifflin, 2002. Strong defense of the genetic engineering of human beings.

Stone, Jeremy J. *"Every Man Should Try:" Adventures of a Public Interest Activist.* New York, NY: PublicAffairs, 1999. An autobiography that focuses on the development of the Federation of American Scientists. Provides an inside, personal look at some of the politics behind nuclear disarmament talks, reflections on why successes and failures occurred, and lessons about the complexities of public interest science.

Sutton, Victoria. *Law and Science: Cases and Materials.* Durham, NC: Carolina Academic Press, 2001. Pp. xxiv, 388. A legal casebook. Includes over sixty cases arranged into five chapters: an introduction, government, private sector, courts, and a future outlook.

Szerszynski, Bronislaw. *Nature, Technology, and the Sacred.* Malden, MA: Blackwell, 2005. Pp. xviii, 222. Uses the term "sacred" to understand the ways in which a range of religious framings are involved in ideas of and interactions with nature and technology. Argues that implicitly religious understandings of nature and technology are widespread in Western cultures. Begins with reflections on modernity and the disenchantment of the world, arguing against contemporary theorists who claim no such thing has occurred. Argues for a conscious reappropriation of sacral traditions and outlines the implications.

Thompson, Alison K., and Ruth F. Chadwick, eds. *Genetic Information: Acquisition, Access, and Control.* New York: Kluwer, 1999. Pp. xi, 335. Collects thirty essays arranged in five sections: eugenics, genetics and insurance, commercialization of genetic information, public awareness, and theoretical concerns.

Thompson, Paul B. *Agricultural Ethics: Research, Teaching, and Public Policy.* Ames: Iowa State University Press, 1998. Pp. xi, 239. Aims to provide an introduction to philosophical reflection on agriculture and food production by reflecting on food system issues with key concepts from ethics. Emphasizes the importance of technological change, ethical extensionism, and questions about the worth of the family farm. Organized in three sections: research, teaching, and public policy with a general introduction and conclusion.

Thompson, Paul B. *The Ethics of Aid and Trade: U.S. Food Policy, Foreign Competition, and the Social Contract*. New York: Cambridge University Press, 1992. Pp. x, 233. Explores the principles of U.S. agricultural policy and foreign aid, arguing that the traditional model of the nation-state should be replaced with the "trading state." Addresses protectionist challenges to foreign aid and development assistance in moral, economic, and political terms. Proposes a model of international relations with greater fluidity of material and intellectual exchange and creates a new interpretation of social contract theory that is geared to the goals of international trade and development policy.

Thomson, Norma, ed. *Instilling Ethics*. Lanham, MD: Rowman and Littlefield, 2000. Pp. xv, 239. Collects fourteen original articles arranged in three sections: sources of ethical reflection, modernity and the problems of ethical reflection, and instilling ethics today.

Valenstein, Elliot S. *Great and Desperate Cures: The Rise and Decline of Psychosurgery and Other Radical Treatments for Mental Illness*. New York: Basic Books, 1986. Pp. xiv, 338. Pursues the history of psychosurgery (e.g., lobotomy) as a cautionary tale, arguing that these procedures were very much a part of mainstream medicine and that the conditions that fostered their development are still active. Sets the tale in context with an opening chapter on the treatment of mental illness.

Verbeek, Peter-Paul. *What Things Do: Philosophical Reflections on Technology, Agency, and Design*. Robert P. Crease, trans. University Park: Pennsylvania State University Press, 2005. Pp. viii, 249. Develops an innovative approach to understanding the role of technological devices in lived experience and how they shape personality and society. Distinguishes analysis from classical philosophy of technology to develop an empirical, "postphenomenological" approach.

Wachs, Martin, ed. *Ethics in Planning*. New Brunswick, NJ: Center for Urban Policy Research, 1985. Pp., xxi, 372. The first compendium of works on ethics in planning. Collects a general introduction (with a fourfold taxonomy of ethical issues) and seventeen essays arranged in four sections: overview of ethical issues in urban planning and administration, corruption and whistle-blowing, ethical issues in policy making, and the emergence of an environmental ethics. Includes four appendices with relevant codes of ethics.

Walter, Jennifer K., and Eran P. Klein, eds. *The Story of Bioethics: From Seminal Works to Contemporary Explorations*. Washington, DC: Georgetown University Press, 2003. Pp. xv, 248.

Wilson, Edward O. *Consilience: The Unity of Knowledge*. New York: Alfred A. Knopf, 1998. Pp. 332. Seeks to develop a unification of knowledge according to the principles found in the natural sciences, especially sociobiology. Espouses a version of material reductionism and champions the Enlightenment ideals of objective knowledge, human progress, and the unity of truth.

Wilson, Edward O. *Sociobiology: The New Synthesis*. 25th Anniversary Edition. Cambridge, MA: Harvard University Press, 2000. Pp. xiii, 697. First published in 1975, established the field of sociobiology, also terms evolutionary psychology. For an overview of early controversies related to this topic, see Arthur L. Caplan, ed., *The Sociobiology Debate: Readings on the Ethical and Scientific Issues Concerning Sociobiology* (New York: Harper and Row, 1978).

4. Textbooks

Almond, Brenda, ed. *Introducing Applied Ethics*. Oxford: Blackwell, 1995. Includes more than twenty texts on family life, professional ethics, law, economics, and international relations. Little focus on science or technology.

Baum, Robert R., and Albert Flores, eds. *Ethical Problems in Engineering*. 2 vols. Troy, NY: Center for the Study of the Human Dimensions of Science and Technology, 1978. Although out of print, this remains a classic engineering ethics collection.

Beauchamp, Tom L., and James F. Childress. *Principles of Biomedical Ethics*. 5th ed. New York: Oxford University Press, 2001. Pp. xi, 454. One of the most influential textbooks in the bioethics field. The most developed use of principlism in bioethics, arranged in three parts that treat moral norms, character, and theories and outline the basic principles of respect for autonomy, nonmaleficence, beneficence, and justice as well as a chapter on professional-patient relationships.

Bowyer, Kevin W. *Ethics and Computing: Living Responsibly in a Computerized World*. Washington, DC: Institute of Electrical and Electronics Engineers (IEEE) Computer Society Press, 1996. Pp. xvi, 449. Examines issues central to computer ethics including hacking, privacy, computers in safety-critical systems, whistle blowing, intellectual property, environmental health, law, and equity. Includes case studies and exercises suitable for undergraduate courses.

Bulger, Ruth Ellen, Elizabeth Heitman, and Stanley Joel Reiser, eds. *The Ethical Dimensions of the Biological*

Sciences. New York: Cambridge University Press, 1993. Pp. xi, 294. Collects thirty-six articles including a general introduction addressed primarily to graduate students and faculty responsible for teaching ethics in science. Includes classic essays, seminal works, policy statements, and research guidelines that address such topics as the ethics of research and teaching, the qualifications for authorship, and the relationship of science, industry, and society. Each section includes questions for discussion.

Cheney, Darwin, ed. *Ethical Issues in Research*. Frederick, MD: University Publishing Group, 1993. Pp. xx, 237. Collects an overview and twenty-two chapters arranged in five parts: misrepresentation of data (U.S. and international perspectives), conflict of interest, research on human subjects, use of embryos and fetuses, and use of animals.

DesJardins, Joseph, eds. *Environmental Ethics: Concepts, Policy, and Theory*. London: Mayfield, 1999. Pp. xvi, 620. A broad overview with discussion and study questions following each of 18 chapters with classic essays arranged into four sections: context, basic concepts, policies and controversies, and philosophy and theory.

Edel, Abraham; Elizabeth Flower; and Finbarr W. O'Connor. *Critique of Applied Ethics: Reflections and Recommendations*. Philadelphia: Temple University Press, 1994. Pp. vi, 274. Surveys theories of applied ethics and argues that the stabilities of traditional morality must be combined with new knowledge to direct the rapid pace of techno-societal change. Divided into two sections: philosophical background and an analysis of practical problems. Conclusion emphasizes the importance of applying theories to complex and changing contexts.

Ermann, M. David, and Michele S. Shauf, eds. *Computers, Ethics, and Society*. 3rd ed. New York: Oxford University Press, 2003. Pp. vi, 249. Standard text covering ethical frameworks, personal decision making, politics, and professional responsibilities. First edition, 1990.

Erwin, Edward, Sidney Gendin, and Lowell Kleiman, eds. *Ethical Issues in Scientific Research: An Anthology*. New York, NY: Garland Publishing, 1994. Pp. xi, 413. Collects twenty-six essays in six sections: science and values, fraud and deception, human experimentation, animal research, genetics research, controversial research topics.

Elliott, Deni, and Judy E. Stern, eds. *Research Ethics: A Reader*. Hanover, NH: University Press of New England, 1997. Pp. xii, 319. A student reader with original and reprinted articles, essays, and case studies. Topics include teaching ethics, misconduct, conducting, reporting, and funding research, conflicts of interest, institutional responsibility, and animal and human experimentation.

Fleddermann, Charles B. *Engineering Ethics*. Upper Saddle River, NJ: Prentice Hall, 1999.

Gorman, Michael E., Matthew M. Mehallik, and Patricia Werhane. Ethical and Environmental Challenges to Engineering. Upper Saddle River, NJ: Prentice Hall, 2000.

Gunn, Alastair S., and P. Aarne Vesilind. *Hold Paramount: The Engineer's Responsibility to Society*. Pacific Grove, CA: Brooks/Cole, 2003. Pp. xiv, 160. Intended for use as a textbook. Includes cases studies, feature boxes, and discussion questions. Topics addressed include expertise and obligation, codes of ethics, terrorism, professional development, conflicts of interest, and much more.

Johnson, Deborah G., and Helen Nissenbaum, eds. *Computers, Ethics, and Social Values*. Upper Saddle River, NJ: Prentice Hall, 1995. Pp. vi, 714. Collects fifty-eight articles organized in seven chapters that seek to define and differentiate the field of computer ethics. Explores the significance of computers in terms of social values such as privacy, justice, democracy, and property. Examines computers in controversies involving traditional ethical notions such as crime, risk, and responsibility. Concludes with a look at the ethical issues of an increasingly networked information society.

Kaplan, David M., ed. *Readings in the Philosophy of Technology*. Lanham, MD: Rowman and Littlefield, 2004. Pp. xvi, 512Thirty-one readings, with sections on "Technology and Ethics," "Technology and Politics," and "Technology and Human Nature" most directly relevant.

Katz, Eric, Andrew Light, and William Thompson, eds. *Controlling Technology*. 2nd ed. Amherst, NY: Prometheus Books, 2003. Pp. 531. Thirty-four essays and a general introduction aimed at humanists, scientists, and engineers. Arranged to address fundamental issues at the intersection of technology and human values, especially democracy. Topics include human autonomy and freedom, the autonomy of technology, human equality, and respect for others. Arranged in eight parts including appropriate technology, technology, ethics, and politics, and computers, information, and virtual reality.

Light, Andrew, and Holmes Rolston III, eds. *Environmental Ethics: An Anthology*. Oxford: Blackwell Publishers, 2003. Pp. x, 554. Collects a general introduction and forty essays arranged in seven sections including definitions of environmental ethics, moral standing, the question of intrinsic value in nature, monism versus pluralism, and reframing environmental ethics. Includes a bibliographic essay by Clare Palmer that sketches the history and central issues of environmental ethics.

Loue, Sana. *Textbook of Research Ethics: Theory and Practice*. Dordrecht: Kluwer, 1999. Provides a brief history of human subjects research and reviews relevant ethical theories and principles. Refers to international documents and national policies and includes case studies and discussion exercises.

Macrina, Francis L. *Scientific Integrity: An Introductory Text with Cases*. Washington, DC: ASM Press, 1995. Pp. xxi, 283. Designed for students pursuing careers in biomedical research. Most chapters conclude with case studies and extended case studies are included in an appendix. Topics include use of animals, human experimentation, mentoring, authorship, ownership of data, and genetics.

Mappes, Thomas A., and David Degrazia. *Biomedical Ethics*. 5th ed. New York: McGraw Hill, 2000.

Martin, Mike W., and Roland Schinzinger. *Ethics in Engineering*. 4th ed. New York: McGraw-Hill, 2005. Pp. xi, 339. (1st ed., 1983.) This widely used text argues for conceiving of engineering as social experimentation and thus applies issues of informed consent to engineering practice. One of the earliest, most original, and widely used books in the field. See also Martin and Schinzinger's shorter version: *Introduction to Engineering Ethics* (Boston: McGraw-Hill, 2000).

Mitcham, Carl, and R. Shannon Duval. *Engineer's Toolkit: Engineering Ethics*. Upper Saddle River, NJ: Prentice Hall, 2000. Pp. x, 131. A short, elementary modular text.

Murphy, Timothy. *Case Studies in Biomedical Research Ethics*. Boston: MIT, 2004. Pp. xvii, 340. Intended as a text for instruction in biomedical research ethics. Collects over 100 case studies organized into nine topics including oversight and study design, informed consent, genetic research, and authorship and publication. Each topical area includes a general introduction and each case study includes study questions.

National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. *On Being a Scientist: Responsible Conduct in Research*, 2nd ed. Washington, DC: National Academy Press, 1995. Pp. 27. Designed to stimulate group discussion, primarily in classrooms. Traces the history of thought about research ethics through brief considerations of several topics including the social foundations of science, data, values in science, conflicts of interest, openness, misconduct, and authorship.

Penslar, Robin Levin, ed. *Research Ethics: Cases and Materials*. Bloomington: Indiana University Press, 1995. Pp. xvi, 278. A collection of case studies designed to aid faculty in raising and discussing ethically problematic aspects of conducting research. Arranged in three main sections that cover cases in biology, psychology, and history. Includes a general introduction to research ethics and ethical theory.

Scharff, Robert C., and Val Dusek, eds. *Philosophy of Technology: The Technological Condition: An Anthology*. Malden, MA: Blackwell, 2003. Pp. xi, 686. Fifty-five readings. Parts V, Technology and Human Ends," and VI, "Technology as Social Practice," constitute half the volume.

Schinzinger, Roland, and Mike W. Martin. *Introduction to Engineering Ethics*. 3rd ed. Boston: McGraw Hill, 2000. Pp. xi, 260. (1st ed. : 2nd ed.) Clarifies key concepts and provides case studies in the basic issues of engineering ethics, with an emphasis on the moral problems faced by engineers in the corporate setting. Includes an appendix with codes of engineering ethics from seven professional societies.

Seebauer, Edmund G., and Robert L. Barry. *Fundamentals of Ethics for Scientists and Engineers*. New York, NY: Oxford University Press, 2001. Pp. xvi, 269. An approach to education in technical ethics that develops a progressive "ethical serial" case study approach and highlights virtue theory. The first half focuses on ethical reasoning and the second half on applications. Organized in four units: foundational principles, resolving ethical conflicts, justice, and advanced topics (e.g., risk, resource allocation, and habit and intuition).

Sherlock, Richard, and John D. Morrey, eds. *Ethical Issues in Biotechnology*. Lanham, MD: Rowman and Littlefield, 2002. Pp. xiii, 643. Intended for use as a text book. Collects thirty-four essays arranged in six sections: fundamental issues, agricultural biotechnology, food biotechnology, animal biotechnology, human genetic testing and therapy, and human cloning and stem cell research. Includes overviews of basic ethics and science and concludes with study cases designed to spark classroom discussion.

Stern, Judy E. and Deni Elliot. *The Ethics of Scientific Research: A Guidebook for Course Development*. Hanover, NH: University Press of New England, 1997. Pp. x, 116. Result of a three-year project to produce a graduate level course in research ethics. Outlines course goals

and plan and discusses how to train faculty to teach ethics and how to evaluate efforts. Concludes with a course reading list and extended case and topic bibliographies as well as a videography.

Tavani, Herman T. *Ethics and Technology: Ethical Issues in an Age of Information and Communication Technology*. New York: John Wiley and Sons, 2003. Pp. xxiv, 344. Introduces the relatively new field of Cyberethics. Discusses key concepts and terms, includes actual and hypothetical case studies, and provides review questions at the end of each chapter.

Unger, Stephen H. *Controlling Technology: Ethics and the Responsible Engineer*. 2nd ed. New York: John Wiley, 1994. Pp. xiv, 353. Argues that the democratic control of technology requires engineers to take responsibility for the consequences of their work. Includes case studies on successful and unsuccessful instances of engineering ethics, codes of ethics for engineers, the role of engineering societies in ethics, and engineering and law.

Veatch, Robert. *The Basics of Bioethics*. 2nd. ed. Upper Saddle River, NJ: Prentice Hall, 2003. Pp. xvii, 205. A brief survey that gives a broad introduction to the field. Covers the basics of ethics, Hippocratic oath, moral standing, patient rights, death and dying, social ethics (e.g., allocation of resources and human subjects research), human control of life and human nature, conflicts among principles, and a new chapter on the virtues (professional, secular, religious, and care) in bioethics.

Vesilind, P. Aarne, and Alastair S. Gunn. *Engineering, Ethics, and the Environment*. New York: Cambridge University Press, 1998.

Zimmerman, Michael E., J. Baird Callicot, George Sessions, Karen J. Warren, and John Clark, eds. *Environmental Philosophy: From Animal Rights to Radical Ecology*. 3rd edition. Upper Saddle River, NJ: Prentice-Hall, 2001. Pp. ix, 486. Collects thirty-two essays in four sections: environmental ethics, deep ecology, ecofeminism, and political ecology. Includes a brief general introduction that places environmental philosophy in historical and conceptual context. First edition, 1993.

5. Twentieth and Twenty-First Century Ethics

Baier, Kurt. *The Moral Point of View: A Rational Basis of Ethics*. Ithaca, NY: Cornell University Press, 1958. Pp. xii, 326. Argues that the distinctly moral perspective is the universalizability of rules and judgments.

Bauman, Zygmunt. *Postmodern Ethics*. Oxford: Blackwell, 1993. Pp. vi, 255. A sociologist's overview the postmodern rejection of the adequacy in ethics of rules, universality, and foundations, and the loss of the sense of self, with a brief statement of the positive possibilities opened by such a stance.

Broad, C.D. *Five Types of Ethical Theory*. London: Routledge and Kegan Paul, 1930. Pp. xxv, 288. An analytic assessment of the ethical theories of Spinoza, Joseph Butler, David Hume, Immanuel Kant, and Henry Sidgwick.

Dewey, John. *Human Nature and Conduct: An Introduction to Social Psychology*. New York: Henry Holt, 1922. Pp. vii, 336. Proposes a pragmatist ethics grounded in psychology. For two other statements of Dewey's pragmatist ethics, see *Ethics* (1908) with James Tufts and *Theory of Valuation* (1939).

Frankena, William K. *Ethics*. Second edition. Englewood Cliffs, NJ: Prentice Hall, 1973. Pp. xvi, 125. (First edition, 1963.) A widely used and influential textbook that defends a version of rule utilitarianism, that is, the moral theory that takes as foundational assessments of the consequences of rules for guiding human behavior. Gives fair consideration to both egoistic and deontological theories, but finds them wanting. No particular effort to consider science or technology, although rule utilitarianism is often the assumed justification for each.

Habermas, Jürgen. *The Theory of Communicative Action*. 2 vols. Trans. Thomas McCarthy. Boston: Beacon Press. 1984-1987.

Hare, R.M. *The Language of Morals*, 2nd ed. Oxford: Clarendon Press, 1961. Pp. viii, 2002. (First edition, 1952.) The single most influential book in meta-ethics. Concerned not with normative issues so much as the nature and function of moral discourse.

Jonsen, Albert R., and Stephen Toulmin. *The Abuse of Casuistry: A History of Moral Reasoning*. Berkeley: University of California Press, 1988. Pp. ix, 420. The title is misleading; this book is in fact a defense of casuistry against those who would too quickly abuse it in the name of principlist ethics. Grew out of the experience of the coauthors working with the National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, 1974-1978.

Kohlberg, Lawrence. *Essays on Moral Development*, vol. 1: *The Philosophy of Moral Development: Moral Stages and the Idea of Justice*. New York: Harper and Row, 1981. Pp. xxxv, 441. Collected papers providing the most complete statement of Kohlberg's influential theory (building on the work of Jean Piaget but based as well on his own empirical observations). Continued with vol. 2, *The Psychology of Moral Development: Moral*

Stages and the Life Cycle, and vol. 3, *Education and Moral Development: Moral Stages and Practice*.

Levinas, Emmanuel. *Totality and Infinity*. Trans. Alphonso Lingis. The Hague: Martinus Nijhoff, 1969. Pp. 307. (French original, 1961.) See also Adriaan T. Peperzak, ed., *Ethics as First Philosophy: The Significance of Emmanuel Levinas for Philosophy, Literature, and Religion* (New York: Routledge, 1995), which collects 21 original essays on Levinas' thought.

MacIntyre, Alasdair. *After Virtue: A Study in Moral Theory*. Second ed. Notre Dame, IN: University of Notre Dame Press, 1984. Pp. xi, 286. (First edition, 1981.) Three subsequent books in which MacIntyre extends his argument: *Whose Justice? Which Rationality?* (Notre Dame, IN: University of Notre Dame Press, 1988), *Three Rival Versions of Moral Enquiry: Encyclopedia, Genealogy, and Tradition* (Notre Dame, IN: University of Notre Dame Press, 1990), and *Dependent Rational Animals: Why Human Beings Need the Virtues* (1999).

Maritain, Jacques. *Integral Humanism: Temporal and Spiritual Problems of a New Christendom*. Trans. Joseph W. Evans. New York: Scribners, 1968. Pp. xii, 308. (French original, 1936.) An effort by one of the founders of Neothomism to develop a humanistic ethics that engages the modern world and responds to both liberalism and Marxism. No direct discussion of science and technology. Subsequent related efforts to restate the Thomistic perspective can be found in Yves R. Simon, *The Definition of Moral Virtue*, ed. Vukan Kuic (New York: Fordham University Press, 1986); and Ralph McInerny, *Ethica Thomistica: The Moral Philosophy of Thomas Aquinas*, revised edition (Washington, DC: Catholic University of America Press, 1997).

Moore, G.E. *Principia Ethica*. Cambridge, UK: Cambridge University Press, 1903. Pp. xxvii, 232. Although published during the first decade of the 20th century this book has exercised a strong influence over Anglo-American analytic ethics (comparable to the influence of Nietzsche's *On the Genealogy of Morals* on continental European phenomenological ethics). Argues that good is a unique, indefinable property that is directly intuited and for which nothing else can be substituted. It formulates in precise terms the so-called "naturalistic fallacy" (of identifying the good with the natural) and argues against naturalistic ethics, hedonism (meaning consequentialism), and metaphysical ethics (meaning the philosophy of Immanuel Kant). The long chapter five, "Ethics in Relation to Conduct," sets forth a program in practical ethics that anticipates applied ethics. The final chapter six, "The Ideal," distinguishes intrinsic goods in themselves, which Moore argues are exemplified in aesthetic enjoyments and personal affection, from extrinsic goods. Moore restates his argument in more textbook form in *Ethics* (London: Oxford University Press, 1912).

Münch, Richard. *The Ethics of Modernity: Formation and Transformation in Britain, France, Germany and the United States*. Lanham, MD: Rowman & Littlefield Publishers, Inc., 2001. Pp. xii, 281. A comparative interpretation of the common impulse of the transformation to modernism and its different expressions in four Western countries. Begins with an assessment of the West compared to the East and traces the formation of ethics through modern secularized and globalizing culture. Describes modern ethics as "instrumental activism," or the refusal to take the world as it is but rather to plan and intervene in it according to ideals. This creates a second world that is unpredictable and often brings unintended side effects that in turn call for more instrumental activism, or control.

Nietzsche, Friedrich. *Zur Genealogie der Moral* [On the genealogy of morals]. 1887. Although published in the last third of the nineteenth century, this book has exercised a strong influence over continental European phenomenological ethics (comparable to the influence of Moore's *Principia Ethica* on Anglo-American analytic ethics). Aiming to clarify his previous book, *Beyond Good and Evil* (1886), this volume, subtitled "A Polemic," is composed of three essays. The first distinguishes between moralities that has their origins in ruling classes (and distinguish between good and bad) and those formulated by the oppressed (who oppose good and evil). The second focuses on explicating the origins of guilt and bad conscience. The third criticizes ascetic ideals.

Ross, W.D. *The Right and the Good*. Oxford: Clarendon Press, 1930. Pp. vii, 176. Attempts to bridge deontological theories of the right and utilitarian theories of the good. Prima facie rights can on occasion be outweighed by anticipated bad consequences.

Scheler, Max. *Formalism in Ethics and Non-Formal Ethics of Values: A New Attempt toward the Foundation of an Ethical Personalism*. Trans. Manfred S. Frings and Roger L. Funk. Evanston, IL: Northwestern University Press, 1973. (Original German, 1913-1916.) Influential approach to ethics in the continental European phenomenological tradition. Criticizes Kantian formalism and defends the person as a source of substantive values, which range from sensible through vital and spiritual to the holy. For one subsequent statement of this approach emphasizing compassion as foundational for ethics see Werner Marx, *Towards a Phenomenological Ethics: Ethos and the Life-World* (Albany: State University of New York Press, 1992).

Scott, Charles E. *The Question of Ethics: Nietzsche, Foucault, Heidegger*. Bloomington: Indiana University Press, 1990. Pp. xii, 225. Argues that Nietzsche's questioning of ethics as a pathology is a fundamental part of ethics, an argument that he deepens with interpretations of Foucault and the problem of Heidegger's Nazism. Scott's thesis is that strong ethical commitments can create their own unethical behaviors, and that the questioning of ethics can (and must) be done on ethical not rejection of ethical grounds. Modest mentions of both science and technology. The argument is extended in Scott's *On the Advantages and Disadvantages of Ethics and Politics* (Bloomington: Indiana University Press, 1996), which includes more extended discussions of the ethical challenge of technology.

Toulmin, Stephen. *An Examination of the Place of Reason in Ethics*. Cambridge, UK: Cambridge University Press, 1950. Pp. xiv, 228. An attempt to develop a theory of moral reasoning in the analytic tradition that is perhaps the first instance to take explicit account of engineering and technology; see section 12.5, "Ethics and Engineering." Toulmin subsequently argues that attention to practical issues actually rescued ethics from abstraction in such articles as "The Recovery of Practical Philosophy," *American Scholar* 57, no. 3 (Summer 1971), pp. 337-352; and "How Medicine Saved the Life of Ethics," *Perspectives in Biology and Medicine* 25, no. 4 (Summer 1982), pp. 736-750. See also Toulmin's criticism of Enlightenment ethical rationalism in *Cosmopolis: The Hidden Agenda of Modernity* (New York: Free Press, 1990).

Williams, Bernard. *Ethics and the Limits of Philosophy*. Cambridge, MA: Harvard University Press, 1985. Pp. xiv, 230. An extended assessment of the limitations of modern ethics as "too much and too unknowingly caught up in ... administrative ideas of rationality" (p. 197). Argues that ethics needs to recover some of the resources of classical Greek philosophy while taking into account scientific knowledge in order to respond to the Socratic question of how one should live by making possible the pursuit of a meaningful life.

6. Journals

Bioethics, Publication of the International Association of Bioethics.

Bulletin of Science, Technology, and Society. Has been associated with the National Association for Science, Technology, and Society.

Environmental Ethics. Publication of the International Society for Environmental Ethics (ISEE).

Environmental Philosophy. Publication of the International Association for Environmental Philosophy (IAEP), University of North Texas.

Environmental Science and Policy. Published by Elsevier.

Ethics and Information Technology. Published by Kluwer.

Hastings Center Report. Publication of the Hastings Center.

IEEE Technology and Society Magazine. Publication of the Society on Social Implications of Technology of the Institute of Electrical and Electronics Engineers.

Philosophy and Public Affairs. Published by Blackwell-Synergy.

Philosophy and Public Policy Quarterly. Publication of The Institute for Philosophy and Public Policy, University of Maryland.

Science and Engineering Ethics. Published by Opragen.

Science and Public Policy. Published by Beechtree.

Science, Technology, and Human Values. Publication of the Society for Social Studies of Science (4S).

Techne: Research in Philosophy and Technology. An electronic journal published by the Society for Philosophy and Technology (SPT).

Technology and Culture. Publication of the Society for the History of Technology (SHOT).

Technology in Society. Published by Elsevier.

The American Journal of Bioethics. Publication of The American Journal of Bioethics at bioethics.net.

The New Atlantis. Publication of The Ethics and Public Policy Center.

COMPILED BY ADAM BRIGGLE AND CARL MITCHAM

APPENDIX II

INTERNET RESOURCES ON SCIENCE, TECHNOLOGY, AND ETHICS

This listing of Internet Resources reflects the fact that science, technology, and ethics discussions tend to be divided according to scholarly communities, as summarized in the specialized introduction entries of the encyclopedia.

General

American Association for the Advancement of Science: http://www.aaas.org/. An international non-profit organization founded in 1848 to advance science and innovation, also publishes the journal Science. Site includes news, publications, career information, and statistics on indicators in research and development. It features several programs, including the "Dialogue on Science, Ethics and Religion" at http://www.aaas.org/spp/dser/.

Carnegie Council on Ethics and International Affairs: http://www.cceia.org/index.php. Contains publications and links. In-depth sections include environment, armed conflict, human rights, and global justice. Features an electronic forum for discussion.

Case Western Reserve Online Ethics Center for Engineering and Science: http://onlineethics.org/. Created with an NSF grant and geared to engineers, scientists, and students. Focuses on engineering and research ethics, diversity, and issues in computer and natural sciences. Features numerous case studies, original materials, links, and an extensive collection of codes of ethics.

European Group on Ethics in Science and New Technologies: http://europa.eu.int/comm/european_group_ethics/index_en.htm. Established in 1997 to advise the European Commission. Features its opinions on diverse subjects, publications, and links.

Institute for Global Ethics: http://www.globalethics.org/default.html. Promotes ethics at several levels through research, dialogue, and action. Provides educational program materials and organizational services. Features white papers and other publications.

Kurzweil AI: http://www.kurzweilai.net/index.html?flash=2. Non-flash version available at http://www.kurzweilai.net/index.html?flash=1. Investigates the accelerating growth of intelligence and knowledge and the growing intersection of various fields of research and technology and their impacts on society. Site includes news, publications, and editorials. Also features Ramona, a photorealistic avatar host, and an innovative networked presentation of information.

Loyola University Center for Ethics and Social Justice: http://www.luc.edu/ethics/. Founded in 1991, provides ethics education to individuals and organizations.

Sigma Xi, The Scientific Research Society: http://www.sigmaxi.org/. A chapter-based organization that promotes the health of the scientific enterprise, supports original research, honors scientific achievement, and publishes the journal *American Scientist*. Site features links to local chapters, information on meetings and events, publications, programs, and news, as well as the booklet "The Responsible Researcher," which supplements "Honor in Science."

UNESCO World Commission on the Ethics of Scientific Knowledge and Technology (COMEST): http://portal.unesco.org/shs/en/ev.php-URL_ID=6193&URL_DO=DO_TOPIC&URL_SECTION=201.html. Created in 1997 to mirror at the international level, national commissions on science, technology, and ethics. Site has information on its functions and full publications.

Agricultural Ethics

Food-Ethics.net: http://food-ethics.net/. A European Union project begun in 2003 that serves as a subject information gateway for professionals to facilitate access to high quality information on ethical principles of food and ethical traceability.

The Food Ethics Council: http://www.foodethics-council.org/index.html. Founded in 1998 to address a broad spectrum of issues from the use of antibiotics to intellectual property. Site includes publications, news, and project information.

Applied Ethics

Ethics Updates: http://ethics.acusd.edu/. Founded in 1994 and edited by Lawrence Hinman at University of San Diego. Site has diverse resources including videos, bibliographic essays, publications, and links arranged in three main groups; ethical theory, resources, and applied ethics.

EthicsWeb.ca: http://www.ethicsweb.ca/resources/. Developed as part of the W. Maurice Young Center. Includes information on topics, institutions, and publications in several areas including business, health care, research, and environmental ethics and resources on ethics in decision making.

Harvard Edmond J. Safra Foundation Center for Ethics: http://www.ethics.harvard.edu/. Features publications, information on ethics in the curriculum, and links to other institutions.

Santa Clara University Center for Applied Ethics: http://www.scu.edu/ethics/. Established in 1986 and has information on diverse subjects including biotechnology and healthcare ethics, business ethics, and government ethics. Also features perspectives on recent events, publications, and links.

University of British Columbia W. Maurice Young Center for Applied Ethics: http://www.ethics.ubc.ca/. Created in 1993 to study, train, and consult in a diverse range of applied ethics topics. Site includes working papers and other publications, information on trainings and courses, and news.

Bioethics

American Journal of Bioethics: http://www.bioethics.net/. Founded in 1993 and the most read source of information on bioethics. Site contains news, editorials, essays, and a discussion forum.

American Society for Bioethics and the Humanities: http://www.asbh.org/index.htm. A professional association founded in 1998 to provide research, teaching, and policy development in bioethics. Site features publications and links for members and non-members.

Bioethics: http://www.web-miner.com/bioethics.htm. A comprehensive site operated by Sharon Stoerger with annotated links to academic centers, government agencies, publications, and other resources.

Bioethics.com: http://bioethics.com/. Features news, commentaries, and links in nine categories including stem cell research, research ethics, and health care.

The Center for Bioethics and Human Dignity: http://www.cbhd.org/. A Christian organization founded in 1994. Site contains news, articles, and a topical listing of bioethics issues, each with a bibliography.

Council of Europe Bioethics Division: http://www.coe.int/T/E/Legal_affairs/Legal_co-operation/Bioethics/. Includes information on legal conventions and protocols as well as research projects.

The Hastings Center: http://www.thehastingscenter.org/. Research institute founded in 1969 to study issues in biotechnology, health care, and the environment. Site includes news, research projects, publications, and a library.

Human Genome Project Ethical, Legal, and, Social Issues (ELSI): http://www.ornl.gov/sci/techresources/Human_Genome/elsi/elsi.shtml. Contains information on societal implications of genetic research, including links and articles on gene testing, gene therapy, privacy, patenting, forensics, courts, and behavior.

International Association of Bioethics: http://www.bioethics-international.org/. Focuses on networking and cross-cultural issues in bioethics and publishes two journals.

International Society of Bioethics: http://www.sibi.org/ingles/home2.htm. Spanish organization founded in 1996. Site features links and a focus on Latin American bioethics.

President's Council on Bioethics: www.bioethics.gov. Homepage for the U.S. federal bioethics panel created by George W. Bush in 2001. Site contains numerous publications, full texts of transcripts and meetings, and several other resources and links arranged topically.

UNESCO Bioethics Programme: http://portal.unesco.org/shs/en/ev.php-URL_ID=1372&URL_DO=DO_TOPIC&URL_SECTION=201.html. Primarily responsible for the Secretariat of two advisory bodies: International Bioethics Committee and Intergovernmental Bioethics Committee. Site links to these bodies and contains general information.

Biotechethics

Biotechnology Watch: http://www.infoshop.org/biotechwatch.html. An activist organization skeptical of biotechnology applications that is part of the Alternative Media Project. Site contains news, links, and information on direct action campaigns.

Ethics for the Biotech Industry: http://www.biotechethics.ca/. A program of academic research that views biotechnology through business and professional ethics. Site contains resources and publications.

Ford Foundation Program on Biotechnology, Religion, and Ethics: http://cohesion.rice.edu/centersandinst/bioreliethics/fordgrant.cfm?doc_id=2378. An expired four-year project on religion and biotechnology. Site has contact information for researchers involved.

Transhuman.com: http://www.transhuman.com/. A pro-biotechnology group advocating for the use of biotechnology to overcome human limitations. Site contains a book store and resources on transhumanism.

Business Ethics

Better Business Bureau: http://www.bbb.org/. Founded in 1912 to solve marketplace problems through self-regulation and consumer education. Site contains news, resources, and connections to local BBB organizations.

Business and Human Rights Resource Centre: http://www.business-humanrights.org/Home. Promotes awareness and discussion on issues involving business and human rights, including resources, news, reports of corporate misconduct, and examples of best practice. Features an in-depth library arranged topically, including information on individual companies and laws.

Business Ethics: http://www.web-miner.com/busethics.htm. Site operated by Sharon Stoerger that contains annotated links to publications, professional societies, case studies, resources, centers, and more.

Business Ethics Magazine: http://www.business-ethics.com/. Homepage for the magazine. Site contains information on events and an extensive business ethics directory with contact information for various organizations.

Business for Social Responsibility: http://www.bsr.org/. Non-profit organization that provides information, tools, training and advisory services to make corporate social responsibility an integral part of business operations and strategies. Site contains information on advisory services, news, links, and reports.

European Business Ethics Network: http://www.eben.org/. An international collaboration dedicated to the promotion of business ethics. Site contains in-house information and external links.

Global Ethics: http://www.ethics.org/i_centers.html. Supports local groups in establishing ethics initiatives. Site features products, resources, and research on organizational ethics, character development, and ethics centers worldwide.

Institute of Business Ethics: http://www.ibe.org.uk/home.html. Founded in 1986 to promote ethical standards and share information. Site includes publications, events, training, news, information on how to create and implement codes of conduct, and resources on teaching business ethics.

International Business Ethics Institute: http://www.business-ethics.org/about.asp. Founded in 1994 to promote business ethics and corporate responsibility through public awareness, education, and fostering international business ethics organizations in companies. Site contains resources on education and professional services and publications.

Communication Ethics

Communication Ethics Limited: http://www.communication-ethics.com/. A consultancy-network and partner of the Institute of Communication Ethics. Site includes information on social justice, information integrity, and more.

Institute of Communication Ethics: http://www.communication-ethics.org.uk/. Offers education, research, and training in communication ethics. Site provides information for members, link to its journal *Ethical Space*, and information on events.

Computer Ethics

Computer Ethics: http://library.thinkquest.org/26658/. Provides basic understanding of ethical issues for internet users. Main portion has introduction to computer ethics, copyrights and licensing information, privacy issues, and censorship information. Users can submit content and create individual accounts. Has news, links, references, and information for teachers.

Ethics in Computing: http://ethics.csc.ncsu.edu/. Arranged topographically by speech issues, commerce, risks, privacy, computer abuse, social justice, intellectual property and basics. Each section has extensive information, links, references, and/or case studies.

The Research Center on Computing and Society: http://www.southernct.edu/organizations/rccs/index.html. Hosted by Southern Connecticut State University.

Features news, links, and resources for researchers, teachers, and students. Contains supplementary materials to be used with a computer ethics textbook.

Development Ethics

Development Studies Association: http://www.devstud.org.uk/studygroups/ethics.htm. Based in and Ireland and the U.K. to promote ethics and knowledge of international development. Site organized by working group topics including development ethics, women in development, sustainability, and information technology and development.

International Development Ethics Association: http://www.development-ethics.org/. Multi-disciplinary, cross-cultural group studying the ethics of global development. Site contains newsletter, links, and information on conferences and other events.

Engineering Ethics

Case Western Reserve Online Ethics Center for Engineering and Science: http://onlineethics.org/. Operating under an NSF grant and geared to engineers, scientists, and students. Focus on engineering and research ethics, diversity, and issues in computer and natural sciences. Features numerous case studies, original materials, links, and an extensive collection of codes of ethics.

National Institute for Engineering Ethics: http://www.niee.org/pd.cfm?pt=NIEE. Founded in 2001 as part of Texas Tech University. Site contains newsletter, links, educational resources, and products and services.

National Society of Professional Engineers: http://www.nspe.org/home.asp. Founded in 1934 and serves over 50,000 members. Site contains information on licensure, ethics, and law, products and services, educational materials, employment opportunities, a journal, links, information on events and conferences, and more.

Texas Tech University Engineering Ethics: http://www.niee.org/. Central hub that links three sites: Applied Ethics in Professional Practice (featuring the case of the month program), National Institute for Engineering Ethics, and the Murdough Center for Engineering Professionalism. Also features events, correspondence courses, videos and other resources, and ethics case studies.

University of Virginia Engineering Ethics: http://repo-nt.tcc.virginia.edu/ethics/. Disseminates engineering ethics cases studies and resources for students and faculties. Access to full case studies requires authorization from the University of Virginia.

Environmental Ethics

Environmental Protection Agency, Office of Environmental Justice: http://www.epa.gov/compliance/resources/ej.html. Features a frequently asked question section, newsletters and listservs, reports, publications, and information on policy and guiding documents.

Institute for Environment, Philosophy, and Public Policy: http://www.lancs.ac.uk/fss/ieppp/. Multi-disciplinary research group founded in 2000 at Lancaster University. Site contains news and events, information for current and prospective students, and research updates.

International Association for Environmental Philosophy: http://www.environmentalphilosophy.org/. Multi-disciplinary group studying broad range of topics in environmental philosophy. Site features news, newsletter, resources, links, and information on membership and events.

International Society for Environmental Ethics: http://www.cep.unt.edu/ISEE.html. Group founded in 1990 as the first major professional environmental ethics organization. Site features a listserv, newsletter, bibliography, selected books and articles, a syllabus project, and links.

University of North Texas Environmental Ethics: http://www.cep.unt.edu/. Features information on books, journals, educational and professional opportunities, links, news, and events.

Genethics

Genethics.ca: http://genethics.ca/index.html. A clearinghouse for social, ethical, and legal issues related to genomic knowledge and technology. Features topics (eugenics, patenting, DNA banking, gene therapy, GMOs, and many more), news, journals, conferences, and links to discussion forums.

Center for Economic and Social Aspects of Genomics: http://www.cesagen.lancs.ac.uk/. Based at the Universities of Lancaster and Cardiff to study the economic, social, and ethical implications of genomic research. Site features research projects, resources, newsletter, and events.

Information Ethics

Information Ethics, Inc.: http://www.info-ethics.com/. Contains resources, links, publications, and focuses on the ethics of software development. Links to a service branch that consults and trains clients.

International Center for Information Ethics: http://icie.zkm.de/. Platform for exchanging information on worldwide teaching and research. Features news, articles, links to institutions in the field, teaching resources, and publications.

Journalism Ethics

European Codes of Journalism Ethics: http://www.uta.fi/ethicnet/. A comprehensive databank offering resources for students, teachers, scholars, and practitioners. Arranged by links to thirty-five European countries (and the International Federation of Journalists) with contact information and codes of journalism ethics for each. Also features supplementary links.

Indiana University Journalism Ethics Cases Online: http://www.journalism.indiana.edu/Ethics/. Collects an extensive list of case studies in thirteen topical areas (including privacy, sensitive news topics, and workplace issues) to be used for students, teachers, practitioners, and media consumers.

Journalism Ethics: http://www.web-miner.com/journethics.htm. A comprehensive site operated by Sharon Stoerger with annotated links to articles, centers, and professional organizations. Many of the article links are broken.

Poynter Online Ethics: http://www.poynter.org/subject.asp?id=32. Includes columns, discussion, case studies and an extensive archive of ethics related stories. Also contains credibility and ethics bibliographies, codes of ethics, and ethics guidelines for publishing featuring seven core values.

Medical Ethics

American College of Physicians Center for Ethics and Professionalism: http://www.acponline.org/ethics/. Devoted to policy development and implementation. Features resources on end-of-life care, managed care ethics, and many other areas. Provides career related information, resources for students, advice for advocates, and services for various practitioners.

American Medical Association, Medical Ethics: http://www.ama-assn.org/ama/pub/category/2416.html. Arranged into eight areas that feature different aspects of AMA work in medical ethics. These include an interactive forum for analysis and discussion, an ethics working group, an effort to develop health care performance measures for ethics, and strategies for teaching and evaluating professionalism.

BMC Medical Ethics: http://www.biomedcentral.com/bmcmedethics/. An open access, peer-reviewed journal that considers articles on the ethics of medical research and practice.

Public Responsibility in Medicine and Research: http://www.primr.org/. Established in 1974 to implement ethical standards in research. Cite contains educational materials, resources, events, and information on certification of IRB professionals.

Stanford Center for Biomedical Ethics: http://scbe.stanford.edu/. Conducts interdisciplinary research and education in biomedical ethics and provides clinical and research ethics consultation. Site features news, events, job opportunities, newsletter, educational materials, and other resources.

Military Ethics

Joint Services Conference on Professional Ethics: http://www.usafa.af.mil/jscope/. An organization of military professionals, academics, and others formed to discuss ethical issues relevant to the military. Site made possible by the U.S. Air Force Academy and features general information, case studies, bibliography, core values of each military branch and links to past conferences.

Naval Academy Center for the Study of Professional Military Ethics: http://www.usna.edu/Ethics/. Formed in 1998 to promote ethical advancement of military leaders through research and education. Site contains events, publications, news, and links.

Nanoethics

Foresight Institute: http://www.foresight.org/. A member of the Foresight family of institutions formed to help society prepare for nanotechnology and other advanced technologies of the future. Site features news, events, quarterly newsletter, discussion, and information on research, public policy, and career opportunities.

Nanoscience and Technology Studies Societal and Ethical Implications: http://www.cla.sc.edu/cpecs/nirt/mission.html. Founded in 2001 at the University of South Carolina to research the ethical, legal, and social implications of nanotechnology. Site includes research, education, outreach, papers and other publications, links, and information on events and grants.

Nanotechnology Now: http://www.nanotech-now.com/. An up-to-the-minute news service on nanotechnology developments geared primarily for those in research and industry. Includes links to a consulting service and technology transfer and patenting service.

National Nanotechnology Initiative (NNI) Societal and Environmental Implications: http://www.nano.-gov/html/facts/society.html. A multi-agency U.S. federal research and development project, part of which is devoted to the ethical, social, environmental, and legal implications of nanotechnology. Site contains links on societal and environmental implications for researchers and educational resources.

Neuroethics

Center for Cognitive Liberty and Ethics: http://www.cognitiveliberty.org/mission.html. A network of scholars promoting freedom of thought through research and advocacy based on core principles of privacy, autonomy, and choice. Site contains news, publications, and resources arranged topically.

Nuclear Ethics

Alsos Digital Library for Nuclear Issues: http://alsos.wlu.edu/. Named after the original Alsos Missions (1944-1945) that followed in the wake of Allied Armies in Europe to investigate the extent to which Nazi Germany was working on developing at atomic bomb. Includes a broad range of annotated references for the study of nuclear issues. This searchable collection includes books, articles, films, CD-ROMs, and websites.

Bulletin of the Atomic Scientists: http://www.thebulletin.org/index.html. Founded in 1945 and educates citizens on national security issues, especially nuclear and other weapons of mass destruction. Site features extensive data on nuclear weapons capabilities around the globe, news, articles, links, current and past issues of the journal, and the doomsday clock.

Planning Ethics

American Planning Association: http://www.planning.org/. Includes information on ethics for professional planners including legislation and policy, careers, news, publications, research, conferences, consultant services, and information on creating local communities.

Professional Ethics

Illinois Institute of Technology Center for the Study of Ethics in the Professions: http://www.iit.edu/departments/csep/. Founded in 1976 to promote education and scholarship on professional ethics. Site features a library, codes of ethics, publications, and links.

Research Ethics

Central Office for Research Ethics Committees: http://www.corec.org.uk/. Organized for three main user groups: patients and the public, research ethics committee community, and applicants. Each section contains news, links, and information about and updates to relevant rules.

Office of Research Integrity: http://ori.dhhs.gov/. Oversees and directs Public Health Service (PHS) research integrity activities and promotes integrity in biomedical and behavioral research. Site contains information on policies, protocols for handling misconduct, links to related international organizations, educational materials, and conference and events announcements.

On Being a Scientist: Responsible Conduct in Research: http://www.nap.edu/readingroom/books/obas/. An on-line booklet published by the National Academy Press in 1994. Chapters span the spectrum from broad considerations such as "Values in Science" to narrower topics such as "The Allocation of Credit."

Plagiarism: http://www.web-miner.com/plagiarism.htm. A comprehensive site operated by Sharon Stoerger with annotated links to articles and resources for instructors and students.

Research Ethics: http://www.web-miner.com/researchethics.htm. A comprehensive site operated by Sharon Stoerger with annotated links to articles, case studies, policies and guidelines, and centers.

Rhetoric of Science and Technology

American Association for the Rhetoric of Science and Technology: http://aarst.jmccw.org/. Founded in 1992. Site features news, discussion forum, merchandise, pedagogical materials, links to similar organizations, and information on conferences and events.

Science and Technology Policy

American Association for the Advancement of Science: Science and Policy: http://www.aaas.org/programs/science_policy/. The Directorate of Science and Policy Programs operates eight programs at the interface of science, government, and society. Site links to these programs: ethics, and religion; fellowships; science, technology, and congress; research and development budget analysis; science, technology, and security policy; research competitiveness; scientific freedom and responsibility; and science and human rights.

Consortium for Science, Policy and Outcomes: http://www.cspo.org/. An intellectual network aimed at enhancing the contribution of science and technology to societal goals such as freedom, equality, and quality of life. Site features news, editorials, projects, education and outreach materials, and a library.

Ethics and Public Policy Center: http://www.eppc.org/about/. Established in 1976 to clarify and reinforce the bond between the Judeo-Christian moral tradition and the public debate over domestic and foreign policy issues. Site contains news, updates, publications, conferences, and events.

European Scientific and Technological Options Assessment: http://www.europarl.eu.int/stoa/default_en.htm. Provides independent assessments of the science and technology components of policy options faced by the European Parliament. Site contains newsletter, publication, work plans, workshops, and links to relevant network of experts.

Humanities/Policy: http://humanitiespolicy.unt.edu/. Network of scholars developing interdisciplinary approaches to integrating ethics and values with science to better meet societal goals. Site features information on policy, the humanities, projects, and resources for scientists and engineers.

New Directions in Science, Policy, and the Humanities: http://newdirections.unt.edu//. Fosters interdisciplinary networks including private sector and government to work toward solutions for environmental problems. Site features interdisciplinary resources, workshops, and project outcomes.

The National Academies Committee on Science, Engineering, and Public Policy (COSEPUP): http://www7.nationalacademies.org/cosepup/. Provides independent analyses of cross-cutting issues in science and technology policy, often for government agencies. Site includes publications, links, resources, and current and recent projects.

United States Office of Science and Technology Policy (OSTP): http://www.ostp.gov/. Established in 1976 to advise the President on science and technology aspects of public policy. Site contains news, outreach, projects, and information on science, technology, and government.

University of Colorado Center for Science and Technology Policy Research: http://sciencepolicy.colorado.edu/. Founded in 2001 to conduct research, education, and outreach to improve the relationship between societal needs and science and technology policies. Site features news, events, publications, educational materials, and several projects with various foci including water, climate, and carbon.

Science Fiction

Asimov's Science Fiction: http://www.asimovs.com/. Site features current and archived journals but also includes discussion forums, links, and other resources.

SciFi.com: http://www.scifi.com/. Site features listings on the television channel but also includes news, events, and pedagogical materials.

Science, Technology, and Art

Interdisciplinarity Resources: http://notes.utk.edu/bio/unistudy.nsf/0/5fd8d0b054118786852566fd008282be?OpenDocument. Maintained by the University of Tennessee, Knoxville, site links to several related projects and resources at the interface of science, technology, art, humanities, and culture.

Science, Technology, and Law

American Bar Association Section of Science and Technology Law: http://www.abanet.org/scitech/home.html. Provides updates, links, publications, and a search engine for documents related to science, technology, and law.

Cornell Law School Legal Ethics Library: http://www.law.cornell.edu/ethics/. A digital library that contains both the codes or rules setting standards for the professional conduct of lawyers and commentary on the law governing lawyers, organized by jurisdiction and topic. Also includes materials on multidisciplinary practice.

National Academies Science, Technology, and Law Program: http://www7.nationalacademies.org/stl/index.html. Established in 1992 to link the science and engineering communities with the law community. Site features links, events, contacts, and current studies.

Science, Technology, and Literature

Society for Literature and Science: http://sls.press.jhu.edu/. Site features a bulletin board, publication, links, educational materials, and a directory.

Science, Technology, and Society Studies

History of Science Society: http://www.hssonline.org/. HSS was founded in 1924 and is dedicated to understanding science, technology, medicine, and their interactions with society in historical context. The HSS site features publications, information on the profession, and educational and research materials.

Society for Philosophy and Technology: http://www.spt.org/ index.html. SPT was founded in 1980 to facilitate philosophically significant reflections on technology. The SPT site includes journal, newsletter, and links.

Society for Social Studies of Science: http://4sonline.org/. 4S grew out of a program on the public understanding of science at Harvard University in the 1960s. It is now an organization devoted to understanding science and technology. The 4S site features scholarly resources, information on the profession, conferences, and information for students.

COMPILED BY ADAM BRIGGLE AND CARL MITCHAM

APPENDIX III

GLOSSARY OF TERMS

The following selection of terms and definitions is based on one originally authored by Caroline Whitbeck at the Online Ethics Center for Engineering and Science (OECES) at Case Western Reserve University (onlineethics.org) with the help of advisors to the OECES and discussed at greater length in her book, Ethics in Engineering Practice. *Its aim is to introduce a number of concepts and terms that figure prominently in many discussions of science, technology, and ethics. Italicized terms within a glossary definition are defined in the glossary.*

Academic Honesty and Academic Integrity: The maintenance of truthfulness and proper crediting of sources of ideas and expressions. Behaviors such as cheating on examinations and lab reports, or plagiarism of course papers and homework assignments violate academic integrity. Violations of academic integrity by students have the same character as violations of research integrity by scholars and research investigators (see *Research Ethics*). Other matters of academic integrity include honesty in writing letters of recommendation and in reporting institutional statistics.

Accountable: To be accountable is to be answerable or required to answer for one's actions. Sometimes the term *accountable* is used with a moral connotation (*normatively*), meaning morally required to answer for one's actions without specifying to whom one is accountable. More often accountable is used to describe the sociological fact that a person or organization in question is required to answer to a particular party by some rules or organizational structure. For example, "the principal is accountable to the school board" gives a description of the social facts without suggesting anything about the ethical legitimacy of the organizational structure.

Confusion arises when "responsible" is used as a synonym for accountable, especially in discussions of official responsibilities. When responsible is used as a synonym for accountable the preposition "to" is also involved, as in "each staff employee is responsible/accountable to a supervisor" (see *Responsibility*). Being a responsible person, that is, the sort of person who fulfills one's moral responsibilities, is an ideal of character, a virtue. Being accountable is not a moral virtue but only a fact about one's social or organizational situation. Although it is often argued that people are more likely to behave responsibly if they are held accountable for their actions, there is no necessary link between being responsible and being accountable.

Administrative Law: *Administrative law* is constituted by that body of regulations, rules, orders, decisions, and policies that carry out the regulatory powers created of administrative agencies. In ordinary use, as contrasted with technical legal use, people often speak of administrative law as "regulation." For example, it is often pointed out that it is easier for regulatory agencies, such as U.S. Environmental Protection Agency or the U.S. Occupational Safety and Health Administration to update their regulations than it is to get Congress to pass new laws. In the technical legal sense, regulation is law has "the force of law." Administrative law, like all other forms of law, is subject to assessment and criticism in terms of ethics and justice. See also *Civil Law* and *Criminal Law*.

Affirmative Action: Positive steps to enhance the diversity of some group, often to remedy the cumulative effect of subtle as well as gross expressions of prejudice. In science and engineering affirmation actions often aim to enhance the participation of women and underrepresented minorities in these fields.

Applied versus Basic Research: Applied research is the investigation of phenomena to discover whether their properties are appropriate to a particular need or want, usually a human need or want. In contrast, basic research investigates phenomena without reference to particular needs and wants. Applied research is more closely associated with technology, engineering, invention, and development. Basic research is sometimes described as "pure research."

Assent: Assent is a variation of the concept of *Informed Consent* specifically used in reference to research subjects such as children or other persons without the full competence to provide informed consent. For instance, because children under 18 are below the legal age of consent, the U.S. Department of Health and Human Services (DHHS) requires additional protections when children are involved as subjects. Assent is defined as "a child's affirmative agreement to participate in research. Mere failure to object should not, absent affirmative agreement, be construed as assent" (45 CFR 46 Subpart D). In addition, the federal regulations require the permission of one or both parents or guardians of the child, depending on the nature of the research to be performed.

Authenticity: The character trait or virtue of being genuine and honest with oneself as well as others. Therefore, authenticity connotes not only candor, but an absence of hypocrisy or self-deception.

Autonomy: See *Right to Self-Determination*

Basic Research: See *Applied versus Basic Research*

Bias: An inclination that influences judgment is a bias. The term may be used in a merely descriptive way to mean an inclination, but more often it is used indicate an inclination that influences judgment but ought not to. *Prejudice* is a synonym for bias in this pejorative sense.

However, the bias that cannot be completely eliminated in the work of scientific investigators, in contrast to bias or prejudice that can and should be eliminated, is also an important topic in research ethics. For example, the way disciplinary training inclines people to interpret the results of an experiment in terms of the established categories of that discipline is a permanent feature of research, and one that must be taken into account in assessing responsible behavior in research. Of course, researchers may hold disciplinary biases and still be unbiased in other respects, that is, they may be impartial on the question of the truth or falsity of a particular research hypothesis.

Biotechnology: As defined by the U.S. government, biotechnology refers to any technique that uses living organisms (or parts of organisms) to make or modify products, to improve plants and animals, or to develop microorganisms for specific use. Biotechnology focuses on the practical applications of science (as opposed to doing basic research). Historically, biotechnology has had an impact in three main areas: health, food and agriculture, and environmental protection. Biotechnologists try to solve problems in these and other areas such as the need to cure or prevent illness, for clean water, and to preserve food.

Bribe: A bribe is something given or offered to a person or organization in a position of trust to induce such a person to behave in a way inconsistent with that trust. As C. E. Harris et al. (2000) point out, offering a bribe is not the same as capitulating to extortion (that is, capitulating to a demand under coercion or intimidation). It may be ethically justified to pay extortion in some circumstances, even though it would be wrong to offer a bribe. Bribes are paid to obtain something to which one does not have a right, such as a special advantage in awarding a contract. In contrast, extortion is paid to secure something to which one has a right, such as the return of expensive equipment one has legally brought into a country but which a corrupt customs official claims has been "lost."

Candor: Candor is the quality of being frank or open. The original, now obsolete sense of the term was of the virtue of purity or innocence. Although being open and unbiased is a positive quality, in some circumstances it is better to be discreet rather than candid with someone about a particular topic. Certainly, there are matters in which a person is morally required to keep something confidential, and therefore being candid with the wrong party about such a matter would be an ethical breach. See also *Authenticity*.

Challenge Study: A study in which researchers intentionally give subjects or patients pharmacological agents in order to induce and study psychiatric symptomology.

Civil Law: That body of law relating to contracts and suits, as contrasted with criminal law. Civil law covers suits of one party by another for such matters as breach of contract or negligence, and as such may have application in scientific and engineering contracts as well certain professional obligations. The standard of proof in civil cases is preponderance of evidence—a greater weight of evidence for than against. This is a weaker standard of proof than exists in criminal cases. Civil law, like all other forms of law, is subject to assessment and criticism in terms of ethics and justice. See also *Administrative Law* and *Criminal Law*.

Civil Rights: Rights associated with citizenship that one acquires simply by being a citizen. Not all of these are inalienable rights, however. See *Rights*. For example, according to the law in some states, a citizen may lose the right to vote if convicted of certain crimes.

Complainant: A person who raises concerns inside or outside her organizations about something she believes to be amiss. The term does not have the negative connotation of "complainer." The complainant is one who speaks up in some way about a problem. This speaking up may or may not include filing a formal charge. See also *Whistleblower*.

Confidential: That which is done or communicated in trust is confidential. Confidential information is information entrusted to another. The implication is that it is information that for some reason (from personal privacy to competitive advantage) the person entrusting the information does not wish some others to know. Thus confidential information is information to be shared only with a very limited group who are involved with furthering certain ends which the one entrusting the information wants served, such as treatment of a disease, or development and manufacture of a new product. Most professions recognize some duty to keep confidential a client's information, although such a duty has limits when the confidential information concerns a danger to others.

Conflict of Interest: Someone has a conflict of interest when that person is in a position of trust requiring the exercise judgment on behalf of others (people, institutions, etc.) and also has interests or obligations of the sort that might interfere with the exercise of such judgment, and which the person is morally required to either avoid or openly acknowledge.

The lesser requirement of open acknowledgment is usually adopted when it seems too burdensome to require that persons in positions of trust divest themselves of the interest that conflicts with a position of responsibility. For example, some journals require that authors disclose any substantial financial interests that might have biased their research assessment. Requiring investigators to divest themselves of investments that they may have made on the basis of their scientific judgment would be too burdensome, and might even suppress publication.

Dictionary definitions frequently apply the term only to conflicts between a person's private interests and those of a public office, and by extension with that person's professional obligations and responsibilities. However, there can also be conflicts of interest in which private interests do not enter. For example, the American Bar Association specifies as part of a general rule on conflict of interest that lawyers should not represent a client if such representation may be materially limited by the lawyer's responsibilities to another client or to a third party. There is no similar rule requiring engineers or engineering firms to avoid, say, building manufacturing facilities for, or supplying parts to, two companies that directly compete in the same market, although the engineering firm might need to be especially careful to avoid disclosing the proprietary information of one company to the other.

This example illustrates the point that one needs to look carefully at the nature of a professional's or public official's obligations and responsibilities in order to know when conflicting interests become a conflict of interest, that is, when a situation that requires discretion to handle the actual or potential conflict fairly is one that he is morally required to avoid altogether, or at least to disclose to all parties.

Policies requiring financial disclosure, that is disclosure of financial interests that might conflict with judgment as a researcher or as public official, are very commonly called a "conflict of interest policy," although such financial conflict of interest is only one specific type.

Contract: As used in ethics, the term contract means an explicit agreement that is freely entered into. Only a small number of these would qualify as legal contracts. A legal contract is a legally binding agreement among two or more parties. Breach of contract is the failure to fulfill a legal contract.

Copyright: A legal right (usually of the author or composer or publisher of a work) to exclusive publication production, sale, and/or distribution of some work for a specified period of time. What is protected by the copyright is the "expression," not the idea. Notice that taking another's idea without attribution may be plagiarism, so copyrights are not the equivalent of legal prohibition of plagiarism.

Cost-Benefit Analysis: To use cost-benefit analysis (also sometimes called risk-benefit or risk-cost-benefit analysis) requires that one consider only those consequences or the probability of consequences that can be quantified, such as number of deaths, days of illness, or monetary costs. Cost-benefit analysis is a technique taken from economics that weighs alternative actions in terms of such consequences. Its great strength is that it can introduce a measure of objectivity into sometimes complex or contentious decision-making. Its weakness is that it is not able to consider consequences such as the loss of moral integrity or human flourishing that do not lend themselves to quantification. See also *Risk*.

Criminal Law: That body of law relating to crimes (which can be classified as either felonies or misdemeanors). Crimes are offenses against the state; they are investigated by the police, prosecuted at public expense, and can be punished by incarceration as well as fines. The uses of science and technology to commit crimes are always subject to criminal prosecution and punishment. The standard of proof in criminal cases is stronger than the standard of proof in civil cases, which is preponderance of evidence and may extend to absence of reasonable doubt. Criminal law, like all other forms of law, is subject to ethical assessment and criticism. See also *Administrative Law* and *Civil Law*.

Data Selection: Involves emphasizing some data over other data or sometimes ignoring certain data. The term is primarily used when data selection is legitimate and clarifies research, as opposed to selection that falsifies the research. Selection of data for analysis or presentation is legitimate only when undertaken on the basis of clear criteria for thinking that in comparison with other related data it is less subject to confounding influences or "noise." Any selection must be disclosed in reporting the research.

Defendant: A party being sued in civil proceedings, or accused of a crime in criminal proceedings.

Dilemma: A dilemma involves a forced choice between courses of action (usually two) which are both unacceptable. Sometimes people will call any challenging moral problem a dilemma, but this is misleading. Only a few moral problems are dilemmas in the technical sense of the term. Calling moral problems "dilemmas" is confusing because it implies that the only possible responses are the two obvious (and unacceptable) ones; this tends to discourage real problem solving.

Discrimination: Discrimination in the common, morally relevant use of the term, is a failure to treat people fairly due to a bias against (or for), based on a characteristic such as race, religion, sex, national origin, sexual orientation, physical appearance, or disability that is irrelevant to the decision at hand (e.g., job skills or qualifications for public housing). Discrimination may be intentional or unintentional. Discrimination is a form of behavior that shows prejudice, but not the only form.

Due Process: That procedure or process required for a given judgment to be fair. Fairness here is specified in terms of the process rather than the outcome. For example, although it is desirable that those and only those who are guilty of a crime be punished for it, infallibility of judgment by the law courts cannot be guaranteed. The feasible goal is to try to ensure everyone a fair trial. Similarly, although it is hoped that important research does not go unrecognized, it is impossible to guarantee that the contributions of those who are "ahead of their time" will be recognized. The feasible goal is to ensure fair process in the reviewing of research proposals for funding or research results for publication.

Duty: See *Obligations*

Ethical Relativism: Ethical relativism or "relativism" may be used to indicate several different views. One view, which is also called "ethical subjectivism," is the view that the truth of some ethical judgment as applied to a person's behavior depends on whether the person believes the actions to be right or wrong. This view is commonly expressed as "there is no right or wrong, it's only a matter of opinion." Acceptance of this view undermines the claim of any ethical judgment to have validity. One who believes in ethical relativism in this sense would have to agree that there was nothing objectively wrong with a person torturing or killing another person, as long as the individual committing those actions sincerely believed it was not wrong to do so.

A second view, which is sometimes called "cultural relativism," is the view that ethical judgments and moral rules always reflect the cultural context from which they are derived and cannot be immediately applied to other cultural contexts. Some who hold this view are skeptical about even the possibility of saying that slavery is wrong in a slave-holding society and so are close to the ethical subjectivists. At the other extreme, some cultural relativists only put the burden of proof on those who think that they can generalize from one social context to another, but accept that the burden of proof is often met.

Many ethical philosophers, such as Alasdair MacIntyre (1988) and Annette Baier (1994), who do not consider themselves relativists, nevertheless argue that moralities are social products constructed by particular people in particular societal contexts and must be understood in relation to those societal contexts. For example, the Hippocratic oath specifies extensive duties toward those who have taught one medicine. In this oath physicians pledge to respect and care for their teachers as for their own parents. The societal context in which these duties of physicians were formulated was very different from what it is in industrialized nations today. It is implausible that the same duties should apply to physicians in all societies, but this does not mean that they did not have validity when the oath was first formulated. What makes the difference is not a person's or the group's opinion, but the social reality in which the person participated.

Ethics and Morals: The term *ethics* is used in several different ways. First, it may mean the study of morals, meaning individual or social forms of behavior. It is also the name for that branch of philosophy concerned with the nature of morals and moral evaluation: what is right and wrong, virtuous or vicious, good and bad, and beneficial or harmful (to oneself or others).

Second, ethics or morality may be used to mean the standards for ethical or moral behavior of a particular group, such as "Buddhist ethics" or "nursing ethics" or "Roman Catholic morality" or "the professional ethics of engineers in the United States." To give a description of such ethical codes and standards is "descriptive ethics." Descriptive ethics does not include a judgment as to whether the code or standards of behavior are ethically justified. The examination of the adequacy of moral or ethical values, standards, or judgments is *normative* ethics.

Third, some authors even use the terms *ethics* or *morality* more loosely to refer to any code of behavior, even one that no one regards as having any moral justification. For example, Robert Jackall (1988) describes what he calls the "ethics" or "morality" of a corporation and takes it to include such judgments as "What is right is what the guy above you wants from you." Such a judgment is about the most immediate way to survive in the organization, but does not pretend to be a statement about what is morally or ethically justified. It may be important to examine such codes of behavior and see how they affect the opportunities for moral action, but not every code of behavior has, or is even claimed to have, moral or ethical justification.

The term "moral" tends to be used for more practical elements, such as "moral problems" and "moral beliefs," and "ethical" tends to be used for more abstract and theoretical elements, such as "ethical principles," but the distinction is by no means hard and fast.

Evaluation: Evaluation can be either descriptive or normative. Descriptive evaluation may range from simple measurement to complex judgment about such things as the presence of mineral deposits. Normative evaluations involve judgments as to whether something is good or bad in some respects—a value judgment.

Explanation: Explanations of human actions typically make reference to the agent's reasons or motives for some action. For example, the student went to the bookstore to buy a text book. Causes are usually cited only for human actions that are not intentional, such as falling. A person's falling might be causally explained by the slipperiness of the road surface, the person having been pushed, or drugged, or having a heart attack. A person's falling with acceleration would be explained in terms of the gravitational field in which the person was falling. Notice that in certain contexts, notably ordinary life and law, it is often the unusual that is explained, whereas scientific explanation more commonly explains typical behavior.

Fabrication: In research ethics, fabrication means making up data, experiments, or other significant information in proposing, conducting, or reporting research. In engineering, fabrication has a benign connotation, meaning to make something. Sometimes the term is used to refer specifically to an intermediate stage between design and manufacture or construction.

Falsification: In research ethics falsification means changing or misrepresenting data or experiments, or misrepresenting other significant matters such as the credentials of an investigator in a research proposal. Unlike fabrication, the distinguishing of falsification data from legitimate data selection often requires judgment and an understanding of statistical methods.

Fraud: An intentional deception perpetrated to secure an unfair gain. Financial fraud, that is, a deception practiced on another party to cheat that party out of money, is the most commonly discussed type of fraud.

The terms "research fraud" or "scientific fraud" are used to mean an intentional deception about experiments or results, and is a type of research misconduct. In this case, the act may not include a financial transaction and there need not be an injured party or even anyone who was actually deceived. Therefore, so-called "research fraud" does not fit the legal criteria for a fraudulent act, which are discussed below.

In a civil law suit charging fraud there is a plaintiff who makes the charge against a defendant. To win a suit the plaintiff must prove five points, which are the five legal criteria for fraud: (1) the defendant made a false representation; (2) the defendant knew that the representation was false or at least recklessly disregarded whether it was true or false; (3) the defendant intended to induce belief in the misrepresentation; (4) the plaintiff had a reasonable belief in the misrepresentation; and (5) the plaintiff suffered damage as a result. As is illustrated in the case of "research fraud," the term "fraud" is often used informally to mean a misrepresentation but in which there may be no injured party who might become a plaintiff and so which satisfies only the first two criteria.

Glass Ceiling: The term *glass ceiling* indicates a barrier to advancement within an organization experienced by members of certain groups because of prejudice (including discomfort in their presence). This term is most often used when the organization recruits members of an affected group but then fails to promote them through the junior ranks on a comparable basis to other favored groups. If members of a group tend to leave the organization soon after entering, this is termed a "revolving door" rather than a "glass ceiling." The barrier in an organization may be different for different groups that are commonly victims of prejudice and usually is strongly influenced by so-called "corporate culture."

Good: The good is that which is rational to want or desire. A good knife is one that has characteristics it is rational to want in a device with one blade used for cutting. When considering what makes a good person, or good character, the matter becomes more complex, because it then becomes important to ask whether the traits under discussion are those that people would want in themselves, or those that they would want in others, and whether these are the same, or in what sort of society they might be the same.

Good Scientific Practice: See *Research Ethics or the Responsible Conduct of Research*

Human Rights: See *Rights*

Inherently Safe: The term *inherently safe* is applied to products, processes, and systems in which operational safety is independent of any user training or auxiliary devices. For instance, Elisha Otis's invention of the safety elevator in the 1850s was designed to function only when the lift cable disengaged a brake; if the cable failed, the brake was automatically engaged. Since the 1970s nuclear reactors that are designed to automatically shut down in the case of any malfunction are also described as inherently safe. With inherently safe technologies, any deviation from expected use or operation leads to a nonhazardous state.

Inherently safe manufacturing processes utilize machines that will not function unless workers have placed themselves in safe positions, as when for example both hands must be placed on two separate switches before a cutting operation can proceed. Another inherently safe process would minimize the use of hazardous materials or the time employed in their use, thus reducing the dependency of safety on worker training or protective equipment.

In contrast, the notion of inherently dangerous or unreasonably dangerous is a legal notion that applies to products, processes, and systems which, under normal operating conditions, entail some level of hazard. Inherently dangerous can entail strict liability in tort.

A related term "intrinsically safe" is applied to electrical or electronic equipment that is incapable of producing a dangerous spark or thermal effect under either normal or abnormal operating conditions.

Informed Consent: Describes the obligation of physicians or researchers to allow patients or subjects to be active participants in decision-making with regard their care or research in which they play a role. Informed consent is rooted in the concept of autonomous choice or the *Right of Self-Determination*, and requires five elements: (1) disclosure (of information to the patient/subject), (2) comprehension (by the patient/subject of the information being disclosed); (3) voluntariness (of the patient/subject in making his/her choice); (4) competence (of the patient/subject to make a decision); and (5) consent (by the patient/subject).

Legal Contract: See *Contract*

Legal Rights: See *Rights*

Liability: A person is liable when obligated by law to make satisfaction, compensation, or restitution for some act or injury. Liability is a legal notion indicating a legal debt or obligation. The liabilities most often at issues in discussions of science, technology, and ethics are those having to do with compensation for injury (to one's person, property, finances, or reputation) or to clean up toxic contamination. Legal liability to compensate for an injury or to clean up contamination does not necessarily require that one has caused the injury or contamination, or that one be guilty in a moral sense. Under the doctrine of strict liability a party may be liable without having been guilty of negligence.

Liberties: See *Rights*

Morals: See *Ethics and Morals*

Moral Agent: One whose actions are capable of moral evaluation. We may say that an avalanche killed three people, but the avalanche is not open to moral evaluation. The avalanche is an amoral force. A competent and reasonably mature human being is the most familiar example of a moral agent. In contrast, most so-called "lower" (that is, non-human) animals are generally understood to be amoral (although this is open to debate regarding species that have complex and flexible social relations, such as primates and dolphins).

Moral Integrity: *Moral integrity* is a complex and subtle ethical notion. As theologian Stanley Hauerwas (1981) has argued, it is central to all the other virtues but more fundamental than any single virtue. The root of the term integrity is wholeness. Moral wholeness rather than rigidity best captures the idea of moral integrity. For example, a person might discover that some long-held ethical belief, attitude, or rule of conduct was mistaken because the person came to see that it was incompatible with other, more fundamental ethical commitments. A person's moral integrity is central to a person's sense of meaning.

Philosophers such as John Ladd (1982) have argued that a person's moral integrity is a central aspect of that person's well-being. Therefore, leading another person to compromise moral integrity is a fundamental injury to that person. Concern for a person's moral integrity requires an understanding of the person's moral convictions and in this respect differs from merely respecting a person's *Right of Self-Determination*, which requires only that one refrain from restricting their actions.

Some professional codes of ethics uphold the right to refuse work that would compromise an individual professional's ethical commitments even when the act in question (say, performing an abortion or developing weapons systems) is something the profession as a whole has not ruled morally objectionable.

Moral Standing: A being's moral standing determines the extent to which its well-being must be ethically considered for its own sake. To say that some groups of beings have moral standing is to say that, as a moral matter, their well-being must be given some consideration. It does not decide the question of whether they have the same moral standing as people (and thus have "human" rights). The welfare of such beings as cattle, for example, might be considered for prudential reasons, but that would not require that they have moral standing. One might decide that it is important to feed one's cattle, just as one might decide it was stupid to throw one's stamp collection into the river, thinking of the cattle or stamps as investments, without believing that either deserves such or better treatment out of consideration for their own well-being.

Moral Values: See *Values*

Motive: That which moves a person to action. Typically these are emotions, desires, or concerns. Thus people say such things as, "The motive for the crime was revenge." However, it is often common to hear someone speak simply of the intended result as "the motive." For example, any of the following sentences might be used to convey the same thought: "Lee's motive in arising early was to avoid traffic." "Lee arose early to avoid traffic." "Lee arose early because he wanted to avoid traffic." In such cases we assume that a desire or concern to realize the intended state is the implied motive. The expression "mixed motives" is used most often to suggest, not just any combination off emotions, desires, and concerns, but more specifically a mixture of selfish and altruistic concerns.

Negligence: A failure to be sufficiently careful in relation to a matter about which one has a moral responsibility to exercise care. Some careless mistakes are negligent, as when a surgeon sews up a patient with surgical instruments inside. Others are not, as when one dribbles soup down the front of one's sweater. Negligence is a legal basis for the recovery of damages from a private or civil wrong or injury, what is called a tort. The failure to fulfill a recognized duty, or to act with less care than would a reasonably prudent person in the same circumstances is the mark of negligence.

Normative: Derived from the Latin *norma,* the name for a carpenter's square, and is a loose synonym for authoritative or required. It is sometimes used broadly to mean that which establishes or reflects any sort of standard, even a statistical one. But in ethics when a standard, judgment, or assessment is normative, it concerns respects in which something is right or wrong, good or bad. Value judgments are normative in the ethical sense, but the judgment that X is greener or heavier than Y is not. In the ethical sense normative is a close synonym for prescriptive, that which "makes or gives rules."

However, not all rules are ethically normative; they may simply establish order. For example, the statement "Put out your trash out for collection on Tuesdays" is a prescription about when to put out trash, but does not suggest or establish that there is anything in Tuesday trash collection that is superior to collection on some other day.

Obligations: Requirements arising from a person's situation or circumstances (e.g., relationships, knowledge, position) that specify what must or must not be done for some moral, legal, religious, or institutional reasons. For example, students may have an obligation see their advisor on or before registration day, simply because this is one of actions students in a particular institutional context are asked to perform. But it can also be argued that persons insofar as they are moral have an obligation to keep their promises, because this is one of things that being moral entails. Notice that usually statements of obligations specify what acts are required or forbidden without reference to the consequences of performing the act (except in so far as these consequences are a part of the characterization of the act itself).

Obligations can be more or less specific. That drivers are obligated to obey the traffic rules is much more specific than "Engineers have an obligation in their work to ensure the public safety." The second obligation names a responsibility that engineers have to achieve a certain end, namely safety of the public, but fails to specify what specific acts they should or should not perform in order to ensure safety.

A legal obligation is one that specifies what types of actions are permitted, forbidden, or required with certain state-enforced penalties attached for failures to comply.

Official Responsibility: See *Responsibility, Official*

Patents: A (special, alienable, prima facie) legal right granted by the government to use, or at least (in cases where other patents that such use would infringe) to bar others from using a device, design, or type of plant that one has created. In the United States restrictions last for 17 years for useful devices, and 14 years for designs. Specific provisions of U.S. patent law may soon change to bring it into conformity with the provisions of other techologically developed countries. To patent a device one must prove that it is useful, original, and not obvious. Patents are subject to challenge in court and may be upheld or overturned.

Paternalism: Derived from the Latin word for father (*pater*) and means acting as a parent toward someone who is not in fact one's child. Acting like a parent toward those who are not one's children may or may not be justified in particular circumstances. Parents need to make judgments about many areas of their young children's lives (with the particular areas depending on the age or maturity of the children), but adults assume the responsibility for making those decisions for themselves. Paternalism may be roughly defined (following Gert and Culver, 1976) as violating a moral rule of conduct toward someone or limiting that person's self-determination (and hence often infringing that person's rights) for what is perceived as being that person's own benefit.

Paternalism may be justified or unjustified, but the paternalistic treatment of adults always requires justification because of the infringement of the person's right that it entails. Paternalism in the treatment of clients most commonly arises in professional contexts where the professional has a face-to-face relationship with those whose well-being they seek to ensure, and in professions where practitioners are in positions of greater power than their clients.

The question of paternalism often arises in medicine and healthcare with respect to the treatment of patients. Because many engineers and scientists in industry must protect the safety and health of anonymous members of the public rather than identified clients, and usually do not occupy positions of greater power than their clients, paternalism is not a frequently discussed topic for engineers in industry. Nevertheless, issues of paternalism often do arise for engineers and scientists in relationships among co-workers and in educational contexts.

Plagiarism: Commonly defined as the unauthorized or unacknowledged appropriation of the words, graphics images, or ideas of another person. In some instances reference is also made to artistic creations such as music. Plagiarism is theft of credit and covers ideas as well as forms of expression and should be distinguished from copyright violation, which does not cover ideas and is a matter of intellectual property violation.

Plaintiff: An injured party suing someone (a defendant) in order to be compensated for an injury or loss.

Preferences: Statements about the person who has them. If statements of preference are false it is because they are not true about that person. Such statements of preferences should be distinguished from *Value Judgments*, which are statements about the thing being judged good or bad.

Economists often avoid getting into substantive value discussions by considering only what people want or prefer and how much they prefer some things over other things. What makes this confusing is that they sometimes speak about what people "value," but they mean only what people prefer, and not what people have reasons for thinking are good or bad in some respect. It is of course possible for someone to prefer something because they judge it to be good. However, many factors other than value judgments enter into people's preferences, such as their early conditioning, habits, and vivid personal experiences. (If this were not the case, there would not be such a large market for cigarettes, for example, since even most smokers do not judge smoking to be a good thing to do.)

Prejudice: Bias for or against someone or something that fails to take true account of their characteristics.

Principal: A principal in an engineering firm (or other company) is a co-owner, that is, a partner or stockholder.

Privacy: It is common to distinguish three species of privacy: physical, informational, and decisional. In addition, philosopher and legal theorist Anita Allen (2003) distinguishes dispositional privacy. Physical privacy is a restriction on the ability of others to experience a person through one or more of the five senses. Informational privacy is a restriction on facts about the person that are unknown or unknowable. Decisional privacy is the exclusion of others from decisions, such as healthcare decisions or marital decisions, made by the person and his group of intimates. Finally, dispositional privacy is a restriction on the ability of others to know a person's state of mind.

Claims to privacy find moral justification in a recognition that people need to have control over some matters that intimately relate to them in order to function as people and be responsible for their own actions. Foremost among these are rights to one's own body. If, for example, people were permitted to drug one another at will, that would effectively undercut the rest of moral life.

Just what a person is expected to do in order to respect another's privacy varies with culture. For example, expectations that people will knock on the door before entering certain areas assumes the existence of both doors and of expectations about the amount of so-called "private space" to which a person is entitled. In some contemporary cultures, parents oversee their children's affairs much more closely than in others. In traditional Chinese families, for example, it is expected that parents will do such things as read the mail addressed to their adolescent children as part of their responsible oversight of their children, whereas in Anglo-American culture such acts would be viewed as intrusions on the adolescent's privacy.

Questions of privacy have become particularly prominent as computers and other technological innovations have made it possible to collect, assemble, and transmit quantities of information in ways that previously were impossible. Once the questions of appropriate levels of privacy protection have been established, the question of how that level of privacy can be practically ensured is a matter of security.

Profession: An occupation, the practice of which directly influences human well-being, and requires mastery of a complex body of knowledge and specialized skills, requiring both formal education and practical experience.

Professional Engineering: In the United States a professional engineer (P.E.) is a person who is licensed to practice engineering in a particular state or U.S. territory after meeting all requirements of the law. To practice in multiple states or territories, the P.E. must be licensed in each state in which he or she wishes to practice.

Professional Responsibility: See *Responsibility, Professional*

Property: A property, from the Latin *proprius*, meaning "one's own" or "special," can refer to the key characteristic of a thing ("One property of water is to be a solvent") or that to which an individual has special rights. In this second sense, very different sorts of things may be regarded as property. Individual rights to property (other than clothing and other personal effects), especially the right to own land, is a major innovation in modern thought. Land was one important kind of property, physical objects that constitute "the fruit of one's labor" were another.

It was a short step from physical property to intellectual property, the fruit of one's intellectual labor, which was given some recognition in the U.S. Constitution (see *Copyright, Patent, Trademark, Trade Secret Patent*). (Notice that "ideas" cannot be owned by these means but only some "expression," design, or device.) The advent of electronic information has raised new issues and problems about intellectual property and rights to such property, because of the extreme ease with which electronic information can be copied and transmitted.

Proprietary/Property Rights: Proprietary rights, claims, etc. are the rights, claims, etc. of owners. Sorting out the rights that go with property ownership is complicated, both because of the variety of types of property, and because of the problem of sorting out conflicting claims regarding property and conflicts between property rights and other rights.

Prudence or Prudential Judgment: See *Values and Value Judgments*

Reparations: Benefits given to some person or group to make amends for damage done by previous injustice. For example, as a result of the "Civil Liberties Act of 1988," Japanese-Americans who were placed in internment camps during World War II were given a monetary payment (of about $20,000 each) as reparations. Because children may be damaged by injustice done to their forebears, e.g. because poverty undermines their health or limits their educational opportunities, arguments are made for reparations to descendants of those who were first injured, if the consequences of the injury are of the sort that pass from one generation to the next.

Research Ethics or the Responsible Conduct of Research: *Research ethics* or *responsible conduct of research* (RCR) are terms used broadly to refer to many ethically significant issues that arise in research, from fair apportionment of credit among members of a research team, to responsible behavior in submitting or reviewing grant applications and the responsible treatment of research subjects.

Since the U.S. government and institutional regulations regarding the treatment of human and animal research subjects predated the increased attention to and the regulation of matters of research integrity (including fair credit) that arose in the 1980s, some RCR resources address only issues of research integrity and not the treatment of research subjects. Similarly, laboratory safety has long been regulated by OSHA, and is not necessarily a matter of research integrity. Therefore, it too is often omitted from discussions of responsible behavior in research. For example, *On Being a Scientist: Responsible Conduct in Research* (1995), put out by the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine, in both its first and second edition omitted any discussion of the treatment of research subjects or laboratory safety. The treatment of research subjects and laboratory safety are nevertheless reasonably classed as matters of research ethics, even if they are not always included under this designation.

In Europe the term "good scientific practice" (GSP) covers much of the same territory as research ethics and RCR.

Research Misconduct: *Research misconduct* is a term used rather narrowly. It does not include all violations of standards of research ethics. In particular, it is not applied to violations of the norms for the use of human or animal subjects.

In the United States the three actions that have been the focus of misconduct definitions are fabrication, falsification, and plagiarism (FFP). In 1995 the Congressionally-mandated Commission on Research Integrity issued a report, "Integrity and Misconduct in Research," arguing that FFP did not cover all serious deviations from accepted practices, and proposed a broader definition of research misconduct as misappropriation, interference, and misrepresentation, but this definition was not adopted. After extensive public debate the U.S. Office of Science and Technology Policy in 2000 issued the following common definition: "Research misconduct is defined as fabrication, falsification, or plagiarism in proposing, performing, or reviewing research, or in reporting research results." See the U.S. Federal Policy on Research Misconduct http://onlineethics.org/fedresmis.html.

Responsible Conduct of Research: See *Research Ethics and Responsible Conduct of Research*

Responsibility: *Responsibility* is a complex concept with both non-moral and moral meanings, and at least forward- and back-looking forms. The moral and forward-looking sense of responsibility is the sense in which one is responsible for achieving (or maintaining) a good result in some matter. The idea is that one is entrusted with achieving or maintaining this outcome, and expected both to have relevant knowledge and skills, and to make a conscientious effort. However, despite one's best efforts, the result may not be achieved. For example, patients of responsible physicians may die. The work of a responsible engineer may result in an accident because the accident was not foreseeable, it was not possible to compensate for the factors causing the accident, or because others were unwilling to heed the engineer's warnings. The moral and backward-looking sense of responsibility is that in which a person or group deserves ethical evaluation for some act or outcome, that is deserves moral praise for a good outcome or blame for a bad one.

The moral sense of responsibility should not be confused with the causal sense of responsibility for some existing or past state of affairs. For example, when we say "the storm was responsible for three deaths and heavy property damage," meaning that it caused these outcomes, we do not mean to attribute moral responsibility to the storm. Storms do not have moral responsibilities, and are neither responsible nor irresponsible in the moral sense. However, when a moral agent is causally responsible for some outcome, that is some reason to think that the agent is morally responsible for it. Causal responsibility is not conclusive evidence of moral responsibility, however. If one's actions cause a terrible outcome only because of bad moral luck, in the form of a freak accident, then one is not morally responsible for the outcome.

Responsibility, Official: The responsibility one is assigned as a result of some job or office. Unfortunately, official responsibilities may require one to behave unethically. But although "It was my job" might be a reason, it is not a valid excuse for immoral behavior. However, even when the requirements of an official responsibility are ethically acceptable, the concept of official responsibility functions differently from moral responsibility. Official responsibility resembles moral responsibility in generating prescriptions for conduct—duties or at least statements about what someone "ought" to do. As philosopher John Ladd points out, moral and official responsibility differ in at least two respects: First, official responsibilities are "exclusionary"—if one person has a particular official responsibility, another person does not (unless, of course, it was part of the job description of both). Second, official responsibilities, together with whatever rights, duties, and requirements for accountability attend them, are all "alienable" (see *Rights*)—they can be given to or taken over by someone else. In contrast, if one has a moral responsibility to inform the public about some matter, then even if one is in the position to delegate that responsibility to someone else, one still must see that the responsibility is fulfilled, because one does not get rid of a moral responsibility by giving it to someone else.

Responsibility, Professional: Professional responsibility is a paradigm case of the moral responsibility that arises from the special knowledge that one possesses. It is mastery of a special body of advanced knowledge, particularly knowledge that bears directly on the well-being of others, which demarcates a profession. As custodians of special knowledge that bears on human well-being, professionals are constrained by special moral responsibilities—that is, moral requirements to apply their knowledge in ways that benefit the rest of the society.

Right of Self-Determination: The right of self-determination equals the right to choose one's own actions or course of life, so long as doing so does not interfere unduly with the lives and actions of others.

Rights: Rights are claims that have some justification behind them. A moral right is a morally justified claim. A legal right is a legally justified claim. When we use the term "right" without specifying the nature of the justification, we usually mean a moral right.

Rights specify acts that are permitted, forbidden, or required. If they specify acts that the rights-holder may perform (such as vote, or drive a car), they are often called licenses. If they specify acts that others may not perform (as the right to life obliges others to refrain from killing the rights holder), they are called liberties or (in law) negative rights. If they specify what the rights-holder should receive, the law commonly calls them positive rights, although some philosophers call them claim rights.

Other major types of classifications of rights are:

- Alienable rights and inalienable rights. Alienable rights may be taken or given away. Inalienable rights cannot be taken or given away.
- Human rights and special rights. Human rights belong to all people, or all people who are competent to exercise them. (Another term that is a close synonym for human rights is "natural rights.") In contrast, a right that only belongs to some people is termed a "special" right.
- Absolute rights and prima facie rights. Absolute rights cannot be outweighed by other considerations; prima facie rights can be outweighed by other considerations. For example, many of those who oppose capital punishment say that the right to life is an absolute right, but those who believe that capital punishment is morally justified in some circumstances say it is only a prima facie right.

See also *Copyright* and *Propietary/Property Rights*.

Risk: *Risk* is used colloquially as a term for a danger that arises unpredictably, such as being struck by a car. Sometimes it is used for the likelihood of a particular danger or hazard, as when someone says, "You can reduce your risk of being hit by a car by crossing at the crosswalk."

When used in technical context, such as in the terms "risk assessment" or "risk management," the notion of risk is the probability or likelihood of some resulting harm (such as the likelihood of being killed by being struck by a car) multiplied by the magnitude of the harm. One can then compare, say, the average citizen's risk of death from crossing the street with such a person's risk of death from cancer in a given period. One could also compare the risk of harms of different magnitudes. For example, two monetary risks: the rather likely event of losing a quarter in a malfunctioning vending machine, and the comparatively unlikely loss of one's wallet due to robbery at gun point. It may turn out that there is a greater risk of monetary loss from malfunctioning vending machines than from robbery at gun point. Notice that use of the technical sense of risk requires that one be able to meaningfully quantify the resulting harms. For many harms this is difficult to do except in an arbitrary way.

Risk and Benefits: See *Costs and Benefits*

Safety: *Safety* involves freedom from danger. A property of a device or process is safe insofar as it limits the risk of accident below some specified acceptable level.

Scientific Misconduct: See *Falsification, Fraud, Plagiarism, Research Misconduct*.

Screening: Involves the testing of a large number of individuals in a way designed to identify those with a particular genetic trait, characteristic, or biological condition. Screening differs from other biological testing in that it is done without any indication that the condition tested for is one possessed by any particular individual who is screened.

Security: The security of a system is the extent of protection against some unwanted occurrence such as the invasion of privacy, theft, and the corruption of information or physical damage.

Self-Deception: A failure to make explicit, even to oneself, some truth about oneself (often one's behavior). It may take the form of making up some rationalization for a behavior that is inconsistent with one's sense of self, or it may take the form of failing to take notice of some of the features of the situation when it would be appropriate to do so. The latter phenomenon is one that psychologists call "denial." Self-deception is a barrier to *authenticity*.

Stakeholder: A person or group who can affect or be affected by an action. Responsible decision-making requires consideration of the effects on all stakeholders. Some stakeholders may not be morally entitled to consideration of the same aspects of their welfare, however. For example, a corporate decision may affect or be influenced by employees, stockholders, customers, suppliers, communities, some government agencies, and corporate competitors. Competitors are entitled to fairness in competition, but not to the same consideration as, say, employees.

Standard: An established basis of comparison in measuring or judging capacity, quantity, content, value, quality, etc. It may also be a specified set of safety or performance criteria that a device or process ought to possess. The meeting of safety or performance standards must generally be demonstrated by a series of tests conducted under predetermined conditions.

Standard of Care: The degree of care that a reasonably prudent person would exercise in some particular circumstances. In negligence law, if someone's conduct falls below such a standard, then the person may be liable in tort for injuries or damages resulting from his or her conduct. In professional malpractice cases, a standard of care is applied to measure the competence as well of the degree of care shown by a professional's actions.

Therapeutic Illusion: A condition under which research subjects falsely believe that taking part in a particular study will likely result in some direct therapeutic benefit for themselves.

Therapeutic Orphan: A term given to children to express the concern that a fear of harming individual children by exposing them to research results is harming children as a class by undermining efforts to gain knowledge about how to better treat them. The question of the best methods for determining safe and effective medications is a continuing problem for drug research.

Tort: A private or civil (as contrasted with criminal) wrong or injury. Sometimes "tort law" is used as a general designation to include provisions concerning breaches of contract as well as a failure in some duty. However, the term *tort* is commonly used more narrowly to refer only to specific failure in some recognized duty, or a failure to exercise reasonable prudence or care. In this narrower sense *tort* is contrasted with "breach of contract" (failure to fulfill a legal agreement).

Trademark: An officially registered and legally restricted name, symbol, or representation, the use of which is restricted to its owner.

Trade Secret: A device, method, or formula that gives one an advantage over the competition, and which must therefore be kept secret if it is to be of special value. It is legal to use reverse engineering to learn a competitor's trade secret. "Know how" concerning research procedures may function as something like a trade secret.

Trust: Confident reliance. We may have confidence in events, people, or circumstances, or at least in our beliefs and predictions about them, but if we do not in some way rely on them, our confidence alone does not amount to trust. Reliance is a source of risk, and risk differentiates trusting in something from merely being confident about it. When one is in full control of an outcome or otherwise immune from disappointment, trust is not necessary. Of course, it is possible to rely on other people or on circumstances simply because one lacks other options.

The bases for confidence in relying on some person may not be morally sound. Trust may be naive or otherwise ill-founded. In this case it is likely to be disappointed. Trust may also rest on a morally unsound foundation as when, for example, one party feigns *trustworthiness* or behaves reliably only because the other party dominates.

Trustworthiness: When *trust* is well-founded and if trust of another person or moral agent is morally sound, then it is based on trustworthiness. Put another way, that which deserves trust is trustworthy.

Values and Value Judgments: Value judgments judge things to be good or bad in some respect. Moral or ethical values are only one type of value, and moral evaluation is only one type of value judgment.

Consider the following nine value judgments:

1. This is a good (important, significant) hypothesis.
2. That is a good (insightful or informative) article.
3. This is a good (beautiful, masterfully executed) symphony.
4. That is a good (prudent or effective) strategy.
5. This is a bad (stupid, short-sighted) idea.
6. That is a good (virtuous, of high moral character) person.
7. This is a bad (evil, vicious) motive.
8. That is a good (kind, generous or right-minded) act or deed.
9. That is the right thing to do.

The first two are judgments of epistemic or knowledge value. The third is an aesthetic judgment. The fourth and fifth are prudential judgments. The sixth, seventh, and eighth are moral judgments. The ninth is also a moral judgment that is similar in some respects to the eighth, although the presence of "the" rather than "a" in the ninth suggests that the act in question is uniquely acceptable.

Assertions such as the ninth are usually justified by an appeal to moral rules, often to the exclusion of any mention of consequences. There are other types of value and value judgments that also come into play in ethics, such as those related to religious value. Religious terms of evaluation include "sacred" and "holy," as contrasted with "profane" and "mundane." In addition to purely religious judgments, the practice of most religions also involves making moral or ethical judgments.

Virtues and Vices: Virtues are positive traits of moral character such as honesty, kindness, or being a courageous or responsible person. Vices are negative traits of moral character such as dishonesty or cowardice. Notice that these terms of moral evaluation are applied to people, rather than to their actions (which may be assessed in terms of rights, obligations, and moral rules) or to the outcomes they seek to achieve (which may be assessed in terms of responsibilities).

Washout Study: A study in which patients or subjects are removed from all psychiatric medication to study baseline states or pure effects of new drug treatment.

Whistleblower: A whistleblower is a person who takes a concern (such as one about safety, financial fraud, or mistreatment of research animals) outside of the organization in which the abuse or suspected abuse is occurring and with which the whistleblower is affiliated. Not all whistleblowing is equally adversarial to the affected organization, even though it is at least an embarrassment for an organization to be exposed as one that cannot correct its own problems.

There are many regulatory agencies, such as the U.S. Occupational Safety and Health Administration, that exist to perform oversight and to which whistleblowers can go anonymously. Going to those charged with oversight, such as regulatory agencies, is usually seen as much less adversarial than, say, going to the media. Some people have used the term *whistlerblower* for those who raise an issue within their organization, but the more general term for a person who raises an issue inside or outside an organization is *complainant*.

BIBLIOGRAPHY

Allen, Anita. (2003). "Privacy and Law." *Privacies: Philosophical Evaluations*, ed. Beate Roessler. Palo Alto, CA: Stanford University Press.

Baier, Annette. (1994). *Moral Prejudices: Essays on Ethics*. Cambridge, MA: Harvard University Press.

Committee on Science, Engineering, and Public Policy. (1995). *On Being a Scientist: Responsible Conduct in Research*, 2nd edition. Washington, DC: National Academy Press. The first edition appeared in 1988.

Gert, Bernard, and Charles M. Culver. (1976). "Paternalistic Behavior." *Philosophy and Public Affairs* 6: 45–57.

Harris, Charles E.; Michael S. Pritchard; and Michael J. Rabins. (2000). *Engineering Ethics: Concepts and Cases* 2nd edition. Belmont, CA: Wadsworth/Thomson Learning.

Jackall, Robert. (1988). *Moral Mazes: The World of Corporate Managers*. New York: Oxford University Press.

Hauerwas, Stanley. (1981). *A Community of Character: Toward a Constructive Christian Social Ethic*. Notre Dame: IN: University of Notre Dame Press.

Ladd, John. (1982). "The Distinction Between Rights and Responsibilities: A Defense." *Linacre Quarterly* 49: 121–142.

MacIntyre, Alasdair. (1988). *Whose Justice? Which Rationality?* Notre Dame, IN: University of Notre Dame Press.

Whitbeck, Caroline. (2006). *Ethics in Engineering Practice*, 2nd edition. New York: Cambridge University Press.

APPENDIX IV

CHRONOLOGY OF HISTORICAL EVENTS RELATED TO SCIENCE, TECHNOLOGY, AND ETHICS

The purpose of this chronology is not to provide an all-inclusive history of science, technology, and ethics. Rather the aim is to highlight enough of the most important developments to capture a sense of the timing and pace of both macro-level (e.g., shifts from pre-modern to modern forms of science) and micro-level (e.g., the interplay of contemporary thinkers) changes and interactions. By organizing information in a historical manner, the chronology provides a supplementary perspective for thinking about science, technology, and ethics. It enables users of the encyclopedia to orient specific article topics within the larger sweep of time that conditions and is in turn conditioned by various persons, events, organizations, and ideas. The compilers of this chronology are grateful to Dr. David Lee for allowing the use of material from his website at http://www.sciencetimeline.net/.

The Ancient World: From the First Tools to 550 B.C.E.

Paleolithic (Old Stone Age) ca. 2 million B.C.E.–13000 B.C.E.

ca. 2 million–10000	Hunting and gathering were the main forms of human sustenance.
ca. 1 million	Chipped or patterned stone tools were first used.
ca. 125000	The control of fire by humans is widespread.
ca. 40000	Specialized instruments, such as needles and harpoons came into use.
ca. 30000	Cro–Magnon Man inhabited the valleys of France.

Mesolithic (Middle Stone Age) 13000 B.C.E.–6000 B.C.E.

ca. 11000	Bands of hunters in Europe depicted animals in cave paintings.
ca. 10000	Humans first began practicing agriculture.
ca. 10000	Wolves were first domesticated.
ca. 9000	Sheep were domesticated in the Middle East.
ca. 7700	Farming people settled in the Fertile Crescent.
ca. 7000	Wheat was domesticated in Mesopotamia.
ca. 6500	The wheel was invented in the Tigris–Euphrates basin by Sumerians.
ca. 6300	The earliest dug-out canoes were being made.

Neolithic (New Stone Age) 6000 B.C.E.–3000 B.C.E.

ca. 5000–3500	Villagers in Mesopotamia began practicing irrigation.
ca. 4800	Astronomical calendar stones were being used on the Nabta plateau.
ca. 4400	The first loom was used in Egypt.
ca. 4000	Light wooden plows were used in Mesopotamia.
ca. 4000–3500	Copper smelting in minute quantities was introduced in Mesopotamia.
ca. 3600	Southwestern Asians began using bronze, which unlike smelted copper, can hold an edge.
ca. 3500	The Sumerian civilization was born, which featured animal drawn vehicles, bronze, and the cuneiform alphabet.
ca. 3400	The first dynasty began in Egypt.
ca. 3000	The Sahara desert changed from a fertile area to an arid desert due to over use.
ca 3200	Wheeled vehicles were used in Uruk.
ca. 3200	The Egyptians were using sailboats with masts and broad, square sails.

	They also painted pictures of these boats.
ca. 3000	Cotton was being grown in India.
ca. 3000	The Egyptians used a writing material called papyrus, which was made from woven reeds.

Bronze and Iron Ages 3000 B.C.E. –550 B.C.E.

ca. 2900–2450	The Great Pyramid of Cheops was built at Giza, Egypt.
ca. 2850	The sphinx was built in Egypt.
ca. 2700	Cuneiform signs and numerals appeared on Sumerian tablets, with a slanted double wedge between number symbols to indicate the absence of a number, or zero.
ca. 2500	Bronze was used widely, enabling the dagger form to be stretched into swords.
ca. 2500	The Iron Age began in the Middle East.
ca. 2500–2000	The dome was first used in architecture.
ca. 2400	The short, composite bow was developed by mounted archers. Unstrung, it curved forward and could pierce armor at 100 yards.
2205	The Xia dynasty came to power in China.
ca. 2000	The Minoan civilization emerged on Crete.
ca. 2000	Chinese thinkers discovered magnetic attraction.
1792–1750	Hammurabi (d. 1750) was king of Mesopotamia and created his code of laws, including "eye for an eye."
ca. 1900–1600	Stonehenge was built in present day England.
ca. 1750	The Babylonians began to use advanced geometry to make astronomical studies.
ca. 1700	The Babylonians created the first windmills, which pumped water for irrigation.
ca. 1700	Judaism was founded by Abraham.
ca. 1650	The first use was made of phonetic signs, derived from Egyptian hieroglyphics, in the Serabit el Khadim inscriptions, in the Sinai peninsula.
ca. 1600	The Mycenaean civilization emerged on the Greek mainland. Rulers constructed hilltop fortresses and were buried with treasures acquired through trade.
ca. 1500	The Chinese began weaving with silk.
ca. 1450	The Egyptians invented the sundial.
ca. 1400	The Egyptians invented the water clock.
ca. 1380	The Egyptians built the first canal, merging the Nile and the Red Sea.
ca. 1200–1000	Iron smelting was introduced on an industrial scale in Armenia.
1193	Troy fell to the Greeks in the Trojan War.
ca. 1100	Modern alphabetic writing was prefigured in the Phoenician alphabet.
ca. 1000	The Olmec civilization flourished in Mesoamerica.
ca. 850	Homer wrote the *Iliad* and *Odyssey*.
ca. 630	Zarathustra (aka Zoroaster) (c. 630–c. 530), of present day Iran, founded the mystical religion of Zorastrianism, one of the first forms of monotheism.
ca. 600	Thales of Miletus (c. 624–c. 547) speculated that the basic stuff of nature is water. He also argued that logic should replace myth as the foundation of human understanding.
ca. 600	Anaximander of Miletus (611–547) discovered the ecliptic (the angle between the plane of the earth's rotation and the plane of the solar system).
597	Babylonian society, with the hanging gardens, reached its zenith.

The Classical World 550 B.C.E.–500C.E.

World Events

509 B.C.E.–476 C.E.	The Roman Empire.
492–400 B.C.E.	Classical Greece introduced the world to democracy and many of the great ideas of philosophy.

432–404 B.C.E. Athens and Sparta engaged each other in the Peloponnesian war. Athens lost, signaling the decline of Greek power and the rise of the Hellenistic age.

334 B.C.E. Alexander the Great (356–323) invaded Asia in the first of many victories that would eventually push his empire as far as India.

321–185 B.C.E. The Maurya Dynasty ruled in India.

221 B.C.E. China was unified under the "First Emperor," Qin Shi Huangdi (259–210). The Great Wall was built around this time.

49–44 B.C.E. Julius Caesar (100–44) was declared dictator for life, marking the transfer of Rome from Republic to Empire.

ca. 7 B.C.E.–ca 33 C.E. Jesus Christ lived in Palestine.

ca. 79 C.E. Domitian (51–96) dedicated the Roman Colosseum.

79 C.E. Mt. Vesuvius erupted, burying Hercaulenum and Pompeii.

313 C.E. Constantine (272–337) became Christian and issued the Edict of Milan, which granted freedom of worship to all inhabitants of the Roman Empire.

415 C.E. A mob of rioters burned down the Library of Alexandria, and much of the recorded knowledge of the western world was lost.

Technological Inventions

ca. 500 B.C.E. The Persians constructed the first highways.

ca. 400 B.C.E. An arrow–shooting catapult was developed at Syracuse. It deliberately and systematically utilized mechanical and physical principles to improve weaponry.

ca. 170 B.C.E. Parchment, superior to papyrus because it can be printed on both sides and folded, was invented in Pergamon.

ca. 150 B.C.E. Hipparchus of Nicaea (c. 190–c. 120) invented the astrolabe, which was widely used until the eighteenth century when the sextant was invented.

ca. 100 B.C.E. Paper was first used in China.

ca. 260 B.C.E. Archimedes of Syracuse (c. 287–212) invented many machines, including a pump, effective levers and compound pulleys, and a mechanical planetarium.

ca. 50 C.E. Hero of Alexandria (c. 10–c. 70) invented the first steam engine (the aeolipile), many feedback control devices, and the first type of analogue computer programming.

105 C.E. The Chinese court official Ts'ai Lun (d. 121) developed a method to make paper out of cotton rags.

271 C.E. Chinese mathematicians invented the magnetic compass.

Philosophy and Ethics

528 B.C.E. Buddhism was founded by Siddhartha (563–483), a former prince, in India.

ca. 500 B.C.E. Lao Tzu, of China, founded the naturalistic philosophy of Taoism.

ca 500 B.C.E. Heraclitus of Ephesus (540–475) maintained that permanence was an illusion and the only possible real state was the process of becoming.

ca. 450 B.C.E. Anaxagoras (500–428) proposed the first clearly materialist philosophy that the universe is made entirely of matter in motion.

ca. 440 B.C.E. Protagoras of Abdera (485–415) held that man is the measure of all things by which he meant that we only know what we perceive, not the thing perceived.

ca. 425 B.C.E. Herodotus of Halicarnassus (c. 485–c. 420) wrote the first scientific history by asking questions rather than just telling what he thinks he knows.

399 B.C.E. Socrates (469–399) drank hemlock as punishment for his subversive views. His fate demonstrated the conflict between the philosopher (knowledge) and the city and the paradox that a liberal education is at once radical (challenging conventions) and conservative (forming good citizens).

ca. 380 B.C.E.	At his Academy in Athens, Plato (420–340) expounded his metaphysics based upon the doctrine of forms, or eternal ideas.
ca. 335 B.C.E.	Aristotle (384–322) established the Lyceum in Athens and wrote on such varied topics as logic, ethics, physics, metaphysics, politics, epistemology, and biology.
ca. 300 B.C.E.	Epicurus (341–270) adopted and expanded the philosophy of atomism, in which all happens purely by chance, raising questions of determinism and freedom.
ca. 50 B.C.E.	Marcus Tullius Cicero (106–43) transformed Greek philosophy into a practical affair, suitable to Roman concerns about law, governance, and military strategy.
ca. 350 C.E.	Christianity began to fluorish and its doctrines became systematized during several ecumenical councils.
397 C.E.	Augustine (354–430) wrote *The Confessions*.

Scientific Discoveries

ca. 530 B.C.E.	Pythagoras (585–497) studied musical intervals and regarded mathematics as the study of ultimate, eternal reality, immanent in nature and the universe.
ca. 450 B.C.E.	Empedocles of Agrigento (d. 433) explained physical changes as movements of the basic particles of which things consisted, Fire, Earth, Air, and Water.
ca. 430 B.C.E.	Hippocrates of Chios (c. 460–c. 377) squared the lune, a major step toward squaring the circle.
ca. 420 B.C.E.	Democritus of Abdera (c. 460–c. 370) developed atomic theory, which held that haphazard collisions of atoms accounted for the formation and dissolution of objects.
ca. 300 B.C.E.	Epicurus (341–270) attempted to deal with the contradictions between constant atoms and the appearance of novel combinations.
ca. 300 B.C.E.	Euclid (365–300) wrote "Elements," a treatise on geometry. He offered an axiomatic system based on a few "common notions" and five basic postulates.
300 B.C.E.	The number of volumes in the Library of Alexandria reached 500,000.
ca. 260 B.C.E.	Archimedes of Syracuse (c. 287–212) formulated the principle that a body immersed in fluid is buoyed up by a force equal to the weight of the displaced fluid.
45 B.C.E.	Sosigenes of Alexandria designed a calendar of 365.25 days, which was introduced by Julius Caesar.
ca. 10 C.E.	Strabo (c. 63 B.C.E. –c. 24C.E.) published his *Geographia*, which served as an encyclopedia of geographical knowledge at that time.
ca. 50 C.E.	Hero of Alexandria explained that the four elements consist of atoms. He also observed that heated air expanded and made contributions to optics and geometry.
127–141 C.E.	Claudius Ptolemaeus (c. 85–c. 165), or Ptolemy, compiled a compendium of opinion and data on the stars. He rejected the Peripatetic physics of the heavens.
ca. 170 C.E.	Claudius Galen (131–201) used pulse taking as a diagnostic, performed animal dissections, and wrote treatises on anatomy.
190 C.E.	Chinese mathematicians calculated pi to five decimal places. Archimedes had previously done so in the third century B.C.E.

Age of Faith 500–1400

World Events

ca. 450–1200	Europe was in the Middle Ages.
ca. 500–900	The Mayan Civilization dominated much of Mesoamerica.
527–565	The Byzantium Empire spread under Justinian's rule.
541	The bubonic plague spread from Egypt throughout the Roman–Byzantine world.
581–907	The Sui and Tang Dynasties ruled in China.

610	Mohammed began to secretly preach at Mecca.
771	Charlemagne became the king of all Franks.
ca. 900–1000	The Vikings discovered Greenland.
960–1279	The Song Dynasty ruled in China.
1066	William of Normandy became the first king of England.
1095–1291	The Crusades.
1211–1223	Genghis Khan invaded China, Persia, and Russia.
1215	King John of England signed the Magna Carta, which limited the powers of the king and guaranteed certain political liberties.
1271	Marco Polo (1254-1324, Venetia) journeyed to China along the Silk Road.
1281–1919	The Ottoman Empire reached its zenith in the sixteenth century, but then declined until it was ultimately dissolved in the aftermath of World War I.
ca. 1300–1600	The Renaissance in Europe marked the end of the Middle Ages. It was a cultural movement that revived the works of ancient Greece and Rome.
1337–1453	France and England fought the Hundred Years' War.
1347–1351	The Black Death, bubonic plague, wiped out roughly a third of Europe's population.
1368–1644	The Ming Dynasty ruled in China.

Technological Inventions

700	Block printing was developed in Japan.
700	The Chinese invented porcelain.
ca. 770	Stirrups were introduced in Frankish lands, enabling the development of the armored knight and mounted shock combat, which vastly altered society.
ca. 770	Iron horseshoes were common.
ca. 850	The Moors in Spain prepared pure copper by reacting its salts with iron, a forerunner of electroplating.
867	Wang Jie printed the oldest book known, *The Diamond Sutra*, in China.
ca. 1045	The Chinese inventor Pi Sheng made moveable type of earthenware.
ca. 1100	The crossbow was developed in Europe and outlawed, in 1139, by the second Ecumenical Lateran Council, as one of the first formal attempts at arms control.
ca. 1250	Gunpowder became known in Europe, perhaps introduced from China through the Mongols.
ca. 1350	Cannons were used widely in European battles. Developments in gunpowder in helped speed the military adoption of cannons.

Philosophy and Ethics

ca. 1250	Albert of Bollstadt (c. 1200–1280, Bavaria), called Albertus Magnus, wrote commentaries on Aristotle and studied plant morphology and ecology.
1267–1268	Roger Bacon (1214–1294, England) championed empiricism and the modern scientific method, asserting that the only basis for certainty is experience, or verification.
1267–1273	Thomas Aquinas (1224–1274, born in Italy) composed a synthesis of Christianity and Aristotelian philosophy.

Scientific Discoveries

ca. 1000	Ibn Sina (980–1037, Persia), or Avicenna, studied medicine and geology and challenged Aristotelian conceptions of motion.
ca. 1000	Ibn al-Haitham (965–1038, Arabia), or al-Hazen, studied optics and challenged Ptolemy by insisting that the hypothetical spheres corresponded to real bodies.
ca. 1190	Moses ben Maimon (1135–1204, born in Spain), or Maimonides, studied astrological systems and maintained the separation of earthly and heavenly spheres.
ca. 1215	Robert Grosseteste (1168–1253, England) studied optics and analyzed the

	inductive and experimental procedures of science.
ca. 1323	William Ockham (1285–1349, England) introduced the distinction between dynamic motion and kinematic motion.
1337	William Merle of Oxford made regular records of the weather.

Age of Discovery 1400–1750

World Events

1418	Prince Henry the Navigator (1394–1460, Portugal) began exploring Africa.
1431	Joan of Arc (1412–1431, France) was burned at the stake.
1486	Bartolomeu Dias (1450–1500, Portugal) sailed around the Cape of Good Hope.
1492–1504	Christopher Columbus (1451–1506, Italy) discovered the Caribbean islands.
1497	Vasco da Gama (1469–1524, Portugal) sailed around Africa, discovering a sea route to India.
1509	Michelangelo (1475–1564, Italy) painted the ceiling of the Sistine Chapel.
1517	Martin Luther (1483–1546, Germany) posted his ninety–five theses in Wittenberg, initiating the Reformation.
1519–1521	Ferdinand Magellan (c. 1470–1521, Portugal) circumnavigated the globe.
1547	Ivan IV (1530–1584), or Ivan the Terrible, became the first ruler of Russia to claim the title of tsar.
1607	Jamestown, Virginia was established as the first English colony in the New World.
1618–1648	The Thirty Years' War raged between Protestants and Catholics.
1619	The first slaves were transported to America.
1620	Pilgrims landed at Plymouth Rock, Massachusetts.
1644	The Ming Dynasty ends in China and the Manchus come to power.
1661	Louis XIV (1638–1715) became absolute monarch of France.
1660	The Royal Society of London was founded.
1682	Peter the Great (1672–1725) became tsar of Russia. His efforts at westernization led to the development of Russia as a major European power.
1704	Johann Sebastian Bach (1685–1750, Germany) began composing music.

Technological Inventions

1437	Johann Gutenberg (c. 1390–1468, Germany) became the first in Europe to print with movable type cast in molds.
1475	The first muzzle-loaded rifles were developed in Italy and Germany.
1502	Peter Henlein of Nuremberg (c. 1480–1542, Germany) constructed the first watch.
1568	Concrete, which had been used in ancient times, was resuscitated by the architect Philibert de l'Orme (c. 1510–1570, France), who publicized its composition.
ca 1595	Spectacle maker Zacharias Janssen (1580–1638, Netherlands) invented the compound microscope.
1592	Galileo (1564–1642, Tuscany) invented a thermometer.
1594	Alexander Cummings (England) invented the flush toilet under English patent number 814. The ancient Cretans, however, used flush toilets as early as ca 2000 B.C.E.
1605	Hans Lippershey (c. 1570–1619, Netherlands) developed the telescope.
1621	Dud Dudley (1599–1684, England) invented the first blast furnace.
1625	William Oughtred (1575–1660, England) invented the slide rule.
1654	Otto von Guericke (1602–1686, Germany) invented the vacuum

pump and the Magdeburg hemispheres.

1707 Denis Papin (1647–c. 1712, France) invented the high–pressure boiler.

1718 James Puckle (1667–1724, England) invented the machine gun. The Puckle Gun was capable of firing nine rounds before being reloaded.

ca. 1730 Two different men, John Hadley (1682–1744, England) and Thomas Godfrey (1704–1749, American colonies) independently invent the Sextant.

Philosophy and Ethics

1503 Desiderius Erasmus (1466–1536, Netherlands) argued that the chief evil of the day was a blind respect for traditions without considering the true message of Christ.

1532 *The Prince* by Niccolò Machiavelli (1469–1527, Italy) was published. It presents an early form of utilitarianism and realpolitik, although Machiavelli was a Republican.

1583 Giordano Bruno (1548–1600, Italy) defended a decentralized, infinite universe, governed by the identity of fundamental laws, rather than two separate spheres.

1620 Francis Bacon (1561–1626, England) published *Novum Organum*, which modeled an early form of empiricism as superior to scholastic a priori methods.

1637 René Descartes (1596–1650, France) wrote *Discourse on Method*

1651 Thomas Hobbes (1588–1679, England), in *Leviathan*, argued that humans must surrender individual autonomy to the state in order to avoid constant war.

1690 John Locke (1632–1704, England) argued that the mind is a blank slate. He also defended a social contract theory of the state and individual property rights.

1710 George Berkeley (1685–1753, Ireland) developed idealism, which holds that qualities, not things, are perceived and that perception is relative to the perceiver.

1725 Giovanni Battista Vico (1668–1774, Italy) critiqued the methodology of the natural sciences and maintained that truth is an act made by humans.

1748 David Hume (1711–1776, Scotland) described the mind as a bundle of perceptions and argued that moral obligation is a function of human passion rather than reason.

Scientific Discoveries

ca. 1482 Leonardo da Vinci (1452–1519, Italy) studied the human body and improved and invented many instruments with a devotion to the Archimedean ideal of measurement.

1536 Philippus Aureolus Paracelsus (1493–1541, Switzerland) foreshadowed systematic, modern medicine by rejecting the bodily "humours" as explanatory terms in physiology.

1543 Nicolaus Copernicus (1473–1543, Poland) defended heliocentrism along NeoPlatonic lines.

1569 Gerard de Cremer (1512–1594, Flanders), or Gerardus Mercator, published the projection map of the world that bears his name.

1572 Tycho Brahe (1546–1601, Denmark) observed a supernova in the constellation *Cassiopeia*, now known as Tycho's star.

1583 Galileo Galilei (1564–1643, Tuscany) pioneered the scientific age due to his systematic, quantitative experiments and his mathematical analysis of their results.

1586 Simon Stevin (1548–1620, Denmark) maintained that perpetual motion was impossible and made contributions to physics and geometry.

1604 Johannes Kepler (1571–1630, Germany) held that the intensity of light varies inversely with the square of the distance from the source.

1619 Kepler stated the third law of planetary motion, argued that the planets' orbits were ellipses, and developed a universal law to explain both heavenly and earthly bodies.

1627 William Harvey (1578–1657, England) confirmed his observation that the blood circulates throughout the body, which he inferred from the structure of the venal valves.

ca. 1629 Pierre de Fermat (1601–1665, France) discovered the fundamental principle of analytic geometry and pioneered differential calculus.

1633 The Inquisition forced Galileo to recant his belief in Copernican theory.

1650 Archbishop Usher estimated by reading the Bible that the earth was created on October 23, 4004 B.C.E. at 9:00 am.

1654 Blaise Pascal (1623–1662, France) and Pierre de Fermat developed the foundation for the theory of probability.

1661 Robert Boyle (1627–1691, England) separated chemistry from alchemy, leading to the general abandonment of ancient concepts of matter.

1665 Robert Hooke (1635–1703, England) named and gave the first description of cells.

1665–1666 Newton (1643–1727, England) made discoveries in calculus, universal gravitation, and optics.

1674 Anton van Leeuwenhoek (1632–1723, Netherlands) reported his discovery of protozoa. He made contributions to the microscope and cell biology.

1675 Gottfried Wilhelm von Leibniz (1646–1716, Germany) developed differential calculus.

1684 Leibniz published his system of calculus, developed independently of Newton. It is Leibniz's notation that has been adopted.

1687 Newton argued that natural laws govern the behavior of earthly and heavenly bodies. These laws of motion the groundwork for classical mechanics.

1693 Edmund Halley (1656–1742, England) discovered the formula for the focus of a lens and suggested a measurement of the distance between the earth and the sun.

Age of Revolution 1750 - 1830

World Events

1756–1763 The Seven Years' War was the first "world war" involving most European countries and their colonies around the globe.

1762 Catherine the Great (1729–1796) ascended the Russian throne.

1775–1783 The American Revolution began with the battle of Lexington and Concord and ended with the Treaty of Paris.

1789–1799 The French Revolution began with the storming of the Bastille and culminated in a coup by Napoleon.

1796 Napoleon Bonaparte (1769–1821, France) defeated Austria in the first of a string of military victories in Europe.

1799 French troops under Bonaparte discovered the Rosetta Stone that permitted Thomas Young and Jean–François Champollian to decipher Egyptian hieroglyphs.

1800–1830 Several Latin American countries won their Independence. For example: Venezuela 1810, Argentina 1816, Peru 1821, Brazil 1822, and Bolivia 1825.

1803 The Louisiana Purchase ushered in an era of expansion in America.

1808 Johann Wolfgang von Goethe (1749–1832, Germany) wrote the first part of *Faust*, a cautionary tale about the corrupting force of the powers that knowledge can unlock.

Technological Inventions

1752 Benjamin Franklin (1706–1790, U.S.) invented a lightening conductor. He also invented the Franklin stove and bifocals.

1764 James Hargreaves (1720–1778, England) invented the spinning jenny.

1769 James Watt (1736–1819, Scotland) patented a new type of steam engine equipped with a simple centrifugal "governor" for safety.

1785 Edmund Cartwright (1743–1823, England) invented the power loom.

1794 Eli Whitney (1765–1825, U.S.) patented the cotton gin, which quickly and easily separated the fiber from the seeds and seedpods.

1796 Edward Jenner (1749–1823, England) developed the first system of vaccination, by infecting patients with cowpox in order to make them resistant to smallpox.

1800 Alessandro Volta (1745–1827, Italy) invented the electric battery, a device that stores energy and makes it available in an electric form.

1804 Richard Trevithick (1771–1833, England) built the first steam–powered locomotive.

1826 Samuel Morey (1762–1843, U.S.) invented the internal combustion engine.

Philosophy and Ethics

1762 Jean-Jacques Rousseau (1712–1778, Switzerland) argued that the only natural association for humans is the family and that society must form a social contract.

1776 Adam Smith (1723–1790, Scotland) advanced the idea that businesses survive through successful trading in pursuit of their self–interest.

1781 and 1787 Immanuel Kant (1724–1804, Prussia) wrote the *Critique of Pure Reason*, in which he distinguished sensory from a priori elements of reason.

1789 Jeremy Bentham (1748–1832, England) outlined an ethical system based on a hedonistic calculation of the utility of actions and the greatest happiness of all.

1807 Georg Wilhelm Friedrich Hegel (1770–1831, Germany) criticized the distinction of objective and subjective and developed a dialectical and comprehensive philosophy.

1819 Arthur Schopenhauer (1788–1860, Germany) developed a life philosophy centered on the concept of will.

Scientific Discoveries

1751 Benjamin Franklin published works on electricity and invented many terms still in use, including positive, negative, conductor, and battery.

1754 Jean Le Rond d'Alembert (1717–1783, France) formulated "D'Alembert's ratio."

1766 Henry Cavendish (1731–1810, England) isolated and described "inflammable air," later named hydrogen, and distinguished it from carbon dioxide.

1772 Daniel Rutherford (1749–1819, England) discovered nitrogen.

1774 Joseph Priestly (1733–1804, England) discovered sulphur dioxide, ammonia, and "dephlogisticated air," later named oxygen.

1780 Antoine Laurent Lavoisier (1743–1794, France) and Pierre-Simon Laplace (1749–1827, France) developed a theory of chemical and thermal phenomena based on the assumption that heat is a substance and held that respiration is a form of combustion.

1783 Lazare Nicolas Marguerite Carnot (1753–1823, France) specified the optimal and abstract conditions for the operation of machines.

1786 Kant suggested the doctrine of the unity and convertibility of forces.

1787 Lavoisier published a nomenclature of chemistry.

1791 Goethe began publishing works on optics and developed a holistic philosophy opposed to Newtonian reductionism's dependence on theoretical constructs.

1795 James Hutton (1726–1797, Scotland) wrote the earliest comprehensive treatise that is a geologic synthesis, featuring uniformitarianism as a guiding principle.

1801 John Dalton (1766–1844, England) formulated the law of gaseous expansion at constant pressure and the law of gaseous partial pressures.

1803 Dalton put forth his theory of the atom.

1808 Dalton published a periodic table based on atomic weights.

1809 Jean-Baptiste Monet de Lamarck (1744–1829, France) stated that acquired characteristics were heritable and was a proponent of evolution.

1811 Amedeo Avogadro (1776–1856, Italy) proposed that equal volumes of gases at the same temperature and pressure contain the same number of molecules.

1824 Sadi Carnot (1796–1832, France) established the fundamental theory of the internal combustion engine and initiated the modern theory of thermodynamics.

1829 Charles Lyell (1797–1875, England) expanded on the principle of uniformitarianism and constant change in geology, which was useful for developing theories of evolution.

The Age of Industry and Empire 1830–1910

World Events

1830 The first railroad came into operation, running between Liverpool and Manchester, England.

1839 China was defeated by Britain in the First Opium War.

1848 Europe was convulsed with political revolutions.

1848 Mexico ceded vast amounts of land to the U.S. at the end of the Mexican War.

1849 The California gold rush drew thousands of settlers out West.

1858 Britain imposed formal colonial rule on India.

1859 Edwin Drake (1819–1880, U.S.) discovers oil near Titusville, Pennsylvania, ushering in the massive exploitation of petroleum to fuel modern industrialization.

1869 The first transcontinental train route in U.S. was completed.

1869 A French company completed the Suez Canal, allowing water transport between Europe and Asia without circumnavigating Africa.

1871 Kaiser Wilhelm I was declared German Emperor and the North German Confederation was transformed into the German Empire (Deutsches Reich).

1861–1865 The American Civil War was fought between the Union and the Confederacy. Slavery was ended by the Thirteenth Amendment in 1865.

1880s The French began using the first pesticide.

1884–1885 The Berlin Conference regulated and formalized the colonization of Africa by European countries.

1887 The U.S. Congress founded the National Institutes of Health (NIH).

1898 The U.S. gained control of Cuba and the Philippines in the Spanish American War.

1904 The New York City subway opened.

Technological Inventions

1831 Michael Faraday (1791–1867, England) invented the electrical generator and the Bunsen burner and performed pioneering experiments in electromagnetism.

1834 Thomas Davenport (1802–1851, U.S.) is generally credited with inventing the electric motor.

1835 Charles Babbage (1791–1871, England) started work on the first "analytical engine," a precursor to the modern computer that used punch cards.

1835 Samuel Colt (1814–1862, U.S.) invented the revolver pistol.

1837 Samuel F. B. Morse (1791–1872, U.S.) invented the electrical telegraph and Morse code.

1838 John Deere (1804–1886, U.S.) invented the first cast-steel plow, a significant improvement over iron plows.

1853 Henry Bessemer (1813–1898, England) and William Kelly (1811–1888, U.S.) invented the Bessemer steel process.

1860 J.J.E. Lenoir (1822–1900, France) developed the first practical internal combustion engine. It relied upon coal gas and was double–acting.

1866 Alfred Nobel (1833–1896, Sweden) patented dynamite. It consisted of a mixture of nitroglycerine with inert, absorbent clay such as kieselguhr.

1866 Wilhelm (1855–1919, Germany) and Carl Friedrich von Siemens (1872–1941, Germany) invented the open–hearth furnace.

1866 Christopher Sholes (1819–1890, U.S.) invented the first modern, practical typewriter.

1876 Alexander Graham Bell (1847–1922, Scotland–Canada–U.S.) invented the telephone.

1876 Nikolas August Otto (1832–1891, Germany) designed the first four–stroke piston engine.

1877 Thomas A. Edison (1847–1931, U.S.) developed the phonograph, or gramophone, the first device for recording and replaying sound.

1879 Edison achieved his goal of making the burning time of the electric light bulb long enough to be commercially viable.

1882 Nikola Tesla (1856–1943, Serbia–U.S.) built the first induction motor, invented the Tesla coil (a type of transformer), and performed work on rotating magnetic fields.

1883 Sir Joseph Swann (1828–1914, England) invented the first synthetic fiber.

1885 Carl Friedrich Benz (1844–1929, Germany) invented the gasoline–powered automobile. The work of Gottlieb Daimler (1834–1900, Germany) was also important.

1885 George Eastman (1854–1932, U.S.) invented roll film, which brought photography into popular usage and was the basis for the later invention of motion picture film.

1898 Rudolf Diesel (1858–1913, France-Germany) received a patent for the diesel engine.

1903 Orville (1871–1948, U.S.) and Wilbur Wright (1867–1912, U.S.) achieved flight in a manned, gasoline power–driven, heavier–than–air flying machine.

1904 Building off the work of Heinrich Hertz (1857–1894, Germany) and James Clerk Maxwell (1831–1879, Scotland), Christian Huelsmeyer invented radar.

Philosophy and Ethics

1830 Auguste Comte (1798–1857, France) developed positivism, a belief that natural science comprises the whole of human knowledge.

1855 Herbert Spencer (1820–1903, England) attempted to generalize from Darwinian evolution a comprehensive account of human social and moral progress.

1861 John Stuart Mill (1806–1873, England) extended and refined Bentham's utilitarian moral theory.

1867 Karl Marx (1818–1883, Prussia) systematically critiqued capitalism and developed a philosophy of dialectical materialism to account for historical change.

1885 Friedrich Wilhelm Nietzsche (1844–1900, Germany) deconstructed all meta-narratives and advocated the transvaluation of values through the strength of will.

1890 William James (1842–1910, U.S.) developed psychological theory into a systematic science and advanced a philosophy of pragmatism.

1900 Sigmund Freud (1856–1939, Austria) developed a tripartite under-

	standing of human being and emphasized the importance of unconscious forces.
1903	G.E. Moore (1873–1958, England) rejected the "naturalistic fallacy" and developed analytic philosophy.

Scientific Discoveries

1820	Hans Christian Orsted (1777–1851, Denmark) discovered the relationship between electricity and magnetism.
1831	Faraday discovered electromagnetic induction.
1839	Charles Goodyear (1800–1860, U.S.) discovered the vulcanization process that creates rubber.
1840	William Whewell (1794–1866, England) introduced the word "scientist" to distinguish science or natural philosophy from a priori reasoning and moral science.
1840	Louis Agassiz (1807–1873, Switzerland-U.S.) published a demonstration of the existence of a glacial epoch in the temperate zones.
1847	Hermann Ludwig Ferdinand von Helmholtz (1821–1894, Germany) formulated the law of the conservation of energy.
1854	George Boole (1815–1864, England) invented Boolean algebra, the foundation of all modern computer arithmetic.
1857	Louis Pasteur (1822–1895, France) demonstrated that lactic acid fermentation is carried out by living bacteria and performed work with chiral molecules.
1858	Rudolf Virchow (1821–1902, Germany) stated that "every cell originates from another cell." He made contributions to pathology, medicine, and anthropology.
1859	Charles Darwin (1809–1882, England) presented his theory of biological evolution by natural selection.
1866	Gregor Mendel (1822–1884, Austria) interpreted heredity in terms of a pairing of unit characters that could in practice be treated as indivisible and independent particles.
1888	Hertz discovered radio waves, verifying Maxwell's prediction of electromagnetic waves.
1891	Marie Eugene Dubois (1858-1940, Netherlands) discovered Javaman, now known as *Homo erectus*.
1893	Émile Durkheim (1858–1917, France) and Max Weber (1864–1920, Germany) founded sociology and explained religion in terms of its social functions.
1895	Wilhelm Conrad Röntgen (1845–1923, Germany) observed a new form of penetrating radiation, which he named X–rays.
1896	J.J. Thompson (1856–1940, England) discovered the electron, which had been posited earlier by G. Johnstone Stoney as a unit of charge in electrochemistry.
1900	Max Planck (1858–1947, Germany) developed Planck's Law of Black Body Radiation, a pioneering works in the development of quantum mechanics.
1905	Albert Einstein (1879–1955, Germany–U.S.) demonstrated that the presence of atoms could be confirmed by observing objects influenced by their fluctuations.
1905	Einstein developed the Special Theory of relativity.

The Modern World 1910–2004

World Events

1914–1919	World War I began with the assassination of Archduke Franz Ferdinand and ended when a vanquished Germany signed the Treaty of Versailles.
1917	The Russian Revolution gave rise to the USSR. The Bolsheviks became the Communist party and held power for most of the twentieth century.
1925	The "Monkey Trial" of John T. Scopes (1900–1970, U.S.) occurred

	in Tennessee after he taught evolution in his classroom.
1927	Charles Lindbergh (1902–1974, U.S.) flew solo across the Atlantic Ocean.
1929	Inflated by speculation with borrowed money, the U.S. stock market crashed in October, initiating the slide into the Great Depression that would last through the 1930s.
1930	The U.S. Food and Drug Administration (FDA) was created.
1931	The International Council for Science (ICSU) was founded.
1932	Aldous Huxley (1894–1963, England) published *Brave New World*, the classical formulation of a techno-scientific dystopia.
1939	Leo Szilard (1898–1964, Hungary–U.S.) and Eugene Paul Wigner (1902–1995, Hungary–U.S.) visited Einstein to discuss methods of averting a German atomic bomb.
1939	Britain and France declared war on Germany, signaling the beginning of World War II.
1941	Pearl Harbor, a U.S. naval base in Hawaii, was attacked by the Japanese.
1944	The liberation of mainland Europe from Nazi occupation commenced with the Battle of Normandy, D–Day, on June 6.
1945	On July 16, a plutonium atomic bomb was detonated at the Trinity Site in the New Mexico desert.
1945	On August 6 and August 9, the U.S. dropped atomic bombs on Hiroshima and Nagasaki, respectively. Hundreds of thousands were killed.
1945	World War II ended with the surrender of Germany and Japan.
1945	The United Nations was founded in San Francisco.
1947	The General Agreement on Tariffs and Trade, later renamed the World Trade Organization, signaled the beginning of institutionalized economic globalization.
1948	The state of Israel was proclaimed.
1949	The North Atlantic Treaty Organization was established to counter Soviet aggression.
1950–1953	The Korean War occurred between the communist North and anti-communist South and was a proxy war between the U.S. and the Soviet Union.
1950	The U.S. Congress established the National Science Foundation (NSF).
1955	Bertrand Russell (1872–1970, England) and Albert Einstein issued the Russell-Einstein Manifesto, which called for international arms control and peace.
1957	The USSR launched Sputnik I, the first artificial satellite to orbit earth. Sputnik II was launched shortly thereafter and carried the first living passenger, a dog named Laika.
1958	The U.S. Congress established the National Aeronautics and Space Administration (NASA).
1959	Richard Feynman (1918–1988, U.S.) delivered his now famous speech "There's Plenty of Room at the Bottom" that foreshadowed later developments in nanotechnology.
1960	The U.S. FDA approved the birth control pill.
1961–1975	The Vietnam War occurred between communist North Korea and its allies and South Korea and its allies, primarily the United States.
1962	Rachel Carson (1907–1964, U.S.) wrote *Silent Spring*, which detailed the negative impact of pesticides on the environment.
1962	Trofim Denisovich Lysenko (1898–1976, U.S.S.R.) was removed from his position as head of the Academy of Agricultural Sciences of the Soviet Union.

1963 The United States, Great Britain, and the Soviet Union signed the Limited Test Ban Treaty.

1966–1976 Mao Zedong (1893–1976) and his wife Jiang Qing (1914–1991) carried out the Cultural Revolution in China.

1966–1979 Workers at the U.S. Center for Disease Control and the World Health Organization eradicated smallpox worldwide with vaccinations and containment.

1968 The Nuclear Non–Proliferation Treaty took effect, prohibiting non-nuclear weapon States from possessing, manufacturing, or acquiring nuclear weapons.

1969 Neil A. Armstrong (b.1930, U.S.) became the first man to walk on Moon. He was accompanied by Edwin E. Aldrin, Jr. (b.1930, U.S.).

1970 The U.S. Environmental Protection Agency (EPA) was created.

1975 The Asilomar Conference established guidelines for the physical and biological containment of recombinant DNA (rDNA).

1976 The two U.S. Viking probes landed on Mars.

1979 On March 28, a reactor at the Three Mile Island Nuclear Generating Station (Pennsylvania, U.S.) suffered a partial core meltdown.

1979 The U.S. spacecraft Voyager 1 photographed Jupiter's rings.

1979 The first "test tube baby," Louise Brown (U.K.), was born using the technique of in vitro fertilization (IVF).

1984 A Union Carbide pesticide plant in Bhopal, India accidentally released forty tons of methyl isocyanate (MIC) into the surrounding environment.

1986 On January 28, the space shuttle Challenger exploded just seventy–three seconds after launch. The accident was caused by the failure of an O–ring seal in the right solid rocket booster.

1986 On April 26, the Chernobyl nuclear power plant in Ukraine (then part of the Soviet Union) suffered a catastrophic nuclear meltdown.

1988 The Intergovernmental Panel on Climate Change (IPCC) was created to assess climate science and the impacts of climate change.

1988 James Watson unilaterally sets aside three to five percent of the budget of the Human Genome Project to study Ethical, Legal, and Social Issues (ELSI) of genomic research.

1989 On March 24, the Exxon Valdez oil tanker spilled eleven million gallons of crude oil into Prince William Sound, Alaska. It was the worst oil spill in United States history.

1989 The Berlin wall was torn down, signaling the end of the cold war. Germany began the process of reunification.

1992 The United States and thirty–four other industrial nations met in Rio de Janeiro, Brazil to discuss world environmental concerns.

1993 The U.S. Supreme Court articulated its set of criteria for the admissibility of scientific expert testimony in the case of Daubert v. Merrell Dow.

1996 The Comprehensive Nuclear Test Ban Treaty was signed by seventy–one nations, banning all nuclear explosions in all environments for military or civilian purposes.

1997 The World Commission on the Ethics of Scientific Knowledge and Technology (COMEST) was created as a U.N. body.

2001 The U.S. President's Council on Bioethics was created as part of a decision by President George W. Bush (b. 1946) to fund limited stem cell research.

2001 On September 11, the World Trade Center and Pentagon were attacked by terrorists who had hijacked commercial airplanes.

2003 The Space Shuttle Columbia was lost when it exploded upon reentry.

Technological Inventions

1913 Henry Ford (1863–1947, U.S.) added the assembly line to his automobile plant at Highland Park, Michigan.

1916 Paul Langevin (1872–1946, France) achieved the first successful use of sonar.

1924 Robert Goddard (1882–1945, U.S.) built and launched the first liquid–fueled rocket.

1927 Vannevar Bush (1890–1974, U.S.) developed the Differential Analyzer, an analog computer, which sped the solution of problems related to the electric power network.

1927 Vladimir Zworykin (1889–1982, Russia–U.S.), Paul Nipkow (1860–1940, Germany), Philo T. Farnsworth (1906–1971, U.S.), and John Baird (1888–1946, Scotland) all contributed to the invention of television.

1935 IBM introduced a punch card machine with an arithmetic unit based on relays that could perform multiplication.

1936 Alan M. Turing (1912–1954, England) conceived the Turing machine, the abstract precursor of the computer that gave a mathematically precise definition to algorithm.

1936 Felix Wankel (1902–1988, Germany) designed a motor (the Wankel engine) that revolved around a central shaft, using a rotary piston instead of reciprocating pistons.

1938 Roy Plunkett (1910–1994, U.S.) accidentally invented Polytetrafluorethylene, commonly known as Teflon, while working at DuPont.

1940 Igor Sikorsky (1889–1972, Russia–U.S.) invented the helicopter.

ca. 1942 John von Neumann (1903–1957, Hungary–U.S.) developed architecture for a computing machine that allows it to be reprogrammable.

1944 Howard W. Aiken (1900–1973, U.S.) and a team of engineers from IBM displayed the first widely known and influential large scale automatic digital computer.

1945 The atomic bomb was developed in Los Alamos as part of the top secret Manhattan Project by J. Robert Oppenheimer (1904–1967, U.S.), Hans Bethe (1906–2005, Germany–U.S.), Einstein, Enrico Fermi (1901–1954, Italy–U.S.), Richard Feynman (1918–1988, U.S.) and hundreds of other scientists.

1946 The Raytheon Corporation patented the microwave oven. It built the first commercial microwave in 1947, which measured six feet tall and weighed 750 pounds.

1947 Working at Bell Labs, John Bardeen (1908–1991, U.S.), Walter Brattain (1902–1987, U.S.), and William Shockley (1910–1989, England–U.S.) invented the transistor, a solid state semiconductor device used for amplification and switching.

1949 Francis Bacon (1904–1992, England) invented a fuel cell, an electrochemical device similar to a battery, employing only hydrogen and water.

1951 Carl Djerassi (b.1923, Austria), Gregory Pincus (1903–1967, U.S.), Min Church Chiang, and John Rock (1890–1984, U.S.) all contributed to the invention of the oral contraceptive pill. Margaret Sanger (1879–1976, U.S.) worked to educate women about different birth control methods.

1954 Joseph Murray (b.1919, U.S.) and J. Hartwell Harrison performed the first successful human organ transplant.

1955 The USS Nautilus (SSN–571), the first nuclear powered submarine, was launched.

1955 Enrico Fermi and Leo Szilard received a joint U.S. patent for the nuclear reactor. The first nuclear power plant began producing electricity in Obninsk, Russia, in 1954.

1958 Jack Kilby (b.1923, U.S.) (Texas Instruments) and Robert Noyce (1927–1990, U.S.) (Fairchild Semiconductor) developed the first integrated circuit, a microelectronic semiconductor device consisting of many interconnected transistors.

1960 Theodore Maiman (b.1927, U.S.) invented the first operable laser, a device that uses generates a very collimated, monochromatic, and coherent beam of light.

1969 Edward Hoff (b.1937, U.S.) and Intel Corp. developed the microprocessor, which is an electronic computer central processing unit (CPU) made from miniaturized transistors and other circuit elements on a single semiconductor intergrated circuit (chip).

1969 The Advanced Research Projects Agency Network (ARPANET) of the U.S. Department of Defense was the world's first operational packet switching network and the progenitor of the global Internet.

1970 The first useful optical fiber was invented by researchers at Corning Glass Works.

1971 Bowmar released the first pocket-sized calculator, the 901B, with four functions and an eight–digit red LED display.

1977 Steven Jobs (b.1955, U.S.) and Steven Wozniak (b.1950, U.S.) introduced the Apple II, initiating the widespread use of home computers.

1979 The first commercial cellular phone service is started in Japan. Researchers at Bell Labs had been working on the technology since the late 1940s.

1980 Heinrich Rohrer (b.1933, Switzerland) and Gerd Binnig (b. 1947, Germany) developed a "scanning tunneling microscope."

1981 NASA launched the first space shuttle, Columbia.

1981 Programmers at Microsoft Corporation developed a computer disk operating system, MS–DOS.

1982 The FDA approved the first recombinant pharmaceutical, insulin. This allowed insulin to be used on a wide scale and reduced reactions to impurities.

1982 Sony and Philips Corporations introduced the compact disc (CD) player.

1983 ARPANET changed its core networking protocols from NCP to TCP/IP, marking the start of the Internet.

1985 Kary Banks Mullis (b. 1944, U.S.) and co-workers invented the polymerase chain reaction (PCR) which multiplies DNA sequences *in vitro*.

1985 Alec Jeffreys (b. 1950, England) invented DNA fingerprinting, a technique to distinguish between two individuals using only samples of their DNA.

1988 Working at the Roussel Uclaf company, Etienne Baulieu (France) developed the RU–486 abortifacient or "abortion pill," Mifepristone.

1989 Charles Bennett and Gilles Brassard built a quantum computer, a device that computes using superpostions and entaglement of quantum states.

1989 The World Wide Web was developed by Tim Berners-Lee (b. 1955, England). The current web can be traced back to a project at CERN (the European Organization for Particles Physics Research) called ENQUIRE. The primary underlying concept of hypertext came from earlier efforts such as Vannevar Bush's memex and Ted Nelson's (b. 1937, U.S.) Project Xanadu.

1990 W. French Anderson (U.S.) performed the first gene transplant on a human being, injecting engineered genes into a four–year–old to repair her faulty immune system.

1990 Scientists at NASA and the European Space Agency (ESA) launched the Hubble Space Telescope.

1993 The work of Ivan Getting and Bradford Parkinson led to the invention of the Global Positioning System (GPS).

1997 The digital versatile disk (DVD) was introduced.

Philosophy and Ethics

1910 Alfred North Whitehead (1861–1947, England) and Bertrand Russell put forth the theory that there is a discontinuity between a class and its members and attempted to overcome certain logical paradoxes by the formal device of branding them meaningless.

1918 Ludwig Wittgenstein (1889–1951, Austria) put forth his theory of language as "picturing" reality, which he later abandoned for language as a system or a game played amongst a community.

1929 John Dewey (1859–1952, U.S.) argued that an experimental approach to moral decision making promised to solve the fact/value gap that had been championed by several analytic philosophers.

1934 Karl R. Popper (1902–1994, Austria)advanced the theory that the test of an empirical system, the demarcation of the limit of scientific knowledge, is its "falsifiability" and not its "verifiability."

1949 Simon de Beauvoir (1908–1986, France)traced the oppression of women through literary and historic sources and argued that the male is objectified as a positive norm.

1951 Willard Van Orman Quine (1908–2000, U.S.) argued against reductionism and the distinction between analytic and synthetic.

1953 Martin Heidegger (1889–1976, Germany) argued that modern technology reveals the world as an undifferentiated standing reserve (Bestand) of energy and resources subordinated to the will of humans, thus, the culmination of modern nihilism. He contrasted the way in which technology conceals Being to the way in which Being is revealed by the language of poetry.

1958 Hannah Arendt (1906–1975, Germany-U.S.) analyzed the modern human condition marked by the hegemony of laboring and making over action and the revolt against natural limits.

1962 Thomas S. Kuhn (1922–1996, U.S.) argued that new scientific paradigms are formed and retained because they are useful and conform to the standards of a community of practitioners, not because they approximate reality.

1971 John Rawls (1921–2002, U.S.) outlined the social arrangement of the "veil of ignorance" that guarantees no interests will be sacrificed arbitrarily to the interests of others. His concept of "justice as fairness" presented a non-historical variation of the social contract theory.

1974 Robert Nozick (1938–2002, U.S.) claimed that direct action by the state is rarely warranted, and that justice should be evaluated by reference to the means by which social policies are implemented, rather than their consequences.

1974 Thomas Nagel (b. 1937, U.S.) attempted to reconcile the subjective elements of human life with the urge for objective, value free truth.

1975 Peter Singer (b.1946, Australia) argued that, since a difference of species entails no moral distinction between sentient beings, it is wrong to mistreat non–human animals.

1978 Mary Daly (b. 1928, U.S.) argued that women must create a separate culture in order to fully effect their power outside of a patriarichal society.

1979 Hans Jonas (1903–1993, born in Germany) formulated a new ethics designed to save humanity from the excesses of its own technological powers.

1981 Jurgen Habermas (b. 1929, Germany) developed a theory of moral discourse and knowledge in society as part of a larger effort to develop a post–metaphysical normativity founded on interpersonal relationships.

1982 Richard Rorty (b. 1931, U.S.) distinguished between Platonic, Positivist, and Pragmatist notions of truth and the consequences for acting on each choice.

1986 Martha Nussbaum (b. 1947, U.S.) argued that the moral philosophy of Aristotle remains relevant in the examination of human emotions and decision making.

Scientific Discoveries

1910 Fritz Haber (1868–1934, Germany) and Carl Bosch (1874–1940, Germany) patented the Haber–Bosch process for producing ammonia from the nitrogen contained in air.

1911 Einstein made predictions about the influence of gravity on the propagation of light.

1913 Niels Bohr (1885–1962, Denmark) calculated closely the frequencies of the spectrum of atomic hydrogen, supporting his conception of electron orbitals and foreshadowing quantum mechanics.

1915 Einstein completed the mathematical generalization of the theory of relativity and attributed the magic of the theory to differential calculus. This theory replaced the Kepler–Newton theory of planetary motion.

1923 Sigmund Freud (1856–1939, Austria) argued that the functioning of the mental apparatus is best understood as being the result of the interaction among three agencies or structures, which he labeled id, ego, and superego.

1925 Werner Heisenberg (1901–1976, Germany) formulated matrix mechanics, the first formalization of quantum mechanics.

1926 Erwin Schrödinger (1887–1961, Austria) initiated the development of the final quantum theory by describing wave mechanics, which predicted the positions of the electrons.

1927 Heisenberg proposed the Uncertainty Principle, which states that one cannot simultaneously determine the position and momentum of a subatomic particle.

1929 Alexander Fleming (1881–1955, Scotland) discovered the antibiotic substance lysozyme and issued a publication about penicillin.

1937 Hans Adolf Krebs (1900–1981, Germany) discovered the citrus acid cycle, also known as the tricarboxylic acid cycle and the Krebs cycle.

1938 Otto Hahn (1879–1968, Germany), Lise Meitner (1878–1968, Austria-Germany), and co–workers discovered nuclear fission.

1942 Paul Herman Mueller discovered the insecticidal properties of DDT (Dichloro–diphenyl–trichloroethane). DDT was first synthesized in 1873.

1943 Selman Waksman (1888–1973, Russia-U.S.) discovered streptomycin, which was the first antibiotic remedy for tuberculosis. It was first isolated by Albert Schatz, Waksman's research student.

1944 Friedrich Hayek (1899–1992, Austria) argued that only the unorganized price system in a free market enables order to arise from the chaos of individual plans.

1945 Vannevar Bush presented his vision of the "memex," which foreshadowed personal computers and hypertext systems like the World Wide Web.

1947 Ilya Prigogine (1917–2003, Belgium) studied dissipative structures and the self-organization of open thermodynamic systems.

1947 Willard Libby (1908–1980, U.S.) and others develop radiocarbon dating.

1948 George Gamow (1904–1968, Russia–U.S.) and Ralph Alpher (b.1921, U.S.) published the big bang theory of how the universe began.

1950 Norbert Wiener (1894–1946, U.S.) popularized the social implications of the emerging field of cybernetics.

1953 Working with the x-ray research of Rosalind Franklin (1920–1958, England), James Watson (b.1928, U.S.-England) and Francis Crick (1916–2004, England) built a model of DNA showing that the structure was two paired, complementary strands, helical and anti-parallel, associated by secondary, noncovalent bonds.

1964 Louis Leaky (1903–1972, U.K.) identified and named *Homo habilis*.

1970 Stephen Hawking (b.1942, England) and Roger Penrose (b.1931, England) proved that the Universe must have had a beginning in time, on the basis of Einstein's theory of General Relativity.

1975 Edward O. Wilson (b.1929, U.S.) analyzed the social instincts of animals and humans, giving rise to sociobiology.

1976 Richard Dawkins (b.1941, England) argued that the gene (or the "meme" in cultural evolution) is the relevant unit of selection.

1984 Luc Montagnier (b.1932, France) and other scientists working at the Pasteur Institute isolated the human immunodeficiency virus, or HIV. Robert Gallo (b.1937, U.S.) published the discovery of the HIV virus in the same year.

1984 Joe Farman, Brian Gardiner, and Jonathan Shanklin (England) published their discovery of the ozone hole.

1996 At the Roslin Institute in Scotland, Ian Wilmut (b.1944, Scotland) and Keith Campbell (England) cloned a sheep, "Dolly" (1996–2003), from adult cells.

1997 The U.S. Pathfinder vehicle studied and photographed Mars.

1998 Robert Waterston, John E. Sulston, and numerous colleagues reported the mapping of the entire genome of *Caenorhabditis elegans*.

2000 Researchers at the Human Genome Project completed a rough draft of the nucleotide sequence of the human genome. The project was completed ahead of schedule due to advances in sequence analysis and computer technologies.

2000 Craig Venter (b.1946, U.S.) led a team which sequenced the genome of *Drosophila melanogaster*.

2004 Mars rovers Spirit and Opportunity sent back photos of the red planet and collected data that further supported the hypothesis that water was once prevalent on Mars.

2004 Researchers at Seoul National University in South Korea became the first to clone a human embryo and then cull master stem cells from it.

COMPILED BY ADAM BRIGGLE AND CARL MITCHAM

APPENDIX V

ETHICS CODES AND RELATED DOCUMENTS

This selective collection of professional ethics codes related to technology, engineering, and science, in both the professional and corporate contexts, along with a few declarations and manifestos, indicates the wide range of responses that exist in the technical and intellectual communities to some of the issues covered in the Encyclopedia of Science, Technology, and Ethics. *Most well developed are codes of conduct in the medical professional (which are well documented in the* Encyclopedia of Bioethics *and thus not duplicated here) and the engineering profession, as is indicated by the number of official documents from engineering societies throughout the world. Two other major resources for professional codes of this and related types can be found at the Case Western Reserve Online Ethics Center for Engineering and Science (onlineethics.org) and the Illinois Institute of Technology Center for the Study of Ethics in the Professions (ethics.iit.edu).*

GERMANY

Association of German Engineers Code of Ethics
Fundamentals of Engineering Ethics

HONDURAS

Association of Civil Engineers of Honduras Code of Ethics

HONG KONG

Hong Kong Institution of Engineers Code of Ethics

INDIA

Indian Institute of Chemical Engineers Code of Ethics
Indian National Academy of Engineering Code of Ethics
India Society of Engineers Code of Ethics
The Institution of Engineers Code of Ethics

IRELAND

The Institution of Engineers of Ireland Code of Ethics

JAMAICA

Jamaican Institution of Engineers Code of Ethics

JAPAN

Science Council of Japan Code of Ethics

MEXICO

Mexican Union of Associations of Engineers Code of Ethics

NEW ZEALAND

The Institution of Engineers Code of Ethics

NORWAY

Association of Norwegian Civil Engineers Code of Ethics

PAKISTAN

The Institution of Engineers Code of Ethics

SINGAPORE

The Institution of Engineers Code of Ethics

SRI LANKA

The Institution of Engineers Code of Ethics

SWEDEN

Swedish Federation of Civil Engineers Code of Ethics

SWITZERLAND

Swiss Technical Association Code of Ethics

UNITED KINGDOM

Institution of Civil Engineers Code of Ethics
Institution of Mechanical Engineers Code of Ethics

VENEZUELA

Association of Engineers of Venezuela Code of Ethics

Transnational Engineering Societies

Fédération Européenne d'Associations Nationales d'Ingénieurs (FEANI, European Federation of National Engineering Associations) Code of Ethics

Founding Statement of the International Network of Engineers and Scientists for Global Responsibility (INES) Appeal to Engineers and Scientists

Unión Panamericana de Asociaciones de Ingenieros (UPADI, Pan American Federation of Engineering Societies) Code of Ethics

World Federation of Engineering Societies Model Code of Ethics

4. Corporations and NGOs

Code of Conduct for NGOs

Dow Corning Ethical Business Conduct

Eaton Ethical Business Conduct

Lockheed Martin Corporation Code of Ethics and Business Conduct

Responsible Care Guiding Principles (Chemical Industry)

5. Declarations and Manifestos

Einstein-Russell Manifesto (1955)

Mount Carmel Declaration on Technology and Moral Responsibility (1974)

Rio Declaration on Environment and Development (1992)

Technorealism Manifesto (1998)

Declaration on Science and the Use of Scientific Knowledge (1999)

Declaration of Santo Domingo (1999)

Rio de Janeiro Declaration on Ethics in Science and Technology (2003)

Ahmedabad Declaration (2005)

6. Science

Chemist's Code of Conduct of the American Chemical Society

Code of Ethics of the American Anthropological Association

Hippocratic Oath for Scientists (U.S. Student Pugwash Group)

International Network of Engineers and Scientists for Global Responsibility

7. Government

Definition of Research Misconduct from the U.S. Federal Register

THE AMERICAN INSTITUTE OF ARCHITECTS (AIA): 2004 CODE OF ETHICS AND PROFESSIONAL CONDUCT

Preamble

Members of The American Institute of Architects are dedicated to the highest standards of professionalism, integrity, and competence. This **Code of Ethics and Professional Conduct** states guidelines for the conduct of Members in fulfilling those obligations. The **Code** is arranged in three tiers of statements:

- Canons, Ethical Standards, and Rules of Conduct:
- Canons are broad principles of conduct.
- Ethical Standards (E.S.) are more specific goals toward which Members should aspire in professional performance and behavior.
- Rules of Conduct (Rule) are mandatory; violation of a Rule is grounds for disciplinary action by the Institute.

Rules of Conduct, in some instances, implement more than one Canon or Ethical Standard. The **Code** applies to the professional activities of all classes of Members, wherever they occur. It addresses responsibilities to the public, which the profession serves and enriches; to the clients and users of architecture and in the building industries, who help to shape the built environment; and to the art and science of architecture, that continuum of knowledge and creation which is the heritage and legacy of the profession. Commentary is provided for some of the Rules of Conduct. That commentary is meant to clarify or elaborate the intent of the rule. The commentary is not part of the *Code*. Enforcement will be determined by application of the Rules of Conduct alone; the commentary will assist those seeking to conform their conduct to the **Code** and those charged with its enforcement.

Statement in Compliance with Antitrust Law

The following practices are not, in themselves, unethical, unprofessional, or contrary to any policy of The American Institute of Architects or any of its components:

1. submitting, at any time, competitive bids or price quotations, including in circumstances where price is the sole or principal consideration in the selection of an architect;
2. providing discounts; or
3. providing free services.

Individual architects or architecture firms, acting alone and not on behalf of the Institute or any of its components, are free to decide for themselves whether or not to engage in any of these practices. Antitrust law permits the Institute, its components, or Members to advocate legislative or other government policies or actions relating to these practices. Finally, architects should continue to consult with state laws or regulations governing the practice of architecture.

CANON I

General Obligations

Members should maintain and advance their knowledge of the art and science of architecture, respect the body of architectural accomplishment, contribute to its growth, thoughtfully consider the social and environmental impact of their professional activities, and exercise learned and uncompromised professional judgment.

E.S. 1.1 Knowledge and Skill: Members should strive to improve their professional knowledge and skill.

Rule In practicing architecture, **1.101** Members shall demonstrate a consistent pattern of reasonable care and competence, and shall apply the technical knowledge and skill which is ordinarily applied by architects of good standing practicing in the same locality.

Commentary: By requiring a ''consistent pattern'' of adherence to the common law standard of competence, this rule allows for discipline of a Member who more than infrequently does not achieve that standard. Isolated instances of minor lapses would not provide the basis for discipline.

E.S. 1.2 Standards of Excellence: Members should continually seek to raise the standards of aesthetic excellence, architectural education, research, training, and practice.

E.S. 1.3 Natural and Cultural Heritage: Members should respect and help conserve their natural and cultural heritage while striving to improve the environment and the quality of life within it.

E.S. 1.4 Human Rights: Members should uphold human rights in all their professional endeavors.

Rule 1.401 Members shall not discriminate in their professional activities on the basis of race, religion, gender, national origin, age, disability, or sexual orientation.

E.S. 1.5 Allied Arts & Industries: Members should promote allied arts and contribute to the knowledge and capability of the building industries as a whole.

CANON II

Obligations to the Public

Members should embrace the spirit and letter of the law governing their professional affairs and should promote and serve the public interest in their personal and professional activities.

E.S. 2.1 Conduct: Members should uphold the law in the conduct of their professional activities.

Rule 2.101 Members shall not, in the conduct of their professional practice, knowingly violate the law.

Commentary: The violation of any law, local, state or federal, occurring in the conduct of a Member's professional practice, is made the basis for discipline by this rule. This includes the federal Copyright Act, which prohibits copying architectural works without the permission of the copyright owner: Allegations of violations of this rule must be based on an independent finding of a violation of the law by a court of competent jurisdiction or an administrative or regulatory body.

Rule 2.102 Members shall neither offer nor make any payment or gift to a public official with the intent of influencing the official's judgment in connection with an existing or prospective project in which the Members are interested.

Commentary: This rule does not prohibit campaign contributions made in conformity with applicable campaign financing laws.

Rule 2.103 Members serving in a public capacity shall not accept payments or gifts which are intended to influence their judgment.

Rule 2.104 Members shall not engage in conduct involving fraud or wanton disregard of the rights of others.

Commentary: This rule addresses serious misconduct whether or not related to a Member's professional practice. When an alleged violation of this rule is based on a violation of a law, or of fraud, then its proof must be based on an independent finding of a violation of the law or a finding of fraud by a court of competent jurisdiction or an administrative or regulatory body.

Rule 2.105 If, in the course of their work on a project, the Members become aware of a decision taken by their employer or client which violates any law or regulation and which will, in the Members' judgment, materially affect adversely the safety to the public of the finished project, the Members shall:

a. advise their employer or client against the decision,
b. refuse to consent to the decision, and
c. report the decision to the local building inspector or other public official charged with the enforcement of the applicable laws and regulations, unless the Members are able to cause the matter to be satisfactorily resolved by other means.

Commentary: This rule extends only to violations of the building laws that threaten the public safety. The obligation under this rule applies only to the safety of the finished project, an obligation coextensive with the usual undertaking of an architect.

Rule 2.106 Members shall not counsel or assist a client in conduct that the architect knows, or reasonably should know, is fraudulent or illegal.

E.S. 2.2 Public Interest Services: Members should render public interest professional services and encourage their employees to render such services.

E.S. 2.3 Civic Responsibility: Members should be involved in civic activities as citizens and professionals, and should strive to improve public appreciation and understanding of architecture and the functions and responsibilities of architects.

Rule 2.301 Members making public statements on architectural issues shall disclose when they are being compensated for making such statements or when they have an economic interest in the issue.

CANON III

Obligations to the Client

Members should serve their clients competently and in a professional manner, and should exercise unprejudiced and unbiased judgment when performing all professional services.

E.S. 3.1 Competence: Members should serve their clients in a timely and competent manner.

Rule 3.101 In performing professional services, Members shall take into account applicable laws and regulations. Members may rely on the advice of other qualified persons as to the intent and meaning of such regulations.

Rule 3.102 Members shall undertake to perform professional services only when they, together with those whom they may engage as consultants, are qualified by education, training, or experience in the specific technical areas involved.

Commentary: This rule is meant to ensure that Members not undertake projects that are beyond their professional capacity. Members venturing into areas that require expertise they do not possess may obtain that expertise by additional education, training, or through the retention of consultants with the necessary expertise.

Rule 3.103 Members shall not materially alter the scope or objectives of a project without the client's consent.

E.S. 3.2 Conflict of Interest: Members should avoid conflicts of interest in their professional practices and fully disclose all unavoidable conflicts as they arise.

Rule 3.201 A Member shall not render professional services if the Member's professional judgment could be affected by responsibilities to another project or person, or by the Member's own interests, unless all those who rely on the Member's judgment consent after full disclosure.

Commentary: This rule is intended to embrace the full range of situations that may present a Member with a conflict between his interests or responsibilities and the interest of others. Those who are entitled to disclosure may include a client, owner, employer, contractor, or others who rely on or are affected by the Member's professional decisions. A Member who cannot appropriately communicate about a conflict directly with an affected person must take steps to ensure that disclosure is made by other means.

Rule 3.202 When acting by agreement of the parties as the independent interpreter of building contract documents and the judge of contract performance, Members shall render decisions impartially.

Commentary: This rule applies when the Member, though paid by the owner and owing the owner loyalty, is nonetheless required to act with impartiality in fulfilling the architect's professional responsibilities.

E.S. 3.3 Candor and Truthfulness: Members should be candid and truthful in their professional communications and keep their clients reasonably informed about the clients' projects.

Rule 3.301 Members shall not intentionally or recklessly mislead existing or prospective clients about the results that can be achieved through the use of the Members' services, nor shall the Members state that they can achieve results by means that violate applicable law or this **Code**.

Commentary: This rule is meant to preclude dishonest, reckless, or illegal representations by a Member either in the course of soliciting a client or during performance.

E.S. 3.4 Confidentiality: Members should safeguard the trust placed in them by their clients.

Rule 3.401 Members shall not knowingly disclose information that would adversely affect their client or that they have been asked to maintain in confidence, except as other wise allowed or required by this **Code** or applicable law.

Commentary: To encourage the full and open exchange of information necessary for a successful professional relationship, Members must recognize and respect the sensitive nature of confidential client communications. Because the law does not recognize an architect-client privilege, however, the rule permits a Member to reveal a confidence when a failure to do so would be unlawful or contrary to another ethical duty imposed by this **Code.**

CANON IV

Obligations to the Profession

Members should uphold the integrity and dignity of the profession.

E.S. 4.1 Honesty and Fairness: Members should pursue their professional activities with honesty and fairness.

Rule 4.101 Members having substantial information which leads to a reasonable belief that another Member has committed a violation of this **Code** which raises a serious question as to that Member's honesty, trustworthiness, or fitness as a Member, shall file a complaint with the National Ethics Council.

Commentary: Often, only an architect can recognize that the behavior of another architect poses a serious question as to that other's professional integrity. In those circumstances, the duty to the professional's calling requires that a complaint be filed. In most jurisdictions, a complaint that invokes professional standards is protected from a libel or slander action if the complaint was made in good faith. If in doubt, a Member should seek counsel before reporting on another under this rule.

Rule 4.102 Members shall not sign or seal drawings, specifications, reports, or other professional work for which they do not have responsible control.

Commentary: Responsible control means the degree of knowledge and supervision ordinarily required by the professional standard of care. With respect to the work of licensed consultants, Members may sign or seal such work if they have reviewed it, coordinated its preparation, or intend to be responsible for its adequacy.

Rule 4.103 Members speaking in their professional capacity shall not knowingly make false statements of material fact.

Commentary: This rule applies to statements in all professional contexts, including applications for licensure and AIA membership.

E.S. 4.2 Dignity and Integrity: Members should strive, through their actions, to promote the dignity and integrity of the profession, and to ensure that their representatives and employees conform their conduct to this **Code**.

Rule 4.201 Members shall not make misleading, deceptive, or false statements or claims about their professional qualifications, experience, or performance and shall accurately state the scope and nature of their responsibilities in connection with work for which they are claiming credit.

Commentary: This rule is meant to prevent Members from claiming or implying credit for work which they did not do, misleading others, and denying other participants in a project their proper share of credit.

Rule 4.202 Members shall make reasonable efforts to ensure that those over whom they have supervisory authority conform their conduct to this **Code.**

Commentary: What constitutes "reasonable efforts" under this rule is a common sense matter. As it makes sense to ensure that those over whom the architect exercises supervision be made generally aware of the **Code**, it can also make sense to bring a particular provision to the attention of a particular employee when a situation is present which might give rise to violation.

CANON V

Obligations to Colleagues

Members should respect the rights and acknowledge the professional aspirations and contributions of their colleagues.

E.S. 5.1 Professional Environment: Members should provide their associates and employees with a suitable working environment, compensate them fairly, and facilitate their professional development.

E.S. 5.2 Intern and Professional Development: Members should recognize and fulfill their obligation to nurture fellow professionals as they progress through all stages of their career, beginning with professional education in the academy, progressing through internship and continuing throughout their career.

E.S. 5.3 Professional Recognition: Members should build their professional reputation on the merits of their own service and performance and should recognize and give credit to others for the professional work they have performed.

Rule 5.301 Members shall recognize and respect the professional contributions of their employees, employers, professional colleagues, and business associates.

Rule 5.302 Members leaving a firm shall not, without the permission of their employer or partner, take designs, drawings, data, reports, notes, or other materials relating to the firm's work, whether or not performed by the Member.

Rule 5.303 A Member shall not unreasonably withhold permission from a departing employee or partner to take copies of designs, drawings, data, reports, notes, or other materials relating to work performed by the employee or partner that are not confidential.

Commentary: A Member may impose reasonable conditions, such as the payment of copying costs, on the right of departing persons to take copies of their work.

RULES OF APPLICATION, ENFORCEMENT, AND AMENDMENT

Application

The **Code of Ethics and Professional Conduct** applies to the professional activities of all members of the AIA.

Enforcement

The Bylaws of the Institute state procedures for the enforcement of the **Code of Ethics and Professional Conduct.** Such procedures provide that:

1. Enforcement of the **Code** is administered through a National Ethics Council, appointed by the AIA Board of Directors.
2. Formal charges are filed directly with the National Ethics Council by Members, components, or any-

one directly aggrieved by the conduct of the Members.

3. Penalties that may be imposed by the National Ethics Council are:

   (a) Admonition
   (b) Censure
   (c) Suspension of membership for a period of time
   (d) Termination of membership

4. Appeal procedures are available.
5. All proceedings are confidential, as is the imposition of an admonishment; however, all other penalties shall be made public.

Enforcement of Rules 4.101 and 4.202 refer to and support enforcement of other Rules. A violation of Rules 4.101 or 4.202 cannot be established without proof of a pertinent violation of at least one other Rule.

Amendment

The Code of Ethics and Professional Conduct may be amended by the convention of the Institute under the same procedures as are necessary to amend the Institute's Bylaws. The **Code** may also be amended by the AIA Board of Directors upon a two-thirds vote of the entire Board.

*2004 EDITION. *This copy of the* **Code of Ethics** *is current as of September 2004. Contact the General Counsel's Office for further information at (202) 626-7311.*

AMERICAN INSTITUTE OF GRAPHIC ARTS (AIGA) STANDARDS OF PROFESSIONAL PRACTICE

• • •

The purpose of the statement of policy on professional practice is to provide all AIGA members with a clear standard of professional conduct. AIGA encourages the highest level of professional conduct in design. The policy is not binding. Rather, it reflects the view AIGA on the kind of conduct that is in the best interest of the profession, clients, and the public.

For the purposes of this document the word "designer" means an individual, practicing design as a freelance or salaried graphic designer, or group of designers acting in partnership or other form of association.

The designer's professional responsibility

1.1 A designer shall at all times act in a way that supports the aims of the AIGA and its members, and encourages the highest standards of design and professionalism.

1.2 A designer shall not undertake, within the context of his or her professional practice, any activity that will compromise his or her status as a professional consultant.

The designer's responsibility to clients

2.1 A designer shall acquaint himself or herself with a client's business and design standards and shall act in the client's best interest within the limits of professional responsibility.

2.2 A designer shall not work simultaneously on assignments that create a conflict of interest without agreement of the clients or employers concerned, except in specific cases where it is the convention of a particular trade for a designer to work at the same time for various competitors.

2.3 A designer shall treat all work in progress prior to the completion of a project and all knowledge of a client's intentions, production methods, and business organization as confidential and shall not divulge such information in any manner whatsoever without the consent of the client. It is the designer's responsibility to ensure that all staff members act accordingly.

The designer's responsibility to other designers

3.1 Designers in pursuit of business opportunities should support fair and open competition based upon professional merit.

3.2 A designer shall not knowingly accept any professional assignment on which another designer has been or is working without notifying the other designer or until he or she is satisfied that any previous appointments have been properly terminated and that all materials relevant to the continuation of the project are the clear property of the client.

3.3 A designer must not attempt, directly or indirectly, to supplant another designer through unfair means; nor must he or she compete with another designer by means of unethical inducements.

3.4 A designer must be fair in criticism and shall not denigrate the work or reputation of a fellow designer.

3.5 A designer shall not accept instructions from a client that involve infringement of another person's property rights without permission, or consciously act in any manner involving any such infringement.

3.6 A designer working in a country other than his or her own shall observe the relevant Code of Conduct of the national society concerned.

Fees

4.1 A designer shall work only for a fee, a royalty, salary, or other agreed-upon form of compensation. A designer shall not retain any kickbacks, hidden discounts, commission, allowances, or payment in kind from contractors or suppliers.

4.2 A reasonable handling and administration charge may be added, with the knowledge and understanding of the client, as a percentage to all reimbursable items, billable to a client, that pass through the designer's account.

4.3 A designer who is financially concerned with any suppliers who may benefit from any recommendations made by the designer in the course of a project shall secure the approval of the client or employer of this fact in advance.

4.4 A designer who is asked to advise on the selection of designers or the consultants shall not base such advice in the receipt of payment from the designer or consultants recommended.

Publicity

5.1 Any self-promotion, advertising, or publicity must not contain deliberate misstatements of competence, experience, or professional capabilities. It must be fair both to clients and other designers.

5.2 A designer may allow a client to use his or her name for the promotion of work designed or services provided but only in a manner that is appropriate to the status of the profession.

Authorship

6.1 A designer shall not claim sole credit for a design on which other designers have collaborated.

6.2 When not the sole author of a design, it is incumbent upon a designer to clearly identify his or her specific responsibilities or involvement with the design. Examples of such work may not be used for publicity, display, or portfolio samples without clear identification of precise areas of authorship.

First published by AIGA, the professional association for design. www.aiga.org.

INDUSTRIAL DESIGNERS SOCIETY OF AMERICA (IDSA) CODE OF ETHICS

Recognizing that industrial designers affect the quality of life in our increasingly independent and complex society; that responsible ethical decision making often requires conviction, courage and ingenuity in today's competitive business context: We, the members of the Industrial Designers Society of America, will endeavor to meet the standards set forth in this code, and strive to support and defend one another in doing so.

Fundamental Ethical Principles

We will uphold and advance the integrity of our profession by:

1. Supporting one another in achieving our goals of maintaining high professional standards and levels of competence, and honoring commitments we make to others;
2. Being honest and fair in serving the public, our clients, employers, peers, employees and students regardless of gender, race, creed, ethnic origin, age, disability or sexual orientation;
3. Striving to maintain sufficient knowledge of relevant current events and trends so as to be able to assess the economic and environmental effects of our decisions;
4. Using our knowledge and skill for the enrichment of human well-being, present and future; and
5. Supporting equality of rights under the law and opposing any denial or abridgement of equal rights by the United States or by any individual state on account of gender, race, creed, ethnic origin, age, disability or sexual orientation.

Articles of Ethical Practice

The following articles provide an outline of ethical guidelines designed to advance the quality of our profession. They provide general principles in which the "Ethics Advisory Council" can resolve more specific questions that may arise.

Article I: We are responsible to the public for their safety, and their economic and general well-being is our foremost professional concern. We will participate only in projects we judge to be ethically sound and in conformance with pertinent legal regulations; we will advise our clients and employers when we have serious reservations concerning projects we have been assigned.

Article II: We will provide our employers and clients with original and innovative design service of high quality; by serving their interests as faithful agents; by treating privileged information with discretion; by communicating effectively with their appropriate staff members; by avoiding conflicts of interest; and by establishing clear contractual understandings regarding obligations of both parties. Only with agreement of all concerned will we work on competing product lines simultaneously.

Article III: We will compete fairly with our colleagues by building our professional reputation primarily on the quality of our work; by issuing only truthful, objective and non-misleading public statements and promotional materials; by respecting competitors' contractual relationships with their clients; and by commenting only with candor and fairness regarding the character of work of other industrial designers.

Article IV: We will be responsible to our employees by facilitating their professional development insofar as possible; by establishing clear contractual understandings; by maintaining safe and appropriate work environments; by properly crediting work accomplished; and by providing fair and adequate compensation for salary and overtime hours.

Article V: We will be responsible to design education by holding as one of our fundamental concerns the education of design students; by advocating implementation of sufficiently inclusive curricula and requiring satisfactory proficiency to enable students to enter the profession with adequate knowledge and skills; by providing opportunities for internships (and collaboratives) with and observation of practicing designers; by respecting students' rights to ownership of their designs; and by fairly crediting them for work accomplished.

Article VI: We will advance the interests of our profession by abiding by this code; by providing a forum within the Society for the ongoing review of ethical concerns; and by publishing, as appropriate, interpretations of this Code.

COMPUTERS

ASSOCIATION FOR COMPUTING MACHINERY (ACM) CODE OF ETHICS AND PROFESSIONAL CONDUCT

Adopted by ACM Council 10/16/92.

Preamble

Commitment to ethical professional conduct is expected of every member (voting members, associate members, and student members) of the Association for Computing Machinery (ACM).

This Code, consisting of 24 imperatives formulated as statements of personal responsibility, identifies the elements of such a commitment. It contains many, but not all, issues professionals are likely to face. *Section 1* outlines fundamental ethical considerations, while *Section 2* addresses additional, more specific considerations of professional conduct. Statements in *Section 3* pertain more specifically to individuals who have a leadership role, whether in the workplace or in a volunteer capacity such as with organizations like ACM. Principles involving compliance with this Code are given in *Section 4*.

The Code shall be supplemented by a set of Guidelines, which provide explanation to assist members in dealing with the various issues contained in the Code. It is expected that the Guidelines will be changed more frequently than the Code.

The Code and its supplemented Guidelines are intended to serve as a basis for ethical decision making in the conduct of professional work. Secondarily, they may serve as a basis for judging the merit of a formal complaint pertaining to violation of professional ethical standards.

It should be noted that although computing is not mentioned in the imperatives of *Section 1*, the Code is concerned with how these fundamental imperatives apply to one's conduct as a computing professional. These imperatives are expressed in a general form to emphasize that ethical principles which apply to computer ethics are derived from more general ethical principles.

It is understood that some words and phrases in a code of ethics are subject to varying interpretations, and that any ethical principle may conflict with other ethical principles in specific situations. Questions related to ethical conflicts can best be answered by thoughtful consideration of fundamental principles, rather than reliance on detailed regulations.

Contents and Guidelines

1. GENERAL MORAL IMPERATIVES.

As an ACM member I will . . .

1.1 Contribute to society and human well-being.

This principle concerning the quality of life of all people affirms an obligation to protect fundamental human rights and to respect the diversity of all cultures. An essential aim of computing professionals is to minimize negative consequences of computing systems, including threats to health and safety. When designing or implementing systems, computing professionals must attempt to ensure that the products of their efforts will be used in socially responsible ways, will meet social needs, and will avoid harmful effects to health and welfare.

In addition to a safe social environment, human well-being includes a safe natural environment. Therefore, computing professionals who design and develop systems must be alert to, and make others aware of, any potential damage to the local or global environment.

1.2 Avoid harm to others.

"Harm" means injury or negative consequences, such as undesirable loss of information, loss of property, property damage, or unwanted environmental impacts. This principle prohibits use of computing technology in ways that result in harm to any of the following: users, the general public, employees, employers. Harmful actions include intentional destruction or modification of files and programs leading to serious loss of resources or unnecessary expenditure of human resources such as the time and effort required to purge systems of "computer viruses."

Well-intended actions, including those that accomplish assigned duties, may lead to harm unexpectedly. In such an event the responsible person or persons are obligated to undo or mitigate the negative consequences as much as possible. One way to avoid unintentional harm is to carefully consider potential impacts on all those affected by decisions made during design and implementation.

To minimize the possibility of indirectly harming others, computing professionals must minimize malfunctions by following generally accepted standards for system design and testing. Furthermore, it is often necessary to assess the social consequences of systems to project the likelihood of any serious harm to others. If system features are misrepresented to users, coworkers, or supervisors, the individual computing professional is responsible for any resulting injury.

In the work environment the computing professional has the additional obligation to report any signs of system dangers that might result in serious personal or social damage. If one's superiors do not act to curtail or mitigate such dangers, it may be necessary to "blow the whistle" to help correct the problem or reduce the risk. However, capricious or misguided reporting of violations can, itself, be harmful. Before reporting violations, all relevant aspects of the incident must be thoroughly assessed. In particular, the assessment of risk and responsibility must be credible. It is suggested that advice be sought from other computing professionals. See *principle 2.5* regarding thorough evaluations.

1.3 Be honest and trustworthy.

Honesty is an essential component of trust. Without trust an organization cannot function effectively. The honest computing professional will not make deliberately false or deceptive claims about a system or system design, but will instead provide full disclosure of all pertinent system limitations and problems.

A computer professional has a duty to be honest about his or her own qualifications, and about any circumstances that might lead to conflicts of interest.

Membership in volunteer organizations such as ACM may at times place individuals in situations where their statements or actions could be interpreted as carrying the "weight" of a larger group of professionals. An ACM member will exercise care to not misrepresent ACM or positions and policies of ACM or any ACM units.

1.4 Be fair and take action not to discriminate.

The values of equality, tolerance, respect for others, and the principles of equal justice govern this imperative. Discrimination on the basis of race, sex, religion, age, disability, national origin, or other such factors is an explicit violation of ACM policy and will not be tolerated.

Inequities between different groups of people may result from the use or misuse of information and technology. In a fair society, all individuals would have equal opportunity to participate in, or benefit from, the use of computer resources regardless of race, sex, religion, age, disability, national origin or other such similar factors. However, these ideals do not justify unauthorized use of computer resources nor do they provide an adequate basis for violation of any other ethical imperatives of this code.

1.5 Honor property rights including copyrights and patent.

Violation of copyrights, patents, trade secrets and the terms of license agreements is prohibited by law in most circumstances. Even when software is not so protected, such violations are contrary to professional behavior. Copies of software should be made only with proper authorization. Unauthorized duplication of materials must not be condoned.

1.6 Give proper credit for intellectual property.

Computing professionals are obligated to protect the integrity of intellectual property. Specifically, one must not take credit for other's ideas or work, even in cases where the work has not been explicitly protected by copyright, patent, etc.

1.7 Respect the privacy of others.

Computing and communication technology enables the collection and exchange of personal information on a scale unprecedented in the history of civilization. Thus there is increased potential for violating the privacy of individuals and groups. It is the responsibility of professionals to maintain the privacy and integrity of data describing individuals. This includes taking precautions to ensure the accuracy of data, as well as protecting it from unauthorized access or accidental disclosure to inappropriate individuals. Furthermore, procedures must be established to allow individuals to review their records and correct inaccuracies.

This imperative implies that only the necessary amount of personal information be collected in a system, that retention and disposal periods for that information be clearly defined and enforced, and that personal information gathered for a specific purpose not be used for other purposes without consent of the individual(s).

These principles apply to electronic communications, including electronic mail, and prohibit procedures that capture or monitor electronic user data, including messages, without the permission of users or bona fide authorization related to system operation and maintenance. User data observed during the normal duties of system operation and maintenance must be treated with strictest confidentiality, except in cases where it is evidence for the violation of law, organizational regulations, or this Code. In these cases, the nature or contents of that information must be disclosed only to proper authorities.

1.8 Honor confidentiality.

The principle of honesty extends to issues of confidentiality of information whenever one has made an explicit promise to honor confidentiality or, implicitly, when private information not directly related to the performance of one's duties becomes available. The ethical concern is to respect all obligations of confidentiality to employers, clients, and users unless discharged from such obligations by requirements of the law or other principles of this Code.

2. MORE SPECIFIC PROFESSIONAL RESPONSIBILITIES.

As an ACM computing professional I will . . .

2.1 Strive to achieve the highest quality, effectiveness and dignity in both the process and products of professional work.

Excellence is perhaps the most important obligation of a professional. The computing professional must strive to achieve quality and to be cognizant of the serious negative consequences that may result from poor quality in a system.

2.2 Acquire and maintain professional competence.

Excellence depends on individuals who take responsibility for acquiring and maintaining professional competence. A professional must participate in setting standards for appropriate levels of competence, and strive to achieve those standards. Upgrading technical knowledge and competence can be achieved in several ways: doing independent study; attending seminars, conferences, or courses; and being involved in professional organizations.

2.3 Know and respect existing laws pertaining to professional work.

ACM members must obey existing local, state, province, national, and international laws unless there is a compelling ethical basis not to do so. Policies and procedures of the organizations in which one participates must also be obeyed. But compliance must be balanced with the recognition that sometimes existing laws and rules may be immoral or inappropriate and, therefore, must be challenged. Violation of a law or regulation may be ethical when that law or rule has inadequate moral basis or when it conflicts with another law judged to be more important. If one decides to violate a law or rule because it is viewed as unethical, or for any other reason, one must fully accept responsibility for one's actions and for the consequences.

2.4 Accept and provide appropriate professional review.

Quality professional work, especially in the computing profession, depends on professional reviewing and critiquing. Whenever appropriate, individual members should seek and utilize peer review as well as provide critical review of the work of others.

2.5 Give comprehensive and thorough evaluations of computer systems and their impacts, including analysis of possible risks.

Computer professionals must strive to be perceptive, thorough, and objective when evaluating, recommending, and presenting system descriptions and alternatives. Computer professionals are in a position of special trust, and therefore have a special responsibility to provide objective, credible evaluations to employers, clients, users, and the public. When providing evaluations the professional must also identify any relevant conflicts of interest, as stated in *imperative 1.3*.

As noted in the discussion of *principle 1.2* on avoiding harm, any signs of danger from systems must be reported to those who have opportunity and/or responsibility to resolve them. See the guidelines for *imperative 1.2* for more details concerning harm, including the reporting of professional violations.

2.6 Honor contracts, agreements, and assigned responsibilities.

Honoring one's commitments is a matter of integrity and honesty. For the computer professional this includes ensuring that system elements perform as intended. Also, when one contracts for work with another party, one has an obligation to keep that party properly informed about progress toward completing that work.

A computing professional has a responsibility to request a change in any assignment that he or she feels cannot be completed as defined. Only after serious consideration and with full disclosure of risks and concerns to the employer or client, should one accept the assignment. The major underlying principle here is the obligation to accept personal accountability for professional work. On some occasions other ethical principles may take greater priority.

A judgment that a specific assignment should not be performed may not be accepted. Having clearly identified one's concerns and reasons for that judgment, but failing to procure a change in that assignment, one may yet be obligated, by contract or by law, to proceed as directed. The computing professional's ethical judgment should be the final guide in deciding whether or not to proceed. Regardless of the decision, one must accept the responsibility for the consequences.

However, performing assignments "against one's own judgment" does not relieve the professional of responsibility for any negative consequences.

2.7 Improve public understanding of computing and its consequences.

Computing professionals have a responsibility to share technical knowledge with the public by encouraging understanding of computing, including the impacts of computer systems and their limitations. This imperative implies an obligation to counter any false views related to computing.

2.8 Access computing and communication resources only when authorized to do so.

Theft or destruction of tangible and electronic property is prohibited by *imperative 1.2*—"Avoid harm to others." Trespassing and unauthorized use of a computer or communication system is addressed by this imperative. Trespassing includes accessing communication networks and computer systems, or accounts and/or files associated with those systems, without explicit authorization to do so. Individuals and organizations have the right to restrict access to their systems so long as they do not violate the discrimination principle (see *1.4*). No one should enter or use another's computer system, software, or data files without permission. One must always have appropriate approval before using system resources, including communication ports, file space, other system peripherals, and computer time.

3. ORGANIZATIONAL LEADERSHIP IMPERATIVES.

• • •

As an ACM member and an organizational leader, I will . . .

BACKGROUND NOTE: This section draws extensively from the draft IFIP Code of Ethics, especially its sections on organizational ethics and international concerns. The ethical obligations of organizations tend to be neglected in most codes of professional conduct, perhaps because these codes are written from the perspective of the individual member. This dilemma is addressed by stating these imperatives from the perspective of the organizational leader. In this context "leader" is viewed as any organizational member who has leadership or educational responsibilities. These imperatives generally may apply to organizations as well as their leaders. In this context "organizations" are corporations, government agencies, and other "employers," as well as volunteer professional organizations.

3.1 Articulate social responsibilities of members of an organizational unit and encourage full acceptance of those responsibilities.

Because organizations of all kinds have impacts on the public, they must accept responsibilities to society. Organizational procedures and attitudes oriented toward quality and the welfare of society will reduce harm to members of the public, thereby serving public interest and fulfilling social responsibility. Therefore, organizational leaders must encourage full participation in meeting social responsibilities as well as quality performance.

3.2 Manage personnel and resources to design and build information systems that enhance the quality of working life.

Organizational leaders are responsible for ensuring that computer systems enhance, not degrade, the quality of working life. When implementing a computer system, organizations must consider the personal and professional development, physical safety, and human dignity of all workers. Appropriate human-computer ergonomic standards should be considered in system design and in the workplace.

3.3 Acknowledge and support proper and authorized uses of an organization's computing and communication resources.

Because computer systems can become tools to harm as well as to benefit an organization, the leadership has the responsibility to clearly define appropriate and inappropriate uses of organizational computing resources. While the number and scope of such rules should be minimal, they should be fully enforced when established.

3.4 Ensure that users and those who will be affected by a system have their needs clearly articulated during the assessment and design of requirements; later the system must be validated to meet requirements.

Current system users, potential users and other persons whose lives may be affected by a system must have their needs assessed and incorporated in the statement of requirements. System validation should ensure compliance with those requirements.

3.5 Articulate and support policies that protect the dignity of users and others affected by a computing system.

Designing or implementing systems that deliberately or inadvertently demean individuals or groups is ethically unacceptable. Computer professionals who are in decision-making positions should verify that systems are designed and implemented to protect personal privacy and enhance personal dignity.

3.6 Create opportunities for members of the organization to learn the principles and limitations of computer systems.

This complements the imperative on public understanding (*2.7*). Educational opportunities are essential to facilitate optimal participation of all organizational members. Opportunities must be available to all members to help them improve their knowledge and skills in computing, including courses that familiarize them with the consequences and limitations of particular types of systems. In particular, professionals must be made aware of the dangers of building systems around oversimplified models, the improbability of anticipating and designing for every possible operating condition, and other issues related to the complexity of this profession.

4. COMPLIANCE WITH THE CODE.

• • •

As an ACM member I will . . .

4.1 Uphold and promote the principles of this Code.

The future of the computing profession depends on both technical and ethical excellence. Not only is it important for ACM computing professionals to adhere to the principles expressed in this Code, each member should encourage and support adherence by other members.

4.2 Treat violations of this code as inconsistent with membership in the ACM.

Adherence of professionals to a code of ethics is largely a voluntary matter. However, if a member does not follow this code by engaging in gross misconduct, membership in ACM may be terminated.

This Code and the supplemental Guidelines were developed by the Task Force for the Revision of the ACM Code of Ethics and Professional Conduct: Ronald E. Anderson, Chair, Gerald Engel, Donald Gotterbarn, Grace C. Hertlein, Alex Hoffman, Bruce Jawer, Deborah G. Johnson, Doris K. Lidtke, Joyce Currie Little, Dianne Martin, Donn B. Parker, Judith A. Perrolle, and Richard S. Rosenberg. The Task Force was organized by ACM/SIGCAS and funding was provided by the ACM SIG Discretionary Fund. This Code and the supplemental Guidelines were adopted by the ACM Council on October 16, 1992.

SOFTWARE ENGINEERING CODE OF ETHICS AND PROFESSIONAL PRACTICE

• • •

IEEE-CS/ACM Joint Task Force on Software Engineering Ethics and Professional Practices

PREAMBLE

• • •

Computers have a central and growing role in commerce, industry, government, medicine, education, entertainment and society at large. Software engineers are those who contribute by direct participation or by teaching, to the analysis, specification, design, development, certification, maintenance and testing of software systems. Because of their roles in developing software systems, software engineers have significant opportunities to do good or cause harm, to enable others to do good or cause harm, or to influence others to do good or cause harm. To ensure, as much as possible, that their efforts will be used for good, software engineers must commit themselves to making software engineering a beneficial and respected profession. In accordance with that commitment, software engineers shall adhere to the following Code of Ethics and Professional Practice.

The Code contains eight Principles related to the behavior of and decisions made by professional software engineers, including practitioners, educators, managers, supervisors and policy makers, as well as trainees and students of the profession. The Principles identify the ethically responsible relationships in which individuals, groups, and organizations participate and the primary obligations within these relationships. The Clauses of each Principle are illustrations of some of the obligations included in these relationships. These obligations are founded in the software engineer's humanity, in special care owed to people affected by the work of software engineers, and in the unique elements of the practice of software engineering. The Code prescribes these as obligations of anyone claiming to be or aspiring to be a software engineer.

It is not intended that the individual parts of the Code be used in isolation to justify errors of omission or commission. The list of Principles and Clauses is not exhaustive. The Clauses should not be read as separating the acceptable from the unacceptable in professional conduct in all practical situations. The Code is not a simple ethical algorithm that generates ethical decisions. In some situations, standards may be in tension with each other or with standards from other sources. These situations require the software engineer to use ethical judgment to act in a manner which is most consistent with the spirit of the Code of Ethics and Professional Practice, given the circumstances.

Ethical tensions can best be addressed by thoughtful consideration of fundamental principles, rather than blind reliance on detailed regulations. These Principles should influence software engineers to consider broadly who is affected by their work; to examine if they and their colleagues are treating other human beings with due respect; to consider how the public, if reasonably well informed, would view their decisions; to analyze how the least empowered will be affected by their decisions; and to consider whether their acts would be judged worthy of the ideal professional working as a software engineer. In all these judgments concern for the health, safety and welfare of the public is primary; that is, the "Public Interest" is central to this Code.

The dynamic and demanding context of software engineering requires a code that is adaptable and relevant to new situations as they occur. However, even in this generality, the Code provides support for software engineers and managers of software engineers who need to take positive action in a specific case by documenting the ethical stance of the profession. The Code provides an ethical foundation to which individuals within teams and the team as a whole can appeal. The Code helps to define those actions that are ethically improper to request of a software engineer or teams of software engineers.

The Code is not simply for adjudicating the nature of questionable acts; it also has an important educational function. As this Code expresses the consensus of the profession on ethical issues, it is a means to educate both the public and aspiring professionals about the ethical obligations of all software engineers.

PRINCIPLES

Principle 1 PUBLIC: Software engineers shall act consistently with the public interest. In particular, software engineers shall, as appropriate:

1.01. Accept full responsibility for their own work.

1.02. Moderate the interests of the software engineer, the employer, the client and the users with the public good.

1.03. Approve software only if they have a well-founded belief that it is safe, meets specifications, passes appropriate tests, and does not diminish quality of life, diminish privacy or harm the environment. The ultimate effect of the work should be to the public good.

1.04. Disclose to appropriate persons or authorities any actual or potential danger to the user, the public, or the environment, that they reasonably believe to be associated with software or related documents.

1.05. Cooperate in efforts to address matters of grave public concern caused by software, its installation, maintenance, support or documentation.

1.06. Be fair and avoid deception in all statements, particularly public ones, concerning software or related documents, methods and tools.

1.07. Consider issues of physical disabilities, allocation of resources, economic disadvantage and other factors that can diminish access to the benefits of software.

1.08. Be encouraged to volunteer professional skills to good causes and to contribute to public education concerning the discipline.

Principle 2 CLIENT AND EMPLOYER: Software engineers shall act in a manner that is in the best interests of their client and employer, consistent with the public interest. In particular, software engineers shall, as appropriate:

2.01. Provide service in their areas of competence, being honest and forthright about any limitations of their experience and education.

2.02. Not knowingly use software that is obtained or retained either illegally or unethically.

2.03. Use the property of a client or employer only in ways properly authorized, and with the client's or employer's knowledge and consent.

2.04. Ensure that any document upon which they rely has been approved, when required, by someone authorized to approve it.

2.05. Keep private any confidential information gained in their professional work, where such confidentiality is consistent with the public interest and consistent with the law.

2.06. Identify, document, collect evidence and report to the client or the employer promptly if, in their opinion, a project is likely to fail, to prove too expensive, to violate intellectual property law, or otherwise to be problematic.

2.07. Identify, document, and report significant issues of social concern, of which they are aware, in software or related documents, to the employer or the client.

2.08. Accept no outside work detrimental to the work they perform for their primary employer.

2.09. Promote no interest adverse to their employer or client, unless a higher ethical concern is being compromised; in that case, inform the employer or another appropriate authority of the ethical concern.

Principle 3 PRODUCT: Software engineers shall ensure that their products and related modifications meet the highest professional standards possible. In particular, software engineers shall, as appropriate:

3.01. Strive for high quality, acceptable cost, and a reasonable schedule, ensuring significant tradeoffs are clear to and accepted by the employer and the client, and are available for consideration by the user and the public.

3.02. Ensure proper and achievable goals and objectives for any project on which they work or propose.

3.03. Identify, define and address ethical, economic, cultural, legal and environmental issues related to work projects.

3.04. Ensure that they are qualified for any project on which they work or propose to work, by an appropriate combination of education, training, and experience.

3.05. Ensure that an appropriate method is used for any project on which they work or propose to work.

3.06. Work to follow professional standards, when available, that are most appropriate for the task at hand, departing from these only when ethically or technically justified.

3.07. Strive to fully understand the specifications for software on which they work.

3.08. Ensure that specifications for software on which they work have been well documented, satisfy the users' requirements and have the appropriate approvals.

3.09. Ensure realistic quantitative estimates of cost, scheduling, personnel, quality and outcomes on any project on which they work or propose to work and provide an uncertainty assessment of these estimates.

3.10. Ensure adequate testing, debugging, and review of software and related documents on which they work.

3.11. Ensure adequate documentation, including significant problems discovered and solutions adopted, for any project on which they work.

3.12. Work to develop software and related documents that respect the privacy of those who will be affected by that software.

3.13. Be careful to use only accurate data derived by ethical and lawful means, and use it only in ways properly authorized.

3.14. Maintain the integrity of data, being sensitive to outdated or flawed occurrences.

3.15. Treat all forms of software maintenance with the same professionalism as new development.

Principle 4 JUDGMENT: Software engineers shall maintain integrity and independence in their professional judgment. In particular, software engineers shall, as appropriate:

4.01. Temper all technical judgments by the need to support and maintain human values.

4.02. Only endorse documents either prepared under their supervision or within their areas of competence and with which they are in agreement.

4.03. Maintain professional objectivity with respect to any software or related documents they are asked to evaluate.

4.04. Not engage in deceptive financial practices such as bribery, double billing, or other improper financial practices.,/item>

4.05. Disclose to all concerned parties those conflicts of interest that cannot reasonably be avoided or escaped.

4.06. Refuse to participate, as members or advisors, in a private, governmental or professional body concerned with software related issues, in which they, their employers or their clients have undisclosed potential conflicts of interest.

Principle 5 MANAGEMENT: Software engineering managers and leaders shall subscribe to and promote an ethical approach to the management of software development and maintenance. In particular, those managing or leading software engineers shall, as appropriate:

5.01 Ensure good management for any project on which they work, including effective procedures for promotion of quality and reduction of risk.

5.02. Ensure that software engineers are informed of standards before being held to them.

5.03. Ensure that software engineers know the employer's policies and procedures for protecting passwords, files and information that is confidential to the employer or confidential to others.

5.04. Assign work only after taking into account appropriate contributions of education and experience tempered with a desire to further that education and experience.

5.05. Ensure realistic quantitative estimates of cost, scheduling, personnel, quality and outcomes on any project on which they work or propose to work, and provide an uncertainty assessment of these estimates.

5.06. Attract potential software engineers only by full and accurate description of the conditions of employment.

5.07. Offer fair and just remuneration.

5.08. Not unjustly prevent someone from taking a position for which that person is suitably qualified.

5.09. Ensure that there is a fair agreement concerning ownership of any software, processes, research, writing, or other intellectual property to which a software engineer has contributed.

5.10. Provide for due process in hearing charges of violation of an employer's policy or of this Code.

5.11. Not ask a software engineer to do anything inconsistent with this Code.

5.12. Not punish anyone for expressing ethical concerns about a project.

Principle 6 PROFESSION: Software engineers shall advance the integrity and reputation of the profession consistent with the public interest. In particular, software engineers shall, as appropriate:

6.01. Help develop an organizational environment favorable to acting ethically.

6.02. Promote public knowledge of software engineering.

6.03. Extend software engineering knowledge by appropriate participation in professional organizations, meetings and publications.

6.04. Support, as members of a profession, other software engineers striving to follow this Code.

6.05. Not promote their own interest at the expense of the profession, client or employer.

6.06. Obey all laws governing their work, unless, in exceptional circumstances, such compliance is inconsistent with the public interest.

6.07. Be accurate in stating the characteristics of software on which they work, avoiding not only false claims but also claims that might reasonably be supposed to be speculative, vacuous, deceptive, misleading, or doubtful.

6.08. Take responsibility for detecting, correcting, and reporting errors in software and associated documents on which they work.

6.09. Ensure that clients, employers, and supervisors know of the software engineer's commitment to this Code of ethics, and the subsequent ramifications of such commitment.

6.10. Avoid associations with businesses and organizations which are in conflict with this code.

6.11. Recognize that violations of this Code are inconsistent with being a professional software engineer.

6.12. Express concerns to the people involved when significant violations of this Code are detected unless this is impossible, counter-productive, or dangerous.

6.13. Report significant violations of this Code to appropriate authorities when it is clear that consultation with people involved in these significant violations is impossible, counter-productive or dangerous.

Principle 7 COLLEAGUES: Software engineers shall be fair to and supportive of their colleagues. In particular, software engineers shall, as appropriate:

7.01. Encourage colleagues to adhere to this Code.

7.02. Assist colleagues in professional development.

7.03. Credit fully the work of others and refrain from taking undue credit.

7.04. Review the work of others in an objective, candid, and properly-documented way.

7.05. Give a fair hearing to the opinions, concerns, or complaints of a colleague.

7.06. Assist colleagues in being fully aware of current standard work practices including policies and procedures for protecting passwords, files and other confidential information, and security measures in general.

7.07. Not unfairly intervene in the career of any colleague; however, concern for the employer, the client or public interest may compel software engineers, in good faith, to question the competence of a colleague.

7.08. In situations outside of their own areas of competence, call upon the opinions of other professionals who have competence in that area.

Principle 8 SELF: Software engineers shall participate in lifelong learning regarding the practice of their profession and shall promote an ethical approach to the practice of the profession. In particular, software engineers shall continually endeavor to:

8.01. Further their knowledge of developments in the analysis, specification, design, development, maintenance and testing of software and related documents, together with the management of the development process.

8.02. Improve their ability to create safe, reliable, and useful quality software at reasonable cost and within a reasonable time.

8.03. Improve their ability to produce accurate, informative, and well-written documentation.

8.04. Improve their understanding of the software and related documents on which they work and of the environment in which they will be used.

8.05. Improve their knowledge of relevant standards and the law governing the software and related documents on which they work.

8.06. Improve their knowledge of this Code, its interpretation, and its application to their work.

8.07. Not give unfair treatment to anyone because of any irrelevant prejudices.

8.08. Not influence others to undertake any action that involves a breach of this Code.

8.09. Recognize that personal violations of this Code are inconsistent with being a professional software engineer.

This Code was developed by the IEEE-CS/ACM joint task force on Software Engineering Ethics and Professional Practices (SEEPP):

Executive Committee: Donald Gotterbarn (Chair), Keith Miller and Simon Rogerson;

Members: Steve Barber, Peter Barnes, Ilene Burnstein, Michael Davis, Amr El-Kadi, N. Ben Fairweather, Milton Fulghum, N. Jayaram, Tom Jewett, Mark Kanko, Ernie Kallman, Duncan Langford, Joyce Currie Little, Ed Mechler, Manuel J. Norman, Douglas Phillips, Peter Ron Prinzivalli, Patrick Sullivan, John Weckert, Vivian Weil, S. Weisband and Laurie Honour Werth.

TEN COMMANDMENTS OF COMPUTER ETHICS OF THE COMPUTER ETHICS INSTITUTE

1. Thou shalt not use a computer to harm other people.
2. Thou shalt not interfere with other people's computer work.
3. Thou shalt not snoop around in other people's computer files.
4. Thou shalt not use a computer to steal.
5. Thou shalt not use a computer to bear false witness.
6. Thou shalt not copy or use proprietary software for which you have not paid.
7. Thou shalt not use other people's computer resources without authorization or proper compensation.
8. Thou shalt not appropriate other people's intellectual output.
9. Thou shalt think about the social consequences of the program you are writing or the system you are designing.
10. Thou shalt always use a computer in ways that ensure consideration and respect for your fellow humans.

Written by Ramon Barguin, pres., Computer Ethics Institute

ENGINEERING

ETHICS CODES IN PROFESSIONAL ENGINEERING: OVERVIEW AND COMPARISONS

The development of ethics codes in professional engineering began in the late 1800s and continues into the present. It has been influenced by the development of ethics codes in other professions, especially medicine and law, but exhibits its own dynamics and characteristics. This historical dynamics is particularly apparent in the United States, in a movement toward responsibility for public safety, health, and welfare. Outside the United States the movement is not as well documented, but modest comparisons can be made between professional engineering codes in different countries.

Engineering Ethics Codes in General

A code of ethics—also known as a code of conduct—is the public expression of guidelines for behavior by a professional organization enforced in some manner by that organization. A professional code is, as it were, regionalized legislation. What law—as a set of rules for behavior articulated and enforced by the state—does for society as a whole, so codes of ethics do for what Alexis de Tocqueville referred to as public associations (*Democracy in America,* vol. II, book 2, chapter 5) and are now called non-governmental organizations (NGOs).

Thus in order for there to be engineering ethics codes there must first be organized associations of engineers. But as the comparison with law also suggests, this is a necessary but not sufficient condition for engineering ethics codes. There are states that are governed by custom or tradition rather than by law. Just as law is often preceded (and complemented) by more informal and even unconscious mores and social norms, so among engineers it might be that the general function served by a code of ethics could be met (as well as complemented) by more implicit social mores.

The comparison invites further consideration of the possibility of diverse forms of professional organization and diverse relationships between professional associations and ethics codes. Complementing comparative government is comparative professional ethics. One aspect of this comparison would have to include consideration of the relation between various engineering standards, "building codes" or "construction codes," and ethics. For instance, one can postulate an inverse relationship between construction and ethics codes. When construction codes are detailed and explicit, ethics codes can be correspondingly ambiguous, whereas when construction codes are loose or non-existent, the engineering would depend on a high degree of moral dedication not to cut corners.

ENGINEERING ASSOCIATIONS. Engineering associations arose during the eighteenth century in two distinct contexts. In the first they arose within the government as formal organizations of those military personnel especially trained to design and operate "engines of war" (hence the term "engineers") and fortifications. In 1716 in France state service took civilian form as the Corps des Ponts et Chaussées; three decades later, for the more effective training of manpower for this corps, there was established the famous Ecole des Ponts et Chaussées (1747). This was followed by the Ecole des Mines (1783) and the Ecole Polytechnique (1794), the latter founded to train officers for the French revolutionary army. (For a general assessment of the complexities of professional engineering in France, including reference to engineering ethics, see Didier 1999.)

In a second instance engineers came together in informal associations independent of government. In England in the late 1700s, John Smeaton, architect of the Eddystone Lighthouse, and colleagues "were accustomed to dine together every fortnight at the Crown and Anchor in the Strand, spending the evening in conversation on engineering subjects" (Smiles, 1861–1862, vol. 2, p. 474). This led to the informal formation of a club called The Society of Civil Engineers, the term "civil engineer" having been coined by Smeaton in 1768 to distinguish those engineers who were not soldiers. It was not until 1828 that this club was incorporated under Royal Charter as the Institute of Civil Engineers.

The implications of these two origins are quite different. In the French system the education or the school, established by the government, has been primary. One becomes an engineer by earning the special academic degree of engineer, and is then entitled to be called "engineer." The professional organization of such engineers is either the bureau or agency for which one works or some kind of alumni association. Under such circumstances a code of ethics stresses governmental or state service and can afford to be largely implicit.

In the British system the professional association is primary. One becomes an engineer not by earning a special academic degree but by meeting the standards for joining a professional organization. Indeed, academic courses of instruction in engineering are not set up in England until the early 1800s, and the engineering degree does not have its wholly unique curriculum but is simply specified as a kind of bachelor degree.

Under such circumstances it has been found more necessary to formulate an explicit code of ethics, which has tended to stress promotion of the profession over governmental service. For instance, the Royal Charter of the British Institution of Mechanical Engineers (founded 1847), gives the aims of the organization as "to encourage invention and research," "to hold meetings," "to print, publish and distribute the proceedings," and "to co-operate with universities" in "matters connected with mechanical engineering." According to the By-Laws of the Institution, members should conduct themselves "in order to facilitate the advancement of the science of mechanical engineering by preserving the respect in which the community holds persons who are engaged in the professional of mechanical engineering." In other words, the primary obligation of engineers is to the engineering profession rather than the state.

Engineering Ethics in the United States

Although the first institution of higher education in the to grant engineering degrees in the United States was the Military Academy at West Point (founded 1802), non-military engineering schools rapidly superseded it in influence, and the U.S. has largely followed the British model in its professional engineering organizations. The engineering degree is simply one type of the bachelor's degree, and to be a professional engineer is effectively constituted by membership in a professional engineering association such as the American Society for Civil Engineers (ASCE, founded 1852) or the American Society for Mechanical Engineers (ASME, founded 1880). (For background on the history of the engineering profession in the U.S., see Layton 1971.)

The professional codes of these associations initially highlighted professional loyalty and—no doubt reflecting a unique commitment to capitalistic enterprise—especially loyalty to a client or employer (and for most engineers, it was an employer). For instance, the 1914 code of the ASME listed the first duty of the engineer to be a "faithful agent or trustee" of some employing client or corporation. Although Michael Davis (2002) has contested a too literal reading of this requirement, the ASME Committee on Code of Ethics (1915) in a contemporaneous commentary emphasized "protection of a client's or employer's interests" as an engineer's "first obligation." At the same time, engineers should also "endeavor to assist the public to a fair and correct general understanding of engineering matters." But across the twentieth century engineering educators returned repeatedly to the difficulties of communicating to engineers a broad conception of their professional responsibilities.

Following World War II, and especially during the 1970s, engineering ethics codes in the United States were subject to considerable discussion and revision to reflect a new awareness of and commitment not just to public education but to public welfare. The background of this new ferment regarding engineering ethics was concern over the enormous powers engineers now exercised, and public concern about a number of specifically technical catastrophes as well as environmental degradation associated with technical engineering developments. Well-known examples were the DC-10 crashes and Ford Pinto car accidents caused by designs that companies refused to correct because of economic constraints, even though engineers called them to attention.

Such experiences led to the development of a new category of technical hero, the "whistle blower" who transgresses company loyalty and goes public with allegations of wrong doing. Here one influential example involved the case of three engineers—Holger Hjortsvang, Max Blankenzee, and Robert Bruder—who, while working on the San Francisco Bay Area Rapid Transit (BART) in 1972, came to the conclusion that the system was unsafe. When the contractor refused to heed their warnings, they appealed to an oversight board and were fired. But the California Society of Professional Engineers supported them, and indeed a few months later a train had an accident of exactly the kind they had predicted.

Subsequent examples included Richard Parks blowing of the whistle (in 1983) on unsafe practices in the clean-up of the Three Mile Island nuclear disaster, and Roger Boisjolay's exposure of the warnings given to Morton-Thiokol and NASA before the launch of the space shuttle Challenger (of 1986). During the 1980s the Accreditation Board for Engineering and Technology also began to require that engineering programs include engineering ethics in their curricula (Stephan

2002), perhaps in part as a result of such cases and the problems they created for practicing engineers.

Engineering Ethics Outside the United States

Although engineering ethics developments in the United States have taken place independent of contact with developments in other countries, the problems with which United States engineers have been trying to deal transcend national boundaries. Moreover, engineering ethics outside the United States can provide welcome new perspectives for U.S. engineers while profiting as well from U.S. achievements.

For example, ethics codes in Canada and in Australia provide other important variations on the British model that have nevertheless historically placed stronger weight on public responsibility. In Europe there exists a multinational and transdiciplinary to develop an approach to engineering ethics that offers an alternative to the standard U.S. case study, individual responsibility emphasis (see Goujon and Hériard Dubreuil 2001). It is also the case that various transnational professional engineering associations such as the Unión Panaméricana de Asociaciones de Ingenieros (UPADI or Pan American Union of Associations of Engineers) and the Européenne d'Associations Nationales d'Ingénieurs (FEANI or European Federation of National Engineering Associations) are making important contributions to engineering ethics. For present purposes, however, and as a general introduction to the collection of professional ethics codes that follow, it is sufficient to consider six national cases of some particular interest: Germany, Japan, Hong Kong, Sweden, the Dominican Republic, and Chile. (For more on code developments in other countries, see Davis1990, 1991, and 1992.)

Philosophical Engineering Ethics in Germany

The development of engineering ethics in Germany has a much more developed theoretical base than in the United States. Nineteenth and early twentieth century attitudes toward engineering were influenced by philosophers such as Immanuel Kant and G. W. F. Hegel, and by the German notion of education as *Bildung*, formation or growth, understood as the perfection of human nature through culture. Ernst Kapp and Friedrich Dessauer, for instance, argued that like the classics and the humanities, the experience of technological creativity could contribute to the development of a higher moral consciousness.

Immediately after World War II, however, because some of its members had been compromised by involvement with National Socialism, the Verein Deutscher Ingenieure (VDI or Association of German Engineers) developed its first explicit ethics code, the "Engineer's Confessions," which exhibited a distinctly religious character. It also undertook to promote a new philosophical reflection among engineers by establishing a *Mensch und Technik* [Humans and technology] committee, an initiative that has led to a more sustained dialogue between engineers and philosophers than in any other country.

During the 1960s and 1980s the discussion of technology and philosophy became a publicly debated issue. The role of the engineer and the impact on society was discussed during an international conference organized by the German Commission for UNESCO. The public became involved and concerns for the environment were brought up and discussed by committees and groups throughout the country. In 1980 the VDI wrote "Future Tasks" which discussed societal, political, and ethical goals such as improving the possibilities for life, as well as what was technically possible.

This work in turn led to replacement of what had become the dated "Engineer's Confessions" and to further interdisciplinary engineering-philosophy research, especially on the theoretical basis of technology assessment. With regard to professional ethics, one *Mensch und Technik* working committee report in 1980 proposed simply that "The aim of all engineers is the improvement of the possibilities of life for all humanity by the development and appropriate application of technical means." With regard to the foundations of technology assessment, a second working committee in 1986 identified eight fields of value (environmental quality, health, safety, functionality, economics, living standards, personal development, and social quality), mapped out their interrelations, and developed a draft set of recommendations for their implementation in the design of technical products and projects. (For a more extended discussion of these developments, see Huning and Mitcham 1993.)

In 2002, no doubt with influence from movements toward globalization, a new generation of philosophers and engineers simplified the VDI ethics code, and stressed raising ethics awareness and conflict resolution at the levels of both individual practice and oppositions between principles. "In the case of conflicting values," engineers are encouraged to give priority "to the values of humanity over the dynamics of nature, to issues of human rights over technology implementation and exploitation, to public welfare over private interests, and to safety and security over functionality and profitability."

Science and Engineering Ethics Combined in Japan

Engineering ethics codes in Japan, the second major World War II defeated power, exhibited a quite different genesis. To begin with, engineering became professionally organized only after World War II and did so in much closer association with science. In Japan science and engineering have not been treated as much as separate enterprises as they have been in Europe or the United States.

Moreover, the first and most influential code-like document is the "Statement on Atomic Research in Japan" issued by the Japanese Science Council (which includes both scientists and engineers) in 1954. This statement sets forth what have become known as "The Three Principles for the Peaceful Use of Atomic Energy": All research shall be conducted with full openness to the public, shall be democratically administered, and shall be carried out under the autonomous control of the Japanese themselves.

As is readily apparent, these principles reflect the desire of Japanese during the 1950s to distance themselves from United States interests (recall that the Allied occupation ended in 1952) and policy. Immediately after World War II, the U.S. prohibited all Japanese research in aviation, atomic energy, and any other war-related area. But by 1951, following the Communist victory in China and the outbreak of the Korean War, U.S. policy began to shift toward encouraging certain kinds of military-related science and engineering and the incorporation of Japan into the Western alliance.

Indeed, Japanese scientists and engineers recognized that the Three Principles were in opposition to, for example, the U.S. policy of secrecy in atomic research, and in order to avoid publicity and the possible development of opposition, the JSC statement was not initially translated into English. It is also a policy which, although formulated by scientists and engineers themselves, was readily adopted by the government, thus perhaps reflecting the greater social prestige and political influence of the Japanese technical community in comparison with that in the United States.

Beginning in the 1980s scientists and engineers developed a new interest in ethics reflective of but with continuing distinctions from interests in the United States. This is illustrated, for instance, by the JSC declarations on "The Basic Principles of International Scientific Exchange" (1988) and "The New Science Scheme: Science for Society and the Fusion of Humanity and Natural Sciences" (2003), both of which have emphasized a responsibility on the part of scientists and engineers to promote sound scientific development and to help educate the public about important issues related to scientific and technological development. In 1999 there was also established the Japan Accreditation Board for Engineering Education (JABEE), an agency that has given special attention to engineering ethics education.

Engineering Ethics as Institutional Protection in Hong Kong

Another special case in Asia that can be briefly mentioned is that of the Hong Kong Institution of Engineers (HKIE, founded 1947). As a British Crown Colony, the professional organization of engineers in Hong Kong originally developed not just on the British model but as a branch of British institutions. With the realization that Hong Kong would in the near future (in 1997) be returned to Chinese sovereignty, however, local engineers in the 1970s began to provide Hong Kong with a truly independent engineering association. Part of this activity involved some intensive discussion of professional ethics, with a special conference being organized in 1980 on "Professional Ethics in the Modern World."

In 1994 the HKIE formally adopted a set of "Rules of Conduct" that differed in a few key respects from the parent organization. Although the primary obligation remained the responsibility to the profession, this was modified by the following statement: "When working in a country other than Hong Kong [the Hong Kong engineer should] order his [or her] conduct according to the existing recognized standards of conduct in that country, except that he should abide by these rules as applicable in the absence of local standards."

The basis of this modification had been clearly spelled out in previous discussions. At an inter-professional symposium in December 1985, F.Y. Kan of the Hong Kong Institute of Surveyors identified the role of his professional association as the promotion of the status of surveyors and the usefulness of the profession. "So far," he is reported to have said,

> the role [has] not changed but, with the Sino-British agreement in operation [to return Hong Kong to Chinese sovereignty in 1992], there might be a tendency to a far-reaching effect on the professions. There was, therefore, a need to break away from U.K. qualifications. However, professional competence must be maintained and this could bring institutions into the political field. (Luscher, 1986, p. 39)

In a world in which engineering easily comes into contact with the political field—something that is increasingly likely to be the case not only in Hong

Kong—it is increasingly important for engineers to think about ethical issues, and to do with awareness of what is happening in their profession throughout the world.

Engineering Ethics as Social Reform in Sweden

In Europe there has also been some desire to establish professional engineering independence of various pressures from other nations. In this regard Sweden provides an instructive case study of a neutral country that used its engineering prowess to provide itself with a strong military by relying on a well-developed domestic weapons industry. One of the leading weapons producing corporations has been Bofors, a primary supplier of advanced field artillery, anti-aircraft artillery, and ship artillery to the Swedish armed forces. Known not only domestically but internationally for such technologies, in the 1960s Bofors increased its exports. In principle, exports of military weapons were prohibited. But the government can legally waive this restriction for special cases, which nevertheless became increasingly questionable.

An engineer named Ingvar Bratt began working for Bofors in 1969 and participated in projects including a missile and anti-aircraft gun which were delivered to Malaysia in 1977. During the 1970s and 1980s, however, Bratt became politically active, and by 1982 was publicly opposed all weapons exports, even approved ones.

Rumors arose that unapproved countries had acquired Bofors missile technology presumably through an approved third-party country. Bratt discovered evidence in a Bofors' office near his own that missiles had in fact been exported to Singapore. He shared this information with a journalist who that Singapore was an arms dealer. This suggested Singapore as a possible approved country through which the unapproved countries such as Dubai and Bahrain were receiving arms. In 1984 Bratt left Bofors and helped to pursue further evidence of these illegal activities.

This exposé contributed to development of a new code of engineering ethics, one that downplayed company loyalty, a focus of the previous code, and emphasized responsibility to "humanity, the environment, and society." In response to the view that engineers were often those who contributed to social or environmental problems, the new ethics codes stressed the social and ecological responsibility of engineers, promoting the idea that engineers might play a more positive role in society. (This section draws heavily on Welin 1991.)

Engineering Ethics to Resist Corruption in the Dominican Republic

Engineers ethics codes in developing countries provide still another point of comparison. Concern for engineering and ethics has emerged in the Dominican Republic in response to numerous engineering failures and catastrophes that have occurred there as a result of professional negligence.

Engineering, architecture, and surveying were first introduced to the Domincan Republic by Spanish conquistadores in the early 1500s. But engineering was not a formal course of study until the 1900s, and there was not much difference between engineers and architects until 1945 when the first engineering organization was formed.

During the 1980s many engineered structures failed, which led to increased calls for governmental regulation. But a civil engineer, Orlando Franco Batlle, also argued that part of the problem rested with a weak tradition in professional engineering ethics, and promoted new guidelines for the ethical and responsible exercise of the civil engineering profession. In this effort he was inspired by the code of the American Society of Civil Engineers.

The Colegio Dominicano de Ingenieros, Arquitectos y Agrimensores (CODIA or Dominican Association of Engineers, Architects, and Surveyors) had in the 1960s created a code of ethics to promote national interest and relationships within the profession and with clients. But there was no mention of public safety, health, or well-being. There was also no reference to responsibility or concern for the negative effects of engineering on society or the environment. Yet Franco Batlle's argument was unable to bring about a change in this code.

However, whether a reform of the professional ethics code would have any substantial impact on the problem of substandard work remained questionable. A survey in 1990 among CODIA members revealed that most had not even read the existing code, and if they had did not take it seriously. Engineering was thought to be simply the best paying job in the country, with medicine is the most prestigious. This implied that engineers had chosen their profession for economic benefit—and, in fact, two thirds of the engineering professors thought that societal interest was secondary to self-interest. (This section adapts research by César Cuello Nieto, 1992.)

Engineering Ethics as Alternative Development in Chile

A second comparison from the perspective of engineering ethics in a developing country is provided by Chile. In Chile, as in many countries other than the United States, professional codes such as the "Code of

Professional Ethics of the Engineers of the Colegio de Ingenieros de Chile [Association of Engineers of Chile]," actually have the force of law, as a result of having been formulated, in this case, in response to general legislation calling for such codes in all professional organizations. Although the Colegio was founded in 1958, its code was not formulated until it was required by the authoritarian regime of Augusto Pinochette (1973-1990). At the same time, as Marcos García de la Huerta (1991) has argued, Pinochette's two-decade dictatorship severely compromised almost all professional practices. This is a degradation that García de la Huerta has himself worked to overcome by publishing what is probably the first textbook on engineering ethics in Latin America (García de la Huerta and Mitcham 2001).

The Chilean code, like many others, includes little by way of positive guidance. There is, for instance, no mention of any responsibility to public safety, health, and welfare. Instead, the code consists primarily of an extended list of actions that are contrary to sound professional conduct, and that are thus punishable by professional censure. Among many unremarkable canons against conflict of interest, graft, and more, however, is one rejecting "actions or failures to act that favor or permit the unnecessary use of foreign engineering for objectives and work for which Chilean engineering is sufficient and adequate." Such a canon, emphasizing national interests, can also be found in other codes throughout Asia and Latin America, from India to Venezuela.

It is important to note that such a canon need not have simply nationalistic implications. Judith Sutz, for example, a computer scientist in Uruguay, in an essay raising important questions about the directions of information technology research in Latin America, argues that

> The basic question is, What do Latin American engineers want? Do they want to seek original solutions to indigenous problems? Or do they only want to identify with that which is more modern, more sophisticated, more powerful—disregarding real usefulness—in order to feel like they "live" in the developed world? (Sutz 1993, p. 304)

Many countries experience a serious difficulty in addressing their own real problems. Driven by what René Girard (1965) calls mimetic desire, engineers and scientists often devote themselves to high-tech research that brings international prestige rather than to less glamorous but more useful tasks. One serious challenge to professional engineering in the age of globalization will be the extent to which various national and cultural differences can be maintained in the face of such pressures.

Acknowledgments

This article has drawn heavily on a research grant from the National Science Foundation Grant (NSF #DIR 8721989), June 1988 to November 1990, with supplemental support from the Philosophy and Technology Studies Center at Polytechnic University, the Science, Technology, and Society Program of Pennsylvania State University. This research has been further extended by participation in the development of a Humanitarian Engineering Program at the Colorado School of Mines funded by a grant from the William and Flora Hewlett Foundation. Michelle DeBacker, a research assistant, has also made numerous contributions to the preparation of this introduction and the collection of codes.

CARL MITCHAM

BIBLIOGRAPHY

Committee on Code of Ethics, American Society of Mechanical Engineers. (1915). "Report of Committee on Code of Ethics," *American Society of Mechanical Engineers Transactions*, vol. 36, pp. 23–27.

Cuello Nieto, César. (1992). "Engineering and Ethics in the Dominican Republic." In Carl Mitcham, *Engineering Ethics thoughout the World: Introduction, Documentation, Commentary, and Bibliography*. University Park: Science, Technology, and Society Program, Pennsylvania State University, pp. II-2–II-18.

Davis, Michael. (1990). "Ethics Around the World," special theme issue, *Perspectives on the Professions*, vol. 10, no. 1 (August), pp. 1–10. Articles on professional ethics in Australia, Canada, the USSR, and Great Britain, with occasional mentions of engineering.

Davis, Michael. (1991). "Ethics Around the World, Part 2," special theme issue, *Perspectives on the Professions*, vol. 11, no. 1 (August), pp. 1–10. Articles on professional ethics in Argentina, Chile, Hong Kong, Sweden, New Zealand, Costa Rica, and Egypt, with occasional mentions of engineering.

Davis, Michael. (1992). "Ethics Around the World, Part 2," special theme issue, *Perspectives on the Professions*, vol. 12, no. 1 (August), pp. 1–10. Articles on professional ethics in Asia (China, India, and Japan), Japan, Albania, Eastern Europe, Peru, and Argentina, with occasional mentions of engineering.

Davis, Michael. (2002). "Three Myths about Codes of Engineers Ethics," in *Profession, Code, and Ethics*. Burlington, VT: Ashgate, pp. 121–131.

Didier, Christelle. (1999). "Engineering Ethics in France: A Historical Perspective," *Technology in Society*, vol. 21, no. 4, pp. 471–486.

García de la Huerta, Marcos. (1991). "The Ethical Codes of Dictatorship: Ethics in Chile," *Perspectives on the Professions*, vol. 11, no. 1 (August).

García de la Huerta, Marcos, and Carl Mitcham. (2001). *Laética en la profesión de inteniero: Ingeniería y ciudadanía*

[Ethics in the engineering profession: Engineering and citizenship]. Santiago, Chile: Departamento de Estudios Humanísticos, Facultad de Ciencias Físicas y Matemáticas, Universidad de Chile.

Girard, René. (1965). *Deceit, Desire, and the Novel: Self and Other in Literary Structure*. Trans. Yvonne Freccero. Baltimore: Johns Hopkins University Press.

Goujon, Philippe, and Bertrand Hérierd Dubreuil, eds. (2001). *Technology and Ethics: A European Quest for Responsible Engineering*. Leuven, Belgium: Peeters.

Layton, Edwin T. Jr. (1971). *The Revolt of the Engineers*. Cleveland: Press of Case Western Reserve University. Revised edition, Baltimore: Johns Hopkins University Press, 1986.

Luscher, D.S. (1986). "The Changing Role of the Professional Institutions in Hong Kong," *Journal of the Hong Kong Institution of Engineers*, vol. 14, no. 2 (February), pp. 39–40.

Smiles, Samuel. (1861–1862). *The Lives of the Engineers, With an Account of Their Principal Works, Comprising also a History of Inland Communication in Britain*. 3 vols. London: J. Murray, 1861–1862.

Stephan, Karl D. (2002). "All This and Engineering Too: A History of Accreditation Requirements," *IEEE Technology and Society Magazine*, vol. 21, no. 3 (Fall), pp. 8–15.

Sutz, Judith Sutz. (1993). "The Social Implications of Information Technologies: A Latin American Perspective." In Carl Mitcham, ed., *Philosophy and Technology, vol. 10: Spanish Language Contributions to the Philosophy of Technology* Boston: Kluwer.

Welin, Stellan. (1991). "Ethics in Sweden," *Perspectives on the Professions*, vol. 11, no. 1 (August).

ACCREDITATION BOARD FOR ENGINEERING AND TECHNOLOGY (ABET) CODE OF ETHICS

As approved by the Board of Directors on October 30, 1999

Preamble

The Accreditation Board for Engineering and Technology, Inc. (ABET) requires ethical conduct by each volunteer and staff member engaged in fulfilling the mission of ABET. The organization requires that every volunteer and staff member exhibit the highest standards of professionalism, honesty, and integrity. The services provided by ABET require impartiality, fairness, and equity. All persons involved with ABET activities must perform their duties under the highest standards of ethical behavior. It is the purpose of this document to detail the ethical standards under which we agree to operate.

The ABET Guidelines for Interpretation of the Canons

The ABET guidelines for interpretation of the Canons represent the objectives toward which its volunteers and staff members should strive. They are principles which those involved in accreditation activities can reference in specific situations. In addition, they provide interpretive guidance to the ABET Professional Development Committee.

1. ABET volunteers and staff members agree to accept responsibility in making accreditation decisions and credential evaluations consistent with approved criteria and the safety, health, and welfare of the public and to disclose promptly factors that may directly or indirectly conflict with these duties and/or may endanger the public. a). All those involved in ABET activities shall recognize that the lives, safety, health and welfare of the general public are dependent upon a pool of qualified graduate professionals to continue the work of their profession. b). Programs shall not receive accreditation that do not meet the criteria as set forth by the profession through ABET in the areas of engineering, technology, computing, and applied science. c). If ABET volunteers or staff members have knowledge of or reason to believe that an accredited program may be non-compliant with the appropriate criteria, they shall present such information to ABET in writing and shall cooperate with ABET in furnishing such further information or assistance as may be required. d). If credential evaluation staff members have reason to believe that the credentials submitted for evaluation are not authentic or information submitted in support of an evaluation is misleading, they shall cooperate with ABET or any other entities affected by this process to verify the validity of facts and proof the authenticity of the academic documents in question.

2. ABET volunteers and staff members agree to perform services only in areas of our competence. All those involved in ABET activities shall undertake accreditation assignments only when qualified by education and/or experience in the specific technical field involved.

3. ABET volunteers and staff members agree to act as faithful agents or trustees of ABET, avoiding conflicts of interest and disclosing them to affected parties when they exist. a). All those involved in ABET activities shall avoid all known conflicts of interest when representing ABET in any situation. b). They shall disclose all known or potential conflicts of interest that could influence or appear to influence their judgment or the quality of their services. c). They shall not serve as a consultant in accreditation matters to a program or institution while serving as a member or alternate of a commission or the Board of Directors. Program evaluators who have or will serve as consultants must disclose this to ABET per the ABET Conflict of Interest Policy and may not participate in any deliberations regarding ABET matters for that institution. d). They shall not undertake any assignments or take part in any discussions that would knowingly create a conflict of interest between them and ABET or between them and the institutions seeking programmatic accreditation. e). They shall not solicit

or accept gratuities, directly or indirectly, from programs under review for accreditation or from individuals/entities when credentials are under evaluation. f). They shall not solicit or accept any contribution, directly or indirectly, to influence the accreditation decision of programs or the outcome of credential evaluations.

4. ABET volunteers and staff members agree to keep confidential all matters relating to accreditation decisions and credential evaluations unless by doing so we endanger the public or are required by law to disclose information. a). All those involved in ABET activities shall treat information coming to them in the course of their assignments as confidential, and shall not use such information as a means of making personal profit under any circumstances. b). They shall not reveal confidential information or findings except as authorized or required by law or court order. c). They shall only reveal confidential information or findings in their entirety where required to do so and then only with the prior consent of ABET and the institution/programs involved.

5. ABET volunteers and staff members agree to issue either public or internal statements only in an objective and truthful manner. a). All those involved in ABET activities shall be objective and truthful in reports, statements or testimony. They shall include all relevant and pertinent information in such reports, statements, or testimony and shall avoid any act tending to promote their own interest at the expense of the integrity of the process. b). They shall issue no statements, criticisms, or arguments on accreditation matters which are inspired or paid for by an interested party, or parties, unless they preface their comments by identifying themselves, by disclosing the identities of the party or parties on whose behalf they are speaking, and by revealing the existence of any financial interest they may have in matters under discussion. c). They shall not use statements containing a misrepresentation of fact or omitting a material fact. d. They shall admit their own errors when proven wrong and refrain from distorting or altering the facts to justify their mistakes or decisions.

6. ABET volunteers and staff members agree to conduct ourselves honorably, responsibly, ethically, and lawfully so as to enhance the reputation, and usefulness of ABET. a). All those involved in accreditation activities and credential evaluations shall refrain from any conduct that deceives the public. b). They shall not falsify or permit misrepresentation of their, or their associates', academic or professional qualifications. c). They shall not maliciously or falsely, directly or indirectly, injure the professional reputation, prospects, practice or employment of another. If they believe others are guilty of unethical or illegal behavior, they shall present such information to the proper authority for action.

7. ABET volunteers and staff members agree to treat fairly all persons regardless of race, religion, gender, disability, age, national origin, marital status or political affiliation. All those involved in accreditation activities and credential evaluations shall act with fairness and justice to all parties.

8. ABET volunteers and staff members agree to assist colleagues and co-workers in their professional development and to support them in following this code of conduct. a). ABET will provide broad dissemination of these canons of conduct to its volunteers, staff, representative organizations, and other stakeholders impacted by accreditation and credential evaluations. b). ABET will provide training in the use and understanding of the Code of Conduct for all new volunteers and staff members. c). All those involved in accreditation matters and credential evaluations shall continue their professional development throughout their service with ABET and shall provide/participate in opportunities for the professional and ethical development of all stakeholders.

9. Through its Committee on Professional Development, ABET will provide a mechanism for the prompt and fair adjudication of alleged violations of the Code of Conduct. Persons found to be in violation of the ABET Code of Conduct may be subject to any of a number of sanctions including being declared ineligible for service in further activities on behalf of ABET.

Fundamental Canons

Now, therefore, as a volunteers and/or staff member of the Accreditation Board for Engineering and Technology, Inc., and/or its member societies and having read and understood the above stated Guidelines, I __________________________ do hereby commit myself to the highest ethical and professional conduct and agree:

1. to accept responsibility in making accreditation decisions and credential evaluations consistent with approved criteria and the safety, health, and welfare of the public and to disclose promptly, factors that may directly or indirectly conflict with these duites and/or may endanger the public;
2. to perform services only in areas of my competence;

3. to act as a faithful agent or trustee of ABET avoiding conflicts of interest and disclosing them to affected parties including but not limited to, ABET when they exist;
4. to keep confidential all matters relating to accreditation decisions and credential evaluations unless by doing so we harm the public or are required by law to disclose information;
5. to issue either public or internal statements only in an objective and truthful manner;
6. to conduct myself honorably, responsibly, ethically, and lawfully so as to enhance the reputation and effectiveness of ABET;
7. to treat fairly all persons regardless of race, religion, gender, disability, age, national origin, marital status, or political affiliation;
8. to assist colleagues and co-workers in their professional development and to support them in following this code of conduct;
9. to support a mechanism for the prompt and fair adjudication of alleged violations of these canons.

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE) CODE OF ETHICS

Fundamental Principles

Engineers uphold and advance the integrity, honor and dignity of the engineering profession by:

(1) using their knowledge and skill for the enhancement of human welfare and the environment;

(2) being honest and impartial and serving with fidelity the public, their employers and clients;

(3) striving to increase the competence and prestige of the engineering profession; and

(4) supporting the professional and technical societies of their disciplines.

Fundamental Canons

(1) *Engineers shall* hold paramount the safety, health and welfare of the public and shall strive to comply with the principles of sustainable development3 in the performance of their professional duties.

(2) *Engineers shall* perform services only in areas of their competence.

(3) *Engineers shall* issue public statements only in an objective and truthful manner.

(4) *Engineers shall* act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest.

(5) *Engineers shall* build their professional reputation on the merit of their services and shall not compete unfairly with others.

(6) *Engineers shall* act in such a manner as to uphold and enhance the honor, integrity, and dignity of the engineering profession.

(7) *Engineers shall* continue their professional development throughout their careers, and shall provide opportunities for the professional development of those engineers under their supervision.

Guidelines to Practice Under the Fundamental Canons of Ethics

CANON 1.

Engineers shall hold paramount the safety, health and welfare of the public and shall strive to comply with the principles of sustainable development in the performance of their professional duties.

(a) Engineers shall recognize that the lives, safety, health and welfare of the general public are dependent upon engineering judgments, decisions and practices incorporated into structures, machines, products, processes and devices.

(b) Engineers shall approve or seal only those design documents, reviewed or prepared by them, which are determined to be safe for public health and welfare in conformity with accepted engineering standards.

(c) Engineers whose professional judgment is overruled under circumstances where the safety, health and welfare of the public are endangered, or the principles of sustainable development ignored, shall inform their clients or employers of the possible consequences.

(d) Engineers who have knowledge or reason to believe that another person or firm may be in violation of any of the provisions of Canon 1 shall present such information to the proper authority in writing and shall cooperate with the proper authority in furnishing such further information or assistance as may be required.

(e) Engineers should seek opportunities to be of constructive service in civic affairs and work for the advancement of the safety, health and well-being of their communities, and the protection of the environment through the practice of sustainable development.

(f) Engineers should be committed to improving the environment by adherence to the principles of sustainable development so as to enhance the quality of life of the general public.

CANON 2.

Engineers shall perform services only in areas of their competence.

(a) Engineers shall undertake to perform engineering assignments only when qualified by education or experience in the technical field of engineering involved.

(b) Engineers may accept an assignment requiring education or experience outside of their own fields of competence, provided their services are restricted to those phases of the project in which they are qualified. All other phases of such project shall be performed by qualified associates, consultants, or employees.

(c) Engineers shall not affix their signatures or seals to any engineering plan or document dealing with subject matter in which they lack competence by virtue of education or experience or to any such plan or document not reviewed or prepared under their supervisory control.

CANON 3.

Engineers shall issue public statements only in an objective and truthful manner.

(a) Engineers should endeavor to extend the public knowledge of engineering and sustainable development, and shall not participate in the dissemination of untrue, unfair or exaggerated statements regarding engineering.

(b) Engineers shall be objective and truthful in professional reports, statements, or testimony. They shall include all relevant and pertinent information in such reports, statements, or testimony.

(c) Engineers, when serving as expert witnesses, shall express an engineering opinion only when it is founded upon adequate knowledge of the facts, upon a background of technical competence, and upon honest conviction.

(d) Engineers shall issue no statements, criticisms, or arguments on engineering matters which are inspired or paid for by interested parties, unless they indicate on whose behalf the statements are made.

(e) Engineers shall be dignified and modest in explaining their work and merit, and will avoid any act tending to promote their own interests at the expense of the integrity, honor and dignity of the profession.

CANON 4.

Engineers shall act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest.

(a) Engineers shall avoid all known or potential conflicts of interest with their employers or clients and shall promptly inform their employers or clients of any business association, interests, or circumstances which could influence their judgment or the quality of their services.

(b) Engineers shall not accept compensation from more than one party for services on the same project, or for services pertaining to the same project, unless the circumstances are fully disclosed to and agreed to, by all interested parties.

(c) Engineers shall not solicit or accept gratuities, directly or indirectly, from contractors, their agents, or other parties dealing with their clients or employers in connection with work for which they are responsible.

(d) Engineers in public service as members, advisors, or employees of a governmental body or department shall not participate in considerations or actions with respect to services solicited or provided by them or their organization in private or public engineering practice.

(e) Engineers shall advise their employers or clients when, as a result of their studies, they believe a project will not be successful.

(f) Engineers shall not use confidential information coming to them in the course of their assignments as a means of making personal profit if such action is adverse to the interests of their clients, employers or the public.

(g) Engineers shall not accept professional employment outside of their regular work or interest without the knowledge of their employers.

CANON 5.

• • •

Engineers shall build their professional reputation on the merit of their services and shall not compete unfairly with others.

(a) Engineers shall not give, solicit or receive either directly or indirectly, any political contribution, gratuity, or unlawful consideration in order to secure work, exclusive of securing salaried positions through employment agencies.

(b) Engineers should negotiate contracts for professional services fairly and on the basis of demonstrated competence and qualifications for the type of professional service required.

(c) Engineers may request, propose or accept professional commissions on a contingent basis only under circumstances in which their professional judgments would not be compromised.

(d) Engineers shall not falsify or permit misrepresentation of their academic or professional qualifications or experience.

(e) Engineers shall give proper credit for engineering work to those to whom credit is due, and shall recognize the proprietary interests of others. Whenever possible, they shall name the person or persons who may be responsible for designs, inventions, writings or other accomplishments.

(f) Engineers may advertise professional services in a way that does not contain misleading language or is in any other manner derogatory to the dignity of the profession. Examples of permissible advertising are as follows:

Professional cards in recognized, dignified publications, and listings in rosters or directories published by responsible organizations, provided that the cards or listings are consistent in size and content and are in a section of the publication regularly devoted to such professional cards.

Brochures which factually describe experience, facilities, personnel and capacity to render service, providing they are not misleading with respect to the engineer's participation in projects described.

Display advertising in recognized dignified business and professional publications, providing it is factual and is not misleading with respect to the engineer's extent of participation in projects described.

A statement of the engineers' names or the name of the firm and statement of the type of service posted on projects for which they render services.

Preparation or authorization of descriptive articles for the lay or technical press, which are factual and dignified. Such articles shall not imply anything more than direct participation in the project described.

Permission by engineers for their names to be used in commercial advertisements, such as may be published by contractors, material suppliers, etc., only by means of a modest, dignified notation acknowledging the engineers' participation in the project described. Such permission shall not include public endorsement of proprietary products.

(g) Engineers shall not maliciously or falsely, directly or indirectly, injure the professional reputation, prospects, practice or employment of another engineer or indiscriminately criticize another's work.

(h) Engineers shall not use equipment, supplies, laboratory or office facilities of their employers to carry on outside private practice without the consent of their employers.

CANON 6.

• • •

Engineers shall act in such a manner as to uphold and enhance the honor, integrity, and dignity of the engineering profession.

Engineers shall not knowingly act in a manner which will be derogatory to the honor, integrity, or dignity of the engineering profession or knowingly engage in business or professional practices of a fraudulent, dishonest or unethical nature.

CANON 7.

• • •

Engineers shall continue their professional development throughout their careers, and shall provide opportunities for the professional development of those engineers under their supervision.

(a) Engineers should keep current in their specialty fields by engaging in professional practice, participating in continuing education courses, reading in the technical literature, and attending professional meetings and seminars.

(b) Engineers should encourage their engineering employees to become registered at the earliest possible date.

(c) Engineers should encourage engineering employees to attend and present papers at professional and technical society meetings.

(d) Engineers shall uphold the principle of mutually satisfying relationships between employers and employees with respect to terms of employment including professional grade descriptions, salary ranges, and fringe benefits.

As adopted September 2, 1914, and most recently amended November 10, 1996.

(1) The American Society of Civil Engineers adopted THE FUNDAMENTAL PRINCIPLES of the ABET Code of Ethics of Engineers as accepted by the Accreditation Board for Engineering and Technology, Inc. (ABET). (By ASCE Board of Direction action April 12-14, 1975)

(2) In November 1996, the ASCE Board of Direction adopted the following definition of Sustainable Development: "ustainable Development is the challenge of meeting human needs for natural resources, industrial products, energy, food, transportation, shelter, and effective waste management while conserving and protecting environmental quality and the natural resource base essential for future development."

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME) CODE OF ETHICS

• • •

ASME requires ethical practice by each of its members and has adopted the following Code of Ethics of Engineers as referenced in the ASME Constitution, Article C2.1.1.

Code of ethics of engineers

THE FUNDAMENTAL PRINCIPLES Engineers uphold and advance the integrity, honor and dignity of the engineering profession by:

(I) using their knowledge and skill for the enhancement of human welfare;

(II) being honest and impartial, and serving with fidelity the public, their employers and clients; and

(III) striving to increase the competence and prestige of the engineering profession.

THE FUNDAMENTAL CANONS

(1) Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties.

(2) Engineers shall perform services only in the areas of their competence.

(3) Engineers shall continue their professional development throughout their careers and shall provide opportunities for the professional and ethical development of those engineers under their supervision.

(4) Engineers shall act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest or the appearance of conflicts of interest.

(5) Engineers shall build their professional reputation on the merit of their services and shall not compete unfairly with others.

(6) Engineers shall associate only with reputable persons or organizations.

(7) Engineers shall issue public statements only in an objective and truthful manner.

(8) Engineers shall consider environmental impact in the performance of their professional duties.

(9) Engineers shall consider sustainable development in the performance of their professional duties.

The Board on Professional Practice and Ethics maintains an archive of interpretations to the ASME Code of Ethics (P-15.7). These interpretations shall serve as guidance to the user of the ASME Code of Ethics and are available on the Board's website or upon request.
Responsibility: Council on Member Affairs/Board on Professional Practice and Ethics
Adopted: March 7, 1976
Revised several times

INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS (IEEE) CODE OF ETHICS

• • •

We, the members of the IEEE, in recognition of the importance of our technologies in affecting the quality of life throughout the world, and in accepting a personal obligation to our profession, its members and the communities we serve, do hereby commit ourselves to the highest ethical and professional conduct and agree:

1. to accept responsibility in making engineering decisions consistent with the safety, health and welfare of the public, and to disclose promptly factors that might endanger the public or the environment;
2. to avoid real or perceived conflicts of interest whenever possible, and to disclose them to affected parties when they do exist;
3. to be honest and realistic in stating claims or estimates based on available data;
4. to reject bribery in all its forms;
5. to improve the understanding of technology, its appropriate application, and potential consequences;
6. to maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations;
7. to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;
8. to treat fairly all persons regardless of such factors as race, religion, gender, disability, age, or national origin;
9. to avoid injuring others, their property, reputation, or employment by false or malicious action;
10. to assist colleagues and co-workers in their professional development and to support them in following this code of ethics.

Approved by the IEEE Board of Directors
August 1990

NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS (NSPE) CODE OF ETHICS

• • •

Preamble

Engineering is an important and learned profession. As members of this profession, engineers are expected to exhibit the highest standards of honesty and integrity. Engineering has a direct and vital impact on the quality of life for all people. Accordingly, the services provided by engineers require honesty, impartiality, fairness, and equity, and must be dedicated to the protection of the public health, safety, and welfare. Engineers must perform under a standard of professional behavior that requires adherence to the highest principles of ethical conduct.

I. Fundamental Canons

Engineers, in the fulfillment of their professional duties, shall:

1. Hold paramount the safety, health and welfare of the public.
2. Perform services only in areas of their competence.
3. Issue public statements only in an objective and truthful manner.
4. Act for each employer or client as faithful agents or trustees.
5. Avoid deceptive acts.
6. Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

II. Rules of Practice

1. Engineers shall hold paramount the safety, health, and welfare of the public.

(a) If engineers' judgment is overruled under circumstances that endanger life or property, they shall notify their employer or client and such other authority as may be appropriate.

(b) Engineers shall approve only those engineering documents that are in conformity with applicable standards.

(c) Engineers shall not reveal facts, data, or information without the prior consent of the client or employer except as authorized or required by law or this Code.

(d) Engineers shall not permit the use of their name or associate in business ventures with any person or firm that they believe are engaged in fraudulent or dishonest enterprise.

(e) Engineers shall not aid or abet the unlawful practice of engineering by a person or firm.

(f) Engineers having knowledge of any alleged violation of this Code shall report thereon to appropriate professional bodies and, when relevant, also to public authorities, and cooperate with the proper authorities in furnishing such information or assistance as may be required.

(2) Engineers shall perform services only in the areas of their competence.

(a) Engineers shall undertake assignments only when qualified by education or experience in the specific technical fields involved.

(b) Engineers shall not affix their signatures to any plans or documents dealing with subject matter in which they lack competence, nor to any plan or document not prepared under their direction and control.

(c) Engineers may accept assignments and assume responsibility for coordination of an entire project and sign and seal the engineering documents for the entire project, provided that each technical segment is signed and sealed only by the qualified engineers who prepared the segment.

(3) Engineers shall issue public statements only in an objective and truthful manner.

(a) Engineers shall be objective and truthful in professional reports, statements, or testimony. They shall include all relevant and pertinent information in such reports, statements, or testimony, which should bear the date indicating when it was current.

(b) Engineers may express publicly technical opinions that are founded upon knowledge of the facts and competence in the subject matter.

(c) Engineers shall issue no statements, criticisms, or arguments on technical matters that are inspired or paid for by interested parties, unless they have prefaced their comments by explicitly identifying the interested parties on whose behalf they are speaking, and by revealing the existence of any interest the engineers may have in the matters.

(4) Engineers shall act for each employer or client as faithful agents or trustees.

(a) Engineers shall disclose all known or potential conflicts of interest that could influence or appear to influence their judgment or the quality of their services.

(b) Engineers shall not accept compensation, financial or otherwise, from more than one party for services on the same project, or for services pertaining to the same project, unless the circumstances are fully disclosed and agreed to by all interested parties.

(c) Engineers shall not solicit or accept financial or other valuable consideration, directly or indirectly, from outside agents in connection with the work for which they are responsible.

(d) Engineers in public service as members, advisors, or employees of a governmental or quasi-governmental body or department shall not participate in decisions with respect to services solicited or provided by them or their organizations in private or public engineering practice.

(e) Engineers shall not solicit or accept a contract from a governmental body on which a principal or officer of their organization serves as a member.

(5) Engineers shall avoid deceptive acts.

(a) Engineers shall not falsify their qualifications or permit misrepresentation of their or their associates' qualifications. They shall not misrepresent or exaggerate their responsibility in or for the subject matter of prior assignments. Brochures or other presentations incident to the solicitation of employment shall not misrepresent pertinent facts concerning employers, employees, associates, joint venturers, or past accomplishments.

(b) Engineers shall not offer, give, solicit or receive, either directly or indirectly, any contribution to influence the award of a contract by public authority, or which may be reasonably construed by the public as having the effect of intent to influencing the awarding of a contract. They shall not offer any gift or other valuable consideration in order to secure work. They shall not pay a commission, percentage, or brokerage fee in order to secure work, except to a bona fide employee or bona fide established commercial or marketing agencies retained by them.

III. Professional Obligations

(1) Engineers shall be guided in all their relations by the highest standards of honesty and integrity.

(a) Engineers shall acknowledge their errors and shall not distort or alter the facts.

(b) Engineers shall advise their clients or employers when they believe a project will not be successful.

(c) Engineers shall not accept outside employment to the detriment of their regular work or interest. Before accepting any outside engineering employment they will notify their employers.

(d) Engineers shall not attempt to attract an engineer from another employer by false or misleading pretenses.

(e) Engineers shall not promote their own interest at the expense of the dignity and integrity of the profession.

(2) Engineers shall at all times strive to serve the public interest.

(a) Engineers shall seek opportunities to participate in civic affairs; career guidance for youths; and work for the advancement of the safety, health, and well-being of their community.

(b) Engineers shall not complete, sign, or seal plans and/or specifications that are not in conformity with applicable engineering standards. If the client or employer insists on such unprofessional conduct, they shall notify the proper authorities and withdraw from further service on the project.

(c) Engineers shall endeavor to extend public knowledge and appreciation of engineering and its achievements.

(3) Engineers shall avoid all conduct or practice that deceives the public.

(a) Engineers shall avoid the use of statements containing a material misrepresentation of fact or omitting a material fact.

(b) Consistent with the foregoing, engineers may advertise for recruitment of personnel.

(c) Consistent with the foregoing, engineers may prepare articles for the lay or technical press, but such articles shall not imply credit to the author for work performed by others.

(4) Engineers shall not disclose, without consent, confidential information concerning the business affairs or technical processes of any present or former client or employer, or public body on which they serve.

(a) Engineers shall not, without the consent of all interested parties, promote or arrange for new employment or practice in connection with a specific project for which the engineer has gained particular and specialized knowledge.

(b) Engineers shall not, without the consent of all interested parties, participate in or represent an adversary interest in connection with a specific project or proceeding in which the engineer has gained particular specialized knowledge on behalf of a former client or employer.

(5) Engineers shall not be influenced in their professional duties by conflicting interests.

(a) Engineers shall not accept financial or other considerations, including free engineering designs, from material or equipment suppliers for specifying their product.

(b) Engineers shall not accept commissions or allowances, directly or indirectly, from contractors or other parties dealing with clients or employers of the engineer in connection with work for which the engineer is responsible.

(6) Engineers shall not attempt to obtain employment or advancement or professional engagements by untruthfully criticizing other engineers, or by other improper or questionable methods.

(a) Engineers shall not request, propose, or accept a commission on a contingent basis under circumstances in which their judgment may be compromised.

(b) Engineers in salaried positions shall accept part-time engineering work only to the extent consistent with policies of the employer and in accordance with ethical considerations.

(c) Engineers shall not, without consent, use equipment, supplies, laboratory, or office facilities of an employer to carry on outside private practice.

(7) Engineers shall not attempt to injure, maliciously or falsely, directly or indirectly, the professional reputation, prospects, practice, or employment of other engineers. Engineers who believe others are guilty of unethical or illegal practice shall present such information to the proper authority for action.

(a) Engineers in private practice shall not review the work of another engineer for the same client, except with the knowledge of such engineer, or unless the connection of such engineer with the work has been terminated.

(b) Engineers in governmental, industrial, or educational employ are entitled to review and evaluate the work of other engineers when so required by their employment duties.

(c) Engineers in sales or industrial employ are entitled to make engineering comparisons of represented products with products of other suppliers.

(8) Engineers shall accept personal responsibility for their professional activities, provided, however, that engineers may seek indemnification for services arising out of their practice for other than gross negligence, where the engineer's interests cannot otherwise be protected.

(a) Engineers shall conform with state registration laws in the practice of engineering.

(b) Engineers shall not use association with a nonengineer, a corporation, or partnership as a "cloak" for unethical acts.

(9) Engineers shall give credit for engineering work to those to whom credit is due, and will recognize the proprietary interests of others.

(a) Engineers shall, whenever possible, name the person or persons who may be individually responsible for designs, inventions, writings, or other accomplishments.

(b) Engineers using designs supplied by a client recognize that the designs remain the property of the client and may not be duplicated by the engineer for others without express permission.

(c) Engineers, before undertaking work for others in connection with which the engineer may make improvements, plans, designs, inventions, or other records that may justify copyrights or patents, should enter into a positive agreement regarding ownership.

(d) Engineers' designs, data, records, and notes referring exclusively to an employer's work are the employer's property. The employer should indemnify the engineer for use of the information for any purpose other than the original purpose.

(e) Engineers shall continue their professional development throughout their careers and should keep current in their specialty fields by engaging in professional practice, participating in continuing education courses, reading in the technical literature, and attending professional meetings and seminars.

—*As Revised January 2003*

"By order of the United States District Court for the District of Columbia, former Section 11(c) of the NSPE Code of Ethics prohibiting competitive bidding, and all policy statements, opinions, rulings or other guidelines interpreting its scope, have been rescinded as unlawfully interfering with the legal right of engineers, protected under the antitrust laws, to provide price information to prospective clients; accordingly, nothing contained in the NSPE Code of Ethics, policy statements, opinions, rulings or other guidelines prohibits the submission of price quotations or competitive bids for engineering services at any time or in any amount."

Statement by NSPE Executive Committee

In order to correct misunderstandings which have been indicated in some instances since the issuance of the Supreme Court decision and the entry of the Final Judgment, it is noted that in its decision of April 25, 1978, the Supreme Court of the United States declared: "The Sherman Act does not require competitive bidding."

It is further noted that as made clear in the Supreme Court decision:

(1) Engineers and firms may individually refuse to bid for engineering services.

(2) Clients are not required to seek bids for engineering services.

(3) Federal, state, and local laws governing procedures to procure engineering services are not affected, and remain in full force and effect.

(4) State societies and local chapters are free to actively and aggressively seek legislation for professional selection and negotiation procedures by public agencies.

(5) State registration board rules of professional conduct, including rules prohibiting competitive bidding for engineering services, are not affected and remain in full force and effect. State registration boards with authority to adopt rules of professional conduct may adopt rules governing procedures to obtain engineering services.

(6) As noted by the Supreme Court, "nothing in the judgment prevents NSPE and its members from attempting to influence governmental action ..."

NOTE: In regard to the question of application of the Code to corporations vis-à-vis real persons, business form or type should not negate nor influence conformance of individuals to the Code. The Code deals with professional services, which services must be performed by real persons. Real persons in turn establish and implement policies within business structures. The Code is clearly written to apply to the Engineer and items incumbent on members of NSPE to endeavor to live up to its provisions. This applies to all pertinent sections of the Code.

PUERTO RICO: ASSOCIATION OF ENGINEERS AND SURVEYORS OF PUERTO RICO CODE OF ETHICS

• • •

College of Engineers and Surveyors of Puerto Rico

RULES OF ETHICS

In order to maintain and extol the integrity, honor, and dignity of their professions, in accordance with the highest moral and ethical professional norms of conduct, the **Engineer** and the **Surveyor:**

1. Should consider their principal function as professionals as that of serving humanity. Their relation as professional and client, and as professional and patron, should be subject to their fundamental function of promoting the wellbeing of humanity and that of protecting the public interest.
2. They will be honest and impartial and will serve faithfully in the development of their professional functions, always maintaining their independence of criteria which constitutes the base of professionalism.
3. They will strive to improve the competence and the prestige of engineering and surveying.

RULES OF PROFESSIONAL ETHICS

The **Engineer** and the **Surveyor**, in fulfilling their professional duties, must:

RULE I: Protect, above all other consideration, the security, environment, health, and wellbeing of the community in the execution of their professional responsibilities.

RULE II: Provide services only in their areas of competence.

RULE III: Make public declarations only in a true and objective form.

RULE IV: Act in professional matters for each patron or client as faithful agents or fiduciaries, and avoid conflicts of interests or the mere appearance of these, always maintaining independence of criteria as the base of professionalism.

RULE V: Build their professional reputation on the merit of their services and not compete disloyally with others.

RULE VI: Not participate in deceitful acts in the pursuit of employment and in offering professional services.

RULE VII: Act with the decorum that sustains and enhances the honor, integrity, and dignity of their professions.

RULE VIII: Associate only with persons and organizations of good reputation.

RULE IX: Continue their professional development throughout their careers and promote opportunities for the professional and ethical development of the engineers and surveyors under their supervision.

RULE X: Strive to and accept to take professional actions only in conformity with the applicable laws and with these Rules.

NORMS OF PRACTICE RULE I: Protect, above all other consideration, the security, environment, health, and wellbeing of the community in the execution of their professional responsibilities.

The **Engineer** and the **Surveyor:**

a. Will recognize that the life, the security, the environment, the health, and the wellbeing of the community depend on the judgments, decisions, and professional practices incorporated in systems, structures, machines, processes, products, and artifacts.

b. Will approve, seal, stamp, or certify, when appropriate, only those documents revised or prepared by those who understand that they are safe for the environment, health, and wellbeing of the community in conformity with the accepted standards.

c. When their professional judgment might have been repealed in circumstances where the security, environment, health, or wellbeing of the community are put in danger, they will inform their clients or patrons of the possible consequences. If the threat to the security, environment, health, or wellbeing of the community continues, they will inform the concerned authorities about the matter.

d. When they have knowledge or sufficient reason to believe that another engineer or surveyor is violating the dispositions of this Code, or that a person or firm is putting in danger the security, environment, health, or wellbeing of the community, they will present such information in writing to the concerned authorities and will cooperate with said authorities by providing what information or assistance that might be required by them.

e. They will serve constructively in civic matters and will work for the advancement of the security, environment, health, and wellbeing of their communities.

f. They will promise to better the environment and do all that which might be within their reach to enhance the quality of life.

RULE II: Provide services only in their areas of competence.

The **Engineer** and the **Surveyor:**

a. Will only undertake those jobs for which they are qualified by education or experience in the specific technical fields which are being dealt with.

b. Will be able to accept a charge that requires education and experience outside of their fields of competence always and whenever their services are restricted to those phases of the project for which they are qualified. All the other phases of such a project will be executed by qualified associates, consultants, or employees who will approve, seal, stamp, or certify, where necessary, the concerned documents.

c. They will not approve, seal, stamp, or certify, where necessary, any plan or document that deals with some material en which they do not have competence by virtue of their education or experience.

RULE III: Make public declarations only in a true and objective form.

The **Engineer** and the Surveyor:

a. Will be objective and true in professional reports, declarations, or testimonies. They will include all relevant or pertinent information in said reports, declarations, or testimonies.

b. Will undertake to make public knowledge the reach and the practice of their professions and will not participate in the dissemination of false, unjust, or exaggerated declarations.

c. When they serve as technical witnesses, experts, or technicians in any forum, they will express a professional opinion only when it is founded in an adequate knowledge of the facts of the controversy, in a technical competence about the material in question, and in an honest conviction of the exactitude and propriety of their testimonies.

d. They will not make declarations, critiques, or arguments about materials of their respective professions that are motivated or paid by an interested party or parties, unless in these commentaries their author is identified, and the identity of the party or parties whose interest is being spoken about is revealed, as well as the existence of any pecuniary interest that they might have in the matters under discussion.

e. They will be serious and restrained in explaining their work and merits, and will avoid any act tending to promote their own interest at the expense of the integrity, honor, and dignity of their profession or of another individual.

f. They will express publicly a professional opinion about technical matters only when that opinion is founded upon an adequate knowledge of the facts, and competence in these matters.

RULE IV: Act in professional matters for each patron or client as faithful agents or fiduciaries, and avoid conflicts of interests or the mere appearance of these, always maintaining independence of criteria as the base of professionalism.

The **Engineer** and the **Surveyor:**

a. Will avoid all known or potential conflicts of interest with their patrons or clients and will inform in a prompt manner said patrons or clients about any business relation, interests, or circumstances that might influence their judgment or the quality of their services.

b. Will not undertake any charge that might, knowingly, create a potential conflict of interest among them and their clients or patrons.

c. Will not accept compensation from third parties for services rendered in a project, or for services pertaining to the same project, unless the circumstances are completely revealed, and agreed upon by all interested parties.

d. Will not solicit or accept significant gratuities, directly or indirectly, from contractors or their agents or other parties in relation to work that is realized for patrons or clients for which they are responsible.

e. Will not solicit or accept considerations or compensations of any kind for specifying products or materials or suppliers of equipment, without divulging it to their clients or patrons.

f. Those who are in public service as members, advisors, or employers of a governmental body or department will not participate in decisions related to professional services solicited or provided by them or by their organizations in professional practice, be it private or public.

g. Will not solicit or accept contracts for professional services from a governmental body en which an individual or official of their organizations serves as a member.

h. When, as a result of their studies, they understand that a project will not be successful, they will make such an opinion part of the report to their patron or client.

i. Will treat all information that arrives to them in the course of their professional duties as confidential and will not use such information as a means to achieve personal benefit if such an action is adverse to the interests of their clients, of their patrons, of the commissions or committees to which they belong, or of the public.

j. Will not reveal confidential information concerning business matters or technical processes of any patron or bidder, current or previous, under evaluation, without their consent, except when it might be required by law.

k. Will not duplicate designs that are supplied to them by their clients for others, without the express authorization of their client and of the designer, considering the relevant contracts and laws.

l. Before undertaking work for others, in which they can make renovations, plans, designs, inventions, or other registers, that can justify obtaining author's rights or patents, will arrive at an agreement in relation to the rights of the respective parts.

m. Will not participate in or represent an adversary interest without the consent of the interested parts, in relation to a specific project or matter in which they have gained a particular specialized knowledge in the name of a former patron or client.

RULE V: **Build their professional reputation on the merit of their services and not compete disloyally with others.**

The **Engineer** and the **Surveyor:**

a. Will not offer, give, solicit, or receive, directly or indirectly, any monetary contribution or contribution of any other type directed at influencing the granting of a contract by a public authority. They will not offer any gift or any other type of consideration of worth with the aim of obtaining work. They will not pay a commission, percent, or rights of brokerage with the aim of obtaining work except to a bonafide employee or to commercial agencies or to established marketing agencies, bonafide and contracted by them for this reason.

b. Will negotiate contracts for professional services on the base of professional competence and demonstrated qualifications for the type of professional service required and then for just and reasonable honorariums.

c. Will not solicit, propose, or accept professional commissions on a base contingent upon circumstances in which their professional judgment may be seen as compromised.

d. Will not attempt to recruit an employee from other patron by means of false or deceitful representations.

e. Will not maliciously or falsely damage, directly or indirectly, the professional reputation, the prospects, the practice, or the employment of another engineer or surveyor, nor will criticize indiscriminately the work of these people.

f. Will not use the equipment, supplies, laboratory, or office of their patrons in order to execute exterior private practice without their consent.

g. Will not take advantage of the advantages of a salaried position in order to disloyally compete with colleagues who exercise the profession privately.

h. Will not attempt to supplant, nor will supplant another engineer or surveyor, after a professional position has been offered to him or her, nor will compete unjustly with said person.

i. The professionals who act as subcontractors on a project or who in some capacity utilize the services of another professional will not be able to retain for themselves the professional honorariums charges without having attended to the payment of the honorariums of their collaborators at least in a form equitable or proportional to their own; or in any manner deprive or further that their professional companions do not receive just or equitable pay for their services.

j. Will not approve, seal, stamp, or certify, according to the case, nor authorize the presentation of plans, specifications, calculations, opinions, briefs, or reports that have not been elaborated by them or by others under their direct responsibility. Furthermore, they will give credit for the engineering, surveying, or architectural work to those who have done it.

RULE VI: **Not participate in deceitful acts in the pursuit of employment and in offering professional services.**

The **Engineer** and the **Surveyor:**

a. Will not falsify or permit the misrepresentation of their academic or professional qualifications, nor that of their associates or employees. They will not misrepresent or exaggerate the degree of their responsibility in previous positions or concerning the matters that these positions entailed. The folders or types of presentations created for the purpose of soliciting employment will not represent the pertinent facts concerning previous patrons, employees, associates, employers, or achievements.

b. Will announce their professional services without self-praise and without deceitful language, and in a manner in which the dignity of their professions is not diminished. Some examples of permissible announcements are as follows:

1. Professional announcements in recognized publications, and listings in registries or directories published by responsible organizations, as long as the announcements and registries are consequent in size and content and are in a section of the publication dedicated regularly to such professional announcements.

2. Brochures that in fact describe the experience, installations, personnel, and capacity to render services, as long as they are not deceitful with respect to the participation of the professionals in the projects described.

3. Announcements in recognized professional and business magazines, as long as they refer to facts, do not contain self-praising expressions or implications, and are not deceitful with respect to the degree of participation of the professionals in the projects described.

4. A declaration of the names of the professionals or the name of the firm and the type of service, announced in projects for which the professionals render service.

5. The preparation or authorization of descriptive articles for the press that refer to facts, are serious, and are free of implicated praise. Such articles will imply nothing more that the direct participation of the professionals in the project described.

6. The authorization of professionals so that their names may be used in commercial announcements, such as those that can be published by contractors, suppliers of materials, etc., only through a serious and restrained annotation, recognizing the participation of the professionals in the project described. Such authorization will not include the public endorsement of brand-name products.

RULE VII: **Act with the decorum that sustains and enhances the honor, integrity, and dignity of their professions.**

The **Engineer** and the **Surveyor:**

a. Will not act, knowingly, in such a manner that might be harmful to the honor, integrity, and dignity of their professions.

b. Will not associate with, employ, or in any other way utilize in practice any person to render professional services as an engineer, surveyor, or architect, unless that person is an engineer, a surveyor, or an architect recognized by valid authorities as being able to render such services.

c. Will not associate their name with the practice of their profession with non-professionals or with persons or entities that are not professionals legally authorized to exercise the professions of engineering, surveying, or architecture.

d. Will not share honorariums except with engineers, surveyors, or architects who have been their collaborators in works of engineering, surveying, and architecture.

e. Will admit and accept their own errors when they are demonstrated to them and will abstain from distorting or altering the facts with the purpose of justifying their decisions.

f. Will cooperate en extending the efficacy of their professions through the exchange of information and experience with other engineers, architects, and surveyors, and with students of these professions.

g. Will not compromise their professional criteria for any other particular interest.

RULE VIII: **Associate only with persons and organizations of good reputation.**

The **Engineer** and the **Surveyor:**

a. Will not associate with or permit the use of their names or that of their firms, knowingly, with businesses run by any other person or firm that they know or have sufficient reason to believe might be involved in professional or business practices of a fraudulent or dishonest nature.

b. Will not use the association with natural or juridical persons to hide unethical acts.

RULE IX: **Continue their professional development throughout their careers and promote opportunities for the professional and ethical development of the engineers and surveyors under their supervision.**

The **Engineer** and the **Surveyor:**

a. Will keep themselves up to date in their fields of specialty by exercising professional practice, participating in continuing education courses, reading technical literature, and attending professional meeting and seminars.

b. Will encourage the engineers and surveyors in their employ to further their education.

c. Will encourage their graduate employees in training in engineering and surveying to obtain their professional licenses as quickly as possible.

d. Will encourage the engineers and surveyors in their employ to attend and present papers in meetings or professional and technical societies.

e. Will support the principle of mutually satisfactory relations between patrons and employees with respect to the conditions of employment, including a description of professional degree, and scales of salary and benefits.

RULE X: **Strive to and accept to take professional actions only in conformity with the applicable laws and with these Rules.**

The **Engineer** and the Surveyor:

a. Will carry out what is laid out in the laws that govern the practice and direction of engineering and surveying, according to reforms, with the rule of the College of Engineers and Surveyors of Puerto Rico (CIAPR) and of the Examination Board of Engineers, Architects, and Surveyors, and with the agreements and directives legitimately adopted by the General Assembly and Governing Board of CIAPR.

b. Will appear at any interview, administrative investigation, viewing, or procedure, before the Tribunal of Discipline and Professional Ethics or the Commission of Defense of the Profession of CIAPR to which they have been duly cited by the College, be it as a witness, plaintiff, or defendant.

Approved at the Annual Ordinary Assembly celebrated Saturday, August 20, 1994, in the El Conquistador Hotel, Fajardo, Puerto Rico.

Engineer José R. Rodríguez Perazza, President

Engineer Benigno Despiau, Secretary

TRANSLATED BY JAMES A. LYNCH

THE INSTITUTION OF ENGINEERS CODE OF ETHICS

National Headquarters
11 National Circuit
Barton, Australian Capital Territory
2600 Australia

Founded 1919
Members: 45,000

Code of Ethics

Preamble

The further development of civilization, the conservation and management of natural resources, and the improvement of the standards of living of mankind are greatly affected by the work of the Engineer. For that work to be fully effective it is necessary not only that Engineers strive constantly to widen their knowledge and improve their skill but also that the community be willing to recognize the integrity and trust the judgment of members of the Profession of Engineering.

For this to happen, the Profession must be recognized in the community for

its skill in using technical expertise for the enhancement of human welfare

its loyalty to the community, to employers and clients

its honesty and impartiality in professional practice

Engineers shall so order their lives and work as to merit this trust.

To this end all members of the Institution are required to comply with the Code of Ethics set out hereunder; to give active support to the proper regulation of the qualifications, employment and practice of the Profession; and to promote the development and application of technology in the public interest.

Members acting in accordance with this Code will have the support of the Institution.

CODE

(1) The responsibility of Engineers for the welfare, health and safety of the community shall at all times come before their responsibility to the Profession, to sectional or private interests, or to other Engineers.

(2) Engineers shall act so as to uphold and enhance the honor, integrity and dignity of the Profession.

(3) Engineers shall perform work only in their areas of competence.

(4) Engineers shall build their professional reputation on merit and shall not compete unfairly.

(5) Engineers shall apply their skill and knowledge in the interests of their employer or client for whom they shall act, in professional matters, as faithful agents or trustees.

(6) Engineers shall give evidence, express opinions or make statements in an objective and truthful manner and on the basis of adequate knowledge.

(7) Engineers shall continue their professional development throughout their careers and shall actively assist and encourage Engineers under their direction to advance their knowledge and experience.

INTERPRETATIONS

It has been found in the past that inquiries are often received by the Institution from Engineers seeking guidance on the way in which the Code of Ethics applies in particular situations. The following interpretations are for the guidance and information of individual members as to the Institution's attitudes toward the implementation of this Code.

Clause 1:

The responsibility of Engineers for the welfare, health and safety of the community shall at all times come before their responsibility to the Profession, to sectional or private interests, or to other Engineers.

The principle here is that the interests of the community have priority over the interests of others. It follows that a member:

(a) shall avoid assignments that may create a conflict between the interests of his client or employer and the public interest;

(b) shall work in conformity with acceptable engineering standards and not in such a manner as to jeopardize the public welfare, health or safety;

(c) shall endeavor at all times to maintain engineering services essential to public welfare;

(d) shall in the course of his professional life endeavor to promote the wellbeing of the community. If his judgment is over-ruled in this matter he should inform his client or employer of the possible consequences (and, if appropriate, notify the proper authority of the situation);

(e) shall, if he considers that by so doing he can constructively advance the wellbeing of the community, contribute to public discussion on engineering matters in his area of competence.

Clause 2:

Engineers shall act so as to uphold and enhance the honor, integrity and dignity of the Profession.

The principle here is that the Profession should endeavor by its behavior to merit the highest esteem of the community. It follows therefore that a member:

(a) Shall not involve himself with any business or professional practice which he knows to be of a fraudulent or dishonest nature;

(b) shall not use association with other persons, corporations or partnerships to conceal unethical acts;

(c) shall not continue in partnership with, nor act in professional matters with, any Engineer who has been removed from membership of the Institution because of unprofessional conduct.

Clause 3:

Engineers shall perform work only in their areas of competence.

To this end the Institution has determined that:

(a) a member shall inform his employer or client, and make appropriate recommendations on obtaining further advice, if an assignment requires qualifications and experience outside his field of competence; and

(b) in the practice of Consulting Engineering a member shall not describe himself, nor permit himself to be described, nor act as a Consulting Engineer unless he is a Corporate Member, occupies a position of professional independence, is prepared to design and supervise engineering work or act as an unbiased and independent adviser on engineering matters, and conduct his practice in strict compliance with the conditions approved by the Council of the Institution.

Clause 4:

Engineers shall build their professional reputation on merit and shall not compete unfairly.

The principle here is that Engineers shall not act improperly in a professional sense to gain a benefit. It follows that a member:

(a) shall only approach prospective clients or employers with due regard to his professional independence and to this Code of Ethics;

(b) shall neither pay nor offer directly or indirectly inducements to secure work;

(c) shall promote the principle of selection of consulting engineers by clients upon the basis of merit, and shall not compete with other consulting engineers on the basis of fees alone. It shall not be a breach of the Code of Ethics for a member, upon an inquiry made in that behalf by a client or prospective client, to provide information as to the basis upon which he usually charges fees for particular types of work. Also it shall not be a breach of the Code of Ethics for a member to submit a proposal for the carrying out of work which proposal includes, in addition to a technical proposal and an indication of the resources which the member can provide, information as to the basis upon which fees will be charged or as to the amount of the fees for the work which is proposed to be done. In this respect it is immaterial whether or not the member is aware that other engineers may have been requested to submit proposals, including fee proposals, for the same work;

(d) shall promote the principle of engagement of engineers upon the basis of merit. He shall uphold the principle of adequate and appropriate remuneration for professional engineering staff and shall give due consideration to terms of employment which have the approval of the profession's appropriate association;

(e) shall not attempt to supplant another Engineer, employed or consulting, who has been appointed;

(f) in the practice of Consulting Engineering, shall not undertake professional work on a basis which involves a speculative fee or remuneration which is conditional on implementation of the work. This does not preclude competitions conducted within Australia provided that such competitions are conducted in accordance with conditions approved by the Institution;

(g) shall neither falsify nor misrepresent his or his associate's qualifications, experience and prior responsibility;

(h) shall neither maliciously nor carelessly do anything to injure, directly or indirectly, the reputation, prospects or business of others;

(i) shall not use the advantages of a privileged position to compete unfairly with other Engineers;

(j) shall exercise due restraint in explaining his own work and shall refrain from unfair criticism of the work of another Engineer;

(k) shall give proper credit for professional work to those to whom credit is due and acknowledge the contribution of subordinates and others;

(l) may properly use circumspect advertising (which includes direct approaches to prospective clients by any means) to announce his practice and availability. The medium or other form of communication used and the content of the announcement shall be dignified, becoming to a professional engineer and free from any matter that could bring disrepute to the profession. Information given must be truthful, factual and free from ostentatious or laudatory expressions or implications.

Clause 5:

Engineers shall apply their skill and knowledge in the interests of their employer or client for whom they shall act, in professional matters, as faithful agents or trustees.

It follows that a member:

(a) shall at all times avoid all known or potential conflicts of interest. He should keep his employer or client fully informed on all matters, including financial interests, which could lead to such a conflict, in no circumstance should he participate in any decision which could involve him in conflict of interest;

(b) shall, when acting as administrator of a contract, be impartial as between the parties in the interpretation of the contract. This requirement of impartiality shall not diminish the duty of engineers to apply their skill and knowledge in the interests of the employer or client;

(c) shall not accept compensation, financial or otherwise, from more than one party for services on the same project, unless the circumstances are fully disclosed to, and agreed to, by all interested parties;

(d) shall neither solicit nor accept financial or other valuable considerations, including free engineering designs, from material or equipment suppliers for specifying their products;

(e) shall neither solicit nor accept gratuities, directly or indirectly, from contractors, their agents, or other parties dealing with his client or employer in connection with work for which he is responsible;

(f) shall advise his client or employer when as a result of his studies he believes that a project will not be viable;

(g) shall neither disclose nor use confidential information gained in the course of his employment without express permission.

Clause 6:

Engineers shall give evidence, express opinions or make statements in an objective and truthful manner and on the basis of adequate knowledge.

It follows that:

(a) a member's professional reports, statements or testimony before any tribunal shall be objective and accurate. He shall express an opinion only on the basis of adequate knowledge and technical competence in the area, but this shall not preclude a considered speculation based intuitively on experience and wide relevant knowledge;

(b) a member shall reveal the existence of any interest, pecuniary or otherwise, that could be taken to affect his judgment in a technical matter about which he is making a statement or giving evidence.

Clause 7:

Engineers shall continue their professional development throughout their careers and shall actively assist and encourage those under their direction to advance their knowledge and experience.

The principle here is that Engineers shall strive to widen their knowledge and improve their skill in order to achieve a continuing improvement of the Profession. It follows therefore that a member:

(a) shall encourage his professional employees and subordinates to further their education; and

(b) shall take a positive interest in, and encourage his fellow Engineers actively to support the Institution and other Professional Engineering organizations which further the general interests of the Profession. In this regard the Councils of The Institution of Engineers, Australia. The Association of Professional Engineers, Australia, and The Association of Consulting Engineers, Australia, have jointly advised and recommend to all Professional Engineers in Australia that the interests of the community and of their profession will be best served by full individual membership and active support for each of these respective organizations for which the member is eligible.

NOTES

This code is promulgated in a small blue four-page pamphlet. On the cover it states that the code was "Approved by the Council of The Institution of Engineers, Australia to be effective from 1 August 1981. Adopted by the Association of Consulting Engineers, Australia. Adopted by the Federal Council of the Association of Professional Engineers, Australia."

BANGLADESH

• • •

THE INSTITUTION OF ENGINEERS CODE OF ETHICS

• • •

Ramna, Dhaka-1000
Bangladesh

Founded: 1948
Members: 10,000

Professional Conduct and Code of Ethics

A. Professional Conducts:All Corporate Members as well as Associate Members, Students and Affiliates are required to order their conduct so as to uphold the reputation of the Institution and the dignity of the profession of Engineers and shall observe and be found by the Code of Ethics. Any alleged breach of this Code by a Corporate Member or an Associate Member or a Student or an Affiliate may be brought before the Council, which shall be investigated with the knowledge of the member. If the Council considers the charge proved, action will be taken by suspension from office, expulsion or admonition by a letter or posting his/her name with description of his/her offence.

B. Code of Ethics:

(1) A member's responsibility to his employer and to the profession shall have full regards to the public interest.

(2) A member shall order his conduct so as to uphold the dignity, standing and reputation of the profession.

(3) A member shall discharge his duties to his employer with complete fidelity. He shall not accept remuneration for services rendered other than from his employer or with his employer's permission.

(4) A member shall not maliciously or recklessly injure or attempt to injure, whether directly, or indirectly, the professional reputation, prospects, or business of another member.

(5) A member shall not improperly canvass or solicit professional employment nor offer to make by way of commission or otherwise payment for the introduction of such employment.

(6) A member shall not, in a self-laudatory language or in any manner derogatory to the dignity of the profession, or professional bodies, advertise or write articles for publication, nor shall he authorize such advertisements to be written or published by any other person.

(7) A member, without disclosing the fact to his employer in writing, shall not be a director of nor have a substantial financial interest in, nor be an agent for any company, firm or person carrying on any contracting, consulting or manufacturing business which is or may be involved in the work to which his employment relates, nor shall he receive directly or indirectly any royalty, gratuity or commission on any article or process used in or for the purposes of the work in respect of which he is employed unless or until such royalty, gratuity or commission has been authorized in writing by his employer.

(8) A member shall not use the advantages of a salaried position to compete unfairly with other engineers.

(9) A member in connection with work in a country other than his own shall order his conduct according to these Rules, so far as they are applicable, but where there are recognized standards of professional conduct, he shall adhere to them.

(10) A member who shall be convicted by a competent tribunal of a criminal offence which in the opinion of the Disciplinary Body renders him unfit to be a member shall be deemed to have been guilty of improper conduct.

(11) A member shall not, directly or indirectly, attempt to supplant another member, nor shall he intervene or attempt to intervene in or in connection with engineering work of any kind to which his knowledge has already been entrusted to another member.

(12) A member shall not be the medium of payments made on his employer's behalf unless so requested by his employer, nor shall he in connection with work on which he is employed place contracts or orders except with the authority of and on behalf of his employer.

(13) A member shall not knowingly compete on the basis of Professional charges with another member.

NOTES

Although the Institution of Engineers, Bangladesh, dates its founding from 1948, the country of Bangladesh did not come into existence until 1971 when East Pakistan declared its independence of West Pakistan. See also the notes for Institution of Engineers, Pakistan.

CANADA

CANADIAN COUNCIL OF PROFESSIONAL ENGINEERS CODE OF ETHICS

Suite 401, 116 Albert Street
Ottawa, Ontario
Canada K1P 5G3

Founded: 1936
Members: 12 consultant associations representing over 137,000 professional engineers

CODE OF ETHICS

Preamble

Provincial and territorial associations of Professional Engineers are responsible for the regulation of the practice of engineering in Canada. Each association has been established under a Professional Engineering Act of its provincial or territorial legislature and serves as the licensing authority for engineers practicing within its jurisdiction. The Canadian Council of Professional Engineers (CCPE) is the national federation of these associations. CCPE provides a coordinating function among the provincial and territorial associations, fostering mutual recognition among them and encouraging the greatest possible commonality of operation in their licensing functions.

CCPE issues national guidelines on various subjects as a means to achieve coordination among its constituent member associations. Such guidelines are an expression of general guiding principles which have a broad basis of consensus, while recognizing and supporting the autonomy of each constituent association to administer the Professional Engineering Act within its jurisdiction. CCPE guidelines enunciate the principles of an issue but leave the detailed applications, policies, practices and exceptions to the judgment of the constituent associations.

CODE OF ETHICS

Professional engineers shall conduct themselves in an honorable and ethical manner. Professional engineers shall uphold the values of truth, honesty and trustworthiness and safeguard human life and welfare and the environment. In keeping with these basic tenets, professional engineers shall:

(1) hold paramount the safety, health and welfare of the public and the protection of the environment and promote health and safety within the workplace;

(2) offer services, advise on or undertake engineering assignments only in areas of their competence and practice in a careful and diligent manner;

(3) act as faithful agents of their clients or employers, maintain confidentiality and avoid conflicts of interest;

(4) keep themselves informed in order to maintain their competence, strive to advance the body of knowledge within which they practice and provide opportunities for the professional development of their subordinates;

(5) conduct themselves with fairness, courtesy and good faith towards clients, colleagues and others, give credit where it is due and accept, as well as give, honest and fair professional criticism;

(6) present clearly to employers and clients the possible consequences if engineering decisions or judgments are overruled or disregarded;

(7) report to their association or other appropriate agencies any illegal or unethical engineering decisions or practices by engineers or others; and

(8) be aware of and ensure that clients and employers are made aware of societal and environmental consequences of actions or projects and endeavor to interpret engineering issues to the public in an objective and truthful manner.

NOTES

This code, adopted November 1991, is the outcome of a workshop on professional issues held in November 1989.

ASSOCIATION OF PROFESSIONAL ENGINEERS OF ONTARIO CODE OF ETHICS

• • •

1155 Yonge Street
Toronto, Ontario
Canada M4T 2Y5

Founded: 1922
Members: 61,000

(1) In this section, "negligence" means an act or an omission in the carrying out of the work of a practitioner that constitutes a failure to maintain the standards that a reasonable and prudent practitioner would maintain in the circumstances.

(2) For the purposes of the Act and this Regulation, "professional misconduct" means

(a) negligence;

(b) failure to make reasonable provision for the safeguarding of life, health or property of a person who may be affected by the work for which the practitioner is responsible;

(c) failure to act to correct or report a situation that the practitioner believes may endanger the safety or the welfare of the public;

(d) failure to make responsible provision for complying with applicable statutes, regulations, standards, codes, by-laws and rules in connection with work being undertaken by or under the responsibility of the practitioner;

(e) signing or sealing a final drawing, specification, plan, report or other document not actually prepared or checked by the practitioner;

(f) failure of a practitioner to present clearly to his employer the consequences to be expected from a deviation proposed in work, if the professional engineering judgment of the practitioner is overruled by non-technical authority in cases where the practitioner is responsible for the technical adequacy of professional engineering work;

(g) breach of the act or regulations, other than an action that is solely a breach of the code of ethics;

(h) undertaking work the practitioner is not competent to perform by virtue of his training and experience;

(i) failure to make prompt, voluntary and complete disclosure of an interest, direct or indirect that might in any way be, or be construed as, prejudicial to the professional judgment of the practitioner in rendering service to the public, to an employer or to a client, and in particular without limiting the generality of the foregoing, carrying out any of the following acts without making such a prior disclosure:

1. Accepting compensation in any form for a particular service from more than one party.
2. Submitting a tender or acting as a contractor in respect of work upon which the practitioner may be performing as a professional engineer.
3. Participating in the supply of material or equipment to be used by the employer or client of the practitioner.
4. Contracting in the practitioner's own right to perform professional engineering services for other than the practitioner's employer.
5. Expressing opinions or making statements concerning matters within the practice of professional engineering of public interest where the opinions or statements are inspired or paid for by other interests;

(j) conduct or an act relevant to the practice of professional engineering that, having regard to all the circumstances would reasonably be regarded by the engineering profession as disgraceful, dishonorable or unprofessional;

(k) failure by a practitioner to abide by the terms, conditions or limitations of the practitioner's license, limited license, temporary license or certificate;

(l) failure to supply documents or information requested by an investigator acting under section 34 of the Act;

(m) permitting, counseling or assisting a person who is not a practitioner to engage in the practice or professional engineering except as provided for in the Act or the regulations.

CODE OF ETHICS

• • •

The following is the Code of Ethics of the Association:

1. It is the duty of a practitioner to the public, to his employer, to his clients, to other members of his profession, and to himself to act at all times with,

i. fairness and loyalty to his associates, employers, clients, subordinates and employees.

ii. fidelity to public needs, and

iii. devotion to high ideals of personal honor and professional integrity.

2. A practitioner shall,

i. regard his duty to public welfare as paramount,

ii. endeavor at all times to enhance the public regard for his profession by extending the public knowledge thereof and discouraging untrue, unfair or exaggerated statements with respect to professional engineering,

iii. not express publicly, or while he is serving as a witness before a court, commission or other tribunal, opinions on professional engineering matters that are not founded on adequate knowledge and honest conviction,

iv. endeavor to keep his license, temporary license, limited license or certificate of authorization, as the case may be, permanently displayed in his place of business.

3. A practitioner shall act in professional engineering matters for each employer as a faithful agent or trustee and shall regard as confidential information obtained by him as to the business affairs, technical methods or processes of an employer and avoid or disclose a conflict of interest that might influence his actions or judgment.

4. A practitioner must disclose immediately to his client any interest, direct or indirect, that might be construed as prejudicial in any way to the professional judgment of the practitioner in rendering service to the client.

5. A practitioner who is an employee-engineer and is contracting in his own name to perform professional engineering work for other than his employer, must provide his client with a written statement of the nature of his status as an employee and the attendant limitations on his services to the client, must satisfy himself that the work will not conflict with his duty to his employer, and must inform his employer of the work.

6. A practitioner must cooperate in working with other professionals engaged on a project.

7. A practitioner shall,

i. conduct himself towards other practitioners with courtesy and good faith,

ii. not accept an engagement to review the work of another practitioner for the same employer except with the knowledge of the other practitioner or except where the connection of the other practitioner with the work has been terminated,

iii. not maliciously injure the reputation or business of another practitioner,

iv. not attempt to gain an advantage over the other practitioners by paying or accepting a commission in securing professional engineering work, and

v. give proper credit for engineering work, uphold the principle of adequate compensation for engineering work, provide opportunity for professional development and advancement of his associates and subordinates, and extend the effectiveness of the profession through the interchange of engineering information and experience.

8. A practitioner shall maintain the honor and integrity of his profession and without fear or favor expose before the proper tribunals unprofessional, dishonest or unethical conduct by any other practitioner.

NOTES

These two sections 86 and 91 are from Ontario Regulation 538/84 made under the Professional Engineers Act, 1984.

CANADIAN INFORMATION PROCESSING SOCIETY (CIPS) CODE OF ETHICS

• • •

430 King Street West, Suite 205
Toronto, Ontario
Canada M5V 1L5

Founded: 1958
Members: 6,000

CODE OF ETHICS AND STANDARDS OF CONDUCT

• • •

Foreword

The field of information processing has a large impact on society. In turn society has the right to demand that practitioners in this field act in a manner which recognizes their responsibilities toward society, to demand that the practitioners are of the highest caliber, and to demand that a mechanism exist to protect society from those practitioners who do not, or can not, live up to these responsibilities. The standards contained in this document, and our agreement to adhere to these standards, is the response of the Canadian Information Processing Society to these rightful demands.

Introduction

This document describes the code of Ethics and Standards of Conduct of the members of the Canadian Information Processing Society, with respect to their professional activities. It should not be construed to deny the existence of other ethical or legal obligations equally imperative, although not specifically mentioned.

First, the general standards and high ideals of the members of CIPS are described in the form of a Code of Ethics. Second, specific rules, the Standards of Conduct, elaborate each element of the Code in a manner which assists determination of whether or not specific activities of an individual violate the Code. They are intended to establish a minimum acceptable level of conduct, below which an individual may be said to be unethical. Third, there is a procedure which details the steps the society will follow in determining whether or not a violation of the rules has occurred, what disciplinary action is possible, and under what circumstances information will be released.

In total, this document describes the professional behavior that members of CIPS demand of themselves and their peers. All members agree to live up to these standards when the join the Society, and reaffirm this commitment each time they renew their membership.

The Code of Ethics and Standards of Conduct deal with matters that are subject to judgment and are difficult to state absolutely. They contain words such as "authority," "competence," and "faithful" which must be judged in light of the professional and moral standards in effect at a given time and place. The enforcement procedures require peers to interpret the areas requiring judgment at the specific time of the complaint using the guidelines contained in this document.

Code of Ethics

The following statements are agreed to by all members of CIPS as a condition of membership.

I acknowledge that my position as an information processing professional carries with it certain important obligations, and I will take diligent personal responsibility for their discharge.

P) To the public: I will endeavor to protect the public interest and strive to promote understanding of information processing and its application, but will not represent myself as an authority on topics in which I lack competence.

M) To myself and my profession: I will guard my competence and effectiveness as a valuable possession, and work at maintaining them despite changing circumstances and requirements. Furthermore, I will maintain high personal standards of moral responsibility, character, and integrity when acting in my professional capacity.

F) To my colleagues: I will treat my colleagues with integrity and respect, and hold their right to success to be as important as my own. I will contribute to the professional knowledge of information processing to the best of my ability.

E) To my employer and management: I will give faithful service to further my employer's legitimate best interests through management's direction.

C) To my clients: I will give frank and careful counsel on matters within my competence, and guard my client's confidential information and private matters absolutely. In my capacity of provider of product or serve, I will provide good value for my compensation, and will endeavor to protect the user of my product or service against consequential loss or harm.

S) To my students: I will provide scholarly education to my students in a sympathetic and helpful manner.

STANDARDS OF CONDUCT

• • •

The Code of Ethics is a set of ideals to which CIPS members aspire. The Standards of Conduct is intended to be more practicably enforceable.

The following statements are agreed to by all members of CIPS as a condition of membership.

Due to my obligation to the public:

P1) I will not unreasonably withhold information pertinent to a public issue relating to computing.

P2) I will not disseminate, nor allow to go unchallenged, false or misleading information that I believe may have significant consequence.

P3) I will not offer information or advice that I know to be false or misleading, of whose accuracy is beyond my competence to judge.

P4) I will not seek to acquire, through my position or special knowledge, for my own or other's use, information that is not rightly mine to possess.

P5) I will obey the laws of the country, and will not counsel, aid, or assist any person to act in any way contrary to these laws.

P6) I will endeavor to enhance public understanding of information processing, particularly its current capabilities and limitations, and the role of the computer as tool, not an authority.

Due to my obligation to myself and my profession:

M1) I will not knowingly allow my competence to fall short of that necessary for reasonable execution of my duties.

M2) I will conduct my professional affairs in such a manner as to cause no harm to the stature of the profession.

M3) I will take appropriate action on reasonably certain knowledge of unethical conduct on the part of a colleague.

Due to my obligation to my colleagues:

F1) I will not unreasonably withhold information pertinent to my work or profession.

F2) I will give full acknowledgement to the work of others.

Due to my obligation to my employer and to my management:

E1) I will accept responsibility for my work, and for informing others with a right and need to know of pertinent parts of my work.

E2) I will not accept work that I do not feel competent to perform to a reasonable level of management satisfaction.

E3) I will guard the legitimate confidentiality of my employer's private information.

E4) I will respect and guard my employer's (and his supplier's) proprietary interest, particularly with regards to data and software.

E5) I will respect the commercial aspect of my obligation to my employer.

Due to my obligation to my clients:

C1) I will be careful to ensure that proper expertise and current professional knowledge is made available.

C2) I will avoid conflicts of interest and give notice of potential conflicts of interest.

C3) I acknowledge that statements E1 to E5, cast in the employee/employer context, are also applicable in the consultant/client context.

Due to my obligation to my students:

S1) I will maintain my knowledge of information processing in those areas that I teach to a level exceeding curriculum requirements.

S2) I will treat my students respectfully as junior scholars, worthy of significant effort on my part.

Enforcement Procedures

It is essential that the Code of Ethics and Standards of Conduct be supported with clear, orderly, and reasonable enforcement procedures if the Society is to be able to discipline members who violate the Standards of Conduct. The enforcement procedures must be equitable to all parties, and must ensure that no actions are taken in an arbitrary or malicious manner. The following Enforcement Procedures have been designed with these points in mind.

The Complaint

The complaint must:

— be against a single individual, and

— be in writing, and

— cite the specific clause of the Standards of Conduct that is alleged to have been violated, and

— describe the specific action in question, and

— describe, in general terms, the substantial negative effect of that action upon the profession, the Society, a business, or an individual, and

— contain a statement that the specific action of the accused in question is or is not already or imminently [to the best knowledge of the complainant(s)] the subject of legal proceedings, and

— contain a signed statement that the facts are true to the best knowledge of the complainant(s).

This complaint must be sent to the National President of CIPS. The National President, or his delegate, will review the complaint to determine if it meets the above criteria. If it doesn't, it will be returned to the complainant(s) for possible change and re-submission. If the specific action of the accused is (imminently) the subject of legal proceedings, no further action will be taken unto those proceedings are concluded. If the complaint is not rejected then, subject to legal advice, the accused member will be notified (by Registered Mail to last known address), provided with a copy of the complaint, and allowed 30 days to prepare a written rebuttal of the complaint if so desired. The President of the Section the accused belongs to will be notified. The rebuttal should address the same points as the complaint, and must also include a statement that the facts contained in the rebuttal are true to the best knowledge of the accused.

The National President of CIPS or his delegate shall review the complaint and, if available, the rebuttal, to determine if there is sufficient evidence to hold a full hearing. If it is determined that a full hearing is warranted, the full information will be forwarded to a three member Hearing Committee appointed within 30 days of the receipt of the rebuttal or of the last date allowed for receipt of the rebuttal.

The Hearing Process

The Hearing Committee shall adhere to the following procedure:

— The Hearing Committee will attempt to interview, at the expense of CIPS, the complainant(s), and the accused, plus any other parties with relevant information. The number of people interviewed, and the extent of the effort to secure interviews, is a matter of judgment by the Hearing Committee. The Hearing Committee will decide if the accused may be present during the interviews. If the accused is not allowed to be present during the interviews, the accused shall be provided with notes documenting the substance of the interviews.

— The accused will be afforded the opportunity for a full hearing, with the complainant present if desired by the accused.

— The Hearing Committee shall have the services of legal counsel available as required. The accused, and the complainant, may obtain counsel, at their own expense, if either or both so desire.

— The Hearing Committee, after full and complete deliberation, will rule in writing as to the individual case.

Additional rules and procedures shall be established by the Hearing Committee as required in their judgment.

The Hearing Committee ruling may be:

1) a clearing of charges, or
2) a warning statement to the accused, or
3) suspension of national and local membership for a specified period of time, or
4) revocation of the current membership of the accused in the Society, and a statement of the accused's eligibility for other grades of membership.
5) Such other ruling as the Hearing Committee in its discretion sees fit (e.g.: change letterhead, business cards to delete reference to being a member of CIPS).

The Hearing Committee will prepare an opinion on the particular case that will cover the facts of the case, the action taken, and the reason for that action. This will be reviewed by the Executive Committee of the National Board of CIPS and by legal counsel at the discretion of the Executive Committee. When approved, this opinion will be sent to the accused, who may consider exercising the Appeal Process.

Due diligence should be used to provide this opinion to the accused within 120 days of the receipt of the complaint by the Hearing Committee. If this is not possible, a letter should be sent to the National President of CIPS, with copies to the accused and complainant(s), requesting an extension of this limit, and stating the reason for this request.

The Appeal Process

If not satisfied with the ruling of the Hearing Committee, the accused may appeal to the Executive Committee of the National Board of CIPS within 30 days of issuance of the Hearing Committee opinion. If appealed, the following procedure will be used.

— The Executive Committee, at its next scheduled meeting, or at a special session, shall review the opinion, and any other information available, and shall determine if:

1) a substantive procedural error has been committed by the Hearing Committee, or
2) substantial new evidence has been produced.

— The accused and the complainant are permitted legal counsel at the Executive Committee appeal session.

— The Executive Committee shall determine if, in its sole judgment, one of the two above noted criteria have been established, in which case the council shall refer the matter back to the previous or a new Hearing Committee for further proceedings.

— The decision of the Executive Committee shall be final: there shall be no further appeal.

Publication and Record Retention

After the Appeal Process and any further proceedings have been exhausted, or after completion of the time allowed to initiate an Appeal Process, the Opinion will be published in the appropriate CIPS publication if the ruling was a suspension or revocation of membership, and will be published at the request of the accused, if the ruling was a clearing of charges or issuing of warning statement.

The record of the Hearing Committee and all appropriate supporting documentation will be retained by National for five years. Response to queries may include statistical information that does not reveal detail about a specific complaint, such as the number of complaints processed, provided the approval of the Executive Committee is obtained, or responses may include copies of information previously published.

Any other information may be released only with the written permission of the Executive Committee, the accused, and the accuser(s).

NOTES

Dated January 1985.Published and promulgated on a two-sided letter-sized sheet.

CHILE

• • •

ASSOCIATION OF ENGINEERS OF CHILE CODE OF ETHICS

• • •

Avenida Santa María 1508
Casilla 13745
Santiago, Chile

Founded: 1958
Members: 18,000

Code of Professional Ethics of the Engineers of the Association of Engineers of Chile

Title I. On General Norms

1ST ARTICLE. The Code of Professional Ethics establishes the responsibilities and regulates the rights and obligations as well as the conduct of engineers.

2ND ARTICLE. It is the imperative obligation of the engineer to maintain a level of professional conduct raised to the highest moral level in defense of the prestige and prerogatives of his profession.

The norms of this Code apply to all engineering activities and professional specialization does not liberate from them.

The engineer enrolled in the Association of Engineers ought to accept, to know, and faithfully to fulfill this Code of Ethics.

Title II. On the Exercise of the Profession

3RD ARTICLE. Engineers are obligated to respect in their professional action, the dispositions of Law 12.851, the Professional Fee Schedule, and the dispositions of the present Code, and also, the agreements of the General Counsel and the appropriate Provincial Counsel.

4TH ARTICLE. Acts contrary to Professional Ethics are the following:

a) To act contrary to the decorum and prestige of the profession, contrary to the discipline of the Institution or contrary to the respect and solidarity that ought to be preserved among the members themselves.

b) To promote or to collaborate in the promulgation of laws or other norms of a legal character, resolutions, judgments or measures that infringe the rights of the engineering profession, of the Association of Engineers, or of one or more colleagues.

c) To concur with deliberate omissions that produce some of the effects indicated in the preceding letter.

d) To permit actions or omissions that favor or permit the unnecessary use of foreign engineering for objectives and work for which Chilean engineering is sufficient and adequate.

e) Engineers are obligated to denounce to the Association all persons who exercise engineering functions without the legal capacity for it, as well as to denounce all acts that indicate transgression of the norms of the Code.

f) To sign off on studies, projects, plans, specifications, reports, judgments or authorizations that have not been personally executed, studied or reviewed and to falsify consultations, the performance of jobs or the work of an organization, society or institution of any nature, in that which by law requires engagement of an association engineer.

g) To give or to receive commissions or other noncontractual benefits through managing, keeping, or granting appointments of any kind.

h) To participate directly or indirectly in the granting of professional titles that infringe or harm the prestige and professional quality of the engineer, of conformity with the principles of technology, of Engineering, laws or regulations in force.

i) To undertake some professional work, be it individually, associated with other colleagues or third parties, or as a member of a legal or def facto association, in return for the payment of a fee less than the minimum established by the Professional Fee Schedule, and to agree or to pay other colleagues, fees less than the minimum established in the Schedule of the Association.

j) To make use of or to utilize studies, projects, plans, reports or other documents related to engineering without the authorization of their authors or owners.

Title III. Relations with Colleagues and Other Professionals

5TH ARTICLE. Acts between engineers and other professionals considered contrary to professional ethics:

a) To publicize opinions that harm the prestige of a colleague.

b) To replace or try to replace a colleague, without his prior consent, in the rendering of previously engaged professional services.

c) To take undue advantage of performing a job to obtain particular clients.

d) To promote one's own appointment to a public or particular job that a colleague exercises, when this person has not manifested an intention to give it up.

e) In the formulation of proposals, public as well as private, the engineer is prohibited: to give or to solicit any information prior to the request for proposal, which would seem to leave the proposer in a favored situation with respect to others; to try to obtain a favorable decision for oneself, or for a third party, by discrediting other bidders on the proposal; or to find out about or to decide a proposal, outside established procedures on the principles or regulations that regulate such decision making.

Title IV. Relations with Directors and Clients

6TH ARTICLE. Acts considered contrary to professional ethics between engineers, directors or employers, are the following:

a) As an employee, functionary or executive of a business or organization, to accept for personal gain commissions, rebates, discounts or other benefits provided, from contractors or from persons interested in the sale of materials, equipment or services, or in the performance of work that has been entrusted to you.

b) To reveal proprietary data of a technical, financial, or personal character concerning interests confidential to your study or case.

c) To act with partiality in discharging the function of specialist, or arbiter, or to one who interpreters or awards contracts, grants, or jobs.

d) To divulge without proper authorization procedures, processes, or characteristics of equipment, that are protected by patents or contracts that establish the obligation to protect professional secrets.

TRANSLATED BY CARL MITCHAM

NOTES

This code is published and promulgated in a small pamphlet entitled *Estatutos y Códigos de Etica Profesional del Colegio de Ingenieros de Chile* A.G. [Statutes and codes of professional ethics of the Association of Engineers of Chile, Inc.] (Santiago, Chile: Colegio de Ingenieros de Chile A.G., n.d.). The pamphlet contains twenty unnumbered pages.

The first section of the pamphlet contains the statutes or by-laws of the Association (10 pages) followed by an official letter of recognition (dated 16 July 1981) from the Assistant Secretary of Economics, Development, and Reconstruction.

The second section contains the code of professional ethics of the Association of Engineers (Law 12.851—2 pages, translated here) along with a printing of the Code of Professional Ethics of the Pan American Union of Associations of Engineers (2 pages).

CHINA, PEOPLE'S REPUBLIC OF

CHINESE MECHANICAL ENGINEERING SOCIETY CODE OF ETHICS

Chapter 1. General Rules and Information

1. The Chinese Mechanical Engineering Society is a national mechanical scientists and technicians organization. It is part of the Chinese Science and Technology Society.

2. The Society is located in Peiking.
3. Our Society encourages dialectic materialism. Our goal is to unite the majority of mechanical technicians to promote mechanical industry, advance technological service, accelerate new technological research, produce more scientists, and speed up national modernization.
4. The duty of our Society is:

4.1 To open technology exchange, organize research and technical investigations and encourage the exploration and application of mechanical technology.

4.2 To offer scientific research such as proofing (theory, design), criticism and comments on equipment (machine and tools), information, etc., and to accept corporations, companies, and agencies' entrust, and to offer technology information service.

4.3 To expand technical training: offer higher education for professional technicians in order to raise the majority of technicians' knowledge levels and practice abilities.

4.4 To spread science and advance technology and science management.

4.5 To open a worldwide technology exchange and develop a good relationship with foreign technology organizations.

4.6 To control technology information: edit and publish scientific magazines and collect reports and technical documents.

4.7 To honor the scientists and technical reporters who contribute to society.

4.8 To deal with the activities and services for economical construction, and increase the majority of scientists', technical benefits and activities.

4.9 To protect the technician's right to express suggestions, ideas, and criticisms.

Chapter 2. Membership

5. Individual membership: anyone who recognizes our regulations, meets the following standards, and obtains our society's permission will become a member of our society. The individual also must:

5.1 Have been educated at a level equal to or above that of engineer, technician, professor, assistant professor, or other technical position.

5.2 Be a scientist or technician with an education level above a master's degree.

5.3 Be a college graduate with a mechanical major who has worked with related material for at least 3 years, has a certain technical knowledge level, and has the ability to work individually. However, if one does not have a college degree, an exception may be made if the individual has had many years worth of work experience which equals or surpasses our standard knowledge level.

5.4 Be a technician with extraordinary distribution.

5.5 Earnestly support the society, the chairman, the director, the manager who works with the mechanic technical organization, and the management.

6. The process for an individual to join the society is as follows: Send in the application, be introduced by other current members, and have recommendations from the company or from another technical society. After being approved, the individual will transport to our society and become a member. The individual will then be classified into whichever expert organization fits his/her work level.
7. Organizations as members: any organization, corporation or research center which earnestly support our society, and has employees who are experts in our field or related fields, can be accepted as a member.
8. Preparatory members and student members: Preparatory members: any mechanical science, technical, or managerial officers who are under 35 years of age and are college graduates or technology school graduates may commence work for a period. They may send in the application to our society, and after approval will become a member immediately.

   Student members are required to have: had a mechanical major in college, received good grades junior and senior years, graduated from college, the ability to transform from student membership to preparing membership.
9. Foreign membership:

   Any foreign mechanics and science technicians who are friendly to our country and want to communicate, exchange information, and participate, must send in our application, go through two members introductions or have a recommendation letter from a division of our society. The individual may also have membership in his/her own country's Mechanical Engineering Society which has participated with our society. After our approval, the individual may become a member immediately.

10. Our society may accept any well-known and respectable mechanical science technician, specialist, or scientist with great scientific accomplishment into our society.
11. The member must adhere to the rights and duties of the individual in his local technical organization.
    11.1 Members have the right to vote, and to be voted on.
    11.2 Members have the right to criticize and suggest new ideas to our society.
    11.3 Members have the right to join related technical activities.
    11.4 Members have the priority to obtain any related technical information date.
    11.5 Members must obey our society's regulation.
    11.6 Members must perform, follow and support our society's decisions and entrusted work.
    11.7 Members may join the society's different types of activities.
    11.8 Members must pay the membership fee according to regulations.
12. The Foreign Member's right and duty: The foreign member:
    12.1 May be invited to join our society and attend a science technology conference meeting, or other international technical activity, and have the meeting's registration fee reduced.
    12.2 Has the right to obtain our society's related technical information.
    12.3 Has the private right to publish and submit reports/articles in our society's magazine.
    12.4 May obtain the help of the society with the arrangement of technical visits.
    12.5 Must support our society's goals and accept the duties entrusted to him/her by our society.
    12.6 Must pay the membership fee according to the regulation.
13. Membership Card: You must get permission from the state engineering society to have a membership card. From this society, you can get Chinese Technical Engineer Prepared Membership card. The student membership card is issued by an organization member.
14. Individual and organization members have to pay annual membership fees. The payment methods and fee amounts are determined by negotiations between the society and local branches. If a member (including foreign members) does not pay the membership fee in the current year, he will be revoked of his membership rights. After failing to pay for two years the membership is automatically cancelled. Once the fee is paid we will reissue the membership card back to you.
15. Members have the right to withdraw from the society if leaving the university will cancel the student membership.

    Prepared members over the age of 35 years will also have their membership cancelled.
16. Any one who loses his/her political rights will naturally lose membership.
17. If a member's work address changes, s/he should connect with the local branch of the society.

Chapter 3. National Congress

18. The society's highest leading organization is national congress. Its jobs are:
    18.1 Checking and grading national council's work report.
    18.2 Deciding the next goal and plan of the society.
    18.3 Vote and select next direction of the council.
    18.4 Comment, check and discuss the society's regulations honoring the Scientists and societal members who have contributed to technological development.
19. National Congress is called by the national council.
20. National Representation Conference representatives are selected by National Council members and the experts in the society (people who work in the specific field).

Chapter 4. National Council

21. The National council is the leading organization after the National Congress. Its duties are:
    21.1 Execute nation congress's decision.
    21.2 Document a working report and record long term plans and work goals.
    21.3 Correct and review the society's regulations.
    21.4 Arrange the next date for the National Representative Conference.
22. The current national council members have been elected by previous council members and experts democratically; "absorb" new elected "members" and several national (or foreign) famous scientist,

expert. Then, through national representative conference's voting, produce new council members.

The total number of national council is around one hundred. They should have experience with technological research and science management. Have good moral standard, anxiously working, have good health, which can join the society's real practice wok. Any member can not been council member for over two terms.During the term, if council member can work due to accident or any other reason, after the board of national council's credential, the council member can be replaced.

23. Nation council select (vote) a director of the council, vice director, and a secretary. Board of national council. The director of the council can only work one term, then he will be one of the next term's board of national council.

24. The duty of the board of national council:

  24.1 Execute all jobs, work which given by national council.

  24.2 Make working plan and goal.

  24.3 Comment committees' working report.

  24.4 Hire people who are going work for the committee.

  24.5 Agreed, forbidden contract and negation.

  24.6 The board national council have conference every year.

25. According to the request of national council, setting several committee. Committee member works under national council's leading.

26. The national managing directors have the secretary department, the senior secretary will response for all regular works. All these senior secretary are given by the mechanical industry department.

Chapter 6. Society of Special Fields

27. We will set few major departments. These departments are responses in science study activity, engineer study or technical study activity. The national managing directors will decide how to set plan, how to regulate it and how to cancel it if it is needed.

28. The managing directors is a leader department its duty is:

  28.1 Perform the duty which is given by the national managing directors.

  28.2 Set the rule or major study activities and economic budget.

  28.3 Response in organization of different study activities.

  28.4 Give people some career advice thought state study society and city studysociety.

  28.5 Support the worker in this study society.

  28.6 The meeting of the board of directors of major study will has once a year.

29. Members in the board of directors of major study have to have the good health, and the honor technical degree. These members are introduced or elected by local departments. The board of directors should have no more than fifty people, and are elected every 4 years.

30. The board of directors has one president, three vise president, few secretaries and others. They will start their duty after the meeting of the meeting of the board of directors.

The president can not perform over one term.

31. The board of directors has two main parts: regular department (includes the secretary department, the accenting department and others beside research department) and the research department.

32. If it is necessary, the board of directors could be changed to few small boards. The small board of directors will be easy to manage and regulate.

33. The representative conference is the highest organization in state, city and local area. Any meeting, production and activity must follow the local rule.

34. According to research activity, we can set some direct and indirect relate departments to help our major study activity.

35. The duty of technical engineer study society is given by state, city or local department.

36. State, city or local department also advice the technical engineer study society to perform the job well.

Chapter 8. Relationship with Leader

37. This study society is lead by Chinese national science and mechanical systems.

Chapter 9. Fee

38. Our income comes from:

  38.1 The contribution of other co-level science research department (or companies).

  38.2 The mechanical industrial system and relate or dependent department.

  38.3 The income comes from the case research and activities.

38.4 The membership fee.

38.5 The national system, foreign system or personal contribution.

RETIRED ENGINEERS ASSOCIATION OF THE NANKING CHEMICAL-INDUSTRIAL CORPORATION CODE OF ETHICS

• • •

First Chapter: General Whole Principle

1. This Association is named "The Retired Engineers Association of The Nanking Chemical-Industrial Corporation." We simple call it "The Retired Association of Nanking Chemical."
2. "The Retired Association of Nanking Chemical" is a system which is consisted by retired engineers (include high technical workers) and under the leading of the communism party. This system will help the Corporation's development. It is a part of The Engineers Association of The Nanking Chemical-Industrial Corporation. Their action will open and develop the technology the technology. Making greater progress; take one more step forward.
3. The principle of this association is to combine and organize all retired engineers. Just as "The Older have some thing to feet; to learn and to practice". According to company's need, to do some Technical help and service.

Chapter 2: Duty

4. Must follow the policy that "Economic growth will dependent on the develop of technology. Technical work must face to economic growth." Manifest the point of "blooming in profusion; using all resources;" execute the democratize in this association. To have a good quality service.

5.1 Face to economical construction, explicate these retired engineers technical knowledge. Supply some suggestions to decisions of different departments improvement. To become a good helper.

5.2 For the company's business, They need to help this company to develop their own technology and learn some new knowledge from the advance countries.

5.3 For science developing, and helping those young engineers, We should offer some classes which can help younger to learn more experience.

5.5 Combine all strains; collect and exchange the sciences information; At some time, should learn English and translate them to Chinese (for us to learn to use).

5.6 Friendly to neighbor companies and related companies. This can help us to learn technology or exchange technology with them.

5.7 Tells the company what ideas do they suggest and what do they want. Study policy, technology, visit and help new members are very necessary.

5.8 Respect the older engineers emotion; respect their life, their health. Set up friendship.

CHAPTER 3: MEMBERSHIP

• • •

6. If you are a junior engineer or above, with a good health and must under 70 year old. And if you agree our associate principle you can fill a application form. Then we will give you a membership card after we discuss your case. For reach a good quality service, we will invite some special technical retired engineers to join with us.
7. The power of member:

7.1 Right for election; Right to be elected; Right to be cancelled.

7.2 Have the right to hear or get the new information and resources.

7.3 Have right to give the suggestion, to criticize the incorrect decision which made by association.

7.4 Have right to join the science, technical research; right to get pay.

7.5 Have right to though this association to tell self-request or other members request.

8. Responsibility of members.

8.1 Respect the principle of association, and execute the decision of association.

8.2 Join the active of association; hand the job that other associative ask for.

8.3 Keep professional morality. Maintain and protect the prefect and reputation. Never be allowed to damage the reputation of our association.

8.4 For some secret science information with a mark "Secret", no one be allowed to divulge a secret.

8.5 Must pay the membership fee on time.

9. Member has right to drop-out the membership. Member can fill out a application for drop-out. He (she) should return his (her) membership card after the association's agreement.
10. If member with no reason, and never perform any member's obligation in one year. He (she) will be cancelled from the membership and be requested to return membership card.
11. Any member who damage the principle of association, violate the benefit and reputation of our association, and also doesn't listen to advise, membership will be cancelled, or be punished.
12. Any member who performed illegal activity and be punished or get in jail, will be cancelled from membership.
13. Any decision of cancelling membership will notice to all members. This is the reference for some department in the future.

CHAPTER 4

• • •

14. Membership meeting is the most powerful in the association. This meeting has one in two years. Date of meeting can be changed if it is necessary.
15. Duty and responsibility of membership meeting:
    - 15.1 Decide the main working principle and duty.
    - 15.2 Listen and exam the working report and economic report of a aboard directors.
    - 15.3 Fix and declare the principle of association.
    - 15.4 Select the new director of board.
16. The board of directors will selected by members. The chairman of the board of directors will selected by the boards of director. The board of directors includes one chairman, one secretary and few wise-chairmen.
17. The chairman of board of directors has right to control the board and has right to use one wise-chairman work with him.
18. We will invest some consul for performing advises.
19. Set two people work in secretary apartment everyday. We will add more departments if we need.

CHAPTER 5

• • •

20. Our active fee from:
    - 20.1 National or some related departments' help
    - 20.2 Income of science resources and technology services
    - 20.3 Membership fee
    - 20.4 Receive subscribe money from corporation or personal.
    - 20.5 Other current income.
21. Active fee will use for:
    - 21.1 Perform the duty and develop activity
    - 21.2 For engineers' additional perform payment.
    - 21.3 Some request office supply expense.
    - 21.4 Expense of some professional (senior) engineers training younger and performing technical service.
    - 21.5 Other expenses.
22. Must set up a strong business rule and oversee the rule. The money will be controlled by the board of directors. Any one who want to use money should go to the board. Though wise-chairman, filled out a application. He (she) can use the money only if the application be agreed.

COLOMBIA

• • •

COLOMBIAN SOCIETY OF ENGINEERS

• • •

Carrera 4 N. 10-41
Bogotá, Colombia

Founded: 1887
Members: 1800

Code of Professional Ethics

The honor and dignity of the profession ought to be for the Engineer his or her major pride; as a result, in order to extol the profession, he should conform his conduct to the following norms that constitute his Code of Professional Ethics:

1. To exercise the profession as well as the activities derived from it with decorum, dignity, and integrity.
2. To always work under the assumption that the exercise of the profession constitutes not only a technical activity but also a social function.
3. To always act honorably and loyally with persons or entities to which services are offered.

4. To abstain from receiving gratuities and rewards other than the agreed upon salary or honorarium.
5. To not use with colleagues unfair methods of competition such as under bidding or offering professional services at a lower than standard price.
6. To try neither to supplant another engineer when a contract has already been awarded or a position determined nor to replace an honorable and competent employee.
7. To abstain from an intervention that would unfairly affect the professional reputation of a colleague.
8. To limit advertised services exclusively to those for which one is qualified by academic education or professional experience.
9. To not propose competitive bidding in which the value of the professional honorarium will be one of the factors that determines the selection of engineering consulting services, nor to participate in such competitive bidding.
10. Finally, to have due respect and consideration for all colleagues.

TRANSLATED BY JUAN LUCENA AND CARL MITCHAM

COSTA RICA

• • •

FEDERAL ASSOCIATION OF ENGINEERS AND ARCHITECTS OF COSTA RICA CODE OF ETHICS

• • •

Apartado 2346
1000 San José, Costa Rica

Founded: 1971
Members: 6,000

Code of Professional Ethics

The following acts are unethical:

A. In relation to the Profession:

a) To perform in bad faith acts that have been established as contrary to good techniques or to incur voluntary omissions even if it be in compliance with the orders of authorities or mandates.

b) To accept a job knowing that it may lend itself to malice or fraud or may be against the general interest;

c) To sign plans, specifications, recommendations, records or reports which have not been executed, studied, or seen personally, except those documents which, in themselves are objects of public faith and must be exercised personally. (As reformed in session 3-82 A.E.R.)

d) To associate one's name with propaganda or activities with persons who appear unqualified as professionals, to honor disproportionately persons or things to commercial or political ends.

e) To receive or give commissions or other benefits for promoting, obtaining or determining plans of any class or in the assignment of professional jobs.

f) To violate or comply with others in violating the laws of the Federated Association or the Codes, Norms, and Rules which are indicated here, in relation to the exercise of the profession.

B. In relation to Colleagues:

a) To utilize ideas, plans or technical documents without consent of the authors.

b) To participate in competitions of price or with a price that is less than that which is established as the minimum by the Federated Association to contract a professional job.

c) To attempt to injure, falsely or maliciously, directly or indirectly the professional reputation, situation or business of another member of the Federated Association.

d) To attempt to supplant fraudulently another engineer or architect after he has made definitive steps in his occupation.

e) To use favors or offer commissions in order to obtain professional work, directly or indirectly.

f) To nominate or intervene so that another should be nominated to be in charge of technical jobs that must be undertaken by a professional, when nominee does not have needed qualifications.

g) To compete unloyally with one's colleagues who work on contract by using the advantages of a position in a company.

h) To promote propaganda in language that is boastful or in any way that affects the dignity of the profession.

i) To establish or influence the establishment of honorariums or remunerations for engineering or architecture, when such honorariums or remunerations obviously present a compensation that is inadequate for the importance and responsibility of the services to be rendered.

j) To act in any manner or compromise oneself in any manner or practice which serves to discredit the honor and dignity of the profession of engineering and architecture.

C. In Relation to the Constituents or Employers:

a) To accept for one's own benefit commissions, discounts, or bonuses from materials providers, contractors or persons concerned in the execution of a job.

b) To reveal reserved technical, financial or personal data about the confidential interests in his study or his contract which is under his care for constituents or employers.

c) To act on behalf of his constituents or employers in a professional capacity or other manner which is not the manner of a loyal and non-prejudiced agent, as trustee, expert or arbiter in any contract or engineering or architectural job.

TRANSLATED BY ANNA H. LYNCH

NOTES

A note at the top of this statement reads as follows:

> The assembly of representatives of the Federated College of Engineers and Architects of Costa Rica, based on the mandates of the "Ley Organica del Colegio" number 4925 dated 17 December 1971, reformed by (the) number 5361 dated 16 October 1973, article 23, incise d), in session number 7-74 A.E.R. on the 24th of May, 1974, agreed to approve the following Code of Professional Ethics of the Federated College of Engineers and Architects of Costa Rica, which says the following:

At the bottom it is noted "Approved in the assembly of representatives in meeting on the 21st of May, 1974."

Following the code are two notes, as follows:

> This code is in force as of its publication in the Official Diary. San Jose, June, 1974, -Carlos Alejandro Garcia Bonilla, Executive Director.Reformed by the Assembly of Representatives of the Federated College in session number 4-76 A.E.R. 4th Article, Thursday, the 4th of March, 1976 with the addition of incision f (to Article A).

When formed in 1971, the Colegio Federado unified five professional associations.

A.E.R. stands for Asemblea Extraordinaria de Representantes.

DOMINICAN REPUBLIC

• • •

DOMINICAN ASSOCIATION OF ENGINEERS, ARCHITECTS, AND SURVEYORS CODE OF ETHICS

• • •

Calle Padre Billini No. 58
Zona Colonial, Apartado 1514
Santo Domingo, Dominican Republic

Founded: 1945
Members: 10,300

Code of Professional Ethics

It is considered contrary to ethics and incompatible with the dignified exercise of the profession for a member of the Dominican Association of Engineers, Architects, and Surveyors:

1st To act in any way that tends to diminish the honor, dignity, respect, honesty, ability and other attributes that support the full exercise of the profession.

2nd To violate, to permit the violation of, or to influence the violation of the laws and regulations related to the exercise of the profession.

3rd To utilize positions in official, semi-official, autonomous or private organizations or institutions to act with disloyalty contrary to the genuine national interests or that would have consequences contrary to the good involvement of professionals.

4th To receive, offer, or confer improper commissions, or to utilize influences in conflict with legitimate competence in order to secure the conference of contracts, works, or the execution of projects as a special favor, or as a favor to ones associates or partners.

5th To offer oneself for the performance of functions or specialties for which one does not have reasonable capacity and experience.

6th To present or talk about oneself in laudatory terms or in any form that acts against the dignity and seriousness of the profession.

7th To exempt oneself by convenience, collusion, or ties of friendship or family from fulfilling the duties that his position or job requires him to do or to respect.

8th To offer, solicit, or render professional services for remunerations below those established as a minimum in Professional Fee Schedule of the Dominican Association of Engineers, Architects, and Surveyors.

9th To sign without permission surveys, calculations, designs or any other intellectual work that is the fruit of the labor of other professionals.

10th To make oneself responsible for works or projects which are not under one's immediate direction, revision, or supervision.

11th To take charge of a work without having completed all technical studies necessary for its correct execution, or when for the realization of such a work there have been appointed terms, prices, or any other conditions in conflict with the good practice of the profession.

12th To use the inherent advantages of a remunerated position in order to compete with the practicing professional independently of other professionals.

13th To act against the reputation and/or legitimate rights and interests of other professionals.

14th To acquire interests that directly or indirectly collide with those of the interests of the company or clients that employ one's services, or to take charge without the knowledge of interested parties of works in which there exist antagonistic interests.

15th To contravene deliberately the principles of justice and loyalty in one's relations with clients, personnel subordinates, and workers; in relation to the last, in a special manner in that relevant to maintaining equitable work conditions and to their just participation in profits.

16th To supplant or intend to supplant a colleague in a particular contract after a definitive decision has been made to employ him for this contract, and to substitute through political or ideological arrangements of a discriminatory or arbitrary character a professional colleague who has been terminated or suspended from his functions.

17th To propitiate, serve as instrument for, or support with one's name the unjust replacement of Dominican professionals by foreign companies or persons settled in the country, or to do the same if living abroad.

18th To intend by any means to undermine and/or slight the prestige of the Dominican Association of Engineers, Architects, and Surveyors, and in any form to contribute, support, or encourage that there be abolished or eliminated the laws, rules, principles, ends, and purposes of the Association without the consent of its competent organs, or to provoke in any way the disintegration or weakening of the instituted organs of the Association.

19th To intend to pervert the principles, ends, and purposes of the Dominican Association of Engineers, Architects, and Surveyors, and in any form to contribute, support, or encourage the abolition of the laws and rules of the Association without the consent of its competent organs or in any way to support the disintegration or weakening of the instituted organs of the Association.

TRANSLATED BY CÉSAR CUELLO NIETO AND CARL MITCHAM

NOTES

According to a parenthetical note following the code, "This code of ethics was approved by the Assembly of Representatives of the Dominican Association of Engineers, Architects, and Surveyors in session 11 October 1969."

FINLAND

• • •

ENGINEERING SOCIETY OF FINLAND CODE OF ETHICS

• • •

Banvaktsg. 2
00520 Helsinki, Finland

Founded 1880
Members: 2,440

Code of Honor

In full knowledge of my rights and duties as a graduate engineer or architect, I will, in all my acts and deeds, obey the rules of life contained in this code of honor.

In my profession, I will not accept bribes. I will be tolerant. I know my duty to be the service of both my country and mankind as a whole.

In the recognition that my own knowledge and skills are inherited from the efforts of individuals over millennia, it is my desire to develop technology and engineering further, and especially to strive to teach the younger generation of engineers and architects the skills and traditions of my profession.

In addition to the development of technology, I will also be responsible for its right application and use, so that its consequences cause damage neither to society nor the individual.

I will participate only in honorable enterprises and deeds and will not take part in activities detrimental to the reputation or honor of engineers and architects.

I will respect the right of another to his ideas, publications and other results of his creativity.

I will strive to protect the interests and good name of every honorable engineer and architect, but if duty demands, I will not shrink from declaring the truth about anyone who has forfeited his right to this profession.

In my activities and strivings for position, I will use only loyal measures and will not attempt to damage my colleagues by unjustified criticism, and if I observe such an attempt, I will do my best to defeat it.

The employer or client for whom I am working can be assured that I will faithfully serve his best interests.

I will do my work well in order to justify honorable payment and will promote the development of my subordinates, as well as the quality of their working conditions and their remuneration.

I regard the participation of engineers and architects in public life, at local and national levels, to be an important factor in the development of our society.

I will continually cultivate my professional knowledge and competence and develop my personality by all means available; and I will remember that in my life and work I also represent the whole professional body of architects and graduate engineers.

NOTES

This code is promulgated in English as a one-page document with decorative border suitable for framing.

At the bottom it states that the code was "adopted in the meeting of the Council of The Engineering Society of Finland—STS, 16th December, 1966."

FRANCE

• • •

CONSEIL NATIONAL DES INGÉNIEURS ET DES SCIENTIFIQUES DE FRANCE (CNISF)

• • •

NATIONAL COUNCIL OF ENGINEERS AND SCIENTISTS OF FRANCE

• • •

Charter of Ethics of the Engineer

Preamble

As they become more and more powerful, technologies promote major changes in everyday life, in the transformation of our society and its environment, while they also bring with them risks of serious harms. Additionally, while their complexity makes them difficult to comprehend, and the force of information increases, misinformation can introduce in public opinion exaggerated worries about security, with baseless psychoses and irrational fears.

Consequently engineers must assume an essential double role in society, first as those who control these technologies in service of the human community, and second as those who diffuse information about the real possibilities and limitations and assessments of the benefits and the risks they generate.

Because of the special characteristics of the exercise of their profession, engineers must conduct themselves with a certain rigor; it becomes more and more imperative that they explicitly clarify the reference points used and reasons for their conduct. This is why the National Council of the Engineers and the Scientists of France has produced a Charter of Ethics. This Charter must be considered as the profession of faith of all those who are listed in the Registry of French Engineers created by the CNISF.

As a reference for engineers, the Charter will help engineering students prepare for the exercise of their profession. It will enable the values that guide engineers to be better comprehended by everyone.

The Charter annuls and replaces the old CNISF "code of ethics."

The term "code of ethics" will henceforth be reserved for documents that define the correct professional conduct in each of the fields of engineering and whose non-observance could entail the application of sanctions.

The CNISF thanks in advance all those who, through their contributions, help the Charter become known, appreciated, enduring, and improved.

Engineers in Society

- Engineers are responsible citizens establish the link between science, technology, and the human community; they are involved in civic action for the common good.
- Engineers spread their knowledge and pass on their experience to serve society.
- Engineers are conscious and make society aware of the impact of technological achievements on the environment.
- Engineers act to ensure the "sustainable development" of resources.

Engineers and Their Abilities

- Engineers are a source of innovation and the engine of progress.
- Engineers are objective and methodical in their procedures and judgments. They attempt to explain the foundations of their decisions.
- Engineers regularly update their knowledge and their abilities according to the evolution of science and technology.
- Engineers listen to their peers; they are open to all other disciplines.
- Engineers know how to admit their mistakes, take them into account, and learn lessons for the future.

Engineers and Their Profession

- Engineers fully use their abilities, while being conscious of their limitations.
- Engineers loyally respect the culture and values of their companies and those of their peers and clients. They would not act contrary to their professional conscience. If need be, they accept the consequences of any contradictions that may arise.
- Engineers respect the opinions of their professional peers. They listen and are open in discussions.
- Engineers behave toward their collaborators with loyalty and equality without any discrimination. They encourage them to develop their abilities and help them to fully realize the potential in their professions.

Engineers and Their Assignments

- Engineers try to attain the best result in utilizing the best means available and in the integration of human, economic, financial, social, and environmental dimensions.
- Engineers take into account all the constraints that their assignments impose, especially with respect to health, safety, and the environment.
- Engineers integrate in their analyses and decisions the ensemble of legitimate interests of their assignments, as well as consequences of any kind on other persons and their welfare. They anticipate risks and the probabilities; they work hard to take advantage of them and to eliminate negative effects.
- Engineers are rigorous in analysis, methods, and in making decision and solution choices.
- Faced with unexpected situations, engineers immediately take permitted initiatives to create better conditions, and directly inform the appropriate persons.

TRANSLATED BY CARL MITCHAM

GERMANY

• • •

ASSOCIATION OF GERMAN ENGINEERS CODE OF ETHICS

• • •

Graf-Recke-Strasse 84
Postfach 1139
W-4000 Düsseldorf 1, Germany

Founded: 1856
Membership: 95,000

ENGINEER'S CONFESSIONS

• • •

The *ENGINEER* should pursue his profession with respect for values beyond science and knowledge and with humbleness toward the Almighty who governs his earthly existence.

The *ENGINEER* should place professional work at the service of humanity and maintain the profession in those same principles of honesty, justice, and impartiality that are the law for all people.

The *ENGINEER* should work with respect for the dignity of human life and so as to fulfill his service to his fellowmen without regard for distinctions of origin, social rank, and worldview.

The *ENGINEER* should not bow down to those who disregard human rights and misuse the essence of technology; he should be a loyal co-worker for human morality and culture.

The *ENGINEER* should always work together with his professional colleagues for a sensible development of technology; he should respect their activity just as he expects them to rightly value his own creativity.

The *ENGINEER* should place the honor of his whole profession above economic advantage; he should behave so that his profession is accorded in all public arenas with as much respect and recognition as it deserves.

Düsseldorf, May 12th 1950

TRANSLATED BY CARL MITCHAM

FUNDAMENTALS OF ENGINEERING ETHICS

• • •

Preface

Natural sciences and engineering are important forces shaping our future. They exert both positive and negative influences upon our world. We all contribute to these changes. The engineering professions, however, have a particular responsibility in structuring these processes. Hence in 1950, the Association of Engineers VDI in Germany presented a document on the specific professional responsibilities of engineers.

Recently the VDI Executive Board passed the new document "Fundamentals of Engineering Ethics." They are intended to offer to all engineers, as creators of technology, orientation and support as they face conflicting professional responsibilities.

These fundamentals have been proposed by the "VDI philosophers" together with representatives of other disciplines within the VDI Committee on People and Technology.

I hope that this document may strengthen awareness and commitment in dealing with ethical issues of the engineering professions.

Dusseldorf, March 2002

Prof. Dr.-Ing. Hubertus Christ, President of the VDI

0. PREAMBLE

• • •

Engineers recognize natural sciences and engineering as important powers shaping society and human life today and tomorrow. Therefore engineers are aware of their specific responsibility. They orient their professional actions towards fundamentals and criteria of ethics and implement them into practice. The fundamentals suggested here offer such orientation and support for engineers as they are confronted with conflicting professional responsibilities.

The Association of Engineers in Germany (VDI)

- contributes to raising awareness about engineering ethics,
- offers consultancy and conflict resolution, and
- assists in all controversies related to issues of responsibility in engineering.

1. *Responsibilities*

1.1 Engineers are responsible for their professional actions and the resulting outcomes. According to professional standards, they fulfill their tasks as they correspond to their competencies and qualifications. Engineers perform these tasks and actions carrying both individual and shared responsibilities.

1.2 Engineers are responsible for their actions to the engineering community, to political and societal institutions as well as to their employers, customers, and technology users.

1.3 Engineers know the relevant laws and regulations of their countries. They honor them insofar as they do not contradict universal ethical principles. They are committed to applying them in their professional environment. Beyond such application they invest their professional and critical competencies into improving and developing further these laws and regulations.

1.4 Engineers are committed to developing sensible technology and technical solutions. They accept responsibility for quality, reliability, and safety of new technical products and processes. Their responsibilities include technical documentation as well as informing customers about both appropriate use and possible dangers of misuse of new technical solutions.

They furthermore include:

- defining the technical characteristics of such products and processes,
- suggesting alternative technical solutions and approaches, and

- taking into consideration the possibilities of unwanted technological developments and deliberate misuse of products and processes.

2. Orientation

2.1 Engineers are aware of the embeddedness of technical systems into their societal, economic and ecological context. Therefore they design technology corresponding to the criteria and values implied: the societal, economic and ecological feasibility of technical systems; their usability and safety; their contribution to health, personal development and welfare of the citizens; their impact on the lives of future generations (as previously outlined in the VDI Document 3780).

2.2 The fundamental orientation in designing new technological solutions is to maintain today and for future generations, the options of acting in freedom and responsibility.

Engineers thus avoid actions which may compel them to accept given constraints (e.g. the arbitrary pressures of crises or the forces of short-term profitability). On the contrary, engineers consider the values of individual freedom and their corresponding societal, economic, and ecological conditions the main prerequisites to the welfare of all citizens within modern society—excluding extrinsic or dogmatic control.

2.3 Engineers orient their professional responsibility on the same fundamentals of ethics as everybody else within society. Therefore engineers should not create products which are obviously to be used in unethical ways (e.g., products banned by international agreement). Furthermore they may not accept far-reaching dangers or uncontrollable risks caused by their technical solutions.

2.4 In cases of conflicting values, engineers give priority:

- to the values of humanity over the dynamics of nature,
- to issues of human rights over technology implementation and exploitation,
- to public welfare over private interests, and
- to safety and security over functionality and profitability of their technical solutions.

Engineers, however, are careful not to adopt such criteria or indicators in any dogmatic manner. They seek public dialogue in order to find acceptable balance and consensus concerning these conflicting values.

3. Implementation

3.1 Engineers are committed to keeping up and continually developing further their professional skills and competencies.

3.2 In cases of conflicting values, they are expected to analyze and weigh controversial views through discussions that cross borders of disciplines and cultures. In this way they acquire and strengthen their ability to play an active part in such technology assessment.

3.3 In all countries, national laws and regulations exist which concern technology use, working conditions, and the natural environment. Engineers are aware of the relevance of engineering ethics for these laws and regulations.

Many of these laws today take up controversial issues related to open questions in engineering sciences and ethics. Engineers are challenged to invest their professional judgment into substantiating such questions.

Concerning national laws, the sequence of priorities is as follows: national laws have priority over professional regulations, such professional regulations have priority over individual contracts.

3.4 There may be cases when engineers are involved into professional conflicts which they cannot resolve co-operatively with their employers or customers. These engineers may apply to the appropriate professional institutions which are prepared to follow up such ethical conflicts. As a last resort, engineers may consider to directly inform the public about such conflicts or to refuse co-operation altogether. To prevent such escalating developments from taking place, engineers support the founding of these supporting professional institutions, in particular within the VDI.

3.5 Engineers are committed to educational activities in schools, universities, enterprises and professional institutions with the aims of promoting and structuring technology education, and enhancing ethical reflection on technology.

3.6 Engineers contribute to developing further and continually adapting these fundamentals of engineering ethics, and they participate in the discussions corresponding.

Fundamentals of Engineering Ethics Summary

- Engineers are responsible for their professional actions and tasks corresponding to their competencies and qualifications while carrying both individual and shared responsibilities.
- Engineers are committed to developing sensible and sustainable technological systems.
- Engineers are aware of the embeddedness of technical systems into their societal, economic and ecological context, and their impact on the lives of future generations.

- Engineers avoid actions which may compel them to accept given constraints and thus lead to reducing their individual responsibility.
- Engineers base their actions on the same ethical principles as everybody else within society. They honor national laws and regulations concerning technology use, working conditions, and the natural environment.
- Engineers discuss controversial views and values across the borders of disciplines and cultures.
- Engineers apply to their professional institutions in cases of conflicts concerning engineering ethics.
- Engineers contribute to defining and developing further relevant laws and regulations as well as political concepts in their countries.
- Engineers are committed to keeping up and continually developing further their professional skills and competencies.
- Engineers are committed to enhancing critical reflection on technology within schools, universities, enterprises, and professional institutions.

TRANSLATED BY CARL MITCHAM

HONDURAS

• • •

ASSOCIATION OF CIVIL ENGINEERS OF HONDURAS CODE OF ETHICS

• • •

CONSIDERING:

That it is urgent that the Code of Professional Ethics be put into practice to guard and sanction the professional conduct of the members of the association;

CONSIDERING:

That the standards that regulate the subject as established by the Organic Law contain guidelines that are general and not concrete ones dealing with particulars;

CONSIDERING:

That it is the obligation of the Directing Council to propose to the General Assembly Regulations of the Association that conform to the Organic Law and to promulgate resolutions that will insure compliance with these Regulations;

CONSIDERING:

That it is necessary to have a Code of Professional Ethics that meets the needs of the growing Association of Civil Engineers of Honduras (CICH);

THEREFORE:

The 38th Regular General Assembly of the Association of Civil Engineers of Honduras (CICH), using the power conferred by Article 16, section (c) of the Organic Law,

AGREES

To the following:

CODE OF PROFESSIONAL ETHICS

• • •

Chapter I

FUNDAMENTAL PRINCIPLES

Engineers ought to maintain and respect the integrity, honor, and dignity of the engineering profession:

I. Utilizing their knowledge and ability to improve human welfare.

II. Being honest and impartial and faithfully serving the public, their employees, and clients.

III. Striving to improve the capability and the prestige of the profession.

IV. Supporting technical and professional societies within their disciplines.

Chapter II

STANDARDS OF ETHICS

Article 1.

—Any colleague who transgresses from one or more of the duties or obligations stipulated by the present code in either his personal character or his engineering firm is considered in contempt of the ethics.

Article 2.

—The ethical misdeeds may be considered "slight," "serious," "grave," or "very grave."

Article 3.

It is the responsibility of the Honor Tribunal of the Association of Civil Engineers of Honduras to determine the qualification that corresponds to a transgression or a group of transgressions incurred by a colleague.

If more than one transgression is committed by the same student it cannot be qualified as "slight" even though each error considered individually may merit such qualification.

Article 4.

—Ethical transgressions are:

A) Toward the Profession:

a) To act in any way that serves to diminish the honor, respectability, and the virtues of honesty, integrity, and truthfulness that should serve as the basis for a full and complete exercise of the profession;

b) To exercise bad faith, engage in acts contrary to good technique, or to be involved in culpable omissions, even if it is done in order to comply with orders from superiors or to comply with commands;

c) To accept a job knowing that it is may lend itself to an evil deceit or be against the general good;

d) To sign as author any title for free or purchased plans, specifications, judgments, accounts, or any other professional information laid out by others;

e) To take charge of projects or works which are not under his immediate direction, review or supervision;

f) To associate with or to have his name linked with propaganda or activities involving people or entities who exercise or practice the engineering profession illegally;

g) To put himself forward for employment in specializations and operations for which he has no capacity, preparation, and reasonable experience;

TRANSLATED BY CARL MITCHAM AND ANNA H. LYNCH

HONG KONG

• • •

THE HONG KONG INSTITUTION OF ENGINEERS CODE OF ETHICS

• • •

9/F Island Centre
No. 1 Great George Street
Causeway Bay, Hong Kong

Founded: 1975
Membership: 7,376

Rules of Conduct

Introduction

The Ordinance and Constitution make it clear that members are required to conduct themselves in a manner which is becoming to professional engineers, as may be seen from the following general statement from clause (1) of Article 12 of the Constitution:

> "Every member shall at all times so order his conduct as to uphold the dignity and reputation of the Institution and act with fairness and integrity towards all persons with whom his work is connected and towards other members."

The Council, in clause (3) of Article 12 of the Constitution, is required to make specific rules which are to be observed by members, and such rules have been drawn up and approved by the Council. These rules, given below, set the standard for the conduct of all Institution members, though they are not wholly relevant to Students.

If members have any comments to make on the application of these rules to the real life situation it would be appreciated if they would send their contributions to the Secretary, preferably before the end of August, for the consideration of the Rules of Conduct Working Party.

Rules of Conduct

Rule 1: Responsibility to the Profession. A member of the Institution shall order his conduct so as to uphold the dignity, standing and reputation of the profession. In pursuance of which a member shall, inter alia:

1.1 discharge his professional responsibilities with integrity, dignity, fairness and courtesy;

1.2 not allow himself to be advertised in self-laudatory language nor in any manner derogatory to the dignity of his profession, nor improperly solicit professional work for himself or others;

1.3 give opinions in his professional capacity that are, to the best of his ability, objective, reliable and honest;

1.4 take reasonable steps to avoid damage to the environment and the waste of natural resources or the products of human skill and industry;

1.5 ensure adequate development of his professional competence;

1.6 accept responsibility for his actions and ensure that persons to whom he delegates authority are sufficiently competent to carry the associated responsibility;

1.7 not undertake responsibility which he himself is not qualified and competent to discharge;

1.8 treat colleagues and co-workers fairly and not misuse the advantage of position;

1.9 when working in a country other than Hong Kong order his conduct according to the existing recognized standards of conduct in that country, except that he should abide by these rules as applicable in the absence of local standards.

1.10 when working within the field of another profession pay due attention to the ethics of that profession.

Rule 2. Responsibility to Colleagues. A member of the Institution shall not maliciously or recklessly injure nor attempt to injure whether directly or indirectly the professional reputation of another engineer, and shall foster the mutual advancement of the profession. In pursuance of which a member shall, inter alia:

2.1 where appropriate seek, accept and offer honest criticism of work and properly credit the contributions of others;

2.2 seek to further the interchange of information and experience with other engineers;

2.3 assist and support colleagues and engineering trainees in their professional development;

2.4 not abuse his connection with the Institution to further his business interest;

2.5 not maliciously or falsely injure the professional reputation, prospects or practice of another member provided however that he shall bring to the notice of the Institution any evidence of unethical, illegal or unfair professional practice;

2.6 support the aims and activities of the Institution.

Rule 3. Responsibility to Employers or Clients. A member of the Institution shall discharge his duties to his employer or client with integrity. In pursuance of which a member shall, inter alia:

3.1 offer complete loyalty to his employer or client, past and present, in all matters concerning remuneration and in all business affairs and at the same time act with fairness between his employer or client and any other part concerned;

3.2 inform his employer or client in writing of any conflict between his personal or financial interest and faithful service to his employer or client;

3.3 not accept any financial or contractual obligation on behalf of his employer or client without their authority;

3.4 where possible advise those concerned of the consequences to be expected if his engineering judgment, in areas of his responsibility, is overruled by non-technical authority;

3.5 advise his employer or client in anticipating the possible consequences of relevant developments that come to his knowledge;

3.6 neither give nor accept any gift, payment or service of more than nominal value to or from those having business relationships with his employer or client without consent of the latter;

3.7 where necessary co-operate with, or arrange for the services of, other experts wherever an employer's or client's interest might best be served thereby.

Rule 4. Responsibility to the Public. A member of the Institution in discharging his responsibilities to his employer and the profession shall at all times be governed by the overriding interest of the general public, in particular their welfare, health and safety. In pursuance of which a member shall, inter alia:

4.1 seek to protect the safety, health and welfare of the public;

4.2 when making a public statement professionally, try to ensure that both his qualification to make the statement and his association with a benefiting party are made known to the recipients of the statement;

4.3 seek to extend public understanding of the engineering profession.

NOTES

Published in *Hong Kong Engineer* 12(7) (July 1984): 7–8.

INDIA

• • •

INDIAN INSTITUTE OF CHEMICAL ENGINEERS CODE OF ETHICS

• • •

Dr. H.L. Roy Building
Raja Subodh Mullick Road

Post Box No. 17001
Calcutta 700032, India

Founded: 1947

CODE OF ETHICS FOR MEMBERS

• • •

INDIAN INSTITUTE OF CHEMICAL ENGINEERS EXPECTS ALL ITS INDIVIDUAL MEMBERS TO BE GUIDED IN THEIR PROFESSIONAL LIFE AND CONDUCT BY THE FOLLOWING CODE OF ETHICS

1. Members shall be guided by the highest standards of integrity in all their professional dealings.
2. The members shall uphold the dignity of the profession and the reputation of the Institute.
3. The members shall avoid sensationalism and misleading claims and statements. In making first publication concerning inventions, discoveries or improvements in their fields, the members shall use the channels of recognized scientific societies or standard technical publications or periodicals.
4. The members shall endeavor at all times to give credit for work to those who, as far as their knowledge goes, are the real authors of such work.
5. The members shall provide sufficient opportunity and take responsibility for the training and development of other engineers under their change.
6. If a member considers another member guilty of unethical practice, he shall present the information to the Council of the Institute. He shall endeavor to avoid, under all circumstances, injuring the reputation of any member directly or indirectly.
7. The members shall not misrepresent their qualifications to clients, employers or others with whom they come in contact in their profession.
8. The members shall not divulge or make use of any confidential information or findings of clients, employers, or professional committees/commissions to which they are appointed as members for their personal gain without prior consent of the concerned authority.
9. The members shall uphold the principle that unreasonably low professional charges encourage inferior and unreliable work. This does not, however, preclude them from honorary work for professional/national advancement.
10. The members should inform their clients or employers of any interest in a business which may compete with or affect the interest of their clients or employers.
11. The members shall refuse to undertake for compensation work which they believe will be unprofitable to clients, without first advising the clients as to the improbability of successful results.
12. When called upon to undertake the use of inventions, equipment, processes and products in which a member has a financial interest, he shall make his status clear before engagement.
13. The members shall always give complete and accurate reports for promotion of business/enterprises and avoid unnecessary claims.
14. The members shall not indulge in any occupation which is contrary to law or public welfare.

INDIAN NATIONAL ACADEMY OF ENGINEERING CODE OF ETHICS

• • •

c/o Institution of Engineers (India) Bldg.
Bahadur Shah Zafar Marg
New Delhi 110002, India

Founded: 1987
Members: 128

Obligation

As a Fellow of the Indian National Academy of Engineering, I shall follow the code of ethics, maintain integrity in research and publications, uphold the cause of Engineering and the dignity of the Academy, endeavor to be objective in judgment, and strive for the enrichment of human values and thoughts.

Signature

Name in full

NOTES

This code is in the form of an obligation which has to be signed by every Fellow upon admission to the Academy. S.N. Mitra, Honorary Secretary of the Academy, explains the undefined reference to "the code of ethics" by simply noting (in a letter dated October 19, 1990) that "We do not have any elaborate Code of

Ethics for the Fellows of our Academy. We have only the Obligation Form, which, in a sense, is a summarized version of the Code of Ethics."

INDIA SOCIETY OF ENGINEERS CODE OF ETHICS

• • •

12-B Netaji Subhas Road
Calcutta 700001, India

Founded: 1934
Members: 8,000

Code of Ethics for Members of Indian Society of Engineers

The most important rules for a Corporate Member in a Professional sphere to follow, in India or abroad, is the code of practice for the society of which he is a member. This is the following:

i) A Corporate Member should observe the principles of honesty, justice, and courtesy in his profession. His personal conduct should uphold his Professional reputation, he should avoid adverse Questions affecting brother associations/Professionals, and he should uphold the dignity and honor of the Society.

ii) A Corporate Member will co-operate with others in his profession by fair interchange of information and experience and endeavor to protect the profession from misrepresentation and misunderstanding, and will not divulge any confidential finding or actions of an engineering commission or committee, as a Member without obtaining permission from the Authority.

iii) A Corporate Member will not directly or indirectly make damage to the reputation or practice of another Corporate Member or criticize technically without proper forum of Engineering Society or Engineering Press.

iv) A Corporate Member will neither misrepresent his Qualification and misguide his employer or client or to the profession, nor disclose trade secrets or technical affairs of his client or employer without proper Authority.

v) A Corporate Member will not review works of another Corporate Member at the same time for the same client, except with the consent of the other Member.

vi) A Corporate Member will, if he considers another Corporate Member is guilty of unethical, illegal or unfair practices, inform the Council of the Society in writing with necessary documents for action.

vii) A Corporate Member shall always confirm the National Interest in his own Professional Engineering areas.

THE INSTITUTION OF ENGINEERS (INDIA) CODE OF ETHICS

• • •

8 Gokhale Road
Calcutta 700020, India

Founded: 1920
Members: 300,000

CODE OF ETHICS FOR CORPORATE MEMBERS

• • •

Foreword

"The task of ethics," said Jacques Maritain, "is a humble one but it is also magnanimous in carrying the mutable application of immutable moral principles even in the midst of agonies of an unhappy world as far as there is in it a gleam of humanity."To uphold the concept of professional conduct amongst Corporate Members, the Institution introduced the professional Conduct Rules for Corporate Members on August 30 th, 1944. They were replaced by the Code of Ethics for Corporate Members on October 15th, 1954. The Code was revised consistent with the changing needs of the profession on August 12th, 1962.

A Corporate Member should allow the principles of honesty, justice and courtesy to guide him in the practice of his profession and in his personal conduct. He should not merely observe them passively, but should apply them dynamically in the discharge of his duties to the public and the profession.

He should scrupulously guard his professional reputation and avoid association with any enterprise of questionable character. He should uphold the dignity and honor of the Institution.

The Code

1. A Corporate Member will cooperate with others in his profession by the free interchange of informa-

tion and experience and will contribute to the work of engineering institutions to the maximum effectiveness he is capable of.

2. A Corporate Member will endeavor to protect the engineering profession from misrepresentation and misunderstanding.
3. A Corporate Member will refrain from expressing publicly an opinion on an engineering subject unless he is informed of the facts relating to that subject.
4. A Corporate Member will express an opinion only when it is founded on adequate knowledge and honest conviction if he is serving as a witness before a court or commission.
5. A Corporate Member will not divulge any confidential findings or actions of an engineering commission or committee, of which he is a member, without obtaining official consent.
6. A Corporate Member will take care that credit for engineering work is given to those to whom credit is properly due.
7. A Corporate Member will not offer his professional services by advertisement or through any commercial advertising media, or solicit professional work either directly, or through an agent or in any other manner derogatory to the dignity of the profession.
8. A Corporate Member will not directly or indirectly injure the professional reputation or practice of another Corporate Member.
9. A Corporate Member will exercise due restraint in criticizing the work of another Corporate Member and remember that the proper forum for technical criticism is an engineering society or the engineering press.
10. A Corporate Member will not try to supplant another Corporate Member in a particular employment.
11. A Corporate Member will not compete unfairly with another Corporate Member by charging fees below those customary for others in his profession practicing in the same field and in the same area.
12. A Corporate Member will not associate in work with an engineer who does not conform to ethical practices.
13. A Corporate Member will act in professional matters for his client or employer as faithful agent or trustee.
14. A Corporate Member will not misrepresent his qualifications to a client or employer or to the profession.
15. A Corporate Member will not disclose information concerning the business or technical affairs of his client or employer without his consent.
16. A Corporate Member will present clearly the consequences to be expected if his professional judgment is overruled by the non-professional authority where he is responsible for the professional adequacy of work.
17. A Corporate Member will act with fairness and justice between his client or employer and the contractor when dealing with contracts.
18. A Corporate Member will not be financially interested in the bids of a contractor on competitive work for which he is employed as an engineer unless he has the written consent of his client or employer.
19. A Corporate Member will not resolve any commission, discount, or other indirect profit in connection with any work with which he is entrusted.
20. A Corporate Member will make his status clear to his client or employer before undertaking an engagement if he may be called upon to decide on the use of inventions or equipment or any other thing in which he may have a financial interest.
21. A Corporate Member will immediately inform his client or employer of any interest in a business which may compete with or affect the business of his client or employer.
22. A Corporate Member will not allow an interest in any business to affect the engineering work for which he is employed or may be called upon to perform.
23. A Corporate Member will engage, or advise engaging, engineering experts and specialists when in his judgment such services are in the interests of his client or employer.
24. A Corporate Member will not review the work of another Corporate Member for the same client except with the knowledge of the second Corporate Member, unless such engineering engagement or the work which is subject to review is terminated.
25. A Corporate Member will not accept financial or other compensation from more than one interested party for the same service, or for services pertaining to the same work, without the consent of all interested parties.
26. A Corporate Member will subscribe to the principles of appropriate and adequate compensation for those engaged in engineering work, including those in subordinate positions.
28. A Corporate Member will endeavor to provide opportunity for the professional development and advancement of engineers in his employ.
29. A Corporate Member will, if he considers that another Corporate Member is guilty of unethical,

illegal or unfair practice, present the information to the Council of the Institution for action.

30. A Corporate Member who is engaged in engineering work in a country abroad will order his conduct according to the professional standards and customs of that country, adhering as closely as is practicable to the principles of this Code.

NOTES

This code is published and promulgated in a pocket-sized pamphlet.

IRELAND

THE INSTITUTION OF ENGINEERS OF IRELAND CODE OF ETHICS

22 Clyde Road, Ballsbridge
Dublin 4, Ireland

Founded: 1835
Members: 5,900

STANDARDS OF PROFESSIONAL CONDUCT

Part I: FUNDAMENTAL PRINCIPLES

1. Every corporate member of the Institution shall order his conduct so as to serve the public interest and uphold the honor and standing of The Institution and of the Engineering Profession.
2. *In his relations with his employers, clients, professional colleagues, subordinates and others with whom he works, and with the public*, he shall maintain high standards of conduct and integrity.
3. *In his relations with an employer or client* he shall act at all times as a faithful agent or trustee, using all his professional skill and experience and making freely available his sincere opinion and advice in the proper interest of his employer or client. He shall do nothing directly or indirectly which might conflict or appear to conflict with those interests or might influence or appear to influence his opinion or advice.
4. *In his relations with another engineer* he shall respect his dignity and professional standing and shall do nothing directly or indirectly to injure maliciously his reputation, practice, employment or livelihood or to lessen the satisfaction that he obtains from his work. He shall never compete unfairly for any engagement or appointment. He shall ensure, so far as he is able, that an engineer receives credit for his professional achievements and the financial and other rewards to which he is entitled, and that a subordinate is provided with opportunities to develop his talents and exercise his skill.
5. *In his relations with all others with whom he works* he shall act with justice and impartiality and with respect for their rights and dignity as citizens and human beings.
6. *In his relations with the public* he shall apply his skill and experience to the common good and the advancement of human welfare and shall perform his professional duties and express his professional opinions with proper regard for true economy and for the safety, health and welfare of the public. Should he come to the conclusion after full consultation with his employer or client that any work required of him by them is likely to be seriously injurious to the public welfare or to create a hazard to the health or safety of the community he has a duty to put his opinion on record and to inform The Institution of this action.
7. *As an independent expert or arbitrator* he shall act with complete impartiality, uninfluenced by any personal consideration.
8. He has a duty to maintain his knowledge up-to-date in relation to that branch of engineering in which he practices.

Part II: GUIDE TO PROFESSIONAL CONDUCT

1. He shall not divulge any confidential information regarding the business affairs, technical processes or financial standing of his clients or employers without their consent. He shall not use information obtained in the course of his assignment for the purpose of making personal profit if such action is contrary to the best interest of his client, his employer or the public. He shall not divulge without authoritative permission any unpublished information obtained by him as a member of an investigating commission or advisory board.
2. His remuneration shall be restricted to his fee, commission or salary (including bonuses, etc.). Where his remuneration is by fee it shall be in accordance with the Conditions of Engagement and Scale of Fees published jointly with the Association of Consulting Engineers of Ireland as in force from time to time. He

shall not knowingly compete with another Chartered Engineer on the basis of professional charges.

3. He shall not receive any royalty or commission on any article or process used on his recommendation on work for which he is responsible unless such payment has the full consent of his client or employer.
4. He shall not while acting in a professional capacity be at the same time a director or substantial shareholder in any contracting, manufacturing or distributing business with which he may have dealings on behalf of his client or employer without divulging the full facts in writing to his client or employer, and obtaining his written agreement thereto.
5. He shall not advertise his practice or his availability except in accordance with such Code of Practice as may be in force from time to time. Under no circumstances shall he pay an agent to introduce clients to him.
6. He shall not practice as a consultant in the following circumstances:
   (a) in partnership with one who is not professionally qualified in engineering or an allied profession;
   (b) as Principal or one of the major shareholders of a limited liability Company unless the Company has the prior approval of the Council of The Institution.
7. A member shall not use the advantage of a salaried position to compete unfairly with other engineers. His outside activities in the engineering field should normally be confined to branches of engineering for which he has special qualifications. He shall not undertake as a part-time consultant any work which he might subsequently have to review in the course of his salaried employment.
8. When acting as a Consultant a member shall not attempt to supplant another Chartered Engineer nor shall he take over or review the work of another Chartered Engineer acting as a Consultant, without either having the written consent of such Engineer or having fully satisfied himself that such Engineer's association with the work has been terminated and his account fully discharged.

NOTES

Approved by the Council of The Institution of Engineers of Ireland at its Meeting of 15th October, 1971.

Published and promulgated as a four-page pamphlet.

Under revision as of November 1991.

JAMAICA

• • •

JAMAICAN INSTITUTION OF ENGINEERS CODE OF ETHICS

• • •

P.O. Box 122, Kingston
10 Jamaica

Founded: 1960
Members: 500

CODE OF ETHICS

• • •

A Professional Engineer

1. owes certain duties to the public, to his employers, to other members of his profession and to himself and shall act at all times with:
   (a) fidelity to public needs;
   (b) fairness and loyalty to his associates, employers, clients, subordinates and employees: and
   (c) devotion to high ideals of personal honor and professional integrity.
2. shall express opinions on engineering matters only on the basis of adequate knowledge and honest conviction.
3. shall have proper regard for the safety health and welfare of the public in the performance of his professional duties.
4. shall endeavor to extend public understanding of engineering and its place in society.
5. shall not be associated with enterprises contrary to the public interest or sponsored by persons of questionable integrity, or which does not conform to the basic principles of the code.
6. shall sign and/or seal only those plans, specifications and reports actually prepared by him or under his direct professional supervision.
7. shall act for his client or employer as a faithful agent or trustee.
8. shall not disclose confidential information pertaining to the interests of his clients or employers without their consent.
9. shall present clearly to his clients or employers the consequences to be expected if his professional judgment is over-ruled by non-technical authority in matters pertaining to work for which he is professionally responsible.

10. shall not undertake any assignment which may create a conflict of interest with his clients or employers without the full knowledge of his clients or employers.
11. shall not accept remuneration for services rendered other than from his client or employer.
12. shall conduct himself towards other professional engineers with courtesy, fairness and good faith.
13. shall not compete unfairly with another engineer by attempting to obtain employment, advancement or professional engagements by competitive bidding, by taking advantage of a salaried position or by criticizing other engineers.
14. shall undertake only such work as he is competent to perform by virtue of his training and experience.
15. shall not advertise his work or merit in a self-laudatory manner and shall avoid all conduct or practice likely to discredit or unfavorably reflect upon the dignity or honor of the profession.
16. shall advise his Association or Institution or the Council of any practice by another Professional Engineer which he believes to be contrary to the Code of Ethics.

GUIDE TO PRACTICE UNDER THE CODE OF ETHICS

• • •

GENERAL:

ARTICLE 1. A Professional Engineer owes certain duties to thepublic, to his employers, to other members of his profession and to himself and shall act at all times with:

(a) fidelity to public needs;

(b) fairness and loyalty to his associates, employers, clients, subordinates and employees; and

(c) devotion to high ideals of personal honor and professional integrity.

DUTIES OF THE PROFESSIONAL ENGINEER TO THE PUBLIC

• • •

A Professional Engineer

ARTICLE 2. shall express opinions on engineering matters onlyon the basis of adequate knowledge and honest conviction.

(a) He shall ensure, to the best of his ability, the statements on engineering matters attributed to him are not misleading and properly reflect his professional opinion;

(b) He shall not express publicly or while he is serving as a witness before a court, commission or other tribunal opinions on professional engineering matters that are not founded on adequate knowledge and honest conviction.

ARTICLE 3. shall have proper regard for the safety health andwelfare of the public in the performance of his professional duties.

(a) He shall notify the proper authorities of any situation which he considers, on the basis of his professional knowledge, to be a danger to public safety or health.

(b) He shall complete, sign, or seal only those plans and/or specifications which reflect proper regard for the safety and health of the public.

ARTICLE 4. shall endeavor to extend public understanding of engineering and its place in society.

(a) He shall endeavor at all times to enhance the public regard for, and its understanding of, his profession by extending the public knowledge thereof and discouraging untrue, unfair or exaggerated statements with respect to professional engineering.

(b) He shall not give opinions or make statements on professional engineering projects connected with public policy where such statements are inspired or paid for by private interests unless he clearly discloses on whose behalf he is giving the opinions or making the statements.

ARTICLE 5. shall not be associated with enterprises contrary to the public interest or sponsored by persons of questionable integrity, or persons who do not conform to the basic principles of the code.

(a) He shall conform with registration laws in his practice of engineering.

(b) He shall not sanction the publication of his reports in part or in whole in a manner calculated to mislead and if it comes to his knowledge that they are so published, he shall take immediate steps to correct any false impressions given by them.

ARTICLE 6. shall sign and/or seal only those plans, specification and reports actually prepared by him or under his direct professional supervision.

DUTIES OF THE PROFESSIONAL ENGINEER TO HIS CLIENT OR EMPLOYER:
A Professional Engineer

ARTICLE 7. shall act for his client or employer as a faithful agent or trustee.

(a) He shall be realistic and honest in all estimates, reports, statements, and testimony.

(b) He shall admit and accept his own errors when proven obviously wrong and refrain from distorting or altering the facts in an attempt to justify his decision.

(c) He shall advise his client or employer when he believes a project will not be successful.

(d) He shall not accept outside employment to the detriment of his regular work or interest, or without the consent of his employer.

(e) He shall not attempt to attract an engineer from another employer by unfair methods.

(f) He shall engage, or advise engaging, experts and specialists when such services are in his clients or employer's best interests.

ARTICLE 8. shall not disclose confidential information pertaining to the interests of his clients or employers without their consent.

(a) He shall not use information coming to him confidentially in the course of his assignment as a means of making personal gain except with the knowledge and consent of his client or employer.

(b) He shall not divulge, without official consent, any confidential findings resulting from studies or actions of any commission or board of which he is a member or for which he is acting.

ARTICLE 9. shall present clearly to his clients or employers the consequences to be expected if his professional judgment is over-ruled by non-technical authority in matters pertaining to work for which he is professionally responsible.

ARTICLE 10. shall not undertake any assignment which may create a conflict of interest with his clients or employers without the full knowledge of his clients or employers.

ARTICLE 11. shall not undertake any assignment which may create a conflict of interest with his clients or employers without the full knowledge of his clients or employers.

(a) He shall inform his client or employer of any business connections, interests, or circumstances which may be deemed as influencing his judgment or the quality of his services to his client or employer.

(b) When in public service as a member, advisor or employee of a governmental body or department, he shall not participate in considerations or actions with respect to services provided by him or his organization in private engineering practice.

(c) He shall not solicit or accept an engineering contract from a governmental body on which a principal or officer of his organization serves as a member.

ARTICLE 11. shall not accept remuneration for services renderedother than from his client or employer.

(a) He shall not accept compensation from more than one interest party for the same service or for services pertaining to the same work, under circumstances that may involve a conflict of interest, without the consent of all interested parties.

(b) He shall not accept any royalty or commission on any article or process used on the work for which he is responsible without the consent of his client or employer.

(c) He shall not undertake work at a fee or salary below the accepted standards of the profession in the area.

(d) He shall not tender on competitive work upon which he may be acting as a consulting engineer.

(e) He shall not act as consulting engineer in respect of any work upon which he may be the contractor.

DUTIES OF THE PROFESSIONAL ENGINEER TO THE PROFESSION

• • •

A Professional Engineer

ARTICLE 12. shall conduct himself towards other professional engineers with courtesy, fairness and good faith.

(a) He shall not accept any engagement to review the work of another professional engineer for the same employer or client except with the knowledge of such engineer, unless such engineer's engagement on the work has been terminated.

(b) He shall not maliciously injure the reputation or business of another professional engineer.

ARTICLE 13. shall not compete unfairly with another engineer by attempting to obtain employment, advancement or professional engagements by competitive bidding, by taking advantage of a salaried position, or by criticizing other engineers.

(a) He shall not attempt to supplant another engineer in a particular employment after becoming aware that definite steps have been taken toward the other's employment.

(b) He shall not offer to pay, either directly or indirectly, any commission, political contribution, or a gift or other consideration in order to secure professional engineering work.

(c) He shall not solicit or submit engineering proposals on the basis of competitive bidding.

(d) He shall not use equipment, supplies, laboratory, or office facilities of his employer to carry on outside private practice without consent.

ARTICLE 14. shall undertake only such work as he is competent to perform by virtue of his training and experience.

(a) He shall not misrepresent his qualifications.

ARTICLE 15. shall not advertise his work or merit in a self-laudatory manner, and shall avoid all conduct or practice likely to discredit or unfavorably reflect upon the dignity or honor of the profession.

(a) Circumspect advertising may be properly employed by the Engineer to announce his practice and availability. Only those media shall be used as are necessary to reach directly an interested and potential client or employer, and such media shall in themselves be dignified, reputable and characteristically free of any factor or circumstance that would bring disrepute to the profession or to the professional using them. The substance of such advertising shall be limited to fact and shall contain no statement or offer intended to discredit or displace another engineer, either specifically or by implication.

ARTICLE 16. shall advise his Association or Institution or the Council of any practice by another Professional Engineer which he believes to be contrary to the Code of Ethics.

NOTES

Adopted by the Jamaica Institution of Engineers September 1986.

The JIE is a non-profit professional organization, comprised of members who are Engineers from all the various disciplines of Engineering, including Civil, Electrical, Mechanical, Chemical, Industrial and Agricultural.

The Institution is currently involved in a six-year program of technical co-operation (concluding in 1993) with the Canadian Society for Civil Engineering (CSCE), and funded by the Canadian International Development Agency (CIDA). The main objective being the improvement of technical expertise within the JIE community as regards to Civil Engineering aspects of transportation infrastructure and other topics.

JAPAN

• • •

SCIENCE COUNCIL OF JAPAN CODE OF ETHICS

• • •

7-22-34 Roppongi
Minatoku, Tokyo 106

Founded: 1949
Members: 210

Statement on "Charter for Scientific Researchers"

PREAMBLE

• • •

In order to promote the sound development of scientific research in Japan, the Science Council of Japan (JSC) recommended twice, in 1962 and in 1976, that the government prepare for the enactment of a Basic Act on Scientific Research to define its responsibility and urged the government to enact such a law. The Council has prepared and hereby issues a "Charter for Scientific Researchers" to complement the proposed Basic Act on Scientific Research, and itself resolves to abide by this "Charter." The Council thus makes public the responsibility of scientific researchers themselves, and expects the researchers of Japan to accomplish their tasks in accordance with the spirit of the "Charter."

CHARTER FOR SCIENTIFIC RESEARCHERS

• • •

Science enriches human life by the rational search for truth with actual evidence and also by applying the results in practical use. The search for truth in scientific research and the application of its results belong to the highest intellectual activities of human beings. Scientific researchers who are engaged in these activities are required to be sincere toward reality, exclude arbitrary decisions and keep their minds pure and strict toward truth.

It is not only the demand of human society but also the duty of scientific researchers to promote the sound development of science and the beneficial application of its results. To fulfill their duty, scientific researchers are required to act upon the following five points:

1. To be conscious of the significance and aim of his or her own research and to contribute to the welfare of mankind and world peace.
2. To defend the freedom of scientific research and to respect originality in research and development.
3. To attach importance to the harmonious development between various fields of science and to propagate the scientific attitude and knowledge among the general public.
4. To guard against disregard and abuse of scientific research and to strive to eliminate such dangers.
5. To place great value on the international nature of scientific research and to endeavor to promote interchanges with the scientific community of the world.

Purport and Process Leading to Adoption of "Charter for Scientific Researchers"

Explanatory note by Special Committee for Promotion of Science

In January 1975, at the opening of the tenth term of the Science Council of Japan, it was decided to take up for examination a proposal for formulation of a Charter for Scientists. Deliberations on this question have continued until now.

From the time of its establishment in 1949, JSC has constantly kept the rights and responsibilities of scientists under consideration, and pledged that it will strive to contribute to world peace and the welfare of mankind, based on the conviction that science provides the foundation for a cultured and peaceful nation.

The Council has continued to deliberate important questions relating to the sciences, and has made many recommendations and issued a wide range of statements. In 1962 and again in 1976 it recommended that preparations be made for legislation of a Basic Act for Scientific Research. The purpose of such an Act would be to define the responsibility of the State for the development of scientific research in Japan, and as complementary to this, the Science Council of Japan declared by resolution, as a representative body of scientific researchers, that it would adopt a "Charter for Scientific Researchers" (provisional name) setting out the responsibility of scientists toward the general public. The "Charter" would declare that scientific researchers must be conscious of the purposes of scientific research and their own social responsibilities, and devote themselves to the sound development of scientific research such as will meet the expectations of the people; that they accept it as their responsibility to protest against any oppression of freedom of scientific research, and make clear the damage which disregard and/or abuse of science and technology would cause to human society, thus to protect the welfare of the nation and the people.

The 18th session of the UNESCO General Conference in October, 1974 adopted a Recommendation on the Status of Scientific Researchers concerned mainly with the rights and status of scientific researchers, and the 70th session of the JSC General Meeting followed this up with its renewed recommendation to the Japanese government for a Basic Act for Scientific Research, in the desire to carry into effect in this country the spirit and contents of the UNESCO Recommendation as soon as possible.

In the hope that the proposed Charter could be drafted during the Council's 10th term, discussions were taken up among the Members, and a subcommittee on a "Charter for Scientific Researchers" was established in the Special Committee for Man and Science, which also had the responsibilities of scientific researchers under consideration. First, second and third drafts of the "Charter" were submitted to scientific researchers all over Japan through the members of JCS and through various academic societies and associations, seeking their comments.

The draft of an "Appeal to Examine the Responsibilities of Scientific Researchers" was presented to the 73rd session of the General Meeting in October, 1977 during the last session of the 10th term. The need for further examination was acknowledged, and it was agreed that the drafting of the "Charter for Scientific Researchers" should be completed as soon as possible in the 11th term.

Basic deliberations during the 11th term (1978-1981) highlighted the following three targets:

(1) high evaluation of creativity, originality and foresightedness in scientific researchers

(2) respect for human dignity and awareness of social responsibility among scientific researchers

(3) emphasis on global concept and on scientific cooperation with developing countries.

On points (1) and (2), it was decided that the Special Committee for Promotion of Science should bear the main responsibility for examining basic policy, and that the draft of the "Charter for Scientific Researchers" should be prepared by the newly appointed Subcommittee within the Special Committee.

Accordingly, the Subcommittee took up the results from considerations in the Council's previous term, and examined also documents from overseas relating to charters for scientists, and literature on the status and responsibility of scientists. Further comments from Members of JSC were received through questionnaires on the requirements, character and content of the "Charter." Based on these, the first draft was completed in February, 1979 and a consensus sought among scientific researchers. The first draft was deliberated at each Division of JSC meeting in that month. Based on these investigations, the Subcommittee presented the second draft of the "Charter" to the 77th session of the general meeting held in May. After receiving opinions on the second draft and making several amendments, the Special Committee for Promotion of Science submitted a draft of the Charter for Scientific Researchers on the second day of meeting of the 79th session of the General Meeting on 24 April, 1980. Seven Members spoke in approval of the draft, which, with minor verbal modification, was then adopted unanimously.

The Science Council of Japan hereby presents the "Charter for Scientific Researchers," with its resolution to abide by it, setting out the responsibilities of scientists toward the general public, and expresses the hope that scientific researchers will carry on their tasks in the spirit of this "Charter."

NOTES

Was founded as the governmental organization representative of all Japanese scientists to promote and reflect scientific development throughout national life, industry and administration, to co-ordinate scientific research and to link scientific organizations abroad.

MEXICO

• • •

MEXICAN UNION OF ASSOCIATIONS OF ENGINEERS CODE OF ETHICS

• • •

Code of Ethics of the Mexican Engineer (UMAI)

Contributed by Araceli Solano

The Code of Mexican Professional Engineering Ethics was published July 1, 1983, and signed by the witness, the Certified Licensed Miguel de la Madrid Hurtado, Constitutional President of the United Mexican States, which is transcribed below.

CONSIDERING THAT:

1. Mexican engineers sustain their conduct with the respect and love for the fatherland.
2. Engineers in our country have achieved the practice of their profession thanks to the opportunity that the Mexican nation affords them.
3. For their preparation they have a great obligation to contribute to the satisfaction of the needs and improvement of the quality of life of the Mexican people, with the moral conviction and responsibility of sustaining a development in accordance with social justice.
4. It is a duty to foster a favorable atmosphere for the development of activity in accordance with the Code of Ethics that specifies social obligations that make possible the respect of each professional for the rest, in search of a just and harmonious human conviviality within each nation and among nations.
5. Universal principles and our greatest traditions consider as a solemn duty both international solidarity and respect for the moral values of other peoples, in particular in those places where engineers forward their education or eventually exercises their profession.
6. The diverse codes of professional ethics of colleges and associations of engineers come together on one and the same conception.
7. The Union of Mexican Engineers has acknowledged principles and norms of conduct.

The Ordinary General Assembly of UMAI adopts the following Code of Professional Ethics of the Mexican Engineer:

Engineers recognize that the greatest merit is work, for which reason they will exercise their profession committed to service to Mexican society, caring for the wellbeing and progress of the majority. When transforming nature for the benefit of humanity, engineers should augment their awareness that the world is the living space of man and that their interest in the universe is a guarantee of the triumph of the spirit and of the knowledge of reality in order to make it more just and happy. Engineers should refuse work that has as its goal a crime against the general interest; in this way they will avoid situations which implicate dangers or constitute a threat to the environment, to life, health, or other rights of the human being. It is an inescapable duty of the engineer to sustain the prestige of the profession and strive for its proper exercise; likewise, to maintain a professional conduct cemented in capability, honor, strength, moderation, magnanimity, modesty, forthrightness, and justice, with consciousness of subordinating the wellbeing of the individual to the wellbeing of society. Engineers should procure the constant perfection of their knowledge, in particular that of their profession, divulge their wisdom, share their experience, provide opportunities for the education and enablement of workers, bestow recognition, moral and material support to the educational institution where they realized their studies; in this way they will return to society the opportunities that they have received. It is the responsibility of engineers that their work be realized with efficiency and aid to legal dispositions. In particular, they will ensure the fulfillment of the norms of protection of workers established in Mexican labor legislation. In the exercise of their profession, engineers must fulfill with diligence the commitments that they have assumed and will develop with dedication and loyalty the jobs assigned to them, avoiding putting personal interests first in the attention to the matters that are entrusted to them, or colluding in order to exercise disloyal competition to the detriment of those who received their services. They will observe decorous conduct, treating with respect, diligence, impartiality, and rectitude the persons with whom they have a relation, particularly their collaborators, abstaining from deviance and abuses of authority and from disposing or authorizing a subordinate to illicit conduct, such as unduly favoring third parties. Engineers must safeguard the interests of the institution or person for whom they are working and make good use of the resources that have been assigned to them for the undertaking of their work. They will fulfill the orders that in the exercise of their powers their superiors dictate to them, will respect and make respected their position and work; if they disagree with their superiors they will have the obligation to manifest before them the reasons for their disagreement. Engineers will have as a norm the creation and promotion of national technology; they will take special care to ensure that the transfer of technology adapted to our conditions conforms to the established legal framework. It is obligatory to keep as a professional secret the confidential data that they learn in the exercise of their profession, except when they might be required by a competent authority.

TRANSLATED BY JAMES A. LYNCH

NEW ZEALAND THE INSTITUTION OF ENGINEERS CODE OF ETHICS

• • •

P.O. Box 12241101
Molesworth Street
Wellington,
New Zealand

Founded: 1914
Members: 6,047

Code of Ethics

Protection of Life and Safeguarding People: Members have a duty of care to protect life and to safeguard people.

Guidelines

To satisfy this clause you need to:

1.1 Give priority to the safety and well-being of the community and have regard to this principle in assessing duty to clients and colleagues.

1.2 Be responsible for ensuring that reasonable steps are taken to minimize the risk of loss of life, injury or suffering which may result from the work or the effects of your work.

1.3 Draw the attention of those affected to the level and significance of risk associated with the work.

1.4 Assess and minimize potential dangers involved in the construction, manufacture and use of your products or projects.

Professionalism and Integrity

Members shall undertake their duties with professionalism and integrity and shall work within their levels of competence.

Guidelines

To satisfy this clause you need to:

2.1 Exercise initiative, skill and judgment to the best of your ability for the benefit of your employer or client.

2.2 Give engineering decisions, recommendations or opinions that are honest, objective and factual. If these are ignored or rejected you should ensure that those affected are made aware of the possible consequences.

In particular, where vested with the power to make decisions binding on both parties under a contract between principal and contractor, act fairly and impartially as between the parties and (after any appropriate consultation with the parties) make such decisions independently of either party in accordance with your own professional judgment.

2.3 Accept personal responsibility for work done by you or under your supervision or direction and take reasonable steps to ensure that anyone working under your authority is both competent to carry out the assigned tasks and accepts a like personal responsibility.

2.4 Ensure you do not misrepresent your areas or levels of experience or competence.

2.5 Take care not to disclose confidential information relating to your work or knowledge of your employer or client without the agreement of those parties.

2.6 Disclose any financial or other interest that may, or may be seen to, impair your professional judgment.

2.7 Ensure that you do not promise to, give to, or accept from any third party anything of substantial value by way of inducement.

2.8 First inform another member before reviewing their work and refrain from criticizing the work of other professionals without due cause.

2.9 Uphold the reputation of the Institution and its members, and support other members as they seek to comply with the Code of Ethics.

2.10 Follow a recognized professional practice (Model Conditions of Engagement are available) in communicating with your client on commercial matters.

Society and Community Well-Being

Members shall actively contribute to the well-being of society and, when involved in any engineering project or application of technology, shall, where appropriate, recognize the need to identify, inform and consult affected parties.

Guidelines

To satisfy this clause you need to:

3.1 Apply skill, judgment and initiative to contribute positively to the well-being of society.

3.2 Recognize in all your work your obligation to anticipate possible conflicts and endeavor to resolve them responsibly, and where necessary utilize the experience of the Institution and colleagues for guidance.

3.3 Treat people with dignity and have consideration for the values and cultural sensitivities of all groups within the community affected by your work.

3.4 Endeavour to be fully informed about relevant public policies, community needs, and perceptions, which affect your work.

3.5 As a citizen, use your knowledge and experience to contribute helpfully to public debate and to community affairs except where constrained by contractual or employment obligations.

Sustainable Management and Care of the Environment

Members shall be committed to the need for sustainable management of the planet's resources and seek to minimize adverse environmental impacts of their engineering works or applications of technology for both present and future generations.

Guidelines

To satisfy this clause you need to:

4.1 Be committed to the efficient use of resources.

4.2 Minimize the generation of waste and encourage environmentally sound reuse, recycling and disposal.

4.3 Recognize adverse impacts of your work on the environment and seek to avoid or mitigate them.

4.4 Recognize the long-term imperative of sustainable management throughout your work. (Sustainable Management is often defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs).

Promotion of Engineering Knowledge

Members shall continue the development of their own and the profession's knowledge, skill and expertise in the art and science of engineering and technology, and shall share and exchange advances for the benefit of society.

Guidelines

To satisfy this clause you need to:

5.1 Seek and encourage excellence in your own and others' practice of the art and science of engineering and technology.

5.2 Contribute to the collective wisdom of the profession and art of engineering and technology in which you practice.

5.3 Improve and update your understanding of the science and art of engineering and technology and encourage the exchange of knowledge with your professional colleagues.

5.4 Wherever possible share information about your experiences and in particular about successes and failures.

NOTES

Approved by Council 5 July 1996.

NORWAY

• • •

ASSOCIATION OF NORWEGIAN CIVIL ENGINEERS CODE OF ETHICS

• • •

RELATION OF THE CIVIL ENGINEER TO SOCIETY

• • •

1. In their professional work, the members shall promote a community-oriented and harmonious technical and industrial development.
2. The members shall execute their work according to sound technical principles. Proper consideration must be given to economic and human factors, to the influence of the work on the environment and the community, and to other demands dictated by circumstances.
3. Professional (technical) questions must be dealt with in a factual and objective manner. The members must attempt to give the public a correct understanding of technical matters and to counteract erroneous conceptions.

RELATION OF CIVIL ENGINEER TO EMPLOYER AND CLIENT

• • •

1. The members shall protect the interests of their employers and clients in matters which have been entrusted to them, as long as this does not contradict general ethical fundamental principles.
2. The members are not allowed to receive compensation from anypartner in a group-deal unless all other partners are also aware of this. The members must not use their professional position to obtain personal advantages.

RELATION OF CIVIL ENGINEER TO COLLEAGUES AND CO-WORKERS

• • •

1. The members shall protect the professional reputation of their colleagues and co-workers against unfair criticism, slander, or false accusations. They should contribute to the fact that whosoever has executed a technical assignment should also receive the acknowledgement and compensation for this.
2. The members should not engage in disloyal competition. The rightful ownership of others with regard to plans, drawings, ideas, inventions, etc., should be respected.
3. A member is not allowed to take over a position after a colleague if there is reason to believe that the latter was unfairly dismissed or in some other manner deprived of his work for reasons which contradict the general ethical fundamental principles.
4. A member is not allowed to take over an assignment which has been entrusted to a colleague without first informing the latter and without ascertaining that there are reasonable grounds for the client's solicitation.
5. Members are not allowed to advertise their activities or to offer their services in an unworthy or misleading manner or to attempt to obtain assignments with improper methods.

TRANSLATED BY BIRGITTA D. KNUTTGEN

NOTES

This code is promulgated by means of a one-page typewritten and photocopied document.

An introductory note states that the code was "passed by the Board of Governors of the NIF [Norwegian Civil Engineers Association] on June 26, 1970, as a supplement to paragraph 8, point 1, of the statutes."

PAKISTAN

• • •

THE INSTITUTION OF ENGINEERS CODE OF ETHICS

• • •

Engineering Centre
Gulberg - III
Lahore, Pakistan

Founded: 1948

Professional Ethics and Code of Conduct

ARTICLE 1

To maintain, uphold and advance the honor and dignity of the engineering profession in accordance with this Code, a member shall:

(a) uphold the Ideology of Pakistan;

(b) be honest, impartial and serve the country, his employer, clients and the public at large with devotion;

(c) strive to increase the competence and prestige of the engineering profession;

(d) use his knowledge and skill for the advancement and welfare of mankind;

(e) promote and ensure the maximum utilization of human and material resources of Pakistan for achieving self-reliance; and

(f) not sacrifice the national interest for any personal gain.

ARTICLE 2

(1) A member shall be guided in all professional matters by the highest standards of integrity and act as a faithful agent or a trustee for each of his client and employer.

(2) A member shall:

(a) be realistic and honest in all estimates, reports, statements, and testimony and shall carry out his professional duties without fear or favor;

(b) admit and accept his own errors when proved and shall refrain from distorting or altering the facts justifying his decision or action;

(c) advise his client or employer honestly about the viability of the project entrusted to him;

(d) not accept any other employment to the detriment of his regular work or interest without the consent of his employer;

(e) not attempt to attract an engineer from another employer by false or misleading pretenses;

(f) not restrain an employee from obtaining a better position with another employer; and

(g) not endeavor to promote his personal interest at the expense of the dignity and integrity of the profession.

ARTICLE 3

A member shall have utmost regard for the safety, health, and welfare of the public in the performance of his professional duties and for that purpose he shall:

(a) regard his duty to the public welfare as paramount;

(b) seek opportunities to be of service in civic affairs and work for the advancement of the safety, health, and well-being of the community;

(c) not undertake, prepare, sign, approve, or authenticate any plan, design or specifications which are not safe for the safety, health, and welfare of a person or persons, or are not in conformity with the accepted engineering standards and if any client or an employer insists on such unprofessional conduct, he shall notify the authorities concerned and withdraw from further service on the project; and

(d) point out the consequences to his client or the employer if his engineering judgment is overruled by any non-technical person.

ARTICLE 4

(1) A member shall avoid all acts or practices likely to discredit the dignity or honor of the profession and for that purpose he shall not advertise his professional services in a manner derogatory to the dignity of the profession. He may, however, utilize the following means of identification:

(i) professional cards and listing in recognized and dignified publications and classified section of the telephone directories;

(ii) sign boards at the site of his office or projects for which he renders services; and

(iii) brochures, business cards, letterheads, and other factual representations of experience, facilities, personnel and capacity to render services.

(2) A member shall write articles for recognized publications but such articles should be dignified, free from ostentations or laudatory implications, based on factual conclusions and should not imply other than his direct participation in the work described unless credit is given to others for their share of the work.

(3) A member shall not allow himself to be listed for employment using exaggerated statements of his qualifications.

ARTICLE 5

(1) A member shall endeavor to extend public knowledge and appreciation of the engineering profession, propagate the achievements of the profession and protect it from misrepresentation and misunderstanding.

ARTICLE 6

(1) A member shall express an opinion of an engineering subject only when founded on adequate knowledge, experience, and honest conviction.

ARTICLE 7

(1) A member shall undertake engineering assignments only when he possesses adequate qualifications,

training, and experience. He shall engage or advise for engaging of the experts and specialists whenever the client's or employer's interests are best served by the service.

(2) A member shall not discourage the necessity of other appropriate engineering services, designs, plans, or specifications or limit-free competition by specifying materials of particular make or model.

ARTICLE 8

(1) A member shall not disclose confidential information concerning the business affairs or technical processes of any present or former client or employer without his consent.

ARTICLE 9

(1) A member shall uphold the principles of appropriate and adequate compensation for those engaged in engineering work and for that purpose he shall not:

(a) undertake or agree to perform any engineering service free except for civic, charitable, religious, or non-profit organizations or institutions;

(b) undertake professional engineering work at a remuneration below the accepted standards of the profession in the discipline; and

(c) accept remuneration from either an employee or employment agency for giving employment.

(2) A member shall offer remuneration in accordance with the qualifications and experience of an engineer employed by him.

(3) A member working in any sales section or department shall not offer or give engineering consultation, designs, or advice, other than specifically applying to the equipment being sold in that section or department.

ARTICLE 10

(1) A member shall not accept compensation, financial, or otherwise, from more than one party for the same service, or for services pertaining to the same work unless all interested parties give their consent to such compensation.

(2) A member shall not accept:

(a) financial or other considerations, including free engineering design, from material or equipment suppliers for specifying their products; and

(b) commissions or allowances, directly or indirectly from contractors or other parties dealing with his clients or employer in connection with work for which he is professionally responsible.

ARTICLE 11

(1) A member shall not compete unfairly with another member or engineer by attempting to obtain employment, professional engagements or personal gains by taking advantage of his superior position or by criticizing other engineers or by any other improper means or methods.

(2) An engineer shall not attempt to supplant another engineer in a particular employment after becoming aware that definite steps have been taken towards other's employment.

(3) A member shall not accept part-time engineering work at a fee or remuneration less than that of the recognized standard for a similar work and without the consent of his employer if he is already in another employment.

(4) A member shall not utilize equipment, supplies, laboratory, or office facilities of his employer or client for the purpose of private practice without his consent.

ARTICLE 12

(1) A member shall not attempt to injure, maliciously or falsely, directly or indirectly, the professional reputation, prospects, practices, or employment of another engineer or member.

(2) A member engaged in private practice shall not review the work of another engineer for the same client, except with knowledge of such engineer or, unless the connection of such engineer with the work has been terminated; provided that a member shall be entitled to review and evaluate the work of other engineers when so required by his employment duties.

(3) A member employed in any sales or industrial concern shall be entitled to make engineering comparisons of his products with products of other suppliers.

ARTICLE 13

(1) A member shall not associate with or allow the use of his name by an enterprise of questionable character; nor will he become professionally associated with engineers who do not conform to ethical practices or with persons not legally qualified to render the professional services for which the association is intended.

(2) A member shall strictly comply with the bye-laws, orders, and instructions issued by the Institution of Engineers (Pakistan) from time to time in professional practice and shall not use the association with a non-engineering corporation, or partnership as a cloak for any unethical act or acts.

ARTICLE 14

(1) A member shall give credit for engineering work to those to whom credit is due, recognize the proprietary interests of others and disclose the name of a person or persons who may be responsible for his designs, inventions, specifications, writings, or other accomplishments.

(2) When a member uses designs, plans, specifications, data, and notes supplied to him by a client or an employer or are prepared by him in reference to such client or the employer's work such designs, plans, specifications, data, and notes shall remain the property of the client and shall not be duplicated by a member for any use without the express permission of the client.

(3) Before undertaking any work on behalf of a person or persons for making improvements, plans, designs, inventions, or specifications which may justify copyright or patent, a member shall get ownership of such improvements, plans, designs, inventions, or specifications determined for the purpose of registration under the relevant copyright and patent laws.

ARTICLE 15

(1) A member shall disseminate professional knowledge by interchanging information and experience with other members or engineers and students to provide them opportunity for the professional development and advancement of engineers under his supervision.

(2) A member shall encourage his engineering employees to improve their knowledge, attend and present papers at professional meetings, and provide a prospective engineering employee with complete information on working conditions and his proposed status of employment and after employment keep him informed of any change in such conditions.

ARTICLE 16

A member employed abroad shall order his conduct according to this Code, so far as this is applicable, and the laws and regulations of the country of his employment.

ARTICLE 17

A member shall report unethical professional practices of an engineer or a member with substantiating data to the Institution of Engineers (Pakistan) as a witness, if required.

NOTES

This code is published in a booklet entitled The Institution of Engineers, Pakistan: Revised Constitution and By-Laws (Lahore, Pakistan: The Institution of Engineers, Pakistan, 1981). The booklet contains 88 numbered pages.

Part I, "Constitution," covers pp. 1-24. Part II, "By-Laws," as amended by the 174th Central Council Meeting held at Karachi 28-29 August 1980, covers pp. 28-81. This second part includes, as chapter II, "Membership," section 17 (last section), the "Professional Ethics and Code of Conduct" (pp. 35-42).

The code itself is prefaced with the statement that "The following Code of Conduct has been approved by the Central Council which shall apply to all members of the Institution of Engineers (Pakistan). This Code of Conduct is identical to the Code of Conduct approved by the Pakistan Engineering Council for its members."

The Institution of Engineers, Pakistan, is the successor to The Institution of Engineers, India, as a result of the independence and partition of these two countries. In the words of the "Preamble" of the Constitution: "whereas the Institution of Engineers (India) registered under the Indian Companies Act 1913 and incorporated by the Royal Charter 1935 existing immediately before the 14th of August, 1947 had its jurisdiction throughout India, has now its jurisdiction limited within the territory under the sovereignty of the Government of the Republic of India and had/has no successor other than 'The Institute of Engineers, Pakistan' anywhere within the territory forming Pakistan . . . 'The Institute of Engineers, Pakistan' is and shall be entitled to all rights or interests as might have accrued to or as might have deemed to accrue to the same as duly and legally constituted successor of 'The Institution of Engineers, India' in Pakistan" (pp. 1-2).

As the "Preface" notes, there was a further reorganization of the Institution of Engineers, Pakistan, in 1973 as a result of "the separation of East Pakistan" (p. vii).

SINGAPORE

• • •

THE INSTITUTION OF ENGINEERS, SINGAPORE CODE OF ETHICS

• • •

Rules for Professional Conduct

These rules shall apply to all forms of engineering employment, and for the purpose of these Rules the term "Employer" shall include the term "Client".

All members of the Institution are enjoined to conform with the letter and the spirit of the Rules set out hereunder.

(1) A member, in his responsibility to his Employer and to the profession, shall have full regard to the public interest.

(2) A member shall order his conduct so as to uphold the dignity, standing, and reputation of the profession.

(3) A member shall discharge his duties to his Employer with complete fidelity.

In whatever capacity he is engaged, he shall assiduously apply this skill and knowledge in the interests of his Employer. If he is confronted by a problem which calls for knowledge and experience which he does not possess, he shall not hesitate to inform his Employer of the fact, and shall make an appropriate recommendation as to the desirability of obtaining further advice. He shall not accept remuneration for services rendered other than from his Employer or with his Employer's permission.

(4) If called upon to give evidence or otherwise to speak on a matter of fact, he shall speak what he believes to be the truth, irrespective of its effect on his own interest, the interests of other Engineers, or other sectional interest.

(5) A member shall not maliciously or recklessly injure or attempt to injure, whether directly or indirectly, the professional reputation, prospects, or business of another Engineer.

Unless he is convinced that his duty to the public or his employer compels him to do so, he shall not express opinions which reflect on the ability or integrity of another Engineer.

(6) A member shall not improperly canvass or solicit professional employment nor offer to make by way of commission or otherwise payment for the introduction of such employment.

(7) A member shall not, in self-laudatory language in any manner derogatory to the dignity of the profession, advertise or write articles for publication, nor shall he authorize such advertisements to be written or published by any other person.

(8) A member, without disclosing the fact to his Employer in writing, shall not be a director of nor have substantial financial interest in, nor be agent for any company, firm or person carrying on any contracting, consulting or manufacturing business which is or may be involved in the work to which his employment relates; nor shall he receive directly or indirectly any royalty, gratuity or commission on any article or process used in or for the purpose of the work in respect of which he is employed unless or until such royalty, gratuity, or commission has been authorized in writing by his Employer.

He shall not report upon or make recommendation on any tender from a company or firm in which he has any substantial interest or on tenders which include such a tender unless specifically requested to do so in writing by his Employer. In this case, he shall maintain an attitude of complete impartiality.

(9) A member shall not use the advantages of a salaried position to compete unfairly with Engineers in private practice to the detriment of salaried engineers.

(10) A member who shall be convicted by a competent tribunal of a criminal offence which in the opinion of the disciplinary body renders him unfit to be a member shall be guilty of improper conduct.

(11) A member shall not, directly or indirectly, attempt to supplant another Engineer; nor shall he intervene or attempt to intervene in or in connection with engineering work of any kind which to his knowledge has been entrusted to another Engineer.

(12) A member shall not be the medium of payments made on his Employer's behalf unless so requested by his Employer; nor shall he in connection with work on which he is employed place contracts or orders except with the authority of and on behalf of his Employer.

(13) When in a position of authority over other Engineers, he shall take every care to afford to those under his direction every reasonable opportunity to advance their knowledge and experience.

He shall ensure that proper credit is given to any subordinate who has contributed in any material way to work for which he is responsible.

(14) A member shall not use for his personal gain or advantage, nor shall he disclose, any confidential information which he may acquire as a result of special opportunities arising out of work for his employer.

(15) In the preparation of plans, specification and contract documents, and on the supervision of construction work, a member shall assiduously watch and conserve the interests of his employer. However, in the interpretation of contract documents, he shall maintain an attitude of scrupulous impartiality as between his employer on the one hand, and the contractor on the other, and shall, as far as he can, ensure that each party in the contract shall discharge his respective duties and enjoy his respective rights as set down in the contract agreement.

SRI LANKA THE INSTITUTION OF ENGINEERS CODE OF ETHICS

• • •

120/15 Wijerama Mawatha
Colombo 7, Sri Lanka

BY-LAWS–APPENDIX I

• • •

1989

• • •

FORWARD

The need for professional ethics is recognized in most professions and the by-laws of the Institution of Engineers, Sri Lanka, require its members to observe certain rules of conduct.

This Code was approved by the General Membership at the Annual General Meeting held on 31st October, 1989.

For society to recognize the integrity and to trust the judgment of engineers they are required to comply with the Code of Ethics set out in this booklet.

Members acting in accordance with this Code would create an image that would stand out as a beacon of competence as well as of uprightness and integrity.

D.G. SENADHIPATHY, PRESIDENT 1990/91
1st March, 1991

CODE OF ETHICS

• • •

Clause 1. Engineers shall hold paramount the safety, health and welfare of the public and proper utilization of funds in the performance of their professional duties. It shall take precedence over their responsibility to the profession, to sectional or private interests, to employers or to other Engineers.

Clause 2. Engineers shall always act in such a manner as to uphold and enhance the honor, integrity and dignity of the profession while safeguarding public interest at all times.

Clause 3. Engineers shall build their reputation on merit and shall not compete unfairly.

Clause 4. Engineers shall perform professional services only in the areas of their competence.

Clause 5. Engineers shall apply their skills and knowledge in the interest of their employer or client for whom they shall act, in professional matters, as faithful agents or trustees, so far as they do not conflict with the other requirements listed here and the general public interest.

Clause 6. Engineers shall give evidence, express opinions or make statements in an objective and truthful manner.

Clause 7. Engineers shall continue their professional development throughout their careers and shall actively assist and encourage engineers under their direction to advance their knowledge and experience.

RULES

• • •

Clause 1

Engineers shall hold paramount the safety, health and welfare of the public and proper utilization of the funds in the performance of their professional duties. It shall take precedence over their responsibility to the profession, sectional or private interests, to employers or to other engineers.

As the first requirement places the interests of the community above all other, Engineers—

Rule 1.1 shall be objective and truthful in professional reports, statements or testimony. They shall include all relevant and pertinent information in such reports, statements or testimony.

Rule 1.2 shall endeavor at all times to maintain engineering services essential to public welfare.

Rule 1.3 shall work in conformity with recognized engineering standards so as not to jeopardize the public welfare, health or safety.

Rule 1.4 shall not participate in assignments that would create conflict of interest between their clients or employers, and the public.

Rule 1.5 shall, in the event of their judgment being overruled in matters pertaining to welfare, health or safety of the community, inform their clients or employers of the possible consequences and bring to their notice their (Engineers') obligations as professionals to inform the relevant authority.

Rule 1.6 Shall contribute to public discussion on engineering matters in their areas of competence if they consider that by so doing they can constructively advance the well-being of the community.

Rule 1.7 having knowledge of any alleged violation of this Code shall co-operate with the proper authorities in furnishing such information or assistance as may be required.

Rule 1.8 shall not knowingly participate in any act which will result in waste or misappropriation of public funds.

Clause 2

Engineers shall always act in such a manner as to uphold and enhance the honor, integrity and dignity of the profession while safeguarding public interest at all times.

This requires that the profession should endeavor by its behavior to merit the highest esteem of the community. It follows therefore that engineers—

Rule 2.1 shall not involve themselves with any business or professional practice which they know to be fraudulent or dishonest in nature.

Rule 2.2 shall not use association with other persons, corporations or partnerships to conceal unethical acts.

Rule 2.3 shall not continue in partnership with, or act in professional matters with any engineer who has been removed from membership of this Institution because of improper conduct.

Clause 3

Engineers shall build their reputation on merit and shall not compete unfairly.

This requirement is to ensure that engineers shall not seek to gain a benefit by improper means. It follows that engineers—

Rule 3.1 shall neither pay nor offer, directly or indirectly, inducements including political contribution.

Rule 3.2 shall promote the principle of engagement of engineers upon the basis of merit. They shall uphold the principle of adequate and appropriate remuneration for professional engineering staff and shall give due consideration to terms of engagement which have the approval of the Professional's appropriate association.

Rule 3.3 shall not attempt to supplant another engineer, employed or consulting, who has been appointed.

Rule 3.4 shall neither falsify nor misrepresent their own or their associate's qualifications, experience and prior responsibilities.

Rule 3.5 shall not maliciously do anything to injure, directly, or indirectly, the reputation, prospects or business of other.

Rule 3.6 shall not use the advantage of a privileged position to compete unfairly with other engineers.

Rule 3.7 shall exercise due restraint in explaining their own work and shall refrain from unfair criticism of the work of other engineers.

Rule 3.8 shall give proper credit for professional work to those to whom credit is due and acknowledge the contribution of subordinates and others.

Clause 4

Engineers shall perform professional services only in the areas of their competence.

To this end engineers—

Rule 4.1 shall undertake assignments only when qualified by education and experience in the specific technical fields involved. If an assignment requires qualification and experience outside their fields of competence they shall engage competent professionals with necessary qualifications and experience and keep the employers and clients informed of such arrangements.

Rule 4.2 shall not affix their signature to any plans or documents dealing with subject matter in which they lack competence, or to any plan or document not prepared under their direction or control.

Clause 5

Engineers shall apply their skills and knowledge in the interest of their employer or client for whom they shall act, in professional matters, as faithful agents or trustees, so far as they do not conflict with other requirements listed here and the general public interest.

It follows that engineers—

Rule 5.1 shall at all times avoid all known or potential conflicts of interest. They should keep their employees or clients dully informed on all matters, including financial interests, which could lead to such a conflict, and in no circumstances should they participate in any decision which could involve them in conflict of interest.

Rule 5.2 shall when acting as administrators of a contract be impartial as between the parties in the interpretation of the contract.

Rule 5.3 shall not accept compensation, financial or otherwise from more than one party for services on the same project, unless the circumstances are fully disclosed and agreed to, by all interested parties.

Rule 5.4 shall neither solicit nor accept financial or other valuable consideration, including free engineering designs, from material or equipment suppliers for specifying their products (except such designs obtained with the knowledge and consent of the employer or client).

Rule 5.5 shall neither solicit nor accept gratuities, directly or indirectly from contractors or their agents, or other parties dealing with their clients or employers in connection with work for which they are responsible.

Rule 5.6 Shall advise their clients or employers when as a result of their studies they believe that a project will not be viable.

Rule 5.7 Shall neither disclose nor use confidential information gained in the course of their employment without express permission (except where public interest and safety are involved).

Rule 5.8 shall not complete, sign, or seal plans and/or specifications that are not of a design safe to the public health and welfare and in conformity with accepted engineering standards. If the client or employer insists on such unprofessional conduct, they shall notify the proper authorities and withdraw from further service on the project.

Clause 6

Engineers shall give evidence, express opinion or make statements in an objective and truthful manner.

It follows that—

Rule 6.1 engineers' professional reports, statements or testimony before any tribunal shall be objective and such opinions shall be expressed only on the basis of adequate knowledge and technical competence in the area, but this does not preclude a considered speculation based intuitively on experience and wide relevant knowledge.

Rule 6.2 engineers shall reveal the existence of any interest, pecuniary or otherwise that could be taken to effect their judgment in a technical matter about which they are making a statement or giving evidence.

Clause 7

Engineers shall continue their professional development throughout their careers and shall actively assist and encourage engineers under their direction to advance their knowledge and experience.

The requirement here is that engineers shall strive to widen their knowledge and improve their skill in order to achieve a continuing improvement of the profession. It follows therefore that engineers—

Rule 7.1 shall encourage their professional employees and subordinates to further their education, and

Rule 7.2 shall take a positive interest in and encourage their fellow engineers actively to support the Institution and other professional engineering bodies which further the general interest of the profession.

GUIDE LINES FOR PROFESSIONAL CONDUCT

• • •

1. Engineers shall be guided in all their professional relations by the highest standards of integrity.

   a. Engineers shall admit and accept their own errors when proven wrong and refrain from distorting or altering the facts in an attempt to justify their decision.

   b. Engineers shall advise their clients or employers when they believe a project will not be successful

   c. Engineers shall not accept assignments outside their employment to the detriment of their regular work or interest. Before accepting any assignments outside their employment they will notify their employers and obtain their prior permission.

2. Engineers shall at all times strive to serve the public interest.

   a. Engineers shall seek opportunities to be of constructive service in civil affairs and work for the advancement of the safety, health and well being of their community.

   b. In public or private sector employment engineers shall refrain from participating knowingly in any act that will result in waste or misappropriation of employers funds.

   3. Engineers shall refrain from all conduct or practice which is likely to discredit the profession or deceive the public.

   a. Engineers shall refrain from using statements containing material misrepresentation of fact, or omitting material fact.

   b. Engineers shall refrain from showmanship, or self-laudation or from attempting to attract clients thereby and making derogatory statements about others. Consistent with the foregoing Engineers may advertise for recruitment of personnel.

   c. Consistent with the foregoing: Engineers may publish articles in the press or in technical journals but such articles shall not imply credit to the author for work performed by other.

4. Engineers shall not disclose confidential information concerning the business affairs or technical processes of employers without their consent.

5. Engineers shall not be influenced in their professional duties by conflicting interests.

   a. Engineers shall not accept financial or other consideration, from material or equipment suppliers for specifying their product.

   b. Engineers shall not accept commissions or allowances, directly or indirectly from contractors or other parties in connection with work for which the Engineer is responsible.

   c. Consistent with the foregoing Engineers may publish articles in the press on in technical journals but such articles shall not imply credit to the author for work performed by other.

6. Engineers shall uphold the principle of appropriate and adequate compensation for those engaged in engineering work.

   a. Engineers shall not accept remuneration from either an employee or employment agency for giving employment.

   b. Engineers, when employing other engineers, shall offer a salary according to professional qualifications, experience and recognized standards.

7. Engineers shall not compete unfairly with other engineers to obtain employment or advancement in employment or in seeking professional engagements by taking advantage of their position, by criticizing other engineers, or by other improper or questionable means.

   a. Engineers shall not request, propose, or accept a professional commission under circumstances in which their professional judgment may be compromised.

   b. Engineers in salaried position shall accept part-time engineering work only with the expressed permission of the employer and at recognized rates for such work.

   c. Engineers shall not use equipment, supplies, laboratory, or office facilities of an employer to carry out outside private work without the consent of the employer.

8. Engineers shall not attempt to injure, maliciously or falsely, (directly or indirectly) the professional reputation, prospects practice or employment of other engineers, nor indiscriminately criticize other engineers' work. Engineers who believe others are guilty of unethical or illegal practice shall present such information to the proper authority for action.

   a. Engineers in private practice shall not review the work of another engineer for the same client, except with the knowledge of such engineer, or unless the connection of such engineer with the work has been terminated for un-ethical practices.

   b. Engineers in governmental, industrial or educational employ are entitled to review and evaluate the work of other engineers when so required by their employers.

   c. Engineers in sales or industrial employ shall not criticize products of other manufactures which are similar to their own.

9. Engineers shall accept personal responsibility for their professional activities.

   a. Engineers shall conform with state registration laws in the practice of engineering.

   b. Engineers shall not use association with a non-engineer, a corporation, or partnership, as a "cloak" for unethical acts, but must accept personal responsibility for their own professional acts.

10. Engineers shall give credit for engineering work of other engineers to whom credit is due, and will recognize the proprietary interests of others.

    a. Engineers shall, when possible, name the person or persons who may be individually responsible for designs, inventions, writings, or other accomplishments.

    b. Engineers using designs supplied by client shall recognize that the designs remain the property of the client and shall not be duplicated by the Engineer for others without expressed permission.

    c. Engineers, before undertaking work for others which may result in the engineers producing inventions, plans, designs, improvements or other such, which may justify copyrights or patents, should enter into a position agreement regarding ownership.

    d. Engineers' designs, data, records, and notes referring exclusively to an employer's work shall not be sued for another client unless with the expressed permission of the employer for whom such work was carried out.

11. Engineers shall cooperate in extending the effectiveness of the profession by interchanging information and experience with other Engineers and Students, and will endeavor to provide opportunity for the professional development and advancement of engineers under their supervision.

    a. Engineers shall encourage Engineer employees' efforts to improve their education.

    b. Engineers shall encourage Engineer employees to attend and present papers at professional and technical society meetings.

    c. Engineers shall urge Engineer employees to become registered engineers at the earliest possible date.

    d. Engineers shall assign a professional engineer duties of a nature to utilize his full training and experience, in so far as is possible, and delegate lesser functions to sub-professionals or to technicians.

    e. Engineers shall provide a prospective employee with complete information on working conditions and proposed status of employment, and after engaging will keep such employees informed of any proposed changes.

SWEDEN

• • •

SWEDISH FEDERATION OF CIVIL ENGINEERS CODE OF ETHICS

• • •

Code of Honor for Civil Engineers

1. The civil engineer should feel, while practicing his profession, a personal responsibility that technology will be utilized in a fashion which benefits humanity, the environment, and society.
2. The civil engineer should strive to improve technology and technical expertise in the direction of a more efficient utilization of resources without detrimental side effects.
3. The civil engineer should be prepared to share his knowledge in public and private contexts in order to reach the best possible basis for a decision and to illustrate the capacities and the risks of technology.
4. The civil engineer should not work within or collaborate with corporations or organizations of a questionable character or ones whose goals are in conflict with the civil engineer's personal convictions.
5. The civil engineer should show complete loyalty to employers and co-workers. Any difficulties in this respect should be dealt with in an open discussion and, first of all, at the place of work.
6. The civil engineer is not permitted to use improper methods in the competition for employments, assignments, or commissions and, furthermore, must not attempt to damage the reputation of colleagues through unjustified accusations.
7. The civil engineer should respect the confidential nature of especially entrusted information, as well as the rights of others with regard to ideas, inventions, research, plans, and designs.
8. The civil engineer is not allowed to favor unauthorized interests and should openly account for financial and other interests that could affect the trust in his impartiality and judgment.
9. The civil engineer should, privately and in public, in speech and in writing, strive for an objective mode of presentation and avoid incorrect, misleading, or exaggerated statements.
10. The civil engineer should actively support colleagues who find themselves in trouble because of actions of the kind described in these rules and should prevent any violations against the rules, according to his best judgment.

TRANSLATED BY BIRGITTA D. KNUTTGEN

NOTES

This code is promulgated by means of a one-page document with a simple double-line border suitable for framing. As a kind of preface to the code it includes the following statement:

Technology and the natural sciences are powerful tools in the service of humankind, for better and for worse. They have thoroughly transformed society and will continue to have a profound effect on humankind also in the future.

The civil engineers are the bearers and managers of technical knowledge. Therefore, they are also given the special responsibility of ensuring that technology will be used in the best interests of society and humankind and that it will be transferred to future generations in an improved state.

In 1929, the Swedish Technological Association established a Code of Honor. The developments in society and technology have warranted a revision of the code. To provide support for the personal decision-making of a civil engineer with regard to ethical considerations, The Swedish Federation of Civil Engineers, on the 15th of November, 1988, established the following.

SWITZERLAND

SWISS TECHNICAL ASSOCIATION CODE OF ETHICS

Swiss Technical Association Honor Code

With reference to your inquiry of 10 April 1990, we regret to inform you that our association has not adopted an actual honor code. On the other hand, we have a so-called Chamber of Experts (architects, engineers), whose members can be consulted for expert opinions of all kinds. The members of this chapter are subject to an honor code. We have enclosed the version currently in force.

HONOR CODE FOR STV EXPERTS

The STV Expert is committed to uphold and apply the following principles:

1. With his specialized knowledge and competence as his guide, the STV Expert safeguards the legitimate concern of his employers. He does not overestimate his own abilities.
2. The STV Expert, in fulfilling his assignments, bears in mind the dignity of his profession. He does not participate in any procedure that could be injurious to this dignity.
3. The STV Expert is committed to maintaining professional secrecy in all aspects of his assignments.
4. The STV Expert, in his capacity as expert or arbitrator, is committed to being strictly objective. Should the danger of a conflict of interest arise, he is obliged to refuse or give up his position.
5. The STV Expert accepts no remunerations or personal privileges from any third party. As the representative or advisor to an employer, he acts with complete independence.
6. The STV Expert observes the appropriate technical standards. He is obliged to constantly further his studies in order to remain at the level of expertise required by his profession.
7. The STV Expert charges the customary fee for his area of expertise.14 March 1990.

UNITED KINGDOM

INSTITUTION OF CIVIL ENGINEERS CODE OF ETHICS

1-7 Great George Street, Westminster
London SW1P 3AA, England

Founded: 1818
Royal Charter: 1828
Members: 4,500

Rules for Professional Conduct

Made by the Council on 19 March 1963, and modified in 1971, 1973 and 1982 in accordance with By-law 32.

Expressions used in these Rules shall have the meaning if any assigned to them by the By-laws, Regulations, and Rules of the Institution. These Rules apply to all forms of engineering employment, and for the purpose of these Rules the term "Employer" shall include the term "Client."

1. A member, in his responsibility to his Employer and to the profession, shall have full regard to the public interest, particularly in matters of health and safety.
2. A member shall discharge his professional responsibilities with integrity.
3. A member shall discharge his duties to his Employer with complete fidelity. He shall not accept remuneration for services rendered other than from his Employer or with his Employer's permission.
4. A member shall not maliciously or recklessly injure or attempt to injure, whether directly or indirectly, the professional reputation, prospects or business of another Engineer.
5. A member shall not improperly canvass or solicit professional employment nor offer to make by way of commission or otherwise payment for the introduction of such employment.
6. A member shall not, in self-laudatory language or in any manner derogatory to the dignity of the profession, advertise or write articles for publication, nor shall he authorize such advertisements to be written or published by any person.
7. A member, without disclosing the fact to his Employer in writing, shall not be a director of nor have a substantial financial interest in, nor be agent for any company, firm or person carrying on any contracting, consulting or manufacturing business which is or may be involved in the work to which his employment relates; nor shall he receive directly or indirectly any royalty, gratuity or commission on any article or process used in or for the purposes of the work in respect of which he is employed unless or until such royalty, gratuity or commission has been authorized in writing by his Employer.
8. A member shall not use the advantages of a salaried position to compete unfairly with other engineers.
9. A member in connection with work in a country other than his own shall order his conduct according to these Rules, so far as they are applicable; but where there are recognized standards of professional conduct, he shall adhere to them.
10. A member who shall be convicted by a competent tribunal of a criminal offence which in the opinion of the disciplinary body renders him unfit to be a member shall be deemed to have been guilty of improper conduct.
11. A member shall not, directly or indirectly, attempt to supplant another Engineer, nor shall he intervene or attempt to intervene in or in connection with engineering work of any kind which to his knowledge has already been entrusted to another Engineer.
12. A member shall not be the medium of payments made on his Employer's behalf unless so requested by his Employer, nor shall he in connection with work on which he is employed place contracts or orders except with the authority of and on behalf of his Employer.
13. A member shall afford such assistance as he may reasonably be able to give to further the Education and Training of candidates for the Profession.

NOTES

This code is promulgated in the last page of a 28-page yellow pamphlet (1985) that includes its Royal Charter, By-laws, Regulations, and Rules.

By-law 32, to which reference is made in the preliminary indication of adoption dates, reads as follows: "Without prejudice to the generality of the last preceding By-law the Council may, for the purpose of ensuring the fulfillment of this requirement, make, amend, and rescind Rules to be observed by Corporate and Non-Corporate Members, with regard to their conduct in any respect which may be relevant to their position or intended position as members of the Institution and may publish directions or pronouncements as to specific conduct which is to be regarded as proper or as improper (as the case may be)."

The current SCET (Institution of Civil Engineers and Technicians) code is a result of past mergers with other professional organizations, i.e. in 1984 with The Institution of Municipal Engineers and again in 1989 with The Society of Civil Engineering Technicians and the Board of Incorporated Engineers and Technicians.

INSTITUTION OF MECHANICAL ENGINEERS CODE OF ETHICS

• • •

1 Birdcage Walk, Westminster
London SW1H 9JJ, England

Founded: 1847
Members: 78,000

PROFESSIONAL CODE OF CONDUCT

• • •

1. INTRODUCTION

The Institution of Mechanical Engineering as a learned body has three main functions: to promote the development of mechanical engineer, to govern the qualifications of its members, and to control their professional conduct. This leaflet, issued by the Professional Affairs Board of the Institution is concerned with the third of these functions and its surrounding circumstances. In this connection members are also referred to other relevant guides issued by the Institution, viz: Health & Safety at Work, Professional Engineers and Trade Unions (PAB 2/83) Guide for Consultancy and Product Liability.

2. CLASSES OF MEMBERSHIP

Under By-Law 2, the membership is divided into Corporate Members, (those entitled to be heard and vote at annual, ordinary, and special meetings) and Non-Corporate Members (with no such privileges except at ordinary meetings where they may be heard on mechanical engineering or allied subjects). The former group consists of three classes of persons viz:

Fellows

Members

The latter group (Non-Corporate Members) consists of six classes of persons viz:

Honorary Fellows who when elected Honorary Fellows were not already Corporate Members.

Companions

Associates

Associate Members

Graduates

Students

3. ABBREVIATED TITLES AND DESCRIPTION OF MEMBERSHIP (BY-LAW 6)

Corporate members may abbreviate their titles to Hon-FIMechE, FIMechE, or MIMechE as applicable, while Non-Corporate members may not use abbreviated titles except Honorary Fellows (Hon FIMechE) and Associate Members (AMIMechE) and, in certain cases of long-standing membership, Companions (CIMechE). By-LAW 6 (iii) states "a member shall not use or permit to be used any of the said titles or abbreviations in letters larger or bolder than those used in the name of the member which they follow."

4. CONDUCT OF MEMBERS (BY-LAW 32)

4.1 The Professional Conduct of all members is governed by By-Law 32 and its associated Rules of Conduct. Extracts are given below.

> 32. (i) In order to facilitate the advancement of the science of mechanical engineering by preserving the respect in which the community holds persons who are engaged in the profession of mechanical engineering, every member of any class shall at all times so order his conduct as to uphold the dignity and reputation of the Institution and act with fairness and integrity towards all persons with whom his work is connected and towards other members.
>
> (ii) Every Corporate Member shall at all times so order his conduct as to uphold the dignity and reputation of his profession, and to safeguard the public interest in matters of safety and health and otherwise. He shall exercise his professional skill and judgment to the best of his ability and discharge his professional responsibilities with integrity.

4.2 By-Law 32 (iii) allows the Council of the Institution to make, vary, or rescind Rules of Conduct for any class of member provided approval is received at a Special Meeting of Corporate members.

The only Rules of Conduct so approved are repeated below:

Pursuant to By-Law 32.

In these Rules, 'member' means a member of any class referred to in By-Law 2, and 'employer' includes 'client'.

1. A member whose professional advice is not accepted shall take all reasonable steps to ensure that the person overruling or neglecting his advice is aware of any danger which the member believes may result from such overruling or neglect.
2. A member shall not recklessly or maliciously injure or attempt to injure whether directly or indirectly the professional reputation, prospects, or business of another.
3. A member shall inform his employer in writing of any conflict between his personal interest and faithful service to his employer.
4. A member shall not improperly disclose any information concerning the business of his employer or any past employer.

5. A member shall not solicit or accept remuneration in connection with professional services rendered to his employer other than from his employer or with his employer's consent; nor shall he receive directly or indirectly any royalty, gratuity, or commission on any article or process used in or for the purpose of the work in respect of which he is employed unless or until such royalty, gratuity, or commission has been authorized in writing by his employer.
6. Where a member of any class has been (a) adjudicated bankrupt or (b) convicted of an offense, he shall be deemed to have been guilty of improper conduct if the circumstances of the offense are such as to constitute a breach of the By-Laws or of these Rules.

4.3 Members frequently seek guidance from the Institution over Rule 1. In considering this question of engineer should have a clear understanding of what he is accountable for. This is best achieved by reference to agreed written terms of reference. If an engineer, in the course of his duties makes a decision which is overruled by his employer and this, in his view, would be detrimental to public health and safety, then his obligation to his Institution will be discharged by issuing a written statement to his employer setting out the reasons why he believes public health and safety will be affected. As an employee, an engineer has no authority to direct his employer, therefore he cannot be held responsible for his employer's conduct. If the employer's action should prove to be detrimental to public health and safety, then this would be a matter for adjudication by the Courts.

Employed engineers finding themselves in such a situation are advised, in the first instance, to seek the view of fellow members of the Institution with whom they work. If further guidance is required, then the Professional Services Manager should be approached at Institution H.Q. Self-employed consulting engineers are able to resolve their own conflicts with professional obligations by being able to choose assignments and methods of working.

4.4 The obligations arising from the Institution's Codes and Rules of Conduct may be interpreted as requiring each member to behave so as:

to maintain and develop his Professional competence in the engineering field in which he practices;

to accept personal responsibility for his work and for those for whom he is accountable;

to give objective and reliable advice on matters within his field of practice when called upon to do so;

to avoid giving professional advice in engineering matters outside his competence;

to avoid malicious injury to the reputation, prospects, or business of others;

to avoid self-laudatory language in advertising his services or in published articles.

5. HEALTH AND SAFETY AT WORK ACT 1974

The 1974 Act imposes statutory duties on all persons at work and failure to comply with these may lead to criminal proceedings against them. All members are therefore expected to be familiar with the provisions of the Act and to read the guidance Booklet published by the Institution. Membership of a Professional body imposes on members the additional obligation of bringing the attention of their colleagues to the requirements of the 1974 Act.

6. PROFESSIONAL NEGLIGENCE

Professional negligence is discussed in the IMechE Booklet "Product Liability". A court judgment going against a member accused of professional negligence may under By-Law 33 (Disciplinary action), be taken as prima facie evidence of improper conduct. However, this is not necessarily so and will always depend upon all the circumstances of the case.

7. THE ENGINEER AS AN EXPERT WITNESS

A member called upon to testify as an Expert Witness should remember that he has a professional obligation to assist the court in reaching an equitable verdict and not to act as an advocate for whoever pays his fee. Guidance on this subject is provided in the IMechE Booklet "Guide for Consultancy".

8. TRADE UNION AND INDUSTRIAL ACTION

The act of joining a Trade Union is not contrary to the Institution's Rules of Professional Conduct. Any member of the Institution is free to join or not to join a Trade Union and if he so wishes to join, then the choice of a Union lies with him, but he is advised, where possible, to join one which supports his professional obligations and status.

Members are not forbidden to engage in industrial action provided such action does not conflict with their professional obligations as set out in the By-Laws. It is also important to exhaust the negotiating procedures before considering action. The Employment Act 1982 makes special provision to protect professional employees from dismissal arising from a conflict between professional obligation and obligations to a Trade Union. Guidance on all aspects of Union membership is given in IMechE leaflet reference PAB 2/83.

9. ADVERTISING AND USE OF SITE BOARDS

Advice on advertising and use of site boards is provided in the IMechE Booklet "Guide for Consultancy".

10. EXPULSION AND OTHER DISCIPLINARY ACTION (BY-LAW 33)

By-Law 33 provides the Council of the Institution with powers to investigate allegations of improper conduct lodged against any member and allows disciplinary action to be taken where a member is found guilty.

By-Law 33(i) is reproduced below:

33. (i) For the purposes of this By-Law improper conduct shall mean:

(a) the making of any false representation in applying for election or transfer to any class of membership of the Institution, or

(b) any breach of these By-Laws or of any Regulation or Rule or direction made or given thereunder, or

(c) any conduct injurious to the Institution.

Under the Disciplinary Regulations pursuant to By-Law 33, two Committees are appointed to investigate and adjudicate upon allegations of improper conduct: they are the Investigating Panel and the Disciplinary Board. Where the Investigating Panel finds that there is a prima facie case to answer, the accused member will be invited to put forward his observations in writing to the Panel for further consideration. If a prima facie case is still evident and the matter is not trivial, then the case goes to the Disciplinary Board for a full hearing. The accused member will be given a full and fair opportunity of being heard, of calling witnesses, and of cross-examining any witnesses testifying before the Board. He will be given the opportunity of being represented by a lawyer or by any other member of the Institution of his own choice. The full procedure covering disciplinary action is set out in the Institution's Disciplinary Rules.

For convenience the use of the words "he" or "his" in the text of this leaflet is to be read as being applicable to both sexes.

November, 1983

NOTES

Promulgation is by means of a two-sided yellow leaflet. At the top in a bold box is the statement: "Members should keep this leaflet for future reference."

VENEZUELA

• • •

ASSOCIATION OF ENGINEERS OF VENEZUELA CODE OF ETHICS

• • •

Aportado 2006, Bosque Los Caobos
Caracas 101, Venezuela

Founded: 1861
Members: 7,000

Code of Professional Ethics

It is considered contrary to ethics and incompatible with the dignified exercise of the profession for a member of the Academy of Engineers of Venezuela:

1. To act in any way that serves to diminish the honor, respectability, and the virtues of honesty, integrity, and truthfulness that should serve as the base for a full and complete exercise of the profession.
2. To violate or to permit the violation of laws, ordinances, and regulations related to professional activity.
3. To neglect the maintenance and improvement of his technical knowledge thus becoming unworthy of the trust society places in the professional activity.
4. To put himself forward for employment in specializations and operations for which the applicant has no capacity, preparation, and reasonable experience, so as to describe or advertise himself in laudatory terms or in any manner which goes against the dignity and seriousness of the profession.
5. To neglect because of friendship, convenience, or coercion the fulfillment of contractual obligations when it is his job to respect and to fulfill them.

6. To offer, solicit, or borrow professional services by means of payments below those established as the minimum by the Academy of Engineers of Venezuela.
7. To lay out projects or prepare reports with negligence or inattention or with overly optimistic criteria.
8. To sign plans laid out by others and to take responsibility for projects or works that are not under his immediate direction, review, or supervision.
9. To take charge of works without having undertaken all of the necessary technical studies for their correct execution, when for their realization schedules incompatible with good professional practice have been set up.
10. To concur deliberately or to invite competitive bidding.
11. To offer, to give, or to receive commissions or loans and to solicit influences or to use them for obtaining or securing professional work or for creating privileged positions in their performance.
12. To use the advantages inherent in a job to compete with the independent practice of other professionals.
13. To act against the reputation or the legitimate interests of other professionals.
14. To acquire interests which directly or indirectly clash with the interests of the company or client that employs his services, or to take charge without knowledge about those parties interested in works in which conflicting interests exist.
15. To act deliberately against the principles of justice and loyalty in his relations with clients, subordinate personnel, and workers, especially in relation to the last, in reference to the maintenance of fair working conditions and their just participation in profits.
16. To intervene directly or indirectly to the destruction of natural resources, or to neglect the corresponding action to avoid the production of products that contribute to environmental deterioration.
17. To act in any way that would permit or facilitate contracting with foreign companies for studies or projects, construction or inspection of works, when in the judgment of the Academy of Engineers there exists in Venezuela the capacity to perform these tasks.

TRANSLATED BY ANNA H. LYNCH AND CARL MITCHAM

NOTES

This code is promulgated in two forms:

(1) It is included in a booklet entitled Reglamento interno [Internal regulation] (Caracas: Colegio de Ingenieros de Venezuela, 1988). This is a booklet of 137 numbered pages.

Following a prefatory note and table of contents, the first major part of this booklet prints decree 444 (24 November 1958), "Ley de Ejercicio de la Ingenieria, la Arquitectura y Profesiones Afines" [Law on the practice of engineering, architecture and related professions], pp. 3-12. This is followed by a commentary which includes both general considerations on the history and development of the Association and remarks on each article in the decree (pp. 15-27), with a one page summary of "Conclusions from the First Interamerican Workshop of University Professionals," Montevideo, November 1957.

Then comes the code of ethics (pp. 29-30). This printing of the code notes that point 15 was adopted on June 27, 1957; point 16 on October 4, 1976; and point 17 on June 27, 1980.

The second major of the booklet contains, in accord with article 21 of the law of 1958, the by-laws of the Association (pp. 31-132) as of August 13, 1984.

(2) The code is also printed as a separate, one-page document suitable for framing.

FÉDÉRATION EUROPÉENNE D'ASSOCIATIONS NATIONALES D'INGÉNIEURS (FEANI, EUROPEAN FEDERATION OF NATIONAL ENGINEERING ASSOCIATIONS) CODE OF ETHICS

The FEANI Code of Conduct is additional to and does not take the place of any Code of Ethics to which the registrant might be subject in his own country.

All persons listed in the FEANI Register have the obligation to be conscious of the importance of science and technology for mankind and of their own social responsibilities when engaged in their professional activities.

They exercise their profession in accordance with the normal rules of good conduct of European societies, respecting particularly the professional rights and the dignity of all those with whom they work.

They thereby undertake to comply with and maintain the following code of ethics.

1. Personal Ethics

The Engineer shall maintain his competence at the highest level, with a view to providing excellence of services in accordance with what is regarded as good practice in his profession and having regard to the laws of the country in which he is working.

His professional integrity and intellectual honesty shall be the guarantees of his impartiality of analysis, judgment and consequent decision. He shall consider himself bound in conscience by any business confidentiality agreement into which he has freely entered.

He shall not accept any payment except those agreed with his relevant employer.

He shall display his commitment to the engineering profession by taking part in the activities of its Associations, notably those which promote the profession and contribute to the continuing training of their members.

He shall use only titles to which he has a right.

2. Professional Ethics

The Engineer shall accept assignments only within the area of his competence.

Beyond this limit, he shall seek the collaboration of appropriate experts.

He is responsible for organizing and executing his assignments.

He must obtain a clear definition of the services required of him. Executing his assignments, he shall take all necessary steps to overcome any difficulties encountered whilst ensuring the safety of persons and property.

He shall take remuneration corresponding to the service rendered and the responsibilities assumed.

He shall try to ensure that the remuneration of each be consonant with the service rendered and the responsibilities assumed.

He strives for a high level of technical achievement which will also contribute to and promote a healthy and agreeable environment for his fellowmen.

3. Social Responsibility

The Engineer shall

- respect the personal rights of his superiors, colleagues and subordinates by taking due account of their requirements and aspirations, provided they conform to the laws and ethics of their professions,
- be conscious of nature, environment, safety and health and work to the benefit and welfare of mankind,
- provide the general public with clear information, only in his field of competence, to enable a proper understanding of technical matters of public interest,

- treat with the utmost respect the traditional and cultural values of the countries in which he exercises his profession.

N.B. : In this text, "he" and "his" are taken respectively for "he/she" and "his/her."

FOUNDING STATEMENT OF THE INTERNATIONAL NETWORK OF ENGINEERS AND SCIENTISTS FOR GLOBAL RESPONSIBILITY (INES)

• • •

November 29, 1991

Rapid changes in our environment and our societies are forcing us to become more conscious of our role in the world. Science and technology are employed in a worldwide competition for military and economic power. The impacts of this competition have global implications. We have entered a phase in which global developments are in conflict with basic requirements for human survival. Large stocks of weapons for mass destruction, the over-exploitation of common limited resources, and a heavily unbalanced world economy provide fundamental challenges to human civilization and may even threaten its further existence. The end of the cold war and the progress towards democracy and national self-determination in many regions provide important opportunities to resolve long-standing threats to international security. Dismantling the vast nuclear and conventional arsenals and demilitarizing international relations remains a high priority. However, after the decline of international bipolar divisions, many major problems remain. Regional and intercommunal conflicts, together with the proliferation of weapons technologies, threaten local and global security. Newly recognized problems such as climate change, ozone depletion and loss of species diversity raise new challenges regarding energy use, population growth and other aspects of development. Gross inequalities and injustice between and within industrialized and developing countries undermine military, economic, social and environmental security.

Developments in science and technology have helped to create global interdependence and to make us more profoundly aware of the planet's condition. Many engineers and scientists play a key role in both the processes that threaten international security and those that provide hope for the future. International organizations and norms are being developed to tackle common problems, and many structures for regional cooperation are emerging to overcome national divisions.

The engineering and scientific community is intrinsically international, with informal networks and channels of communication. However most existing professional organizations are highly specialized. It is now time to establish a multidisciplinary international network of engineers and scientists for global responsibility to promote the following aims:

- to encourage and facilitate international communication among engineers and scientists seeking to promote international peace and security, justice and sustainable development, and working for a responsible use of science and technology. This includes:
- to work for the reduction of military spending and for the transfer of resources thus liberated to the satisfaction of basic needs,
- to promote environmentally sound technologies, taking into account long-term effects,
- to enhance the awareness of ethical principles among engineers and scientists, and to support those who have been victimized for acting upon such principles.

In order to accomplish these aims, members and bodies of the network will

Promote collaborative and interdisciplinary research relating to such issues,

Publicize relevant research, contribute to education and scientific training and inform the public and professional colleagues,

Facilitate and undertake expert and responsible contributions to relevant policy debates, and advocate changes in national and international policies pertinent to the above aims.

We are convinced that it is our continuous task to reflect on values and standards of behavior which take into account basic human needs and our interrelationship with the biosphere. Membership of the network is open to non-governmental organizations and individual engineers and scientists. It will be a network seeking to provide a central resource for, and to promote coordination among, its members. We hope that the synergy of different approaches will facilitate steps from vision toward action.

UNIÓN PANAMERICANA DE ASOCIACIONES DE INGENIEROS

• • •

(UPADI, PANAMERICAN UNION OF ASSOCIATIONS OF ENGINEERS)

• • •

CODE OF PROFESSIONAL ETHICAL CONDUCT

• • •

I. The Fundamentals

1. The Code of Professional Ethics adopted by UPADI member organizations is intended to establish the responsibilities, to regulate rights, and to fix norms of conduct that should be observed by all engineers, both within their professional circles as well as within the larger society, nationally as well as internationally.
2. It is the imperative duty of the Pan-American engineers to maintain their professional and moral conduct at the highest level, in defense of the prestige and rights of the profession, and to be vigilant regarding the correct and proper practice and observation at all times of the dignity, integrity, and respect and loyal adherence to this code.
3. The UPADI engineers shall constantly seek to improve their knowledge and their profession, communicating and sharing their knowledge and experience, in an attempt to provide opportunities for the professional development of their colleagues.

II. Professional Practices

1. The practice of the engineering profession shall be understood exclusively in terms of engineers who hold university titles qualifying them in diverse specialties, in accordance with the current legislation in each country.
2. The practice of engineering shall be considered first and foremost a social function. Projects which might be used against the public interest should be refused, thus avoiding situations which involve danger and constitute a threat to life, health and the environment, or affect property and other human rights.
3. Professional practice implies obligatory service in whatever form the professional assumes: Individual, in society or in a dependent relationship.
4. The formation of professional prestige of engineers shall be based on ability and honesty.

III. Acts Contrary to Ethics

To be considered unethical and incompatible with the dignity of the profession:

1. To act against the honor decorum and prestige of the profession and against the dignity and solidarity which the engineers should guard within their professional circles.
2. To intervene directly or indirectly in the destruction of natural resources or to fail to engage in activity corresponding to the avoidance of the production of anything that contributes to the deterioration of the environment.
3. To permit or contribute to the committing of injustices against engineers.
4. To falsely attribute errors to other engineers.
5. To attempt to substitute of replace other engineers in the offering of professional services.
6. To authorize with one's firm, studies, projects, plans, specifications, reports, or professional opinions that have not been personally developed, executed, controlled or authenticated.
7. To offer or lend professional services for remuneration below the standards already established in the respective tariffs.
8. To utilize studies, projects, plans, reports or other documents that are not subject to public domain, without authorization from its authors or owners.
9. To reveal information reserved of a technical, financial or professional nature, as well as divulge, without proper authorization, procedures, processes or group characteristics that are protected by patents or contracts which establish obligations of professional secrecy.
10. To commit deliberate omissions or negligence in professional activities.
11. To fail to respect the norms established by the authorities and institutions of engineering of the country in which one is executing work.

IV. Organization and Control

1. The offering of professional service involves security and the well-being of the community and is of the character of public service. Thus said, it is necessary that the engineers of each country are matriculated in colleges, counsels or associations is obligatory.
2. The integration and government of these organizations shall be exercised by those same who are matriculated in these organizations and who should fulfill and follow this Code of Professional Ethics.

THE WORLD FEDERATION OF ENGINEERING SOCIETIES MODEL CODE OF ETHICS

• • •

Final version adopted in 2001

I. BROAD PRINCIPLES

Ethics is generally understood as the discipline or field of study dealing with moral duty or obligation. This typically gives rise to a set of governing principles or values which in turn are used to judge the appropriateness of particular conducts or behaviors. These principles are usually presented either as broad guiding principles of an idealistic or inspirational nature, or, alternatively, as a detailed and specific set of rules couched in legalistic or imperative terms to make them more enforceable. Professions that have been given the privilege and responsibility of self regulation, including the engineering profession, have tended to opt for the first alternative, espousing sets of underlying principles as codes of professional ethics which form the basis and framework for responsible professional practice. Arising from this context, professional codes of ethics have sometimes been incorrectly interpreted as a set of "rules" of conduct intended for passive observance. A more appropriate use by practicing professionals is to interpret the essence of the underlying principles within their daily decision-making situations in a dynamic manner, responsive to the need of the situation. As a consequence, a code of professional ethics is more than a minimum standard of conduct; rather, it is a set of principles which should guide professionals in their daily work.

In summary, the model Code presented herein expresses the expectations of engineers and society in discriminating engineers' professional responsibilities. The Code is based on broad principles of truth, honesty and trustworthiness, respect for human life and welfare, fairness, openness, competence and accountability. Some of these broader ethical principles or issues deemed more universally applicable are not specifically defined in the Code although they are understood to be applicable as well. Only those tenets deemed to be particularly applicable to the practice of professional engineering are specified. Nevertheless, certain ethical principles or issues not commonly considered to be part of professional ethics should be implicitly accepted to judge the engineer's professional performance.

Issues regarding the environment and sustainable development know no geographical boundaries. The engineers and citizens of all nations should know and respect the environmental ethic. It is desirable, therefore, that engineers in each nation continue to observe the philosophy of the Principles of Environmental Ethics delineated in Section III of this code.

II. PRACTICE PROVISION ETHICS.

Professional engineers shall:

- hold paramount the safety, health and welfare of the public and the protection of both the natural and the built environment in accordance with the Principles of Sustainable Development;
- promote health and safety within the workplace;
- offer services, advise on or undertake engineering assignments only in areas of their competence and practice in a careful and diligent manner;
- act as faithful agents of their clients or employers, maintain confidentially and disclose conflicts of interest;
- keep themselves informed in order to maintain their competence, strive to advance the body of knowledge within which they practice and provide opportunities for the professional development of their subordinates and fellow practitioners;
- conduct themselves with fairness, and good faith towards clients, colleagues and others, give credit where it is due and accept, as well as give, honest and fair professional criticism;
- be aware of and ensure that clients and employers are made aware of societal and environmental consequences of actions or projects and endeavor to interpret engineering issues to the public in an objective and truthful manner;
- present clearly to employers and clients the possible consequences of overruling or disregarding of engineering decisions or judgment;
- report to their association and/or appropriate agencies any illegal or unethical engineering decisions or practices of engineers or others.

III. ENVIRONMENTAL ENGINEERING ETHICS

Engineers, as they develop any professional activity, shall:

- try with the best of their ability, courage, enthusiasm and dedication, to obtain a superior technical achievement, which will contribute to and promote a healthy and agreeable surrounding for all people, in open spaces as well as indoors;
- strive to accomplish the beneficial objectives of their work with the lowest possible consumption of raw materials and energy and the lowest production of wastes and any kind of pollution;

- discuss in particular the consequences of their proposals and actions, direct or indirect, immediate or long term, upon the health of people, social equity and the local system of values;
- study thoroughly the environment that will be affected, assess all the impacts that might arise in the structure, dynamics and aesthetics of the ecosystems involved, urbanized or natural, as well as in the pertinent socioeconomic systems, and select the best alternative for development that is both environmentally sound and sustainable;
- promote a clear understanding of the actions required to restore and, if possible, to improve the environment that may be disturbed, and include them in their proposals;
- reject any kind of commitment that involves unfair damages for human surroundings and nature, and aim for the best possible technical, social, and political solution;
- be aware that the principles of eco-systemic interdependence, diversity maintenance, resource recovery and inter-relational harmony form the basis of humankind's continued existence and that each of these bases poses a threshold of sustainability that should not be exceeded.

IV. CONCLUSION

Always remember that war, greed, misery and ignorance, plus natural disasters and human induced pollution and destruction of resources, are the main causes of the progressive impairment of the environment and that engineers, as an active member of society, deeply involved in the promotion of development, must use our talent, knowledge and imagination to assist society in removing those evils and improving the quality of life for all people.

INTERPRETATION OF THE CODE OF ETHICS

• • •

The interpretive articles which follow expand on and discuss some of the more difficult and interrelated components of the Code especially related to the Practice Provisions. No attempt is made to expand on all clauses of the Code, nor is the elaboration presented on a clause-by-clause basis. The objective of this approach is to broaden the interpretation, rather than narrow its focus. The ethics of professional engineering is an integrated whole and cannot be reduced to fixed "rules". Therefore, the issues and questions arising from the Code are discussed in a general framework, drawing on any and all portions of the Code to demonstrate their interrelationship and to expand on the basic intent of the Code.

Sustainable Development and Environment

Engineers shall strive to enhance the quality of the biophysical and socioeconomic urban environment and the one of buildings and spaces and to promote the principles of sustainable development.

Engineers shall seek opportunities to work for the enhancement of safety, health, and the social welfare of both their local community and the global community through the practice of sustainable development.

Engineers whose recommendations are overruled or ignored on issues of safety, health, welfare, or sustainable development shall inform their contractor or employer of the possible consequences.

Protection of the Public and the Environment

Professional Engineers shall hold paramount the safety, health and welfare of the public and the protection of the environment. This obligation to the safety, health and welfare of the general public, which includes one's own work environment, is often dependent upon engineering judgments, risk assessments, decisions and practices incorporated into structures, machines, products, processes and devices. Therefore, engineers must control and ensure that what they are involved with is in conformity with accepted engineering practice, standards and applicable codes, and would be considered safe based on peer adjudication. This responsibility extends to include all and any situations which an engineer encounters and includes an obligation to advise the appropriate authority if there is reason to believe that any engineering activity, or its products, processes, etc. do not confirm with the above stated conditions.

The meaning of paramount in this basic tenet is that all other requirements of the Code are subordinate if protection of public safety, the environment or other substantive public interests are involved.

Faithful Agent of Clients and Employers

Engineers shall act as faithful agents or trustees of their clients and employers with objectivity, fairness and justice to all parties. With respect to the handling of confidential or proprietary information, the concept of ownership of the information and protecting that party's rights is appropriate. Engineers shall not reveal facts, data or information obtained in a professional capacity without the prior consent of its owner. The only exception to respecting confidentially and maintaining a trustee's position is in instances where the public interest or the environment is at risk as discussed in the preceding section; but even in these circumstances, the engineer should endeavor to have the client and/or employer appropriately redress the situation, or at least, in the absence of a compelling reason to the contrary, should make every reasonable effort to contact them and explain clearly the potential risks, prior to informing the appropriate authority.

Professional Engineers shall avoid conflict of interest situations with employers and clients but, should such conflict arise, it is the engineer's responsibility to fully disclose, without delay, the nature of the conflict to the party(ies) with whom the conflict exists. In these circumstances where full disclosure is insufficient, or seen to be insufficient, to protect all parties' interests, as well as the public, the engineer shall withdraw totally from the issue or use extraordinary means, involving independent parties if possible, to monitor the situation. For example, it is inappropriate to act simultaneously as agent for both the provider and the recipient of professional services. If client's and employer's interests are at odds, the engineer shall attempt to deal fairly with both. If the conflict of interest is between the intent of a corporate employer and a regulatory standard, the engineer must attempt to reconcile the difference, and if that is unsuccessful, it may become necessary to inform.

Being a faithful agent or trustee includes the obligation of engaging, or advising to engage, experts or specialists when such services are deemed to be in the client's or employer's best interests. It also means being accurate, objective and truthful in making public statements on behalf of the client or employer when required to do so, while respecting the client's and employer's rights of confidentiality and proprietary information.

Being a faithful agent includes not using a previous employer's or client's specific privileged or proprietary information and trade practices or process information, without the owner's knowledge and consent. However, general technical knowledge, experience and expertise gained by the engineer through involvement with the previous work may be freely used without consent or subsequent undertakings.

Competence and Knowledge

Professional Engineers shall offer services, advise on or undertake engineering assignments only in areas of their competence by virtue of their training and experience. This includes exercising care and communicating clearly in accepting or interpreting assignments, and in setting expected outcomes. It also includes the responsibility to obtain the services of an expert if required or, if the knowledge is unknown, to proceed only with full disclosure of the circumstances and, if necessary, of the experimental nature of the activity to all parties involved. Hence, this requirement is more than simply duty to a standard of care, it also involves acting with honesty and integrity with one's client or employer and one's self. Professional Engineers have the responsibility to remain abreast of developments and knowledge in their area of expertise, that is, to maintain their own competence. Should there be a technologically driven or individually motivated shift in the area of technical activity, it is the engineer's duty to attain and maintain competence in all areas of involvement including being knowledgeable with the, technical and legal framework and regulations governing their work. In effect, it requires a personal commitment to ongoing professional development, continuing education and self-testing.

In addition to maintaining their own competence, Professional Engineers have an obligation to strive to contribute to the advancement of the body of knowledge within which they practice, and to the profession in general. Moreover, within the framework of the practice of their profession, they are expected to participate in providing opportunities to further the professional development of their colleagues.

This competence requirement of the Code extends to include an obligation to the public, the profession and one's peers, that opinions on engineering issues are expressed honestly and only in areas of one's competence. It applies equally to reporting or advising on professional matters and to issuing public statements. This requires honesty with one's self to present issues fairly, accurately and with appropriate qualifiers and disclaimers, and to avoid personal, political and other nontechnical biases. The latter is particularly important for public statements or when involved in a technical forum.

Fairness and Integrity in the Workplace

Honesty, integrity, continuously updated competence, devotion to service and dedication to enhancing the life quality of society are cornerstones of professional responsibility. Within this framework, engineers shall be objective and truthful and include all known and pertinent information on professional reports, statements and testimony. They shall accurately and objectively represent their clients, employers, associates and themselves consistent with their academic, experience and professional qualifications. This tenet is more than 'not misrepresenting'; it also implies disclosure of all relevant information and issues, especially when serving in an advisory capacity or as an expert witness. Similarly, fairness, honesty and accuracy in advertising are expected.

If called upon to verify another engineer's work, there is an obligation to inform (or make every effort to inform) the other engineer, whether the other engineer is still actively involved or not. In this situation, and in any circumstance, engineers shall give proper recognition and credit where credit is due and accept, as well as give, honest and fair criticism on professional matters, all the while maintaining dignity and respect for everyone involved.

Engineers shall not accept nor offer covert payment or other considerations for the purpose of securing, or as remuneration for engineering assignments. Engineers should prevent their personal or political involvement from influencing or compromising their professional role or responsibility.

Consistent with the Code, and having attempted to remedy any situation within their organization, engineers are obligated to report to their association or other appropriate agency any illegal or unethical engineering decisions by engineers or others. Care must be taken not to enter into legal arrangements which compromise this obligation.

Professional Accountability and Leadership

Engineers have a duty to practice in a careful and diligent manner and accept responsibility, and be accountable for their actions. This duty is not limited to design, or its supervision and management, but applies to all areas of practice. For example, it includes construction supervision and management, preparation of shop drawings, engineering reports, feasibility studies, environmental impact assessments, engineering developmental work, etc.

The signing and sealing of engineering documents indicates the taking of responsibility for the work. This practice is required for all types of engineering endeavor, regardless where or for whom the work is done, including but not limited to, privately and publicly owned firms, crown corporations, and government agencies/departments. There are no exceptions; signing and sealing documents is appropriate whenever engineering principles have been used and public welfare may be at risk.

Taking responsibility for engineering activity includes being accountable for one's own work and, in the case of a senior engineer, accepting responsibility for the work of a team. The latter implies responsible supervision where the engineer is actually in a position to review, modify and direct the entirety of the engineering work. This concept requires setting reasonable limits on the extent of activities, and the number of engineers and others, whose work can be supervised by the responsible engineer. The practice of a "symbolic" responsibility or supervision is the situation where an engineer, say with the title of "chief engineer", takes full responsibility for all engineering on behalf of a large corporation, utility or government agency/department, even though the engineer may not be aware of many of the engineering activities or decisions being made daily throughout the firm or department. The essence of this approach is that the firm is taking the responsibility of default, whether engineering supervision or direction is applied or not.

Engineers have a duty to advise their employer and, if necessary, their clients and even their professional association, in that order, in situations when the overturning of an engineering decision may result in breaching their duty to safeguard the public. The initial action is to discuss the problem with the supervisor/employer. If the employer does not adequately respond to the engineer's concern, then the client must be advised in the case of a consultancy situation, or the most senior officer should be informed in the case of a manufacturing process plant or government agency. Failing this attempt to rectify the situation the engineer must advise in confidence his professional association of his concerns.

In the same order as mentioned above, the engineer must report unethical engineering activity undertaken by other engineers or by non-engineers. This extends to include for example, situations in which senior officials of a firm make "executive" decisions which clearly and substantially alter the engineering aspects of the work, or protection of the public welfare or the environment arising from the work.

Because of the rapid advancements in technology and the increasing ability of engineering activities to impact on the environment, engineers have an obligation to be mindful of the effect that their decisions will have on the environment and the well-being of society, and to report any concerns of this nature in the same manner as previously mentioned. Further to the above, with the rapid advancement of technology in today's world and the possible social impacts on large populations of people, engineers must endeavor to foster the public's understanding of technical issues and the role of Engineering more than ever before.

Sustainable development is the challenge of meeting current human needs for natural resources, industrial products, energy, food, transportation, shelter, and effective waste management while conserving and, if possible, enhancing the Earth's environmental quality, natural resources, ethical, intellectual, working and affectionate capabilities of people and socioeconomic bases, essential for the human needs of future generations. The proper observance to these principles will considerably help to the eradication of the world poverty.

CORPORATIONS AND OTHER NGOs

CODE OF CONDUCT FOR NGOs

Preamble

(1) The following represents the work of several non-governmental organizations (NGOs) working from late 1991 through the NGO Conference in Paris, the outcomes of the Agenda Ya Wananchi, from meeting during the New York PrepCom and in the intervening months up to and including the Global Forum in Rio de Janeiro in June, 1992.

(2) The goal of this NGO Code of Conduct process is to eventually have a Code that NGOs can sign on to.

(3) We pledge to continue to engage in the process to analyze and deepen this activity and make recommendations that groups may adopt.

(4) There has been a dramatic growth of community groups and NGOs during the past 10 years. The work of community and citizen groups and organisations and NGOs now constitutes the best option for citizen action to change the forces against a sustainable future.

(5) In order to build up our constituency base, to truly serve the people within our community/organization, certain ethical and accountable agreements need to be acknowledged.

Principles

(6) An NGO Code of Conduct could contain the following principles:

(7) National and local NGOs (in North and South) should:

(a) be rooted in issues at home

(b) have some definable constituency or membership

(c) have open democratic working systems, gender parity, consultative problem-solving, non-discriminatory practices

(d) have clear conflict of interest guidelines

(e) have a code of ethics for staff

(f) publish an annual report and audited financial statements

(g) be non-profit, non-party political

(h) foster justice and equity, alleviate poverty and preserve cultural integrity

(i) endeavor to enhance the total environment - physical, biological and human

(j) have a fair wage structure, with a credible scale between highest and lowest paid worker

(k) be truly with people and not impose their agendas on them

(l) base all their work on the resources available to the people, their expertise, existing institutions, culture and religions; be self-sufficient while remaining open to the assistance offered by their various partners

(m) avoid being corrupted both materially and spiritually

(n) facilitate people's efforts

(o) share information with all members; set up necessary mechanisms to gather and exchange experiences; and get actively involved in environmental education (awareness-building) and training

(p) articulate a broad political framework and code of ethics to guide their internal operations and their work with community groups and people's organisations, as well as their relations with the South, NGOs and the North

(q) ensure the highest levels of accountability, starting with their own constituencies - the people. This includes uncompromising evaluations involving the participation of the local populations. Campaigns

(8) Northern and Southern NGOs often have non-project or non-funding based relationships. Generally, these relationships are the basis for campaigns to protest certain social or environmental problems in a Northern or Southern country; or the campaigns may be on international issues, like the World Bank's Global Environmental Facility (GEF).

(9) This treaty should be designed to make clear the process of consultation and decision-making

among all the participants to facilitate a process of dialogue between Northern and Southern NGOs on campaigns. At this point, we have only questions, not answers:

(a) The overriding principle this treaty seeks to ensure is consultation among NGOs before anyone takes a position that might affect another. But that is not as easy as it seems.

(b) If a group in one country sends out an international action alert about a problem in its country, what obligation does it have to first assure that there is a consensus among the NGOs in that country about that problem? Conversely, what obligation has a group that receives an action alert to first assure that the alert is the result of a consensus position in the country of origin before responding to the action alert?

(c) Who has the obligation to compile a reasonable list of NGOs in each country (without a list it is not possible for groups elsewhere to consult with NGOs in one country before taking positions on issues that might affect that country)?

(d) What constitutes reasonable consultation? How many groups is "enough"?

(e) How long should the consultation process be allowed to take? Can deadlines be set for responses if there is a hearing or legislative action coming up? What if there is no response - is that consultation?

(f) Can a contact person be chosen in each region or country to facilitate communications and consultation? How would that person be chosen? In a crisis, may that person speak for their constituency without consultation?

(g) What if groups within a region disagree? Who gets listened to? What if regions disagree? Declaration of Solidarity

(10) Before making public expression of solidarity for NGOs and individuals a proper consultation process should be undertaken to ensure the safety of the affected parties.

Regarding NGOs working outside their country

(11) Northern and Southern NGOs should collaborate on the basis of:

(a) equitable and genuine partnership

(b) two-way flow of all information, ideas and experiences

(c) financial transparency.

(12) Southern NGOs not Northern NGOs have the major responsibility for activities within their own countries.

(13) Northern NGOs when working in the South must have transparent advisory systems within the country of operation; there must be transparent criteria for selection of working partners.

(14) Northern NGOs should monitor Northern government/corporate activity in their host country.

(15) Northern NGOs in their host country should live in an appropriate comparative level as counterpart NGOs, not in expatriate style.

(16) Northern NGOs should develop effective policy on international issues.

(17) Because development groups get most of their funding from their national governments, most Northern NGOs hardly question the policies and activities of their governments in the South. On the contrary, they have become accessories to the hidden agendas pursued by their governments and transnational corporations in gaining control over the resources of the South. In order for Northern NGOs to be able to forge genuine people-to-people solidarity, they should:

(a) build a relationship that is based on mutual respect and collaboration as equal partners, and that fosters self-determination and self-reliance

(b) use their comparative advantage of easy access to information and pass it on to their partners in the South

(c) challenge their governments and educate the public in order to change the prevailing inequitable international economic order and development paradigms which have been largely responsible for the deteriorating global environment

(d) campaign for genuine grassroots democracy in their own countries

(e) campaign for sustainable life-styles based on their own local resources as much as possible, and paying fair (ecological) prices for imported products. Action Plan for Follow-Up

(18) Regional focal points to publicize and maximize NGO input

(19) Broad correspondence

(20) 1993 meeting to prepare final copy for widespread adoption.

DOW CORNING ETHICAL BUSINESS CONDUCT

• • •

Dow Corning's Responsibilities to Employees:

All relations with employees will be guided by our belief that the dignity of the individual is primary.

Opportunity without bias will be afforded each employee in relation to demonstrated ability, initiative and potential.

Management practices will be consistent with our intent to provide continuing employment for all productive employees.

Qualified citizens of countries where we do business will be hired and trained for available positions consistent with their capabilities.

We will strive to create and maintain a work environment that fosters honesty, personal growth, teamwork, open communications and dedication to our vision and values.

We will provide a safe, clean and pleasant work environment that at minimum meets all applicable laws and regulations.

The privacy of an individual's records will be respected. Employees may review their own records upon request.

Management will provide, communicate and implement a Problem Resolution Process for use by all employees to identify and resolve business ethics and employee conduct problems and other disagreements between employees.

Our Responsibilities as Dow Corning Employees:

Employees will treat Dow Corning proprietary information as a valued asset and diligently protect it from loss or negligent disclosure.

Employees will respect our commitment to protect the confidentiality of information entrusted to us by customers, suppliers and others in our business dealings.

The proprietary information of others will be obtained only through the use of legal and ethical methods.

Employees will not engage in activities that either jeopardize or conflict with the company's interests. Recognizing and avoiding conflicts of interest is the responsibility of each employee.

When a potential conflict of interest exists, the employee is obligated to bring the situation to the attention of Dow Corning management for resolution.

Employees will use or authorize company resources only for legitimate business purposes.

The cost of goods or services purchased for Dow Corning must be reasonable and in line with competitive standards.

Employees will not engage in bribery, price fixing, kickbacks, collusion or any related practice that might be, or give the appearance of being, illegal or unethical.

Employees will avoid contacts with competitors, suppliers, government agencies and other parties that are, or appear to be, engaging in unfair competition or the restriction of free trade.

Business interactions with our competitors will be limited to those necessary for buyer-seller agreements, licensing agreements or matters of general interest to industry or society. All such interactions will be documented.

Relations with Customers, Distributors, Suppliers

We are committed to providing products and services that meet the requirements of our customers. We will provide information and support necessary to effectively use our products.

Business integrity is a criterion for selecting and retaining those who represent Dow Corning.

Dow Corning will regularly encourage its distributors, agents and other representatives to conduct their business on our behalf in a legal and ethical manner.

The purchase of goods and services will be based on quality, price, service, ability to supply and the supplier's adherence to legal and ethical business practices.

Environmental, Product Stewardship and Social Responsibility

- We are committed to the responsible management of chemicals through our support and practice of the principles of Responsible Care.
- Environmental consideration will be integrated into all appropriate business decisions and will be guided

by Dow Corning's Principles of Environmental Management.

- We will continually strive to assure that our products and services are safe, efficacious and accurately represented for their intended uses. We will fully represent the nature and characteristics of our raw materials, intermediates and products—including toxicity and other potential hazards—to our employees, suppliers, transporters and customers.
- We will build and maintain positive relationships with communities where we have a presence. Our efforts will focus on education, civic, cultural, environmental, and health and safety programs.

*A registered trademark of the Chemical Manufacturers Association.

International Business Guidelines

Dow Corning will be a responsible corporate citizen wherever we do business. We recognize that laws, business practices and customs differ from country to country. If legal conflicts arise in or between locations where we do business, or if conflicts with this Code present themselves, we will seek reasonable ways to resolve the differences. Failing timely resolution, we will remove ourselves from the particular business situation. Dow Corning employees will not authorize or give payments or gifts to government employees or their beneficiaries or anyone else in order to obtain or retain business. Facilitating payments to expedite the performance of routine services are strongly discouraged. In countries where local business practice dictates such payments and there is no alternative, facilitating payments are to be for the minimum amount necessary and must be accurately documented and recorded. No contributions to political parties or candidates will be given by Dow Corning, even in countries where such contributions are legal. Dow Corning considers its technology and know-how to be valuable assets and encourages their inter-company and transborder transfer to achieve its overall business objectives. Dow Corning, its subsidiaries and its majority-owned joint ventures expect to pay or receive fair compensation for the value provided or received for the technology or know-how transferred.

Financial Responsibilities

Dow Corning funds will be used only for purposes that arc legal and ethical and all transactions will be properly and accurately recorded.

We will maintain a system of internal accounting controls for Dow Corning and assure that all involved employees are fully apprised of that system.

Dow Corning encourages the free flow of funds for investment, borrowing, dividending and the return of capital throughout the world.

Dow Corning Corporation, its subsidiaries and its majority-owned joint venture companies will strive to establish and maintain inter-company prices and fees for goods and services comparable to those which would prevail in open-market transactions between unrelated parties. Within this context, the goal is to have inter-company prices and fees for goods and services that meet all applicable laws and are mutually agreed upon by the Dow Corning entities involved.

We will not participate in any financial arrangement where the perceived intent of the transaction would be a violation of this Code of Conduct.

Dow Corning Values

Integrity: Our integrity is demonstrated in our ethical conduct and in our respect for the values cherished by the society of which we are a part.

Employees: Our employees are the source from which our ideas, actions and performance flow. The full potential of our people is best realized in an environment that breeds fairness, self-fulfillment, teamwork and dedication to excellence.

Customers: Our relationship with each customer is entered in the spirit of a long-term partnership and is predicated on making the customer's interests our interests.

Quality: Our never-ending quest for quality performance is based on our understanding of our customers' needs and our willingness and capability to fulfill those needs.

Technology: Our advancement of chemistry and related sciences in our chosen fields is the Value that most differentiates Dow Corning.

Environment: Our commitment to the safekeeping of the natural environment is founded on our appreciation of it as the basis for the existence of life.

Safety: Our attention to safety is based on our full-time commitment to injury-free work, individual self-worth and a consideration for the well being of others.

Profit. Our long-term profit growth is essential to our long-term existence. How our profits are derived, and the purposes for which they are used, are influenced by our Values and our shareholders.

EATON ETHICAL BUSINESS CONDUCT

• • •

Eaton Corporation's commitment to the highest degree of integrity and honesty in the conduct of its business affairs is stated in the following letter. This letters, and prior versions of it, have been distributed periodically to Eaton employees since 1976.

Eaton Corporation
Eaton Center
Cleveland, OH 44114-2584
September 1, 1996

Dear Fellow Employee:

Eaton has always had a well-deserved reputation for honesty and integrity—a reputation which we have all helped build and maintain. My purpose in writing is to reaffirm Eaton's commitment to the highest standards of ethical behavior. I particularly want to emphasize that our standards remain constant even as Eaton experiences new international growth and evolution into a truly global company.

If you're concerned about any particular situation involving ethics, please don't hesitate to contact your supervisor or another member of management.

Here are the broad concepts that we regard as fundamental principles of ethical business behavior.

Obeying the Law—We respect and obey the laws of the cities, states and countries where we operate.

Competition—We respect the rights of competitors, customers and suppliers. The only competitive advantages we seek are those gained through superior research, engineering, manufacturing and marketing. We do not engage in unfair or illegal trade practices.

Conflicts of Interest—We expect Eaton employees to avoid any association which might conflict with their loyalty to the company or compromise their judgment. Under this guideline, it would be a conflict of interest for an Eaton employee to work simultaneously for a competitor, supplier or a customer.

Government Contracts—Eaton's customers include national, state and local governments. We take care to comply with the special laws, rules and regulations which govern these contracts.

Payments to Government Personnel—We do not make illegal payments to government officials of any country. In the case of U.S. federal government employees, we must comply with the stringent rules on business gratuities that they are permitted to accept.

Kickbacks and Gratuities—We do not offer or accept kickbacks or bribes, or gifts of substantial value.

Political Contributions—Our policy prohibits company contributions to political candidates or parties even where such contributions are lawful. We encourage individual employees to be involved in the political process and make personal contributions as they see fit.

It is important that the policies and principles set forth in this letter be understood and followed on a consistent basis by each of us. Our reputation for integrity is an important corporate asset. The principles as outlined are designed to help us protect that asset. Anyone violating these principles will face appropriate disciplinary action. Your commitment to ethical behavior is essential if Eaton is to maintain the highest degree of honesty and integrity in its business activities.

LOCKHEED MARTIN CORP. CODE OF ETHICS AND BUSINESS CONDUCT

• • •

Introduction

Dear Colleague:

This booklet, Setting the Standard, has been adopted by the Lockheed Martin Board of Directors as our Company's Code of Ethics and Business Conduct. It summarizes the virtues and principles that are to guide our actions in business. We expect our agents, consultants, contractors, representatives, and suppliers to be guided by them as well.

There are numerous resources available to assist you in meeting the challenge of performing your duties and responsibilities. There can be no better course of action for you than to apply common sense and sound judgment to the manner in which you conduct yourself. However, do not hesitate to use the resources that are available whenever it is necessary to seek clarification.

Lockheed Martin aims to "set the standard" for ethical business conduct. We will achieve this through six virtues: Honesty, Integrity, Respect, Trust, Responsibility, and Citizenship.

Honesty: to be truthful in all our endeavors; to be honest and forthright with one another and with our customers, communities, suppliers, and shareholders.

Integrity: to say what we mean, to deliver what we promise, and to stand for what is right.

Respect: to treat one another with dignity and fairness, appreciating the diversity of our workforce and the uniqueness of each employee.

Trust: to build confidence through teamwork and open, candid communication.

Responsibility: to speak up - without fear of retribution - and report concerns in the work place, including violations of laws, regulations and company policies, and seek clarification and guidance whenever there is doubt.

Citizenship: : to obey all the laws of the United States and the other countries in which we do business and to do our part to make the communities in which we live better.

You can count on us to do everything in our power to meet Lockheed Martin's standards. We are counting on you to do the same. We are confident that our trust in you is well placed and we are determined to be worthy of your trust.

Daniel M. Tellep
Norman R. Augustine
Bernard L. Schwartz

June 1996

Treat in an Ethical Manner Those to Whom Lockheed Martin Has an Obligation

We are committed to the ethical treatment of those to whom we have an obligation.

For our employees we are committed to honesty, just management, and fairness, providing a safe and healthy environment, and respecting the dignity due everyone.

For our customers we are committed to produce reliable products and services, delivered on time, at a fair price.

For the communities in which we live and work we are committed to acting as concerned and responsible neighbors, reflecting all aspects of good citizenship.

For our shareholders we are committed to pursuing sound growth and earnings objectives and to exercising prudence in the use of our assets and resources.

For our suppliers we are committed to fair competition and the sense of responsibility required of a good customer.

Obey the Law

We will conduct our business in accordance with all applicable laws and regulations. The laws and regulations related to contracting with the United States government are far reaching and complex, thus placing burdens on Lockheed Martin that are in addition to those faced by companies without extensive government contracts. Compliance with the law does not comprise our entire ethical responsibility. Rather, it is a minimum, absolutely essential condition for performance of our duties.

Promote a Positive Work Environment

All employees want and deserve a work place where they feel respected, satisfied, and appreciated. Harassment or discrimination of any kind and especially involving race, color, religion, gender, age, national origin, disability, and veteran or marital status is unacceptable in our work place environment.

Providing an environment that supports the honesty, integrity, respect, trust, responsibility, and citizenship of every employee permits us the opportunity to achieve excellence in our work place. While everyone who works for the Company must contribute to the creation and maintenance of such an environment, our executives and management personnel assume special responsibility for fostering a context for work that will bring out the best in all of us.

Work Safely: Protect Yourself and Your Fellow Employees

We are committed to providing a drug-free, safe, and healthy work environment. Each of us is responsible for compliance with environmental, health, and safety laws and regulations. Observe posted warnings and regulations. Report immediately to the appropriate management any accident or injury sustained on the job, or any environmental or safety concern you may have.

Keep Accurate and Complete Records

We must maintain accurate and complete Company records. Transactions between the Company and outside individuals and organizations must be promptly and accurately entered in our books in accordance with generally accepted accounting practices and principles. No one should rationalize or even consider misrepresenting facts or falsifying records. It is illegal, will not be tolerated, and will result in disciplinary action.

Record Costs Properly

Employees and their supervisors are responsible for ensuring that labor and material costs are accurately recorded and charged on the Company's records. These costs include, but are not limited to, normal contract work, work related to independent research and development, and bid and proposal activities.

Strictly Adhere to All Antitrust Laws

Antitrust is a blanket term for strict federal and state laws that protect the free enterprise system. The laws deal with agreements and practices "in restraint of trade" such as price fixing and boycotting suppliers or customers, for example. They also bar pricing intended to run a competitor out of business; disparaging, misrepresenting, or harassing a competitor; stealing trade secrets; bribery, and kickbacks.

Antitrust laws are vigorously enforced. Violations may result in severe penalties such as forced sales of parts of businesses and significant fines for the Company. There may also be sanctions against individual employees including substantial fines and prison sentences. These laws also apply to international operations and transactions related to imports into and exports from the United States. Employees involved in any dealings with competitors are expected to know that U.S. and foreign antitrust laws may apply to their activities and to consult with the Legal Department prior to negotiating with or entering into any arrangement with a competitor.

Know and Follow the Law When Involved in International Business

The Foreign Corrupt Practices Act (FCPA), a federal statute, prohibits offering anything of value to foreign officials for the purpose of improperly influencing an official decision. It also prohibits unlawful political contributions to obtain or retain business. Finally, it prohibits the use of false records or accounts in the conduct of foreign business. Employees involved in international operations must be familiar with the FCPA. You must also be familiar with the terms and conditions of 1976 Securities and Exchange Commission and Federal Trade Commission consent decrees resulting from past issues. The FCPA and the consent decrees govern the conduct of all Lockheed Martin employees throughout the world.

If you are not familiar with documents or laws, consult with the Legal Department prior to negotiating any foreign transaction.

International transfers of equipment or technology are subject to other U.S. Government regulations like the International Traffic and Arms Regulations (ITAR), which may contain prior approval and reporting requirements. If you participate in this business activity, you should know, understand, and strictly comply with these regulations.

It may be illegal to enter into an agreement to refuse to deal with potential or actual customers or suppliers, or otherwise to engage in or support restrictive international trade practices or boycotts.

It is also important that employees doing business in foreign countries know and abide by the laws of those countries.

Follow the Rules in Using or Working with Former Government Personnel

U.S. government laws and regulations governing the employment or services from former military and civilian government personnel prohibit conflicts of interest ("working both sides of the street"). These laws and rules must be faithfully and fully observed.

Follow the Law and Use Common Sense in Political Contributions and Activities

Federal law prohibits corporations from donating corporate funds, goods, or services—directly or indirectly—to candidates for federal offices. This includes employees' work time. As a matter of policy we will not make political contributions in foreign countries.

Carefully Bid, Negotiate, and Perform Contracts

We must comply with the laws and regulations that govern the acquisition of goods and services by our customers. We will compete fairly and ethically for all business opportunities. In circumstances where there is reason to believe that the release or receipt of non- public information is unauthorized, do not attempt to obtain and do not accept such information from any source.

Appropriate steps should be taken to recognize and avoid organizational conflicts in which one business unit's activities may preclude the pursuit of a related activity by another Company business unit.

If you are involved in proposals, bid preparations, or contract negotiations, you must be certain that all statements, communications, and representations to prospective customers are accurate and truthful. Once awarded, all contracts must be performed in compliance with specifications, requirements, and clauses.

Avoid Illegal and Questionable Gifts or Favors

To Government Personnel:

Federal, state and local government departments and agencies are governed by laws and regulations concerning acceptance by their employees of entertainment, meals, gifts, gratuities, and other things of value from firms and persons with whom those departments and agencies do business or over whom they have regulatory authority. It is the general policy of Lockheed Martin to strictly comply with those laws and regulations. With regard to all federal Executive Branch employees and any other government employees who work for customers or potential customers of the Corporation, it is the policy of Lockheed Martin to prohibit its employees from giving them things of value. Permissible exceptions are offering Lockheed Martin advertising or promotional items of *nominal value* such as a coffee mug, calendar, or similar item displaying the *Company logo*, and providing modest refreshments such as soft drinks, coffee, and donuts on an occasional basis in connection with business activities. "Nominal value" is $10.00 or less. (Note: Even though this policy may be more restrictive than the U.S. Government's own policy with regard to federal Executive Branch employees, this policy shall govern the conduct of all Lockheed Martin employees.) Legislative, judicial, and state and local government personnel are subject to different restrictions; both the regulations and Corporate Policies pertaining to them must be consulted before courtesies are offered.

To Non-Government Personnel:

As long as it doesn't violate the standards of conduct of the recipient's organization, it's an acceptable practice to provide meals, refreshments, and entertainment of reasonable value in conjunction with business discussions with non-government personnel. Gifts, other than those of nominal value ($50.00 or less), to private individuals or companies are prohibited unless specifically approved by the appropriate Ethics Officer or Corporate Office of Ethics and Business Conduct.

To Foreign Government Personnel and Public Officials:

The Company may be restricted from giving meals, gifts, gratuities, entertainment, or other things of value to personnel of foreign governments and foreign public officials by the Foreign Corrupt Practices Act and by laws of foreign countries. Employees must discuss such situations with the Legal Counsel and consult the Hospitality Guidelines (maintained by the Legal Department) prior to making any gifts or providing any gratuities other than advertising items.

To Lockheed Martin Personnel:

Lockheed Martin employees may accept meals, refreshments, or entertainment of nominal value in connection with business discussions. While it is difficult to define "nominal" by means of a specific dollar amount, a common sense determination should dictate what would be considered lavish, extravagant, or frequent. It is the personal responsibility of each employee to ensure that his or her acceptance of such meals, refreshments, or entertainment is proper and could not reasonably be construed in any way as an attempt by the offering party to secure favorable treatment.

Lockheed Martin employees are not permitted to accept funds in any form or amount, or any gift that has a retail or exchange value of $20 or more from individuals, companies, or representatives of companies having or seeking business relationships with Lockheed Martin. If you have any questions about the propriety of a gift, gratuity, or item of value, contact your Ethics Officer or the Corporate Office of Ethics and Business Conduct for guidance.

If you buy goods or services for Lockheed Martin, or are involved in the procurement process, you must treat all suppliers uniformly and fairly. In deciding among competing suppliers, you must objectively and impartially weigh all facts and avoid even the appearance of favoritism. Established routines and procedures should be followed in the procurement of all goods and services.

Steer Clear of Conflicts of Interest

Playing favorites or having conflicts of interest—in practice or in appearance—runs counter to the fair treatment to which we are all entitled. Avoid any relationship, influence, or activity that might impair, or even appear to impair, your ability to make objective and fair decisions when performing your job. When in doubt, share the facts of the situation with your supervisor, Legal Department, or Ethics Officer.

Here are some ways a conflict of interest could arise:

- Employment by a competitor or potential competitor, regardless of the nature of the employment, while employed by Lockheed Martin.
- Acceptance of gifts, payment, or services from those seeking to do business with Lockheed Martin.
- Placement of business with a firm owned or controlled by an employee or his/her family.
- Ownership of, or substantial interest in, a company which is a competitor or a supplier.
- Acting as a consultant to a Lockheed Martin customer or supplier.

Maintain the Integrity of Consultants, Agents, and Representatives

Business integrity is a key standard for the selection and retention of those who represent Lockheed Martin. Agents, representatives, or consultants must certify their willingness to comply with the Company's policies and procedures and must never be retained to circumvent our values and principles. Paying bribes or kickbacks, engaging in industrial espionage, obtaining the proprietary data of a third party, or gaining inside information or influence are just a few examples of what could give us an unfair competitive advantage in a government procurement and could result in violations of law.

Protect Proprietary Information

Proprietary company information may not be disclosed to anyone without proper authorization. Keep proprietary documents protected and secure. In the course of normal business activities, suppliers, customers, and competitors may sometimes divulge to you information that is proprietary to their business. Respect these confidences.

Obtain and Use Company and Customer Assets Wisely

Proper use of company and customer property, facilities, and equipment is your responsibility. Use and maintain these assets with the utmost care and respect, guarding against waste and abuse. Be cost-conscious and alert to opportunities for improving performance while reducing costs. The use of company time, material, or facilities for purposes not directly related to company business, or the removal or borrowing of company property without permission, is prohibited.

All employees are responsible for complying with requirements of software copyright licenses related to software packages used in fulfilling job requirements.

Do Not Engage in Speculative or Insider Trading

In our role as a U.S. corporation and a major government contractor, we must always be alert to and comply with the security laws and regulations of the United States.

It is against the law for employees to buy or sell Lockheed Martin stock based on "insider" information about or involving the Company. Play it safe: don't speculate in the securities of Lockheed Martin when you are aware of information affecting the company's business that has not been publicly released or in situations where trading would call your judgment into question. This includes all varieties of stock trading such as options, puts and calls, straddles, selling short, etc. Two simple rules can help protect you in this area: (1) Don't use non-public information for personal gain. (2) Don't pass along such information to someone else who has no need to know.

This guidance also applies to the securities of other companies (suppliers, vendors, subcontractors, etc.) for which you receive information in the course of your employment at Lockheed Martin.

For More Information:

In order to support a comprehensive Ethics and Business Conduct Program, Lockheed Martin has developed education and communication programs in many subject areas.

These programs have been developed to provide employees with job-specific information to raise their level of awareness and sensitivity to key issues.

Interactive video training modules and related brochures are planned to be available on the following topics:

Antitrust ComplianceLabor Charging

Domestic Consultants Leveraging Differences

Drug-Free WorkplaceMaterial Costs

Environment, Health, and SafetyOrganizational Conflicts of Interest

Ethics Procurement

Ex-Government Employees Procurement Integrity

Export Control Product Substitution

Foreign Corrupt Practices Act

Government PropertySecurity

International ConsultantsSexual Harassment

International Military Sales Software License Compliance

Kickbacks re On Thin Ethical Ice When You Hear . . .

"Well, maybe just this once . . ."

"No one will ever know . . ."

"It doesn't matter how it gets done as long as it gets done."

You can probably think of many more phrases that raise warning flags. If you find yourself using any of these expressions, take the Quick Quiz on the following page and make sure you are on solid ethical ground.

Quick Quiz—When In Doubt, Ask Yourself . . .

Are my actions legal?

Am I being fair and honest?

Will my action stand the test of time?

How will I feel about myself afterwards?

How will it look in the newspaper?

Will I sleep soundly tonight?

What would I tell my child to do?

If you are still not sure what to do, ask . . . and keep asking until you are certain you are doing the right thing.

Our Goal: An Ethical Work Environment

We have established the Office of Vice President - Ethics and Business Conduct to underscore our commitment to ethical conduct throughout our Company.

This office reports directly to the Office of the Chairman and the Audit and Ethics Committee of the Board of Directors, and oversees a vigorous corporate-wide effort to promote a positive, ethical work environment for all employees.

Our Ethics Officers operate confidential ethics helplines at each operating company, as well as at the corporate level. You are urged to use these resources whenever you have a question or concern that cannot be readily addressed within your work group or through your supervisor.

In addition, if you need information on how to contact your local Ethics Officer - or wish to discuss a matter of concern with the corporate Office of Ethics and Business Conduct - you are encouraged to use one of the following confidential means of communication:

Call: 1-800-LM ETHIC (1-800-563-8442)

For the Hearing or Speech Impaired: (1-800-441- 7457)

Write: Office of Ethics and Business Conduct

Office of Ethics and Business Conduct

Lockheed Martin Corporation

P.O. Box 34143 Bethesda, MD 20827-0143

Fax: 818-876-2082

Internet E-Mail:Corporate.Ethics@den.mmc.com

When you contact your Company Ethics Officer or the Corporate Office of Ethics and Business Conduct:

- You will be treated with dignity and respect.
- Your communication will be protected to the greatest extent possible.
- Your concerns will be seriously addressed and, if not resolved at the time you call, you will be informed of the outcome.
- You need not identify yourself.
- Remember, there's never a penalty for using the HelpLine. People in a position of authority can't stop you; if they try, they're subject to disciplinary action up to and including dismissal.

RESPONSIBLE CARE GUIDING PRINCIPLES (CHEMICAL INDUSTRY)

Our industry creates products and services that make life better for people around the world - both today and in the future. The benefits of our industry are accompanied by enduring commitments to Responsible Care in the management of chemicals worldwide. We will make continuous progress toward the vision of no accidents, injuries, or harm to the environment and will publicly report our global health, safety, and environmental performance. We will lead our companies in ethical ways that increasingly benefit society, the economy and the environment while adhering to the following principles:

1. To seek and incorporate public input regarding our products and operations.
2. To provide chemicals that can be manufactured, transported, used and disposed of safely.
3. To make health, safety, the environment and resource conservation critical considerations for all new and existing products and processes.
4. To provide information on health or environmental risks and pursue protective measures for employees, the public and other key stakeholders.

5. To work with customers, carriers, suppliers, distributors and contractors to foster the safe use, transport and disposal of chemicals.
6. To operate our facilities in a manner that protects the environment and the health and safety of our employees and the public.
7. To support education and research on the health, safety and environmental effects of our products and processes.
8. To work with others to resolve problems associated with past handling and disposal practices.
9. To lead in the development of responsible laws, regulations, and standards that safeguard the community, workplace and environment.
10. To practice Responsible Care by encouraging and assisting others to adhere to these principles and practices.

EINSTEIN-RUSSELL MANIFESTO (1955)

In the tragic situation which confronts humanity, we feel that scientists should assemble in conference to appraise the perils that have arisen as a result of the development of weapons of mass destruction, and to discuss a resolution in the spirit of the appended draft.

We are speaking on this occasion, not as members of this or that nation, continent, or creed, but as human beings, members of the species Man, whose continued existence is in doubt. The world is full of conflicts; and, overshadowing all minor conflicts, the titanic struggle between Communism and anti-Communism.

Almost everybody who is politically conscious has strong feelings about one or more of these issues; but we want you, if you can, to set aside such feelings and consider yourselves only as members of a biological species which has had a remarkable history, and whose disappearance none of us can desire.

We shall try to say no single word which should appeal to one group rather than to another. All, equally, are in peril, and, if the peril is understood, there is hope that they may collectively avert it.

We have to learn to think in a new way. We have to learn to ask ourselves, not what steps can be taken to give military victory to whatever group we prefer, for there no longer are such steps; the question we have to ask ourselves is: what steps can be taken to prevent a military contest of which the issue must be disastrous to all parties?

The general public, and even many men in positions of authority, have not realized what would be involved in a war with nuclear bombs. The general public still thinks in terms of the obliteration of cities. It is understood that the new bombs are more powerful than the old, and that, while one A-bomb could obliterate Hiroshima, one H-bomb could obliterate the largest cities, such as London, New York, and Moscow.

No doubt in an H-bomb war great cities would be obliterated. But this is one of the minor disasters that would have to be faced. If everybody in London, New York, and Moscow were exterminated, the world might, in the course of a few centuries, recover from the blow. But we now know, especially since the Bikini test, that nuclear bombs can gradually spread destruction over a very much wider area than had been supposed.

It is stated on very good authority that a bomb can now be manufactured which will be 2,500 times as powerful as that which destroyed Hiroshima. Such a bomb, if exploded near the ground or under water, sends radio-active particles into the upper air. They sink gradually and reach the surface of the earth in the form of a deadly dust or rain. It was this dust which infected the Japanese fishermen and their catch of fish.

No one knows how widely such lethal radioactive particles might be diffused, but the best authorities are unanimous in saying that a war with H-bombs might possibly put an end to the human race. It is feared that if many H-bombs are used there will be universal death, sudden only for a minority, but for the majority a slow torture of disease and disintegration.

Many warnings have been uttered by eminent men of science and by authorities in military strategy. None of them will say that the worst results are certain. What they do say is that these results are possible, and no one can be sure that they will not be realized. We have not yet found that the views of experts on this question depend in any degree upon their politics or prejudices. They depend only, so far as our researches have revealed, upon the extent of the particular expert's knowledge. We have found that the men who know most are the most gloomy.

Here, then, is the problem which we present to you, stark and dreadful and inescapable: Shall we put an end to the human race; or shall mankind renounce war? People will not face this alternative because it is so difficult to abolish war.

The abolition of war will demand distasteful limitations of national sovereignty. But what perhaps impedes understanding of the situation more than anything else is that the term “mankind” feels vague and abstract. People scarcely realize in imagination that the danger is to themselves and their children and their grandchildren, and not only to a dimly apprehended humanity. They can scarcely bring themselves to grasp that they, individually, and those whom they love are in imminent danger of perishing agonizingly. And so they hope that perhaps war may be allowed to continue provided modern weapons are prohibited.

This hope is illusory. Whatever agreements not to use H-bombs had been reached in time of peace, they would no longer be considered binding in time of war, and both sides would set to work to manufacture H-bombs as soon as war broke out, for, if one side manufactured the bombs and the other did not, the side that manufactured them would inevitably be victorious.

Although an agreement to renounce nuclear weapons as part of a general reduction of armaments would not afford an ultimate solution, it would serve certain important purposes. First: any agreement between East and West is to the good in so far as it tends to diminish tension. Second: the abolition of thermo-nuclear weapons, if each side believed that the other had carried it out sincerely, would lessen the fear of a sudden attack in the style of Pearl Harbor, which at present keeps both sides in a state of nervous apprehension. We should, therefore, welcome such an agreement though only as a first step. Most of us are not neutral in feeling, but, as human beings, we have to remember that, if the issues between East and West are to be decided in any manner that can give any possible satisfaction to anybody, whether Communist or anti-Communist, whether Asian or European or American, whether White or Black, then these issues must not be decided by war. We should wish this to be understood, both in the East and in the West. There lies before us, if we choose, continual progress in happiness, knowledge, and wisdom. Shall we, instead, choose death, because we cannot forget our quarrels? We appeal, as human beings, to human beings: Remember your humanity, and forget the rest. If you can do so, the way lies open to a new Paradise; if you cannot, there lies before you the risk of universal death.

Resolution

We invite this Congress, and through it the scientists of the world and the general public, to subscribe to the following resolution:

> "In view of the fact that in any future world war nuclear weapons will certainly be employed, and that such weapons threaten the continued existence of mankind, we urge the Governments of the world to realize, and to acknowledge publicly, that their purpose cannot be furthered by a world war, and we urge them, consequently, to find peaceful means for the settlement of all matters of dispute between them."

Max Born

Perry W. Bridgman

Albert Einstein

Leopold Infeld

Frederic Joliot-Curie

Herman J. Muller

Linus Pauling

Cecil F. Powell

Joseph Rotblat

Bertrand Russell

Hideki Yukawa

MOUNT CARMEL DECLARATION ON TECHNOLOGY AND MORAL RESPONSIBILITY (1974)

We, meeting at Haifa to celebrate the fiftieth anniversary of the Technion-Israel Institute of Technology, deeply troubled by the threats to the welfare and survival of the human species that are increasingly posed by improvident uses of applied science and technology, offer the following Declaration for consideration and adoption. It is addressed, most urgently, to all whom it concerns, to governments and other political agencies, to administrators and managers, experts and laymen, educators and students, to all who have the power to influence decisions or the right to be consulted about them.

1. We recognize the great contributions of technology to the improvement of the human condition. Yet continued intensification and extension of technology has unprecedented potentialities for evil as well as good. Technological consequences are now so ramified and interconnected, so sweeping in unforeseen results, so grave in magnitude of the irreversible changes they induce, as to constitute a threat to the very survival of the species.
2. While actions at the level of community and state are urgently needed, legitimate local interests must not take precedence over the common interest of *all* human beings in justice, happiness, and peace. Responsible control of technology by social systems and institutions is an urgent *global* concern, overriding all conflicts of interest and all divergencies in religion, race or political allegiance. Ultimately all must benefit from the promise of technology, or all must suffer—even perish—together.
3. Technological applications and innovations result from human actions. As such, they demand politi-

cal, social, economic, ecological and above all *moral* evaluation. No technology is morally "neutral."

4. Human beings, both as individuals and as members or agents of social institutions, bear the sole responsibility for abuses of technology. Invocation of supposedly inflexible laws of technological inertia and technological transformation is an evasion of moral and political responsibility.

5. Creeds and moral philosophies that teach respect for human dignity can, in spite of all differences, unite in actions to cope with the problems posed by new technologies. It is an urgent task to work toward new codes for guidance in an age of pervasive technology.

6. Every technological undertaking must respect basic human rights and cherish human dignity. We must not gamble with human survival. We must not degrade people into *things* used by machines: every technological innovation must be judged by its contributions to the development of genuinely free and creative *persons*.

7. The "developed" and the "developing" nations have different priorities but an ultimate convergence of shared interests:

   For the developed nations: rejection of expansion at all costs and the selfish satisfaction of ever-multiplying desires–and adoption of policies of *principled restraint*—with unstinting assistance to the unfortunate and the underprivileged.

   For the developing nations: complementary but appropriately modified policies of principled restraint, especially in population growth, and a determination to avoid repeating the excesses and follies of the more "developed" economies.

   Absolute priority should be given to the relief of human misery, the eradication of hunger and disease, the abolition of social injustice and the achievement of lasting peace.

8. These problems and their implications need to be discussed and investigated by all educational institutions and all media of communication. They call for intense and imaginative research enlisting the cooperation of humanists and social scientists, as well as natural scientists and technologists. Better technology is needed, but will not suffice to solve the problems caused by intensive uses of technology. We need guardian *disciplines* to monitor and assess technological innovations, with especial attention to their moral implications.

9. Implementation of these purposes will demand improved social institutions through the active participation of statesmen and their expert advisers, and the informed understanding and consent of those most directly affected—especially the young, who have the greatest stake in the future.

10. This agenda calls for sustained work on three distinct but connected tasks: the development of "guardian disciplines" for watching, modifying, improving, and restraining the human consequences of technology (a special but not exclusive responsibility of the scientists and technologists who originate technological innovations); the confluence of varying moral codes in common action; and the creation of improved educational and social institutions.

Without minimizing the prevalence of human irrationality and the potency of envy and hate, we have sufficient faith in ourselves and our fellows to hope for a future in which all can have a chance to close the gap between aspiration and reality—a chance to become at last truly human.

No agenda is more urgent for human welfare and survival. This declaration, henceforth to be called the Mount Carmel Declaration on Technology and Moral Responsibility, is proclaimed in Jerusalem on this day, Wednesday, the twenty-fifth of December, 1974, in the Residence of the President of the State of Israel.

RIO DECLARATION ON ENVIRONMENT AND DEVELOPMENT (1992)

• • •

The United Nations Conference on Environment and Development,

Having met at Rio de Janeiro from 3 to 14 June 1992,

Reaffirming the Declaration of the United Nations Conference on the Human Environment, adopted at Stockholm on 16 June 1972, and seeking to build upon it,

With the goal of establishing a new and equitable global partnership through the creation of new levels of cooperation among States, key sectors of societies and people,

Working towards international agreements which respect the interests of all and protect the integrity of the global environmental and developmental system,

Recognizing the integral and interdependent nature of the Earth, our home,

Proclaims that:

Principle 1

Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature.

Principle 2

States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental and developmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.

Principle 3

The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations.

Principle 4

In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it.

Principle 5

All States and all people shall cooperate in the essential task of eradicating poverty as an indispensable requirement for sustainable development, in order to decrease the disparities in standards of living and better meet the needs of the majority of the people of the world.

Principle 6

The special situation and needs of developing countries, particularly the least developed and those most environmentally vulnerable, shall be given special priority. International actions in the field of environment and development should also address the interests and needs of all countries.

Principle 7

States shall cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command.

Principle 8

To achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies.

Principle 9

States should cooperate to strengthen endogenous capacity-building for sustainable development by improving scientific understanding through exchanges of scientific and technological knowledge, and by enhancing the development, adaptation, diffusion and transfer of technologies, including new and innovative technologies.

Principle 10

Environmental issues are best handled with the participation of all concerned citizens, at the relevant level. At the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in decision-making processes. States shall facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, shall be provided.

Principle 11

States shall enact effective environmental legislation. Environmental standards, management objectives and priorities should reflect the environmental and developmental context to which they apply. Standards applied by some countries may be inappropriate and of unwarranted economic and social cost to other countries, in particular developing countries.

Principle 12

States should cooperate to promote a supportive and open international economic system that would lead to economic growth and sustainable development in all countries, to better address the problems of environmental degradation. Trade policy measures for environmental purposes should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade. Unilateral actions to deal with environmental challenges outside the jurisdiction of the importing country should be avoided. Environmental measures addressing transboundary or global environmental problems should, as far as possible, be based on an international consensus.

Principle 13

States shall develop national law regarding liability and compensation for the victims of pollution and other environmental damage. States shall also cooperate in an expeditious and more determined manner to develop further international law regarding liability and compensation for adverse effects of environmental damage caused by activities within their jurisdiction or control to areas beyond their jurisdiction.

Principle 14

States should effectively cooperate to discourage or prevent the relocation and transfer to other States of any activities and substances that cause severe environmental degradation or are found to be harmful to human health.

Principle 15

In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

Principle 16

National authorities should endeavour to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment.

Principle 17

Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority.

Principle 18

States shall immediately notify other States of any natural disasters or other emergencies that are likely to produce sudden harmful effects on the environment of those States. Every effort shall be made by the international community to help States so afflicted.

Principle 19

States shall provide prior and timely notification and relevant information to potentially affected States on activities that may have a significant adverse transboundary environmental effect and shall consult with those States at an early stage and in good faith.

Principle 20

Women have a vital role in environmental management and development. Their full participation is therefore essential to achieve sustainable development.

Principle 21

The creativity, ideals and courage of the youth of the world should be mobilized to forge a global partnership in order to achieve sustainable development and ensure a better future for all.

Principle 22

Indigenous people and their communities and other local communities have a vital role in environmental management and development because of their knowledge and traditional practices. States should recognize and duly support their identity, culture and interests and enable their effective participation in the achievement of sustainable development.

Principle 23

The environment and natural resources of people under oppression, domination and occupation shall be protected.

Principle 24

Warfare is inherently destructive of sustainable development. States shall therefore respect international law providing protection for the environment in times of armed conflict and cooperate in its further development, as necessary.

Principle 25

Peace, development and environmental protection are interdependent and indivisible.

Principle 26

States shall resolve all their environmental disputes peacefully and by appropriate means in accordance with the Charter of the United Nations.

Principle 27

States and people shall cooperate in good faith and in a spirit of partnership in the fulfillment of the principles embodied in this Declaration and in the further development of international law in the field of sustainable development.

TECHNOREALISM MANIFESTO (1998)

• • •

1. Technologies are not neutral.

A great misconception of our time is the idea that technologies are completely free of bias—that because they are inanimate artifacts, they don't promote certain kinds of behaviors over others. In truth, technologies come loaded with both intended and unintended social, political, and economic leanings. Every tool provides its users with a particular manner of seeing the world and specific ways of interacting with others. It is important for each of us to consider the biases of various technologies and to seek out those that reflect our values and aspirations.

2. The Internet is revolutionary, but not Utopian.

The Net is an extraordinary communications tool that provides a range of new opportunities for people, communities, businesses, and government. Yet as cyberspace becomes more populated, it increasingly resembles society at large, in all its complexity. For every empowering or enlightening aspect of the wired life, there will also be dimensions that are malicious, perverse, or rather ordinary.

3. Government has an important role to play on the electronic frontier.

Contrary to some claims, cyberspace is not formally a place or jurisdiction separate from Earth. While governments should respect the rules and customs that have arisen in cyberspace, and should not stifle this new world with inefficient regulation or censorship, it is foolish to say that the public has no sovereignty over what an errant citizen or fraudulent corporation does online. As the representative of the people and the guardian of democratic values, the state has the right and responsibility to help integrate cyberspace and conventional society.

Technology standards and privacy issues, for example, are too important to be entrusted to the marketplace alone. Competing software firms have little interest in preserving the open standards that are essential to a fully functioning interactive network. Markets encourage innovation, but they do not necessarily insure the public interest.

4. Information is not knowledge.

All around us, information is moving faster and becoming cheaper to acquire, and the benefits are manifest. That said, the proliferation of data is also a serious challenge, requiring new measures of human discipline and skepticism. We must not confuse the thrill of acquiring or distributing information quickly with the more daunting task of converting it into knowledge and wisdom. Regardless of how advanced our computers become, we should never use them as a substitute for our own basic cognitive skills of awareness, perception, reasoning, and judgment.

5. Wiring the schools will not save them.

The problems with America's public schools—disparate funding, social promotion, bloated class size, crumbling infrastructure, lack of standards—have almost nothing to do with technology. Consequently, no amount of technology will lead to the educational revolution prophesied by President Clinton and others. The art of teaching cannot be replicated by computers, the Net, or by "distance learning." These tools can, of course, augment an already high-quality educational experience. But to rely on them as any sort of panacea would be a costly mistake.

6. Information wants to be protected.

It's true that cyberspace and other recent developments are challenging our copyright laws and frameworks for protecting intellectual property. The answer, though, is not to scrap existing statutes and principles. Instead, we must update old laws and interpretations so that information receives roughly the same protection it did in the context of old media. The goal is the same: to give authors sufficient control over their work so that they have an incentive to create, while maintaining the right of the public to make fair use of that information. In neither context does information want "to be free." Rather, it needs to be protected.

7. The public owns the airwaves; the public should benefit from their use.

The recent digital spectrum giveaway to broadcasters underscores the corrupt and inefficient misuse of public resources in the arena of technology. The citizenry should benefit and profit from the use of public frequencies, and should retain a portion of the spectrum for educational, cultural, and public access uses. We should demand more for private use of public property.

8. Understanding technology should be an essential component of global citizenship.

In a world driven by the flow of information, the interfaces—and the underlying code—that make information visible are becoming enormously powerful social forces. Understanding their strengths and limitations, and even participating in the creation of better tools, should be an important part of being an involved citizen. These tools affect our lives as much as laws do, and we should subject them to a similar democratic scrutiny.

DECLARATION ON SCIENCE AND THE USE OF SCIENTIFIC KNOWLEDGE (1999)

• • •

Preamble

1. We all live on the same planet and are part of the biosphere. We have come to recognize that we are in a situation of increasing interdependence, and that our future is intrinsically linked to the preservation of the global life-support systems and to the survival of all forms of life. The nations and the scientists of the world are called upon to acknowledge the urgency of using knowledge from all fields of science in a responsible manner to address human needs and aspirations without misusing this knowledge. We seek active collaboration across all the fields of scientific endeavor, that is the natural sciences such as the physical, earth and biological sciences, the biomedical and engineering sciences, and the social and human sciences. While the *Framework for Action* emphasizes the promise and the dynamism of the natural sciences but also their potential adverse effects, and the need to understand their impact on and relations with society, the commitment to science, as well as the challenges and the responsibilities set out in this Declaration, pertain to all fields of the sciences. All cultures can contribute scientific knowledge of universal value. The sciences should be at the service of humanity as a whole, and should contribute to providing everyone with a deeper understanding of nature and society, a better quality of life and a sustainable and healthy environment for present and future generations.
2. Scientific knowledge has led to remarkable innovations that have been of great benefit to humankind. Life expectancy has increased strikingly, and cures have been discovered for many diseases. Agricultural output has risen significantly in many parts of the world to meet growing population needs. Technological developments and the use of new energy sources have created the opportunity to free humankind from arduous labour. They have also enabled the generation of an expanding and complex range of industrial products and processes. Technologies based on new methods of communication, information handling and computation have brought unprecedented opportunities and challenges for the scientific endeavor as well as for society at large. Steadily improving scientific knowledge on the origin, functions and evolution of the universe and of life provides humankind with conceptual and practical approaches that profoundly influence its conduct and prospects.
3. In addition to their demonstrable benefits the applications of scientific advances and the development and expansion of human activity have also led to environmental degradation and technological disasters, and have contributed to social imbalance or exclusion. As one example, scientific progress has made it possible to manufacture sophisticated weapons, including conventional weapons and weapons of mass destruction. There is now an opportunity to call for a reduction in the resources allocated to the development and manufacture of new weapons and to encourage the conversion, at least partially, of military production and research facilities to civilian use. The United Nations General Assembly has proclaimed the year 2000 as International Year for the Culture of Peace and the year 2001 as United Nations Year of Dialogue among Civilizations as steps towards a lasting peace; the scientific community, together with

other sectors of society, can and should play an essential role in this process.

4. Today, whilst unprecedented advances in the sciences are foreseen, there is a need for a vigorous and informed democratic debate on the production and use of scientific knowledge. The scientific community and decision-makers should seek the strengthening of public trust and support for science through such a debate. Greater interdisciplinary efforts, involving both natural and social sciences, are a prerequisite for dealing with ethical, social, cultural, environmental, gender, economic and health issues. Enhancing the role of science for a more equitable, prosperous and sustainable world requires the long-term commitment of all stakeholders, public and private, through greater investment, the appropriate review of investment priorities, and the sharing of scientific knowledge.

5. Most of the benefits of science are unevenly distributed, as a result of structural asymmetries among countries, regions and social groups, and between the sexes. As scientific knowledge has become a crucial factor in the production of wealth, so its distribution has become more inequitable. What distinguishes the poor (be it people or countries) from the rich is not only that they have fewer assets, but also that they are largely excluded from the creation and the benefits of scientific knowledge.

6. We, participants in the *World Conference on Science for the Twenty-first Century:A New Commitment*, assembled in Budapest, Hungary, from 26June to 1 July 1999 under the aegis of the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the International Council for Science (ICSU):

Considering:

7. where the natural sciences stand today and where they are heading, what their social impact has been and what society expects from them,

8. that in the twenty-first century science must become a shared asset benefiting all peoples on a basis of solidarity, that science is a powerful resource for understanding natural and social phenomena, and that its role promises to be even greater in the future as the growing complexity of the relationship between society and the environment is better understood,

9. the ever-increasing need for scientific knowledge in public and private decision-making, including notably the influential role to be played by science in the formulation of policy and regulatory decisions,

10. that access to scientific knowledge for peaceful purposes from a very early age is part of the right to education belonging to all men and women, and that science education is essential for human development, for creating endogenous scientific capacity and for having active and informed citizens,

11. that scientific research and its applications may yield significant returns towards economic growth and sustainable human development, including poverty alleviation, and that the future of humankind will become more dependent on the equitable production, distribution and use of knowledge than ever before,

12. that scientific research is a major driving force in the field of health and social care and that greater use of scientific knowledge would considerably improve human health,

13. the current process of globalization and the strategic role of scientific and technological knowledge within it,

14. the urgent need to reduce the gap between the developing and developed countries by improving scientific capacity and infrastructure in developing countries,

15. that the information and communication revolution offers new and more effective means of exchanging scientific knowledge and advancing education and research,

16. the importance for scientific research and education of full and open access to information and data belonging to the public domain,

17. the role played by the social sciences in the analysis of social transformations related to scientific and technological developments and the search for solutions to the problems generated in the process,

18. the recommendations of major conferences convened by the organizations of the United Nations system and others, and of the meetings associated with the World Conference on Science,

19. that scientific research and the use of scientific knowledge should respect human rights and the dignity of human beings, in accordance with the Universal Declaration of Human Rights and in the light of the Universal Declaration on the Human Genome and Human Rights,

20. that some applications of science can be detrimental to individuals and society, the environment and human health, possibly even threatening the continuing existence of the human species, and that the contribution of science is indispensable to the cause of peace and development, and to global safety and security,
21. that scientists with other major actors have a special responsibility for seeking to avert applications of science which are ethically wrong or have an adverse impact,
22. the need to practice and apply the sciences in line with appropriate ethical requirements developed on the basis of an enhanced public debate,
23. that the pursuit of science and the use of scientific knowledge should respect and maintain life in all its diversity, as well as the life-support systems of our planet,
24. that there is a historical imbalance in the participation of men and women in all science-related activities,
25. that there are barriers which have precluded the full participation of other groups, of both sexes, including disabled people, indigenous peoples and ethnic minorities, hereafter referred to as disadvantaged groups,
26. that traditional and local knowledge systems, as dynamic expressions of perceiving and understanding the world, can make, and historically have made, a valuable contribution to science and technology, and that there is a need to preserve, protect, research and promote this cultural heritage and empirical knowledge,
27. that a new relationship between science and society is necessary to cope with such pressing global problems as poverty, environmental degradation, inadequate public health, and food and water security, in particular those associated with population growth,
28. the need for a strong commitment to science on the part of governments, civil society and the productive sector, as well as an equally strong commitment of scientists to the well-being of society,

Proclaim the following:

1. Science for knowledge; knowledge for progress

29. The inherent function of the scientific endeavor is to carry out a comprehensive and thorough inquiry into nature and society, leading to new knowledge. This new knowledge provides educational, cultural and intellectual enrichment and leads to technological advances and economic benefits. Promoting fundamental and problem-oriented research is essential for achieving endogenous development and progress.
30. Governments, through national science policies and in acting as catalysts to facilitate interaction and communication between stakeholders, should give recognition to the key role of scientific research in the acquisition of knowledge, in the training of scientists and in the education of the public. Scientific research funded by the private sector has become a crucial factor for socio-economic development, but this cannot exclude the need for publicly-funded research. Both sectors should work in close collaboration and in a complementary manner in the financing of scientific research for long-term goals.

2. Science for peace

31. The essence of scientific thinking is the ability to examine problems from different perspectives and seek explanations of natural and social phenomena, constantly submitted to critical analysis. Science thus relies on critical and free thinking, which is essential in a democratic world. The scientific community, sharing a long-standing tradition that transcends nations, religions and ethnicity, should promote, as stated in the Constitution of UNESCO, the "intellectual and moral solidarity of mankind", which is the basis of a culture of peace. Worldwide cooperation among scientists makes a valuable and constructive contribution to global security and to the development of peaceful interactions between different nations, societies and cultures, and could give encouragement to further steps in disarmament, including nuclear disarmament.
32. Governments and society at large should be aware of the need to use natural and social sciences and technology as tools to address the root causes and impacts of conflict. Investment in scientific research which addresses them should be increased.

3. Science for development

33. Today, more than ever, science and its applications are indispensable for development. All levels of government and the private sector should provide

enhanced support for building up an adequate and evenly distributed scientific and technological capacity through appropriate education and research programs as an indispensable foundation for economic, social, cultural and environmentally sound development. This is particularly urgent for developing countries. Technological development requires a solid scientific basis and needs to be resolutely directed towards safe and clean production processes, greater efficiency in resource use and more environmentally friendly products. Science and technology should also be resolutely directed towards prospects for better employment, improving competitiveness and social justice. Investment in science and technology aimed both at these objectives and at a better understanding and safeguarding of the planet's natural resource base, biodiversity and life-support systems must be increased. The objective should be a move towards sustainable development strategies through the integration of economic, social, cultural and environmental dimensions.

34. Science education, in the broad sense, without discrimination and encompassing all levels and modalities, is a fundamental prerequisite for democracy and for ensuring sustainable development. In recent years, worldwide measures have been undertaken to promote basic education for all. It is essential that the fundamental role played by women in the application of scientific development to food production and health care be fully recognized, and efforts made to strengthen their understanding of scientific advances in these areas. It is on this platform that science education, communication and popularization need to be built. Special attention still needs to be given to marginalized groups. It is more than ever necessary to develop and expand science literacy in all cultures and all sectors of society as well as reasoning ability and skills and an appreciation of ethical values, so as to improve public participation in decision-making related to the application of new knowledge. Progress in science makes the role of universities particularly important in the promotion and modernization of science teaching and its coordination at all levels of education. In all countries, and in particular the developing countries, there is a need to strengthen scientific research in higher education, including postgraduate programs, taking into account national priorities.

35. The building of scientific capacity should be supported by regional and international cooperation, to ensure both equitable development and the spread and utilization of human creativity without discrimination of any kind against countries, groups or individuals. Cooperation between developed and developing countries should be carried out in conformity with the principles of full and open access to information, equity and mutual benefit. In all efforts of cooperation, diversity of traditions and cultures should be given due consideration. The developed world has a responsibility to enhance partnership activities in science with developing countries and countries in transition. Helping to create a critical mass of national research in the sciences through regional and international cooperation is especially important for small States and least developed countries. Scientific structures, such as universities, are essential for personnel to be trained in their own country with a view to a subsequent career in that country. Through these and other efforts conditions conducive to reducing or reversing the brain drain should be created. However, no measures adopted should restrict the free circulation of scientists.

36. Progress in science requires various types of cooperation at and between the intergovernmental, governmental and non-governmental levels, such as: multilateral projects; research networks, including South-South networking; partnerships involving scientific communities of developed and developing countries to meet the needs of all countries and facilitate their progress; fellowships and grants and promotion of joint research; programs to facilitate the exchange of knowledge; the development of internationally recognized scientific research centers, particularly in developing countries; international agreements for the joint promotion, evaluation and funding of mega-projects and broad access to them; international panels for the scientific assessment of complex issues; and international arrangements for the promotion of postgraduate training. New initiatives are required for interdisciplinary collaboration. The international character of fundamental research should be strengthened by significantly increasing support for long-term research projects and for international collaborative projects, especially those of global interest. In this respect particular attention should be given to the need for continuity of support for research. Access to these facilities for scientists from developing countries should be actively supported and open to all on the basis of scientific merit. The use of information

and communication technology, particularly through networking, should be expanded as a means of promoting the free flow of knowledge. At the same time, care must be taken to ensure that the use of these technologies does not lead to a denial or restriction of the richness of the various cultures and means of expression.

37. For all countries to respond to the objectives set out in this Declaration, in parallel with international approaches, in the first place national strategies and institutional arrangements and financing systems need to be set up or revised to enhance the role of sciences in sustainable development within the new context. In particular they should include: a long-term national policy on science to be developed together with the major public and private actors; support to science education and scientific research; the development of cooperation between R&D institutions, universities and industry as part of national innovation systems; the creation and maintenance of national institutions for risk assessment and management, vulnerability reduction, safety and health; and incentives for investment, research and innovation. Parliaments and governments should be invited to provide a legal, institutional and economic basis for enhancing scientific and technological capacity in the public and private sectors and facilitate their interaction. Science decision-making and priority-setting should be made an integral part of overall development planning and the formulation of sustainable development strategies. In this context, the recent initiative by the major G-8 creditor countries to embark on the process of reducing the debt of certain developing countries will be conducive to a joint effort by the developing and developed countries towards establishing appropriate mechanisms for the funding of science in order to strengthen national and regional scientific and technological research systems.

38. Intellectual property rights need to be appropriately protected on a global basis, and access to data and information is essential for undertaking scientific work and for translating the results of scientific research into tangible benefits for society. Measures should be taken to enhance those relationships between the protection of intellectual property rights and the dissemination of scientific knowledge that are mutually supportive. There is a need to consider the scope, extent and application of intellectual property rights in relation to the equitable production, distribution and use of knowledge. There is also a need to further develop appropriate national legal frameworks to accommodate the specific requirements of developing countries and traditional knowledge and its sources and products, to ensure their recognition and adequate protection on the basis of the informed consent of the customary or traditional owners of this knowledge.

4. Science in society and science for society

39. The practice of scientific research and the use of knowledge from that research should always aim at the welfare of humankind, including the reduction of poverty, be respectful of the dignity and rights of human beings, and of the global environment, and take fully into account our responsibility towards present and future generations. There should be a new commitment to these important principles by all parties concerned.

40. A free flow of information on all possible uses and consequences of new discoveries and newly developed technologies should be secured, so that ethical issues can be debated in an appropriate way. Each country should establish suitable measures to address the ethics of the practice of science and of the use of scientific knowledge and its applications. These should include due process procedures for dealing with dissent and dissenters in a fair and responsive manner. The World Commission on the Ethics of Scientific Knowledge and Technology of UNESCO could provide a means of interaction in this respect.

41. All scientists should commit themselves to high ethical standards, and a code of ethics based on relevant norms enshrined in international human rights instruments should be established for scientific professions. The social responsibility of scientists requires that they maintain high standards of scientific integrity and quality control, share their knowledge, communicate with the public and educate the younger generation. Political authorities should respect such action by scientists. Science curricula should include science ethics, as well as training in the history and philosophy of science and its cultural impact.

42. Equal access to science is not only a social and ethical requirement for human development, but also essential for realizing the full potential of scientific communities worldwide and for orienting scientific progress towards meeting the needs of humankind.

The difficulties encountered by women, constituting over half of the world's population, in entering, pursuing and advancing in a career in the sciences and in participating in decision-making in science and technology should be addressed urgently. There is an equally urgent need to address the difficulties faced by disadvantaged groups which preclude their full and effective participation.

43. Governments and scientists of the world should address the complex problems of poor health and increasing inequalities in health between different countries and between different communities within the same country with the objective of achieving an enhanced, equitable standard of health and improved provision of quality health care for all. This should be undertaken through education, by using scientific and technological advances, by developing robust long-term partnerships between all stakeholders and by harnessing programs to the task.

• • •

44. We, participants in the *World Conference on Science for the Twenty-first Century: A New Commitment*, commit ourselves to making every effort to promote dialogue between the scientific community and society, to remove all discrimination with respect to education for and the benefits of science, to act ethically and cooperatively within our own spheres of responsibility, to strengthen scientific culture and its peaceful application throughout the world, and to promote the use of scientific knowledge for the well-being of populations and for sustainable peace and development, taking into account the social and ethical principles illustrated above.

45. We consider that the Conference document *Science Agenda—Framework for Action* gives practical expression to a new commitment to science, and can serve as a strategic guide for partnership within the United Nations system and between all stakeholders in the scientific endeavor in the years to come.

46. We therefore adopt this *Declaration on Science and the Use of Scientific Knowledge* and agree upon the *Science Agenda—Framework for Action* as a means of achieving the goals set forth in the Declaration, and call upon UNESCO and ICSU to submit both documents to the General Conference of UNESCO and to the General Assembly of ICSU. The United Nations General Assembly will also be seized of these documents. The purpose is to enable both UNESCO and ICSU to identify and implement follow-up action in their respective programs, and to mobilize the support of all partners, particularly those in the United Nations system, in order to reinforce international coordination and cooperation in science.

DECLARATION OF SANTO DOMINGO (1999)

• • •

We, the Heads of State and/or Government of the States, Countries and Territories of the Association of Caribbean States (ACS), meeting in the City of Santo Domingo de Guzmán, Dominican Republic, on 16 and 17 April 1999;

Committed to the principles and objectives enshrined in the Convention Establishing the ACS, and recognizing the validity of the Declaration of Principles and Plan of Action on Tourism, Trade and Transport resulting from the historic First Summit held in Port of Spain, Trinidad and Tobago, in August 1995 and the priorities identified for promoting regional integration, functional co-operation and co-ordination among the Member States and Associate Members of the ACS;

Have decided to analyze the progress made by the ACS from Port-of-Spain 1995 to Santo Domingo 1999 and determine the projection of the Caribbean Region into the 21st Century; and therefore:

1. We identify tourism as the activity where the Association has achieved the most significant progress. We recognize that sustainable tourism constitutes an adequate response to the challenges of increasing rates of growth in employment and foreign exchange earnings, protecting and preserving the environment and natural resources, protecting cultural patrimony and values. We support community participation, as well as the involvement of local interests in aspects of the tourism development process, such as policy making, planning, management, ownership and the sharing of benefits generated by this activity. In this respect, we adopt the Declaration on the Sustainable Tourism Zone of the Caribbean (STZC).
2. We reiterate our commitment to work jointly for the consolidation of an enhanced economic space

for trade and investment, based on the principles of the World Trade Organization (WTO), for which we shall continue to encourage integration and co-operation measures that permit the strengthening of intra-regional trade and investment.

3. We note with satisfaction the progress yielded in the area of trade liberalization and economic integration in the sub-regional and bilateral spheres among the Member States and Associate Members of the ACS. Within the framework of Article XX of the Convention Establishing the ACS, the interested countries will continue to encourage according to their priorities, trade agreements and tariff preferences, as identified in the initiative to establish the Caribbean Preferential Tariff (CPT).

4. We reiterate that the rationalization and definition of regional transport policies are among the highest priorities of the ACS Plan of Action. We consider that transport must be the fundamental instrument for the development of tourism and trade in the region. In this respect, we emphasize our commitment to the objectives of the program "Uniting the Caribbean by Air and Sea".

5. Based on the fulfillment of commitments made in Agenda 21, we support the activities for the protection and conservation of the environment and natural resources. In addition, we support the effort of CARICOM to have the Caribbean Sea declared a Special Area in the context of Sustainable Development, and instruct that this subject be included in the Caribbean Environmental Strategy. For this purpose, a high level meeting of experts will be convened to study this topic. Participation in this meeting will be open to all members of the Association.

6. We consider the Caribbean Sea an invaluable asset and agree to give special priority to its preservation. We therefore deplore its ecological degradation and reject its continuous use for the transport of nuclear and toxic waste that may in any way cause a greater degradation of the Caribbean Sea.

7. We express our deepest solidarity with the countries and territories of the ACS affected by natural disasters in recent years, as well as by the extensive losses of lives and material resources, caused by these phenomena, which have increased their difficulties in implementing their programs of economic and social development.

8. We instruct the national authorities responsible for the prevention, mitigation and preparation for disasters, to put into practice, as soon as possible, the implementation mechanisms of the Regional Co-operation Agreement in the Area of Natural Disasters, signed by the Ministers of Foreign Affairs. In this respect, special focus will be placed on strengthening co-operation with the Caribbean Disaster and Emergency Response Agency (CDERA) and the Central American Co-ordination Centre for the Prevention of Natural Disasters (CEPREDENAC).

9. We emphasize the importance of co-operation in science and technology as the basis for the promotion of sustainable development of the region and in this respect, we observe with satisfaction the progress made in the development of the Co-operation Mechanism in the area of Science and Technology.

10. We recognize the efforts to widen regional collaboration and co-operation with respect to the linguistic integration program, the promotion of the teaching of the official languages of the ACS and the development of programs of integration, co-operation and exchanges in the areas of education and culture. Similarly, we express our support for the activities being developed in the region with regard to the preservation of the cultural patrimony, and the promotion and defense of our cultural values.

11. We appreciate the importance of international co-operation for the development of the peoples and economies of the region, and we take note of the renewed effort by the ACS Special Fund to work in this direction.

12. We are aware that globalization constitutes for the region an enormous challenge, that entails risks and opportunities. We therefore reiterate our interest in strengthening consultation and co-ordination of our positions in all those issues of mutual interest in the international agenda.

13. We agree that, faced with the rapid globalization process, multilateralism is the indispensable response for dealing with its challenges and utilizing its advantages, and in particular, for ensuring the effective exercise of the juridical equality of the States. We are aware moreover that the transparent and democratic functioning of multilateral bodies should be based on international law.

14. We reiterate our categorical rejection of all unilateral coercive measures, as well as the extraterritorial application of national laws by any State, since this is contrary to International Law, and more-

over threatens the sovereignty of States and international co-existence. In this context, we reiterate our exhortation to the Government of the United States of America to put an end to the application of the Helms-Burton Law, in accordance with the Resolutions approved by the United Nations General Assembly.

15. We reaffirm our commitment to the preservation, consolidation and strengthening of democracy, political pluralism and the Rule of Law, as an ideal framework that allows respect for the defense and promotion of all human rights, including the right to development and basic liberties. In this respect, we reiterate that civic participation is an indispensable element in the creation of a new political culture. We also reiterate respect for the principles of sovereignty and non-intervention, in addition to the right of all peoples to build their own political system in peace, stability and justice.

16. We reiterate moreover the need to implement social and economic measures aimed at achieving integrated and harmonious development, based on equity, social justice, the raising of the standards of living of the population, and the eradication of poverty, with the human being as the fundamental focus of development plans.

17. We renew our commitment to work for the sustainable development of the Caribbean through co-operation and integration.

18. We recognize the differences in the size and levels of development of the economies of the countries of the ACS and attach special significance to the vulnerability of the small economies of our region. We will take into consideration these differences in the treatment of the countries in the activities being developed within the framework of the ACS. We will search for means, complementary with suitable internal policies that would afford opportunities to encourage participation and further the level of development of the small and less developed economies.

19. We urge the international community to strengthen programs of technical and financial assistance, human resource training, and the transfer of technology, in order to improve the opportunities for the small and less developed economies to prosper in the international system.

20. In this context, we agree that there is a need to promote co-operation and concerted action among the Member States and Associate Members of the ACS, so as to increase the negotiating capability of our region in international fora.

21. We reaffirm the principles adopted at the First ACS Summit, with regard to the international problem of the illicit traffic of drugs and related crimes, which represents a serious threat to tourism, trade and transport, and indeed, endangers the sovereignty and security of each State.

22. We reiterate the principles governing international co-operation for dealing with the international problem of the illicit traffic of drugs and related crimes, including shared responsibility, the global, integrated and balanced approach, unrestricted respect for the principles of International Law, in particular those of sovereignty and territorial integrity. We therefore strongly reject every type of intervention in the internal matters of States and the extraterritorial application of domestic laws and unilateral measures. In this respect, we agree that programs, actions and results must be considered within an agreed intergovernmental framework.

23. We are aware of the great wealth of the cultural diversity in the Caribbean region and as a result, we agree to increase efforts in defense of our cultural identity, to protect and promote its expressions, given that culture is one of the fundamental bases for the integration of the Caribbean peoples.

24. We reiterate the commitment of our governments to work in close collaboration in order to contribute to the success of the European Union/Latin America and the Caribbean Summit, which constitutes an exceptional opportunity for promoting concerted action among ACS Members, increasing co-operation and enhancing existing dialogues and agreements between the two regions. To this end, we will promote the Latin American and Caribbean proposal, adopted in Mexico City, in December 1998, aimed at identifying inter-regional co-operation activities that contribute to enhancing relations with the countries of the European Union.

25. This Summit will also be a special occasion to establish a direct and frank dialogue with the leaders of the European Union, in order to advance in a decisive manner economic relations between both regions, especially in the areas of trade and investment, as well as to promote the convergence of efforts to restore international financial stability

and to redress the continued imbalances that might provoke a global recession.

26. We call for the optimization of the potential and opportunities provided by the sectoral links among the programs of the ACS and collaboration with relevant regional and national organizations, in order to ensure increasing complementarity among the activities of Member States and Associate Members.
27. We express our deep gratitude to the President of the Dominican Republic, His Excellency Leonel Fernández, and to the Government and people of the Dominican Republic, for the warmth, friendliness and lavish hospitality accorded to us throughout the Second Summit.

To give impetus to the goals and objectives outlined in this Declaration, we agree to adopt and execute the attached Plan of Action.

RIO DE JANEIRO DECLARATION ON ETHICS IN SCIENCE AND TECHNOLOGY (2003)

• • •

We, the Ministers and Higher Authorities of Science and Technology of South America, gathered in Rio de Janeiro on this 4th day of December, 2003, to reflect upon the limits that ethics impose on the production and use of scientific knowledge,

Considering:

the Declaration on the Use of Scientific Knowledge, signed in Budapest in 1999, that placed science in its social and international context as an instrument for the well being of all peoples, and called upon all countries to work for the good of humanity;

the overwhelming process of economic globalization and the growing impact of scientific development and technological innovations on our societies;

that the South American countries represented at this meeting recognize the need in the elaboration of their management policies for scientific and technological development to pay special attention to the ethical implications, so that principles founded upon such policies may serve as guidance for efforts to achieve the well-being of their peoples and their autonomy as nations;

that a more democratic and far-reaching application of this knowledge requires national and regional development projects that include society as a whole;

that such projects must be viewed from the harmonic perspective of our peoples' common international interests, in order to confront the current trends of globalization in the realm of science, technology, economics, politics, and culture;

that the ethical and human conscience that grows at the heart of our societies impels us to prioritize, in the distribution of the benefits of knowledge to all, especially to women and children as well as all facets of excluded and marginalized segments of society, and the production of knowledge by women;

that the principles of democracy and social justice should govern international relations, serving as a reference for fraternity among countries, nations, and peoples;

that democracy, independence, and respect not only for individual and regional differences but also for the right and the struggle for peace, must reflect, within our countries, the same struggle for liberty, respect for human rights and, fundamentally, access for all to the intangible and practical benefits of human knowledge in culture, the arts, science and technology, through education and democratization of the results of economic development;

that we must defend an international system that elects to combat hunger and exclusion, especially exclusion from all forms of knowledge, as the highest priority, promoting universal quality education and that assures the right of all to healthcare, education, and housing while at the same time hinders abuses of power, condemns discrimination, and denounces intolerance and all other conditions or interests that may lead to war and the breakdown of democratic structures;

that free access to scientific knowledge and to effective participation in its creation, as well as the technological development and innovation, allowing the integration of our efforts, especially with respect to the establishment of an effective network of scientific and technological cooperation;

recognizing that the scientific and technological component forms the basis of the so-called "knowledge economy" - the economy of the third millennium - and that improved scientific and technological capacity will allow the participation in this economy and therefore in development; and

Facing limits imposed by international trade rules which, most of the time, do not consider the interests of the developing countries and their populations, and that our countries will also face competition from those countries possessing technology, as well as their transnational companies, the main beneficiaries of so-called "globalization".

Do recommend:

that the foundational activities for science and technology, such as education, scientific research, culture and technological development, be recognized and treated as public goods, and that an effort be made to diffuse knowledge, placing it at the disposal of humanity, especially the communities of the Third World;

that the governments of the Region support UNESCO in its efforts to allow the sectors and activities which constitute the "knowledge economy" (education, science, and culture) to contribute to socio-economic development in order to ensure the effective democratization of the components of knowledge generated by the digital industry and to render more flexible trade practices in the international regime of intellectual property, particularly in public health;

that the governments devote greater attention to the treatment given to science and technology in the context of the international trade rules and negotiations, adopting new critical approaches to the rules in effect and generating innovative proposals that increase access for the countries in the Region to knowledge and its benefits;

that our governments promote and stimulate the dissemination of information and knowledge through significant investments in R&D, information technology, robotics and computer science, software and hardware, popularizing the sources and the means of information as well as promoting universal access for all citizens;

that our governments support the increase in the use and production of software, seeking autonomy and cost reductions for the countries of the region;

that national and regional research groups be established with the objective of studying alternatives for the production of low-cost personal computers, aimed at universalizing usage of such computers, as well as implementing projects for regional cooperation in this field;

Do further recommend:

that attention be given to non-proprietary treatment of software, transmissions, and other digital technologies essential to ensuring the linguistic-cultural diversity of countries with relatively low representation on the Internet as well as in the use of electronic databases;

that an international network of scientific and technological knowledge be created, public in nature and freely accessible, also linked to databases on patents and inventions;

that a fund be established for the promotion of education, science, and culture in cyberspace, in support of networks of public schools, universities and research institutes in the countries of the Region, whose objective would be to promote science in the classroom and its popularization;

that the protection of individual rights and freedoms be promoted in measures relating to the fight against terrorism and to the promotion of a culture of cybersecurity;

that nations work together for the creation of an international consensus for the conversion of a portion of the payment of the external debt of developing countries into national investments in science and technology;

that our governments consider, the development of capacities which allow people to have access to new knowledge that make possible their productive participation in new sectors, if technological change so demands;

that the commitment to create spaces of cooperation in science and technology among our countries be reiterated, in both the public and private sectors, taking into account the ethical, political, social, and economic challenges they face;

that the essential role of the United Nations System's specialized agencies, particularly UNESCO, be recognized in supporting the elaboration of effective policies and guidelines in the field of ethics of Science and Technology and in technical cooperation through the exchange of international specialists, resource mobilization programs for the promotion of integrated interdisciplinary approaches to cooperation for development in science and technology and for the transfer of technological knowledge;

that UNESCO's work in the field of Ethics of Science and Technology and its role as focal point and legitimate participant in the world-wide debate over this issue be recognized and supported;

that the establishment, by UNESCO, of a mechanism that integrates and proposes dialogue on issues related to the Ethics of Science and Technology among our Governments be supported in order to promote the creation of programs for the teaching of ethics in basic, secondary and higher education and teacher training programs in this area; and the establishment of a network of governmental and non-governmental institutions in this area be supported;

that the work of COMEST as an independent advisory body of UNESCO regarding issues of Ethics in Science and Technology be recognized and that participation in this Commission be improved by the continued inclusion of representatives from all continents;

that the recommendations set forth by COMEST in such areas as the teaching of ethics, outer space, energy, and water be examined, in order to reinforce and to incorporate where necessary this ethical reflection in national and regional policies, in strategies, and in projects;

that States, organizations and other institutions interested in promoting and deepening reflection on the ethics of science be encouraged to create national and institutional commissions on scientific ethics;

that States be urged to implement, within the shortest time possible, the Universal Declaration on the Human Genome and Human Rights, approved in 1997 at the United Nations General Assembly;

and that the International Declaration on Human Genetic Data, approved at the 32nd UNESCO General Conference, be supported.

Thus, the Ministers and Higher Authorities of Science and Technology of South America, gathered in Rio de Janeiro, request the Heads of State and Government to confirm the growing importance of the ethical dimension of Science and Technology for the promotion of sustainable and equitable development, supporting the strengthening of cooperation in Science and Technology, above all with respect to their ethical implications, among the countries of South America, under the terms of the present Declaration.

The signatories hereby agree to transmit this Declaration to the Secretary General of the United Nations, as well as to the Director-General of UNESCO.

Rio de Janeiro, December 4, 2003

Signatories:

ROBERTO AMARAL—Minister of Science and Technology of Brazil

TULIO DEL BONO—Secretary of Science and Technology of Argentina

LUIS ALBERTO LIMA—President of the National Council of Science and Technology (CONCYT) of Paraguay

MARIA DEL ROSÁRIO GUERRA—Director of the Colombian Institute for Development of Science and Technology (CONCIENCIAS)

BENJAMIN MARTICORENA—President of the National Council of Science and Technology (CONCYTEC) of Peru

CPLP Authorities:

JOÃO BATISTA NGANDAJINA—Minister of Science and Technology of Angola

MARIA DE FÁTIMA SILVA BARBOSA—Minister of National Education of Guinea-Bissau

LÍDIA MARIA ARTHUR BRITO—Minister of Higher Education, Science and Technology of Mozambique

MARIA DA GRAÇA CARVALHO—Minister of Science and Higher Education of Portugal

MARIA DE FÁTIMA SILVA BARBOSA—Minister of National Education of Guinea-Bissau

AHMEDABAD DECLARATION (2005)

• • •

This Declaration was made on January 20th, 2005, by more than 800 learners, thinkers and practitioners from over 40 countries, engaged in education for sustainable development, at the *Education for a Sustainable Future* conference held at Centre for Environment Education, Ahmedabad, India.

As the first international gathering of the United Nations Decade of Education for Sustainable Development (DESD), we warmly welcome this Decade that highlights the potential of action education to move people towards sustainable lifestyles and policies.

If the world's peoples are to enjoy a high quality of life, we must move quickly toward a sustainable future. Although most indicators point away from sustainability, growing grassroots efforts worldwide are taking on the enormous task of changing this trend.

We accept our responsibility and we urge all people to join us in doing all we can to pursue the principles of the Decade with humility, inclusivity, and a strong sense of humanity. We invite wide participation through networks, partnerships, and institutions.

As we gather in the city where Mahatma Gandhi lived and worked, we remember his words: "Education for life; education through life; education throughout life". These words underscore our commitment to the ideal of education that is participatory and lifelong.

We firmly believe that a key to sustainable development is the empowerment of all people, according to the principles of equity and social justice, and that a key to such empowerment is action-oriented education.

ESD implies a shift from viewing education as a delivery mechanism, to the recognition that we are all learners as well as teachers. ESD must happen in villages and cities, schools and universities, corporate offices and assembly lines, and in the offices of ministers and civil servants. All must struggle with how to live and work in a way that protects the environment, advances social justice, and promotes economic fairness for present and future generations. We must learn how to resolve conflicts, create a caring society, and live in peace.

ESD must start with examining our own lifestyles and our willingness to model and advance sustainability in our communities. We pledge to share our diverse experiences and collective knowledge to refine the vision of sustainability while continually expanding its practice. Through our actions we will add substance and vigor to the UNDESD processes.

We are optimistic that the objectives of the Decade will be realized and move forward from Ahmedabad in a spirit of urgency, commitment, hope, and enthusiasm.

CHEMIST'S CODE OF CONDUCT OF THE AMERICAN CHEMICAL SOCIETY

The American Chemical Society expects its members to adhere to the highest ethical standards. Indeed, the federal Charter of the Society (1937) explicitly lists among its objectives **"the improvement of the qualifications and usefulness of chemists through high standards of professional ethics, education and attainments"**

Chemists have professional obligations to the public, to colleagues, and to science. One expression of these obligations is embodied in "The Chemist's Creed," approved by the ACS Council in 1965. The principles of conduct enumerated below are intended to replace "The Chemist's Creed". They were prepared by the Council Committee on Professional Relations, approved by the Council (March 16, 1994), and adopted by the Board of Directors (June 3, 1994) for the guidance of society members in various professional dealings, especially those involving conflicts of interest.

Chemists Acknowledge Responsibilities To:

- The Public: Chemists have a professional responsibly to serve the public interest and welfare and to further knowledge of science. Chemists should actively be concerned with the health and welfare of co-workers, consumer and the community. Public comments on scientific matters should be made with care and precision, without unsubstantiated, exaggerated, or premature statements.
- The Science of Chemistry: Chemists should seek to advance chemical science, understand the limitations of their knowledge, and respect the truth. Chemists should ensure that their scientific contributions, and those of the collaborators, are thorough, accurate, and a unbiased in design, implementation, and presentation.
- The Profession: Chemists should remain current with developments in their field, share ideas and information, keep accurate and complete laboratory records, maintain integrity in all conduct and publications, and give due credit to the contributions of others. Conflicts of interest and scientific misconduct, such as fabrication, falsification, and plagiarism, are incompatible with this Code.
- The Employer: Chemists should promote and protect the legitimate interests of their employers, perform work honestly and competently, fulfill obligations, and safeguard proprietary information.
- Employees: Chemists, as employers, should treat subordinates with respect for their professionalism and concern for their well-being, and provide them with a safe, congenial working environment, fair compensation, and proper acknowledgment of their scientific contributions.
- Students: Chemists should regard the tutelage of students as a trust conferred by society for the promotion of the student's learning and professional development. Each student should be treated respectfully and without exploitation.
- Associates: Chemists should treat associates with respect, regardless of the level of their formal education, encourage them, learn with them, share ideas honestly, and give credit for their contributions.
- Clients: Chemists should serve clients faithfully and incorruptibly, respect confidentiality, advise honestly, and charge fairly.
- The Environment: Chemists should understand and anticipate the environmental consequences of their work. Chemists have responsibility to avoid pollution and to protect the environment.

CODE OF ETHICS OF THE AMERICAN ANTHROPOLOGICAL ASSOCIATION

I. Preamble

Anthropological researchers, teachers and practitioners are members of many different communities, each with its own moral rules or codes of ethics. Anthropologists have moral obligations as members of other groups, such as the family, religion, and community, as well as the profession. They also have obligations to the scholarly discipline, to the wider society and culture, and to the human species, other species, and the environment. Furthermore, fieldworkers may develop close relationships with persons or animals with whom they work, generating an additional level of ethical considerations.

In a field of such complex involvements and obligations, it is inevitable that misunderstandings, conflicts, and the need to make choices among apparently incompatible values will arise. Anthropologists are responsible for grappling with such difficulties and struggling to resolve them in ways compatible with the principles stated here. The purpose of this Code is to foster discussion and education. The American Anthropological Association (AAA) does not adjudicate claims for unethical behavior.

The principles and guidelines in this Code provide the anthropologist with tools to engage in developing and maintaining an ethical framework for all anthropological work.

II. Introduction

Anthropology is a multidisciplinary field of science and scholarship, which includes the study of all aspects of humankind—archaeological, biological, linguistic and sociocultural. Anthropology has roots in the natural and social sciences and in the humanities, ranging in approach from basic to applied research and to scholarly interpretation.

As the principal organization representing the breadth of anthropology, the American Anthropological Association (AAA) starts from the position that generating and appropriately utilizing knowledge (i.e., publishing, teaching, developing programs, and informing policy) of the peoples of the world, past and present, is a worthy goal; that the generation of anthropological knowledge is a dynamic process using many different and ever-evolving approaches; and that for moral and practical reasons, the generation and utilization of knowledge should be achieved in an ethical manner.

The mission of American Anthropological Association is to advance all aspects of anthropological research and to foster dissemination of anthropological knowledge through publications, teaching, public education, and application. An important part of that mission is to help educate AAA members about ethical obligations and challenges involved in the generation, dissemination, and utilization of anthropological knowledge.

The purpose of this Code is to provide AAA members and other interested persons with guidelines for making ethical choices in the conduct of their anthropological work. Because anthropologists can find themselves in complex situations and subject to more than one code of ethics, the AAA Code of Ethics provides a framework, not an ironclad formula, for making decisions.

Persons using the Code as a guideline for making ethical choices or for teaching are encouraged to seek out illustrative examples and appropriate case studies to enrich their knowledge base.

Anthropologists have a duty to be informed about ethical codes relating to their work, and ought periodically to receive training on current research activities and ethical issues. In addition, departments offering anthropology degrees should include and require ethical training in their curriculums.

No code or set of guidelines can anticipate unique circumstances or direct actions in specific situations. The individual anthropologist must be willing to make carefully considered ethical choices and be prepared to make clear the assumptions, facts and issues on which those choices are based. These guidelines therefore address *general* contexts, priorities and relationships which should be considered in ethical decision making in anthropological work.

III. Research

In both proposing and carrying out research, anthropological researchers must be open about the purpose(s), potential impacts, and source(s) of support for research projects with funders, colleagues, persons studied or providing information, and with relevant parties affected by the research. Researchers must expect to utilize the results of their work in an appropriate fashion and disseminate the results through appropriate and timely activities. Research fulfilling these expectations is ethical, regardless of the source of funding (public or private) or purpose (i.e., "applied," "basic," "pure," or "proprietary").

Anthropological researchers should be alert to the danger of compromising anthropological ethics as a condition to engage in research, yet also be alert to proper demands of good citizenship or host-guest relations. Active contribution and leadership in seeking to shape public or private sector actions and policies may be as ethically justifiable as inaction, detachment, or noncooperation, depending on circumstances. Similar principles hold for anthropological researchers employed or otherwise affiliated with nonanthropological institutions, public institutions, or private enterprises.

A. Responsibility to people and animals with whom anthropological researchers work and whose lives and cultures they study.

1. Anthropological researchers have primary ethical obligations to the people, species, and materials they study and to the people with whom they work. These obligations can supersede the goal of seeking new knowledge, and can lead to decisions not to undertake or to discontinue a research project when the primary obligation conflicts with other responsibilities, such as those owed to sponsors or clients. These ethical obligations include:

- To avoid harm or wrong, understanding that the development of knowledge can lead to change which may be positive or negative for the people or animals worked with or studied
- To respect the well-being of humans and nonhuman primates
- To work for the long-term conservation of the archaeological, fossil, and historical records
- To consult actively with the affected individuals or group(s), with the goal of establishing a working relationship that can be beneficial to all parties involved

2. Anthropological researchers must do everything in their power to ensure that their research does not harm the safety, dignity, or privacy of the people with whom they work, conduct research, or perform other professional activities. Anthropological researchers working with animals must do everything in their power to ensure that the research does not harm the safety, psychological well-being or survival of the animals or species with which they work.

3. Anthropological researchers must determine in advance whether their hosts/providers of information wish to remain anonymous or receive recognition, and make every effort to comply with those wishes. Researchers must present to their research participants the possible impacts of the choices, and make clear that despite their best efforts, anonymity may be compromised or recognition fail to materialize.

4. Anthropological researchers should obtain in advance the informed consent of persons being studied, providing information, owning or controlling access to material being studied, or otherwise identified as having interests which might be impacted by the research. It is understood that the degree and breadth of informed consent required will depend on the nature of the project and may be affected by requirements of other codes, laws, and ethics of the country or community in which the research is pursued. Further, it is understood that the informed consent process is dynamic and continuous; the process should be initiated in the project design and continue through implementation by way of dialogue and negotiation with those studied. Researchers are responsible for identifying and complying with the various informed consent codes, laws and regulations affecting their projects. Informed consent, for the purposes of this code, does not necessarily imply or require a particular written or signed form. It is the quality of the consent, not the format, that is relevant.

5. Anthropological researchers who have developed close and enduring relationships (i.e., covenantal relationships) with either individual persons providing information or with hosts must adhere to the obligations of openness and informed consent, while carefully and respectfully negotiating the limits of the relationship.

6. While anthropologists may gain personally from their work, they must not exploit individuals, groups, animals, or cultural or biological materials. They should recognize their debt to the societies in which they work and their obligation to reciprocate with people studied in appropriate ways.

B. Responsibility to scholarship and science

1. Anthropological researchers must expect to encounter ethical dilemmas at every stage of their work, and must make good-faith efforts to identify potential ethical claims and conflicts in advance when preparing proposals and as projects proceed. A section raising and responding to potential ethical issues should be part of every research proposal.

2. Anthropological researchers bear responsibility for the integrity and reputation of their discipline, of scholarship, and of science. Thus, anthropological researchers are subject to the general moral rules of scientific and scholarly conduct: they should not deceive or knowingly misrepresent (i.e., fabricate evidence, falsify, plagiarize), or attempt to prevent reporting of misconduct, or obstruct the scientific/scholarly research of others.

3. Anthropological researchers should do all they can to preserve opportunities for future fieldworkers to follow them to the field.

4. Anthropological researchers should utilize the results of their work in an appropriate fashion, and

whenever possible disseminate their findings to the scientific and scholarly community.

5. Anthropological researchers should seriously consider all reasonable requests for access to their data and other research materials for purposes of research. They should also make every effort to insure preservation of their fieldwork data for use by posterity.

C. Responsibility to the public

1. Anthropological researchers should make the results of their research appropriately available to sponsors, students, decision makers, and other nonanthropologists. In so doing, they must be truthful; they are not only responsible for the factual content of their statements but also must consider carefully the social and political implications of the information they disseminate. They must do everything in their power to insure that such information is well understood, properly contextualized, and responsibly utilized. They should make clear the empirical bases upon which their reports stand, be candid about their qualifications and philosophical or political biases, and recognize and make clear the limits of anthropological expertise. At the same time, they must be alert to possible harm their information may cause people with whom they work or colleagues.

2. Anthropologists may choose to move beyond disseminating research results to a position of advocacy. This is an individual decision, but not an ethical responsibility.

IV. Teaching

Responsibility to students and trainees

While adhering to ethical and legal codes governing relations between teachers/mentors and students/ trainees at their educational institutions or as members of wider organizations, anthropological teachers should be particularly sensitive to the ways such codes apply in their discipline (for example, when teaching involves close contact with students/trainees in field situations). Among the widely recognized precepts which anthropological teachers, like other teachers/mentors, should follow are:

1. Teachers/mentors should conduct their programs in ways that preclude discrimination on the basis of sex, marital status, "race," social class, political convictions, disability, religion, ethnic background, national origin, sexual orientation, age, or other criteria irrelevant to academic performance.

2. Teachers'/mentors' duties include continually striving to improve their teaching/training techniques; being available and responsive to student/trainee interests; counseling students/ trainees realistically regarding career opportunities; conscientiously supervising, encouraging, and supporting students'/trainees' studies; being fair, prompt, and reliable in communicating evaluations; assisting students/ trainees in securing research support; and helping students/ trainees when they seek professional placement.

3. Teachers/mentors should impress upon students/ trainees the ethical challenges involved in every phase of anthropological work; encourage them to reflect upon this and other codes; encourage dialogue with colleagues on ethical issues; and discourage participation in ethically questionable projects.

4. Teachers/mentors should publicly acknowledge student/trainee assistance in research and preparation of their work; give appropriate credit for coauthorship to students/trainees; encourage publication of worthy student/trainee papers; and compensate students/trainees justly for their participation in all professional activities.

5. Teachers/mentors should beware of the exploitation and serious conflicts of interest which may result if they engage in sexual relations with students/trainees. They must avoid sexual liaisons with students/trainees for whose education and professional training they are in any way responsible.

V. Application

1. The same ethical guidelines apply to all anthropological work. That is, in both proposing and carrying out research, anthropologists must be open with funders, colleagues, persons studied or providing information, and relevant parties affected by the work about the purpose(s), potential impacts, and source(s) of support for the work. Applied anthropologists must intend and expect to utilize the results of their work appropriately (i.e., publication, teaching, program and policy development) within a reasonable time. In situations in which anthropological knowledge is applied, anthropologists bear the same responsibility to be open and candid about their skills and intentions, and monitor the effects of their work on all persons affected. Anthropologists may be involved in many types of work, frequently affecting individuals and groups with diverse and sometimes conflicting interests. The individual anthropologist must make carefully considered ethical choices and be prepared to make clear the assumptions, facts and issues on which those choices are based.

2. In all dealings with employers, persons hired to pursue anthropological research or apply anthropological knowledge should be honest about their qualifications, capabilities, and aims. Prior to making any professional commitments, they must review the purposes of prospective employers, taking into consideration the employer's past activities and future goals. In working for governmental agencies or private businesses, they should be especially careful not to promise or imply acceptance of conditions contrary to professional ethics or competing commitments.

3. Applied anthropologists, as any anthropologist, should be alert to the danger of compromising anthropological ethics as a condition for engaging in research or practice. They should also be alert to proper demands of hospitality, good citizenship and guest status. Proactive contribution and leadership in shaping public or private sector actions and policies may be as ethically justifiable as inaction, detachment, or noncooperation, depending on circumstances.

VI. Epilogue

Anthropological research, teaching, and application, like any human actions, pose choices for which anthropologists individually and collectively bear ethical responsibility. Since anthropologists are members of a variety of groups and subject to a variety of ethical codes, choices must sometimes be made not only between the varied obligations presented in this code but also between those of this code and those incurred in other statuses or roles. This statement does not dictate choice or propose sanctions. Rather, it is designed to promote discussion and provide general guidelines for ethically responsible decisions.

HIPPOCRATIC OATH FOR SCIENTISTS (U.S. STUDENT PUGWASH GROUP VERSION)

"I promise to work for a better world, where science and technology are used in socially responsible ways.

I will not use my education for any purpose intended to harm human beings or the environment. Throughout my career, I will consider the ethical implications of my work before I take action. While the demands placed upon me may be great, I sign this declaration because I recognize that individual responsibility is the first step on the path to peace."

INTERNATIONAL NETWORK OF ENGINEERS AND SCIENTISTS FOR GLOBAL RESPONSIBILITY (INES)

Appeal to Engineers and Scientists (1995)

APPEAL Science and technology influence the social, economic and political development of civilization throughout the world. In many ways science and technology have made our life easier, richer and safer. However, science and technology can be used for destructive purposes and are key factors in the current growth economy that is threatening the viability of the biosphere and of human societies.

In its origins, science is a search for truth about our world. Its results can be used for good and misused for evil. Technological consequences are now so powerful and interconnected, so sweeping in unforeseen results, that they endanger basic requirements for sustaining life on earth. Without adherence to generally accepted ethical standards, science and technology can damage the future of society and life itself.

The greatest challenge of our time is to enable to all members of the world population to live in dignity in a manner that is sustainable for humankind and nature. In meeting this challenge science and technology—if used in the right way—play a decisive role by providing the necessary means or by analyzing the various consequences of human activities.

The web of humanity and life as a whole must not be endangered by vested interests. Knowledge gives power, and power may corrupt and be used for destructive purposes. Therefore, social structures and institutions on local, national, regional and global levels are urgently needed to promote responsible uses of science and technology. We appeal to engineers and scientists to respect human rights and human dignity unconditionally.

Secrecy of scientific and technological research allows its misuse. Our vision is a science which seeks truth in open discourse.

In the last decades several initiatives promoting ethical pledges of scientists have been launched. The values underlying these pledges can form the foundation of a worldwide community of responsibility among scientists and engineers. In adherence to the UNESCO Declaration for Scientific Professionals of November 1974, we have attempted to harmonize existing pledges into the following code of ethics:

PLEDGE 1. I acknowledge as a scientist or engineer that I have a special responsibility for the future of humankind. I share a duty to sustain life as a whole. I therefore pledge to reflect upon my scientific work and its possible consequences in advance and to judge it according to ethical standards. I will do this even though it is not possible to foresee all possible consequences and even if I have no direct influence on them.

2. I pledge to use my knowledge and abilities for the protection and enrichment of life. I will respect human rights, and the dignity and importance of all forms of life in their interconnectedness. I am aware that curiosity and pressure to succeed may lead me into conflict with that objective. If there are indications that my work could pose severe threats to human life or to the environment, I will abstain until appropriate assessment and precautionary actions have been taken. If necessary and appropriate, I will inform the public.

3. I pledge not to take part in the development and production of weapons of mass destruction and of weapons that are banned by international conventions. Aware that even conventional arms can contribute to mass destruction, I will support political efforts to bring arms production, arms trade, and the transfer of military technology under strict international control.

4. I pledge to be truthful and to subject the assumptions, methods, findings and goals of my work, including possible impacts on humanity and on the environment, to open and critical discussion. To the best of my ability I shall contribute to public understanding of science. I shall support public participation in a critical discussion of the funding priorities and uses of science and technology. I will carefully consider the arguments from such discussions which question my work or its impact.

5. I pledge to support the open publication and discussion of scientific research. Since the results of science ultimately belong to humankind, I will conscientiously consider my participation in secret research projects that serve military or economic interests. I will not participate in secret research projects if I conclude that society will be injured thereby. Should I decide to participate in any secret research, I will continuously reflect upon its implications for society and the environment.

6. I pledge to enhance the awareness of ethical principles and the resulting obligations among scientists and engineers. I will join fellow scientists and others willing to take responsibility. I will support those who might experience professional disadvantages in attempting to live up to the principles of this pledge. I will support the establishment and the work of institutions that enable scientists to exercise their responsibilities more effectively according to this pledge.

7. I pledge to support research projects, whether in basic or applied science, that contribute to the solution of vital problems of humankind, including poverty, violations of human rights, armed conflicts and environmental degradation.

8. I acknowledge my duty to present and future generations, and pledge that the fulfillment of this duty will not be influenced by material advantages or political, national or economic loyalties.

The above text incorporates material and ideas from the following declarations:

- The Mount Carmel Declaration on Technology and Moral Responsibility (Haifa, 1974)
- The Biologists Pledge (MIT, 1987)
- Hippocratic Oath for Scientists (Nuclear Age Peace Foundation, (1987)
- The Buenos Aires Oath (Buenos Aires, 1988)
- The Uppsala Code of Ethics for Scientists (Uppsala, 1984)
- Hippocratic Oath for Scientists, Engineers and Executives (Inst. for Social Inventions, 1987)
- Scientists Pledge Not to Take Part in Military-Directed Research (SANA, London, 1991)
- Appeal to Scientists (Wittenberg, 1989)
- A Pledge for Scientists (Berlin, 1984)
- The Toronto Resolution (Toronto, 1991)

We see these declarations as a part of a wider movement which has expressed itself in particular in the Declaration of a Global Ethic of the Parliament of the World's Religions (Chicago, 1993) and in the Trieste Declaration of Human Duties (Trieste, 1994).

7. GOVERNMENT

DEFINITION OF RESEARCH MISCONDUCT FROM THE U.S. FEDERAL REGISTER

Research misconduct is defined as fabrication, falsification, or plagiarism in proposing, performing, or reviewing research, or in reporting research results.

1. No rights, privileges, benefits or obligations are created or abridged by issuance of this policy alone. The creation or abridgment of rights, privileges, benefits or obligations, if any, shall occur only upon implementation of this policy by the Federal agencies.

2. Research, as used herein, includes all basic, applied, and demonstration research in all fields of science, engineering, and mathematics. This includes, but is not limited to, research in economics, education, linguistics, medicine, psychology, social sciences, statistics, and research involving human subjects or animals.

Fabrication is making up data or results and recording or reporting them.

Falsification is manipulating research materials, equipment, or processes, or changing or omitting data or results such that the research is not accurately represented in the research record.

3. The research record is the record of data or results that embody the facts resulting from scientific inquiry, and includes, but is not limited to, research proposals, laboratory records, both physical and electronic, progress reports, abstracts, theses, oral presentations, internal reports, and journal articles.

Plagiarism is the appropriation of another person's ideas, processes, results, or words without giving appropriate credit.

Research misconduct does not include honest error or differences of opinion.

INDEX

Page references to entire articles are in **boldface.** *References to tables, figures, and illustrations are denoted by italics*, sometimes followed by *t* (table) or *f* (figure).

• • • B

• • • C

V1: 1–462; V2: 463–1109; V3: 1111–1672; V4: 1673–2090

• • • D

• • • E

• • • F

V1: 1–462; V2: 463–1109; V3: 1111–1672; V4: 1673–2090

• • • G

V1: 1–462; V2: 463–1109; V3: 1111–1672; V4: 1673–2090

• • • H

• • • I

• • • L

• • • M

• • • N

• • • O

• • • P

V1: 1–462; V2: 463–1109; V3: 1111–1672; V4: 1673–2090

• • • S

• • • T

• • • U

• • • V

• • • W

V1: 1–462; V2: 463–1109; V3: 1111–1672; V4: 1673–2090

X

Y

Z